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A Ruggedized Thin-Window Proportional-Counter Tube

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FOREWORD

The work described in this Memorandum was performed by the authors as a cooperative effort during a period in which Dr. Schnopper was stationed at JPL under special assignment by the U. S. Army. Dr. Schnopper is now associated with the Physics Department and the Laboratory of Atomic and Solid State Physics at Cornell University.

ABSTRACT

The design and testing of a thin-window proportional-counter tube are described. The objective of this investigation was the development of a component suitable for use in space experiments involving the detection of X-rays from light elements. The stability, efficiency, and resolution of the tube described here are consistent with space-application requirements. In a series of tests, it was determined that 0.25-mil aluminum-coated Mylar, supported by a nickel screen, provided maximum strength with minimum absorption. Two methods of sealing the window are described: (1) an O-ring and (2) a potting compound. Sodium Kα pulse-height distributions from the thin-window tubes are compared with those from a standard commercial tube having a mica window.

I. TUBE DESIGN AND ASSEMBLY

For space applications, a proportional-counter tube must exhibit good stability under changing intensity and other environmental conditions, and also good efficiency and resolution in the region of 7 to 12 Å. Although tube design is already a well developed art (Ref. 1), a need has existed for improvement in window construction and installation techniques. The window described here produces results consistent with the objective of detecting X-rays from light elements in space experiments.

The tubes used in the present investigation were made from a 3-in. length of ¾-in. square brass tubing with a 0.038-in. wall thickness (Fig. 1). Convenient connections for filling and sealing were fabricated from ⅛-in. copper tubing, silver-soldered to the tube. End caps with glass-to-metal feedthroughs were soft-soldered to each end of the tube as mounts for the anode wire.

The recessed-window body was soft-soldered to the tube body at the midpoint on the length of the tube. A groove for a Viton 2-14 O-ring was machined on the floor of the ¾-in. recess, the depth of the groove allowing approximately 10% compression of the O-ring. A ⅜-in. window opening was machined through the tube wall. After each assembly step, the tube was liquid-honed inside and out to maintain a clean surface.

The last assembly step prior to the window installation was the installation of the tungsten anode wire, which was 0.002 in. in diameter, and 1.7 in. long. This wire was welded at each end to a length of 0.050-in. stainless steel wire, which was then soft-soldered into the small tubing in the glass-to-metal feedthroughs.

The window support screen was of etched nickel,[1] 0.001 in. thick, having 40 wires per inch and a transmission

[1] Screen supplied by Buckbee-Mears Company, St. Paul, Minnesota.

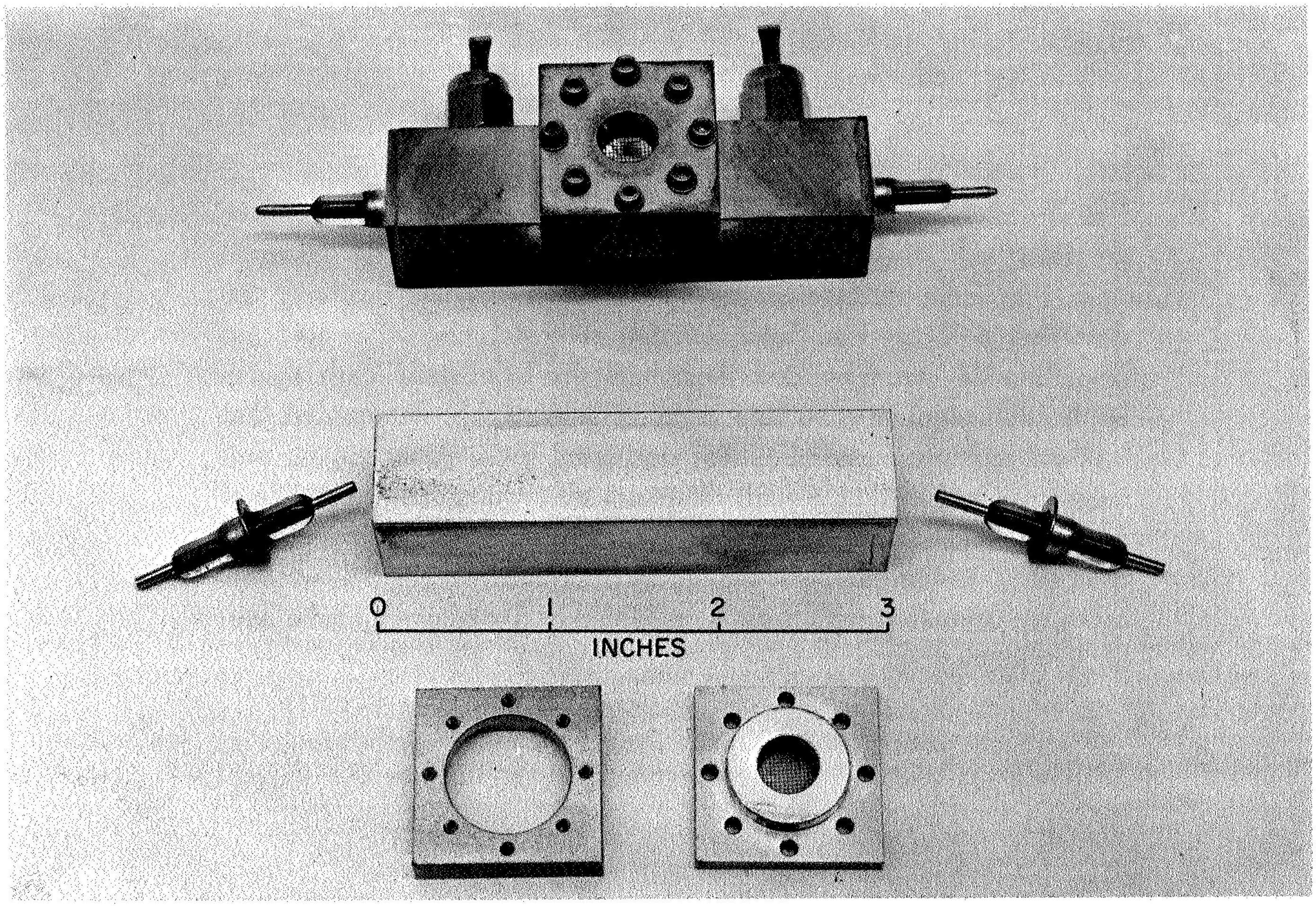

Fig. 1. Thin-window counter before and after assembly

of 70%. The wires were found to have rough edges capable of puncturing the window material. This roughness was eliminated by lapping the screen with a fine diamond dust between two microscope slides. The screen was cemented to the compression surface of the window cap by applying a small amount of Selectron.[2] While the Selectron was curing, the assembly was held in place by a lightly greased, weighted microscope slide. After curing, the window-cap assembly was placed in a lathe, and the Selectron that had flowed through the screen was machined smooth and flat to within approximately 0.002 in. of the screen. The entire tube assembly was then cleaned and dried before installation of the window.

[2]Commercial potting compound supplied by Pittsburgh Plate Glass Company, Torrance, California.

II. WINDOW INSTALLATION

Several pieces of 0.25-mil Mylar were vacuum-coated, each with a different thickness of aluminum. Absorption tests were performed to select the thickness of coating that would render the Mylar leak-free and still give reasonable transmission for Na $K\alpha$ X-rays.

One piece of aluminized Mylar was selected, after inspection to ensure complete aluminum coating. A thin film of vacuum grease was applied to the compression surface of the window cap, over which was placed the aluminized Mylar with the aluminum surface toward the inside of the tube. The O-ring was lightly greased before it was placed in its groove. With the aluminized Mylar held in place by the vacuum grease, the window cap was tightened against the window body.

Because the use of an O-ring was a new approach in window sealing, another tube was prepared for comparison. The second tube was identical to the first except that it contained no O-ring groove. In place of the O-ring, a small amount of Selectron was painted on the floor of the window body to seal the window assembly.

Both tubes were filled and sealed with P10 gas at a pressure slightly above atmospheric, thus reducing window flexing by holding the window against the screen.

After a short test period in atmosphere, both counters were placed in a vacuum chamber with an Fe^{55} source over each window, and were connected so that they could be checked while in vacuum. At the end of a month's testing, during which both counters operated satisfactorily, they were removed from the vacuum. Because the window sealed by the O-ring was more easily installed and replaced, this design, designated as S-3/8, was chosen as the test counter.

III. TEST PROCEDURES

A. *Environmental Tests*

Counter S-3/8 was subjected to a standard series of environmental tests, including: an acceleration test of 14 *g* for 5 min; a shake test of 100 *g*, repeated five times in three planes; and a vacuum temperature test at -50 to 70°C. There was no apparent change in the counter operation after the tests.

B. *Pulse-Height Distributions*

As a test of the performance of the thin-window counter after the environmental tests, a series of pulse-height distributions was obtained from X-ray sources, including NaF and NaCl. Three counters filled with P10 gas were used for this test: (1) an Amperex counter having a mica window 0.25 in. in diameter and 1.5 mg/cm^2 thick; (2) a modified Amperex counter incorporating a 0.25-in.-diameter 0.25-mil aluminized-Mylar window; and (3) counter S-3/8. The samples were excited by an electron gun operated at 12.5 kv and 5μ amp. The counters were masked by metal disks with small holes to cut down intensity. The only variation in the operating conditions was the adjustment of the counter voltages to control peak positioning in a pulse-height analyzer. Figure 2 shows the NaF and NaCl distributions for the three counters. The X-ray peak of sodium is clearly seen in the record for the two aluminized-Mylar counters, but is indistinguishable above background in the data for the mica-window counter. Table 1 lists the NaF and Fe^{55} peak resolutions of the two thin-window counters. These resolutions are of a quality sufficient to permit use of these counters for nondispersive X-ray analysis.

Table 1. Resolution of aluminized-Mylar-window counters

Counter	X-ray source	Resolution, %
Amperex (modified)	NaF	44
Amperex (modified)	Fe^{55}	21
S-3/8	NaF	56
S-3/8	Fe^{55}	24

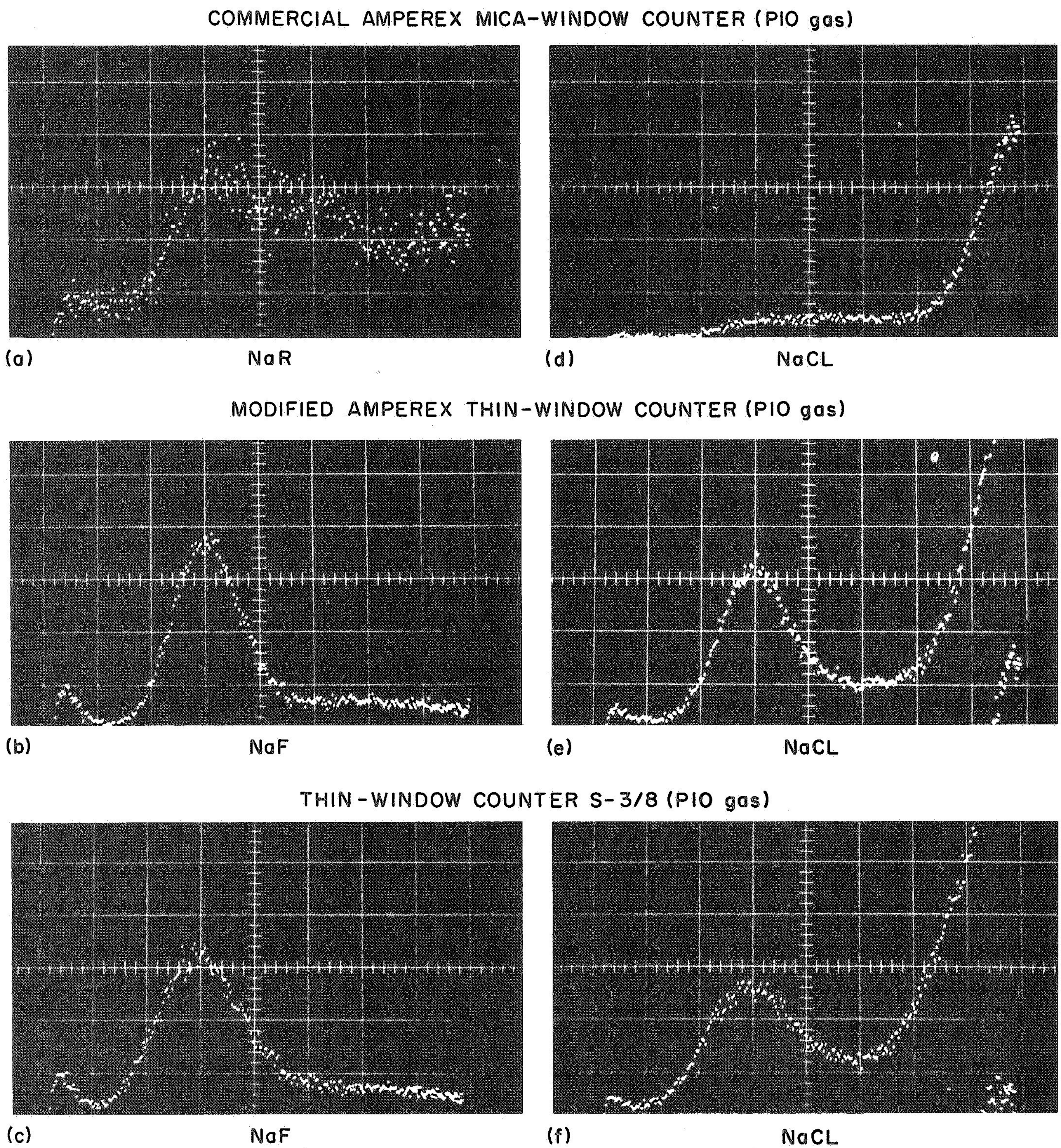

Fig. 2. Pulse-height distributions of test counters

Transmission values were obtained by absorption measurements at several wavelengths. The transmission of the aluminized Mylar used in counter S-3/8 is 7% for Na Kα X-rays, 30% for Mg Kα X-rays, and 52% for Al Kα X-rays.

At this writing, twelve counters have been constructed: six having 0.25-mil aluminized-Mylar windows; four of the S-3/8 design (0.71-cm^2 window area); and two of the modified Amperex type (0.31-cm^2 window area). All are operating satisfactorily.

IV. COUNTER APPLICATIONS

A rugged proportional counter providing adequate transmission in the range of 7 to 12 Å can be utilized for several types of space experiments. The counter described here was developed for the detection of Na, Mg, Al, and Si in lunar material by an X-ray spectrograph placed upon the surface (Ref. 2). Fluorescent emission from the lunar surface will be induced by solar radiation; thus, the detector could also be used to measure this emission from a spacecraft orbiting the Moon (Ref. 3). A third application would be for the measurement of interstellar X-ray fluxes from sounding rockets or satellites.

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