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The FFTF (Flast Flux Test Facility) nearing completion at the Hanford Engineering Development Laboratory near Richland, Washington, under the direction of The Westinghouse Hanford Co., is designed to test components and materials for the development of Liquid Metal Fast Breeder Reactors. During the initial stages of operation, the FFTF will be shut down when a fuel or control pin has a detectable cladding leak. To achieve maximum reactor operating time, monitoring methods for detecting and locating leaking pins were developed.

Monitoring techniques to signal a leak are based on changes of specific activity levels of individual xenon and krypton fission product isotopes. Gas tagging is the method used to locate the failed pin. Isotopically differing tags of a gas or gases can be used as a fingerprint technique for sealed assemblies such as fuel or control pins with mass spectrometer detection to locate a specific leaker. Gas tagging with xenon was first employed by the Argonne National Laboratory at the Experimental Breeder Reactor II near Idaho Falls, Idaho.[-1] The Westinghouse Hanford gas tag system uses xenon + Krypton.[-2]

104 unique tags were blended for the 80 fuel assemblies and 24 control assemblies. The isotopic ratios Xe 126/129, Kr 78/80 and Kr 82/80 can be represented in three-dimensional tag-ratio space. And by careful selection of the individual tags, multiple failure detection is possible.[-3] Figure 1 shows the 3d array of the tags.

One cc each of xenon and krypton are placed in each fuel and control pin via a gas tag capsule. The capsules contain magnetic penetrators for release of the gas to the pin. Each pin in an assembly receives the same gas tag. When a pin develops a leak the gas tag along with the He fill gas and fission gases are swept via the sodium coolant into the $10^{+4}\ell$ argon cover gas. Mass spectrometer identification of a tag from a leaking pin, requires isolation of the tag from the argon cover gas. Charcoal trapping followed by a neon purge to remove argon from the trap gives a good separation. The separation must be fairly complete because argon forms a dimer ion (Ar_2^+) which inteferes with the krypton ratio measurements (fig.2). The dimer formation appears to be a second order reaction depending on the pressure of argon in the ion source, (fig. 3 & 4), and the electron accelerating potential (fig. 5).

The mass spectrometer used is a Nuclide Model 6-60SGA equipped with static, molecular and capillary inlets. The original ion pumps were removed due to Xe and Kr regurgitation and replaced with mercury pumps. A small valvable ion pump on the static inlet was retained as a holding pump. The molecular leak oil pump was also replaced with a mercury pump to reduct C_xH_y interferences.

The vacuum-gas trapping system for developing the separation technique was built using 304 L and 316 stainless steel and is equipped with mercury pumps. The charcoal traps required extensive baking at over 400°C to reduce the very presistant hydrocarbon contents. Fig. 6 shows a typical C_xH_y spectra from a blank run compared to 10^{-4}cc of krypton via the molecular leak.

In order to recover 10^{-4}cc of tag from a 1% leak approximately 140ℓ of argon cover gas is passed through a 170 gm charcoal trap held at -100°C. We purge the trap with Ne to remove most of the argon, and then transfer the tag to a small (2.5 gm) trap for concentration of the tag and pump most of the Ne off while holding the small trap at -90°C. The tag gases are then pumped off while holding the small trap at -90°C. The tag gases are then pumped off at +150°C via a small one inch mercury pump to a receiver bulb for analysis. Recoveries routinely are over 80% for both xenon and krypton.

In analyzing the gas tags, the mass spectrometer is operated with the electron accelerating voltage set at 30 volts. This voltage is about optimum for our instrument. The Ar_2^+ production is minimal while the xenon and krypton sensitivities are quite good. Figure 5, 7 and 8.

Tables 1 and 2 show the results of several simulated runs. Two tags were selected at random and used as "blind tags", and run through the separation along with 140ℓ of argon gas and then analyzed and identified. The identification is quite straight forward. Each tag is well separated from adjacent tags. The isotopic ratio changes due to radiation flux in the reactor would not require additional corrections for gas tag identification until very late in the core lifetime of an assembly.

The use of krypton along with xenon for gas tagging can complicate the analysis of gas tags due to the argon interference. However, by using krypton a much larger number of distinct tags can be blended than with xenon alone. And the interferences can be overcome by good separation techniques and optimization of the mass spectrometer.

1. P. B. Henault, G. J. Bernstein, L. F. Coleman, E. R. Ebersole, W. J. Larson and R. R. Smith, Trans. Am. Nucl. Soc., 12, 102 (1969)

2. McCormick and Schenter, Nucl. Technol., 24, 149 (1974)

3. McCormick, Nucl. Technol., 24, 156 (1974)

GAS TAG, 3 DIMENSIONAL ARRAY

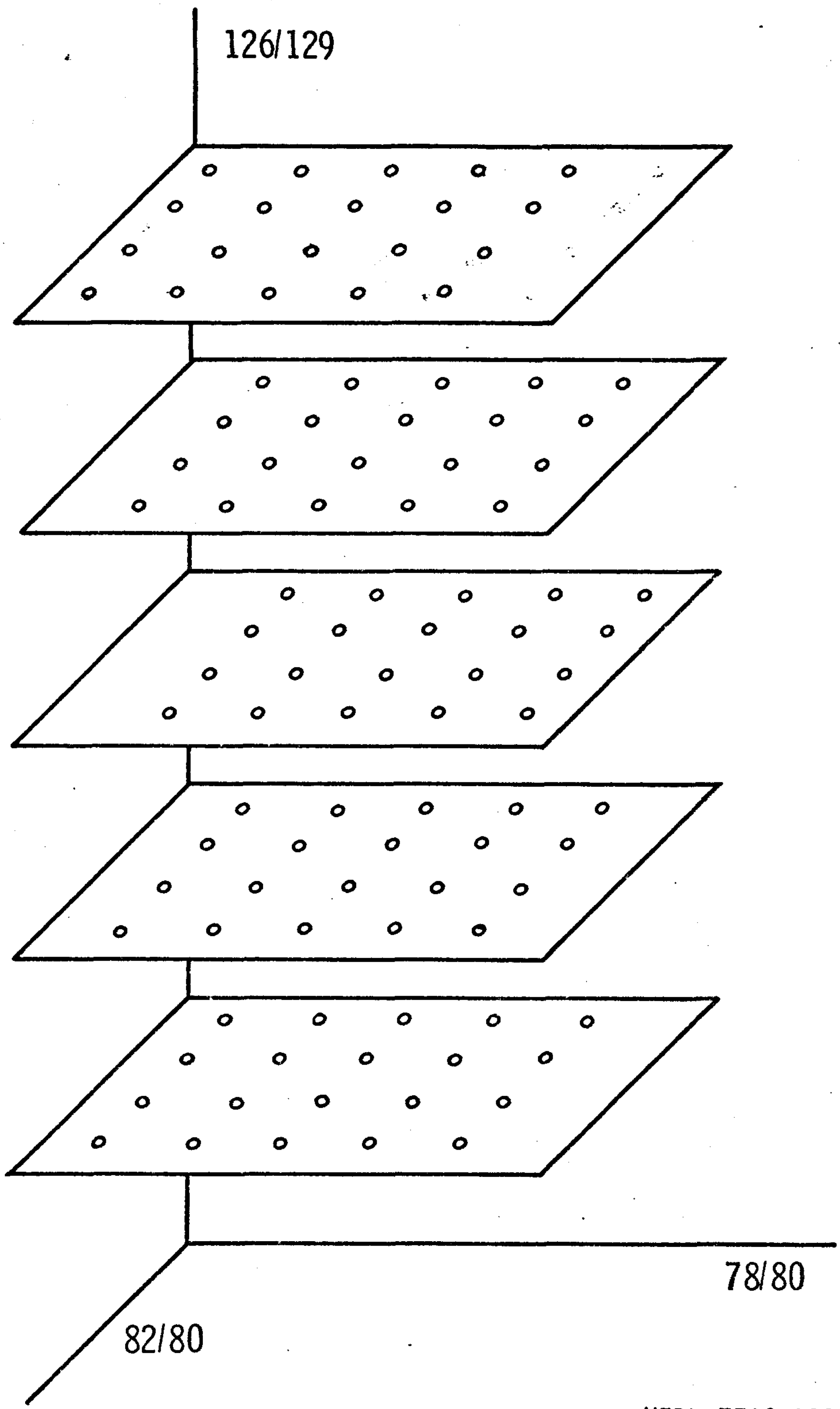

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Fig. 1

ARGON INTERFERENCE

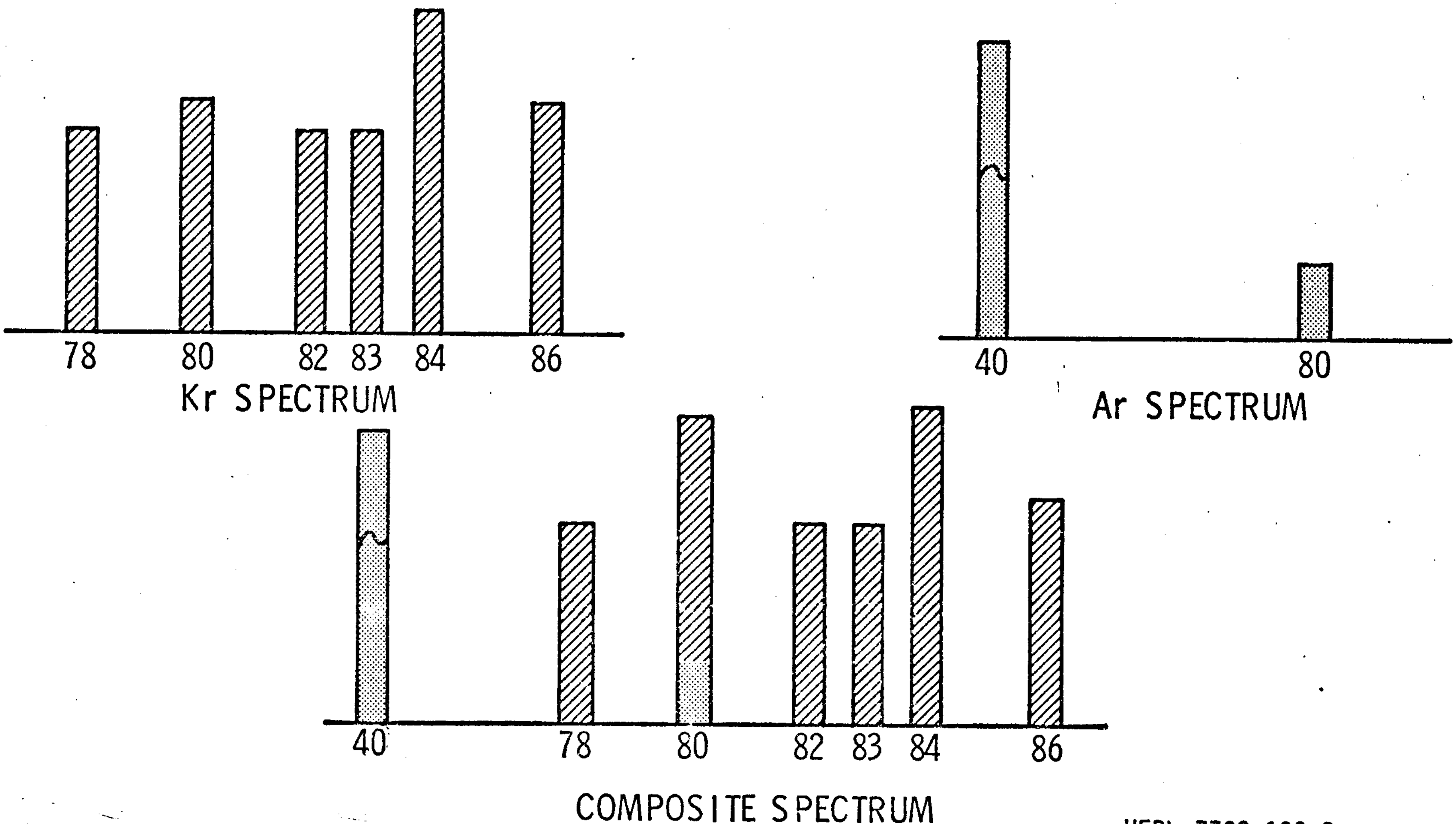

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Fig. 2

A_2^+ PRODUCTION VS SOURCE ARGON PRESSURE

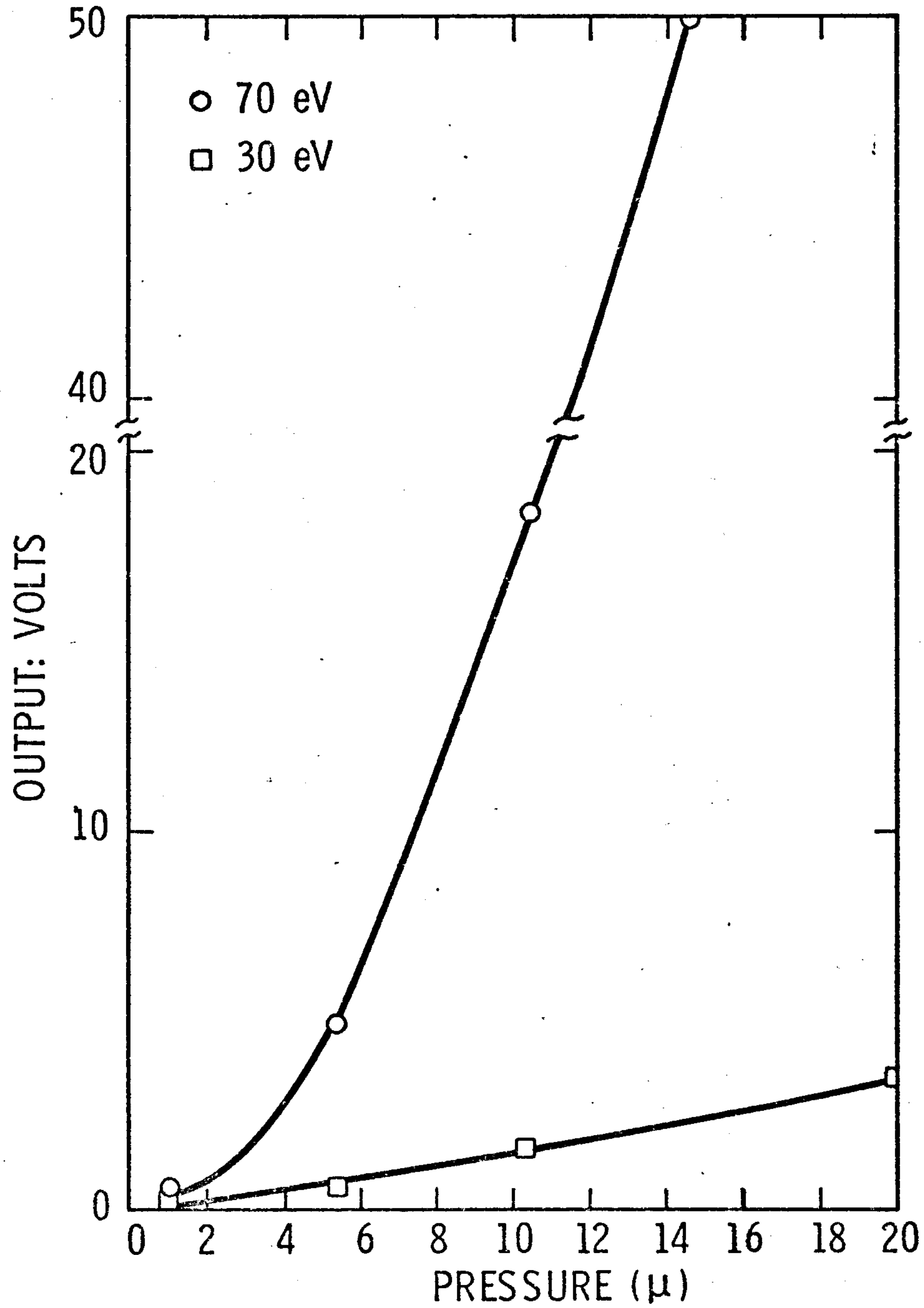

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Fig. 3

Ar_2^+ VS ELECTRON VOLTAGE

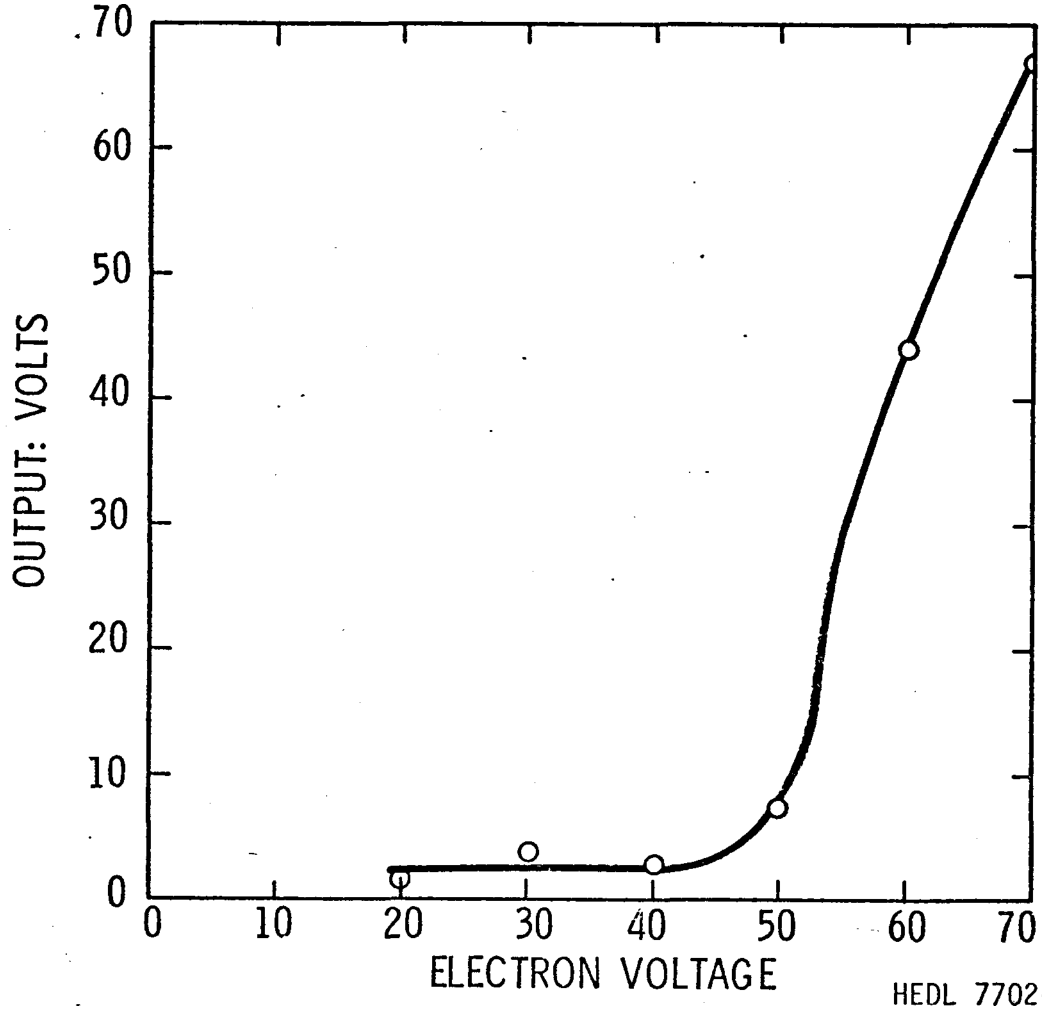

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Fig. 4

Ar_2^+/Ar^+ VS ELECTRON VOLTAGE

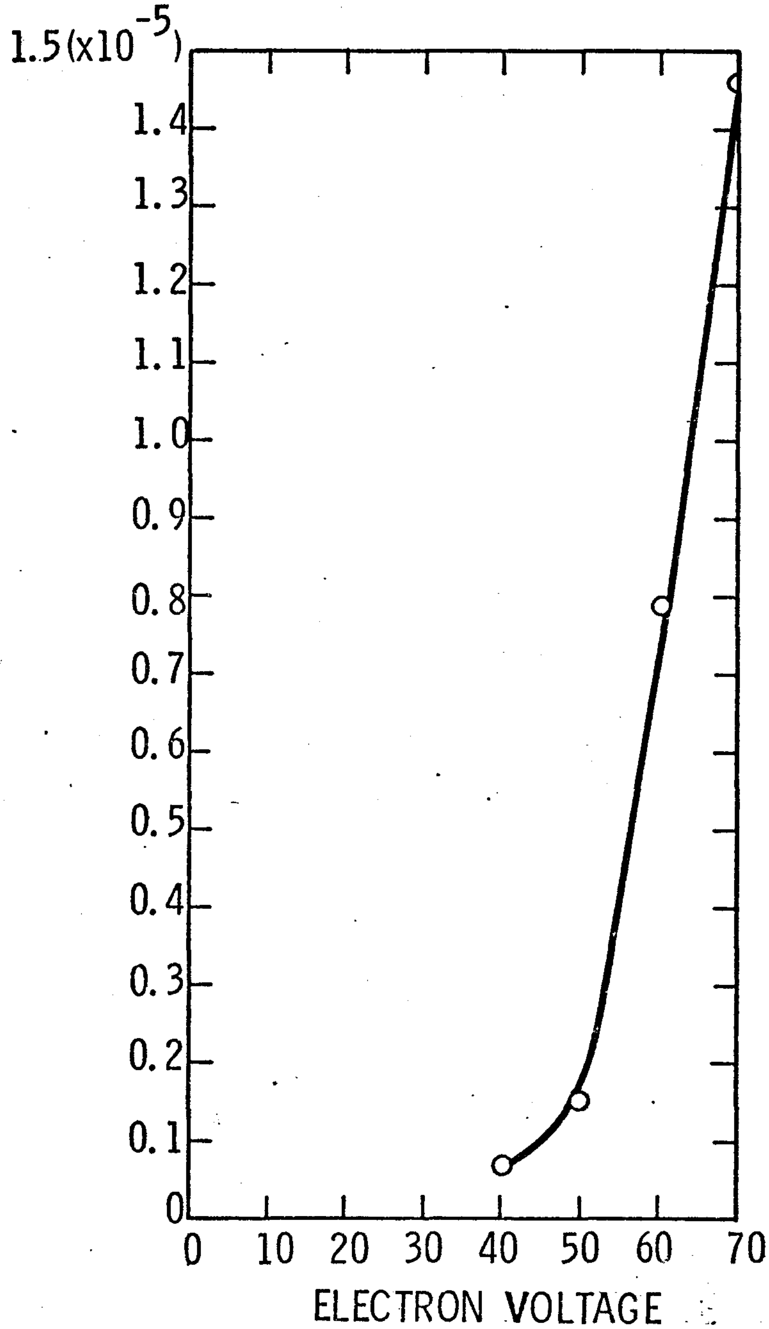

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Fig. 5

HYDROCARBON INTERFERENCE

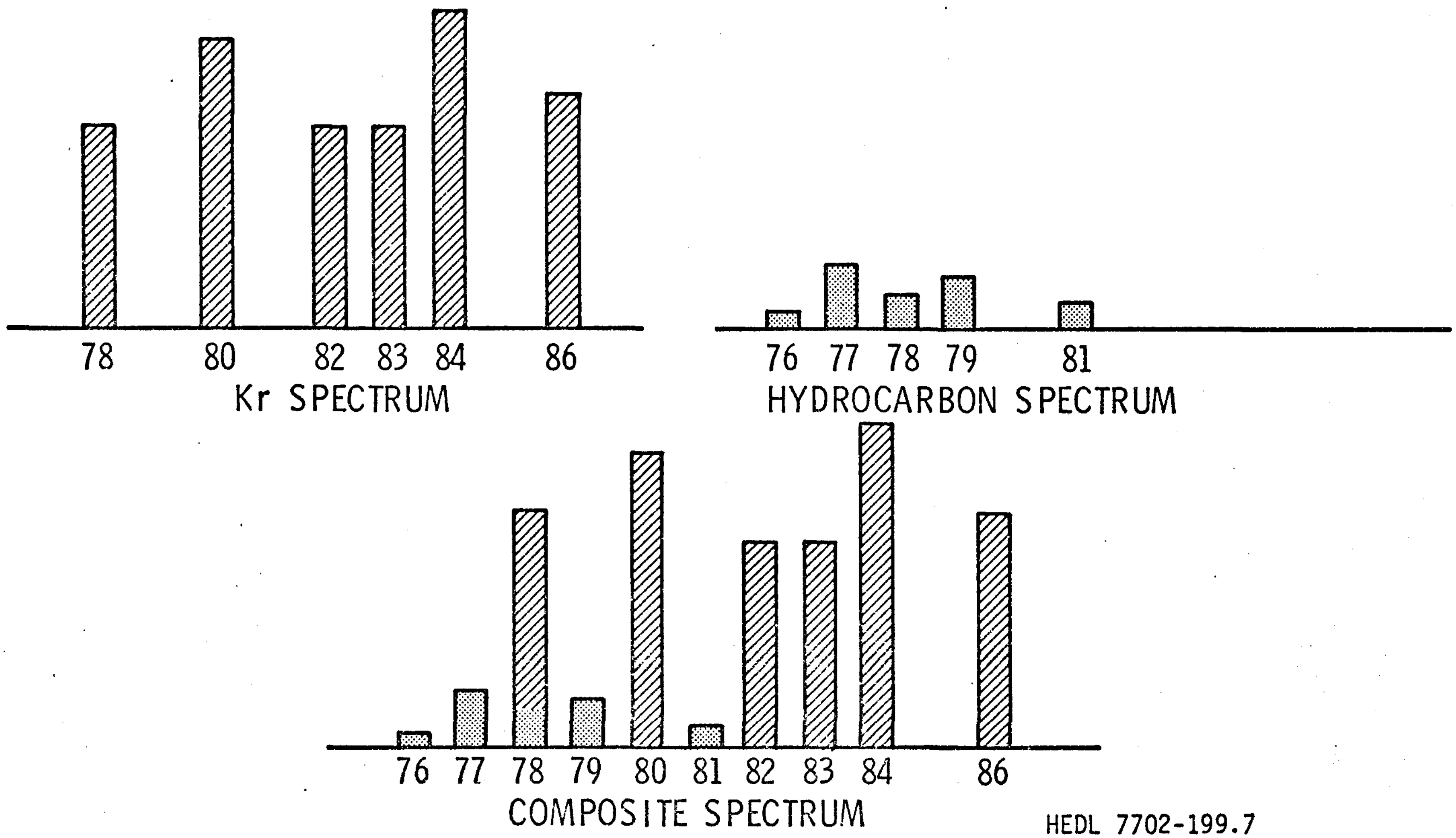

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Fig. 6

XENON-131 SENSITIVITY VS ELECTRON VOLTAGE

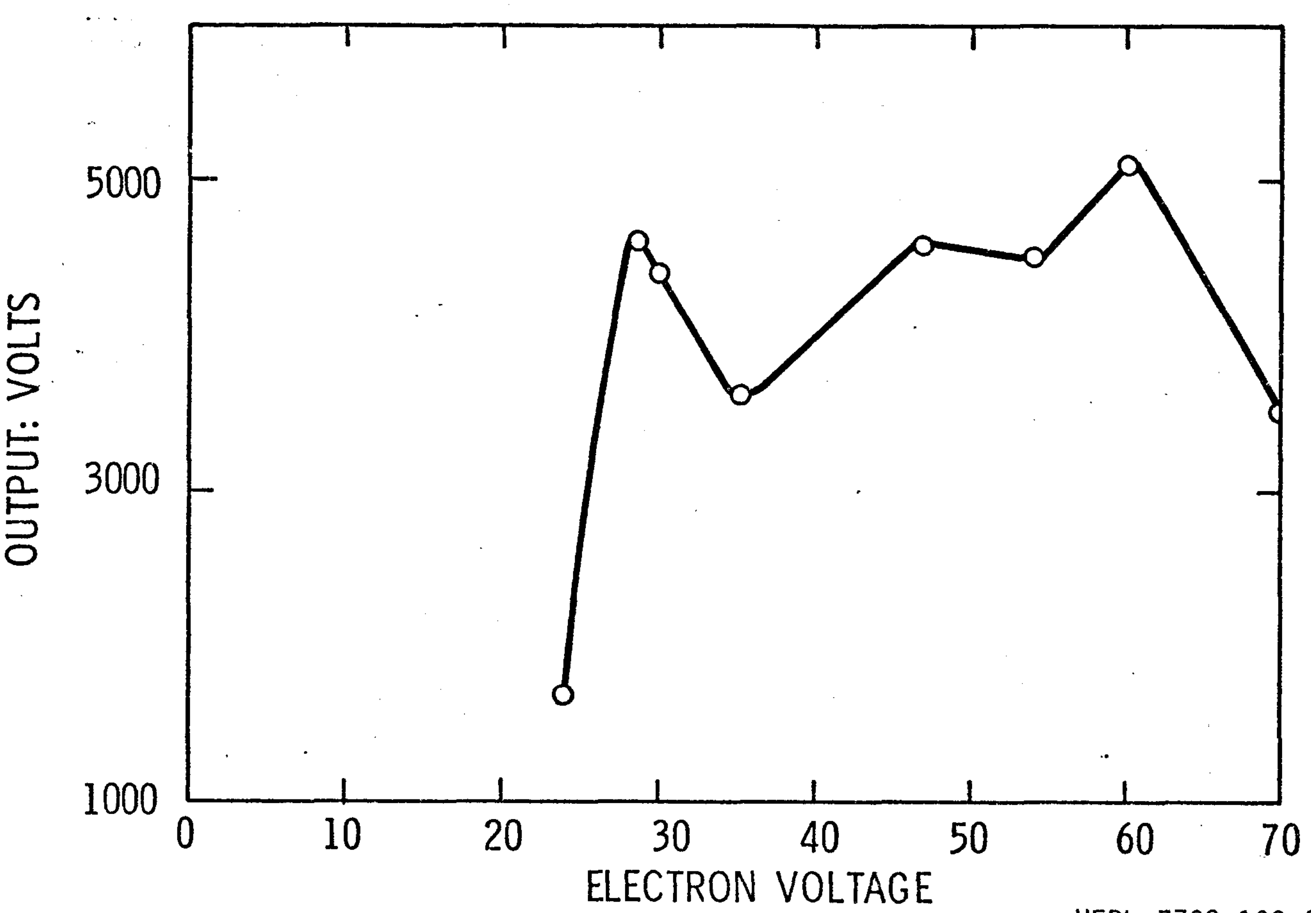

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Fig. 7

KRYPTON-84 SENSITIVITY VS ELECTRON VOLTAGE

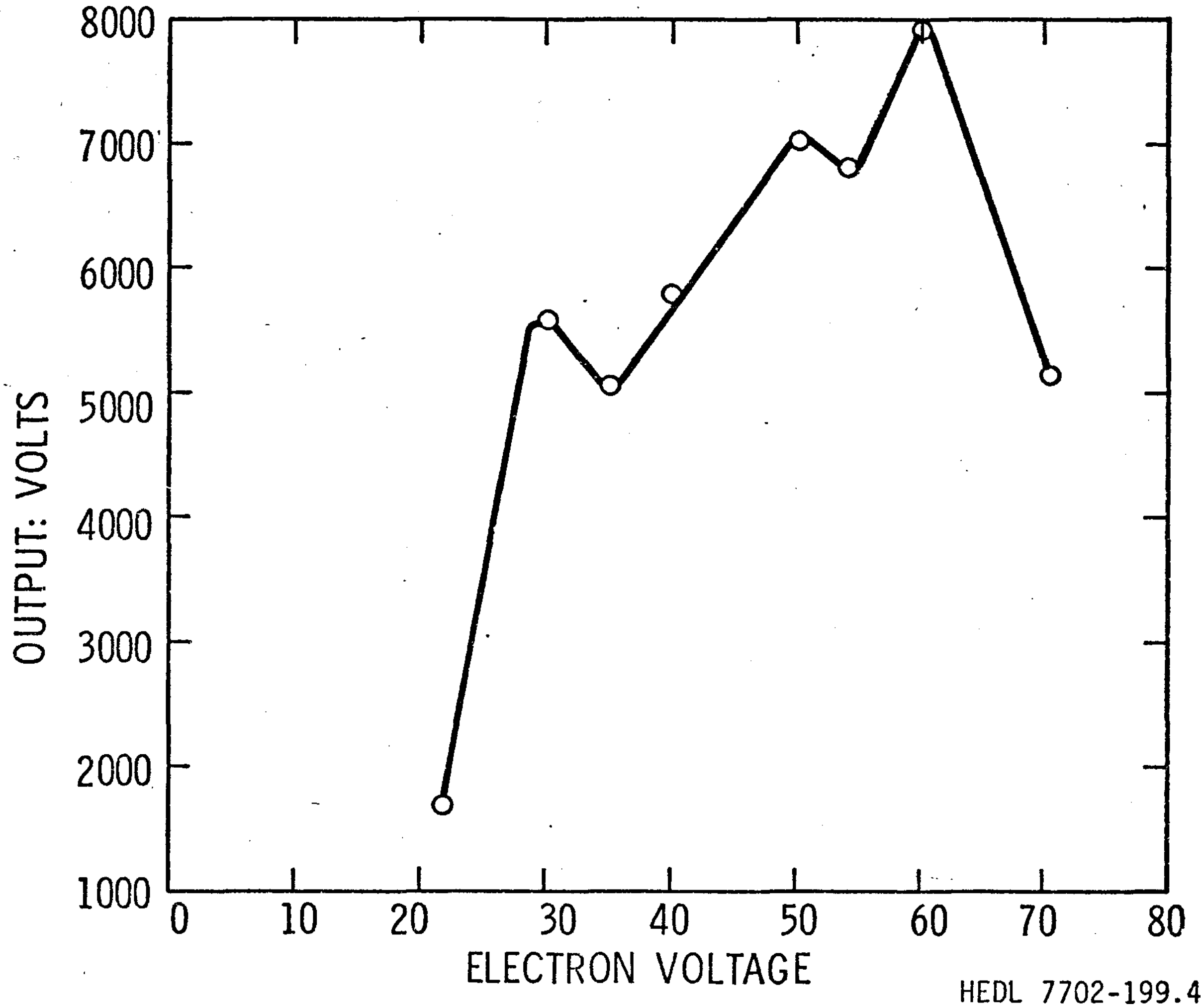

Fig. 8

IDENTIFICATION OF BLIND TAG #1

	78/80	82/80	126/129	128/129
BLIND TAG	.4496	3.185	.0150	.1014
TAG A	.2973	3.639	.01455	.0930
TAG B	.2493	2.928	.01463	.1021
TAG C	.5788	3.333	.0147	.0934
TAG D	.4704	3.1280	.01490	.1012
TAG E	.5008	2.4918	.0150	.1139

IDENTIFICATION OF BLIND TAG #2

	78/80	82/80	126/129	128/129
BLIND TAG	.5007	2.5180	.0103	.09952
TAG A	.4888	2.5112	.01218	.09810
TAG B	.6130	2.6755	.00998	.1119
TAG C	.4906	2.5187	.01004	.09820
TAG D	.3930	2.1253	.01021	.09850
TAG E	.3134	2.8073	.01006	.09820