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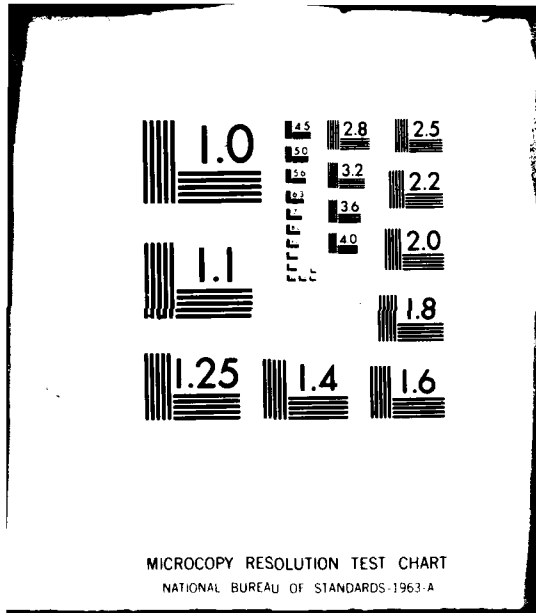
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EVALUATION OF THE ENERGY AND ANGULAR DEPENDENCE
OF THE VICTORIAN MODELS 470A AND 471 SURVEY METERS

BROOKS AFB TX 78235

20 FEBRUARY 1968

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16. ABSTRACT (Continue on reverse side if necessary and identify by block number) The angular and energy dependence of the Victoreen models 470A and 471 have been evaluated. The instruments were exposed to x-rays of 9, 21, 42, 64 and 120 keV effective energies as well as to CS-137 gamma rays. Instrument response was also evaluated as a function of incident radiation angle between 0° and 90°. Both instruments met or exceeded manufacturer's performance specifications.		16. 410936 GM

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REPORT NO. 80-8

EVALUATION OF THE ENERGY AND ANGULAR DEPENDENCE
OF THE VICTOREEN MODELS 470A AND 471 SURVEY METERS

BROOKS AFB TX 78235

20 FEBRUARY 1980

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I. INTRODUCTION

A. This Laboratory has evaluated the angular and energy dependence exhibited by two radiation survey meters manufactured by the Victoreen Instrument Company: The Model 470A, SN 2017, and the Model 471, SN 134. Manufacturer's specifications of the Victoreen Model 470A are contained in Attachments 1 and 2; the Victoreen Model 471's specifications are presented in Attachments 3 and 4.

B. Section II of this report describes the evaluation procedures and irradiation methods. Section III presents and discusses the results of the evaluation and Section IV contains recommendations made based on the evaluation results.

II. PROCEDURES

A. This evaluation was conducted to study the dependence of the instruments' response on radiation energy and angle of incidence. Both instruments were exposed to x-rays of effective energies of 9, 21, 42, 64 and 120 keV, as well as to 662 keV gammas of Cs-137 (Attachment 5). The instruments were exposed at 0° , 22.5° , 45° , 67.5° and 90° from the incident radiation beam direction for each energy level. This geometry is depicted in Attachment 6.

B. The exposure rate at all energies was determined using Victoreen Intercomparison Standard Ionization Chambers calibrated by the NBS. The Victoreen Model 415A, SN 11, was used for techniques LFD and LFI, the Victoreen Model 415B, SN 111 was used for techniques MFG, MFI, and HFG, and the Victoreen Model 415, SN 121, was used to determine the exposure rate at the Cs-137 energy.

C. The intercomparison standards were used in a charge collection mode; the ionization currents being integrated by a 1×10^{-9} Farad Reference Standard Capacitor, General Radio type 1404-A, SN 583. The integrating capacitor was connected in the feedback loop of a Cary Model 471 Vibrating Reed Electrometer, SN 1094, in series with a Keithley Precision Voltage Source, Model 660A, SN 35454. Measurement was effected by manually nulling, with the precision voltage source, the voltage developed across the integrating capacitor.

D. The beam monitor for the x-ray source consisted of a locally fabricated transmission ionization chamber. The ionization currents produced were measured using the same technique as described above. The integration capacitor is of high quality 1% polystyrene specially processed type whose value is 1×10^{-7} Farad. The electrometer is a Victoreen Model 475A Dynamic Capacitor Electrometer, SN 206 and the precision voltage source is a Fluke Model 341A, SN 11505.

E. The attainable exposure rates are dependent upon the x-ray generator and Cs-137 source characteristics, therefore, it was impossible

to evaluate the instruments at all exposure ranges. Cs-137 exposures were delivered at 100 and 10 milliroentgens per hour (mR/hr). Techniques MFG, MFI LFD, and LFI were delivered at a rate of 20 R/hr and technique HFG was delivered at a rate of 5 R/hr. The instruments were tested in both "rate" and "integrate" modes. No appreciable differences were noted between the results obtained in the two modes.

F. Air density corrections were not applied to the measured values. However, the lack of air density corrections should account for no more than $\pm 4\%$ variation of the instruments' relative response.

III. RESULTS

A. The results of the evaluation of the Victoreen Model 470A and 471 are presented in the tables contained in Attachments 7 and 8, respectively. These values are expressed as ratios of the measured exposure rate to the actual delivered exposure rate (measured/actual).

B. The energy dependence of both instruments could best be evaluated by plotting the instruments' relative response as function of radiation effective energy at 0° incident radiation. These data are provided in Attachments 9 (Model 470A) and 10 (Model 471). Relative response is equal to measured/actual exposure; energy dependence variations observed were:

1. $\pm 20\%$ for the Model 470A with cap "off" from 9 keV to 662 keV.
2. $\pm 5\%$ for the Model 470A with cap "on" from 42 keV to 662 keV.
3. $\pm 5\%$ for the Model 471 with cap "off" from 9 keV to 662 keV.
4. $\pm 5\%$ for the Model 471 with cap "on" from 26 keV to 662 keV.

C. Due to the symmetrical configuration of both instruments' sensitive volume, variations in relative response as a function of the angle of the incident radiation beam were evaluated only between 0° and 90° (see Atch 6). The same variations can be expected between 0° and -90° . Angular dependence of the instruments, with beta shields off, at 9, 42, and 662 keV effective photon energies is presented in Attachments 11 and 12.

IV. CONCLUSIONS

A. Both the Victoreen Model 470A and the Victoreen Model 471 met or exceeded manufacturer's specifications of energy dependence, accuracy and precision. Due to the difference in the chamber construction material, the Model 470A exhibited less angular dependence than the Model 471. The Model 471, on the other hand, exhibited less energy dependence.

B. Both instruments were found to perform excellently and should be considered as a possible replacement for the Victoreen Models 440 and 592B and the Heat Pipe VR-10 presently being utilized for Industrial Radiographic operations.

List of Attachments

1. **Table I: Specifications for Model 470A**
2. **Table I: Specifications for Model 470A (Cont'd)**
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4. **Table I: Specifications (Cont'd)**
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TABLE I: SPECIFICATIONS FOR MODEL 470A

Feature	Specification
Range:	
Rate	0-3, 10, 30, 100, 300, 1000 mR/h and R/h
Integrate	0-3, 10, 30, 100, 300, 1000 mR
Radiation DetectedAlpha, Beta, Gamma and X-ray
DetectorUnsealed, air ionization chamber
MaterialExpanded polystyrene/275cc vol
Wall Thickness17 mg/cm ²
Cycloac Equilibrium Sleeve/Cap.	500 mg/cm ² thick
Readout Meter.	3-1/8 inch (7.94 cm) scale, taut band movement (Spring-loaded trigger switch permits scale illumination for night use.)
Controls:	
External.	Function Switch (R/h, mR/h, mR Integrate) Range Switch (Off, Battery Check, 1000, 300, 100, 30, 10, 3) Zero Set Zero Adjust Scale Illumination Switches
Internal.Calibration Adjustment High Voltage Check Switch Coarse Zero Adjust Potentiometer
Energy Response.+ 15% from 8.0 keV to 300 keV-bare + 10% from 40 keV to 2 MeV-Covered
Response Time.	8 seconds on 3 mR/h range 3 seconds on 10 mR/h range Less than 1 second on all other
<u>Switching Transients...Less than 8 seconds on Function & Set Zero</u>	

TABLE I: SPECIFICATIONS FOR MODEL 470A (CONT'D)

Feature	Specification
Batteries	Two 1.5 volt D cells and four 22½ volt #505
Battery Life	D type: 150 h 22½ volt: shelf life
Zero Adjust.	Can be properly adjusted in a radiation field
Warm-up Time	Less than one minute
Environmental Effects:	
Temperature Range	-20° to + 120° F (-29° + 49° C)
Humidity Range.	0 to 95%, non-condensing
Geotropism.	Negligible
Response to Other Radiation:	
Minimum energy to penetrate chamber.	Alpha; 8 MeV Beta; 120 keV
Zero Drift with Temperature.	6% per 10 C on 3 mR/h and 3 R/h range; 2% per 10 C on 10 mR/h and 10 R/h range; 0.6% per 10 C on 30 mR/h range and 30 R/h range. Can be completely eliminated by rezeroing
Collection Efficiency	See Figure 1
Dimensions.	11 in. long (27.9 cm) 4-¾ in. wide (12.1 cm) 9½ in. high (24.1 cm)
Weight.	Less than 4 pounds

TABLE I: SPECIFICATIONS

Feature	Specification
Dimensions	11 inches long (27.9 cm), 4-3/4 inches wide (12.1 cm), 9 1/2 inches high (24.1 cm)
Weight	Less than 4 pounds including batteries (1.8 Kg approximately)
Range	Twelve overlapping ranges; 0-1, 10, 30, 100, 300 mR/hr and R/hr (rate) Six overlapping ranges; 0-1, 10, 30, 100, 300 mR (integrate).
Radiation Detected.	Alpha, beta, gamma and X-ray
Detector.	Unsealed, air ionization chamber. The chamber consists of a bakelite wall, 200 mg/cm ² and a mylar window 1.1 mg/cm ² . The volume of the chamber is 450cc. An equilibrium cap of 300 mg/cm ² is provided for the chamber.
Readout Meter	3-1/8 (7.94) scale, taut band movement.
Control:	
External.	Function Switch (R/hr, mR/hr mR Integrate) Range Switch (Off, battery check 300, 100, 10, 3, 1). Zero Adjust.
Internal.	Single Calibration Adjustment. Collecting Voltage check switch. Coarse Zero Adjust.
Energy Response	± 15% 6 keV to 300 keV along chamber axis, cap off. ± 10% 12 keV to 2 MeV with equilibrium cap on, 2π solid angle.
Response Time	8 seconds on 1 mR/hr range. 3 seconds on 10 mR/hr range decreasing to less than 1 second on all other ranges for 1 to 90% of final reading.
Switching Transients.	Last less than 8 seconds when moving Function or Set Zero controls. No transients on other controls.
Batteries	Two 1.5 volt "D" cells and four 22.5 volt #505 Batteries

TABLE I: SPECIFICATIONS (CONT'D)

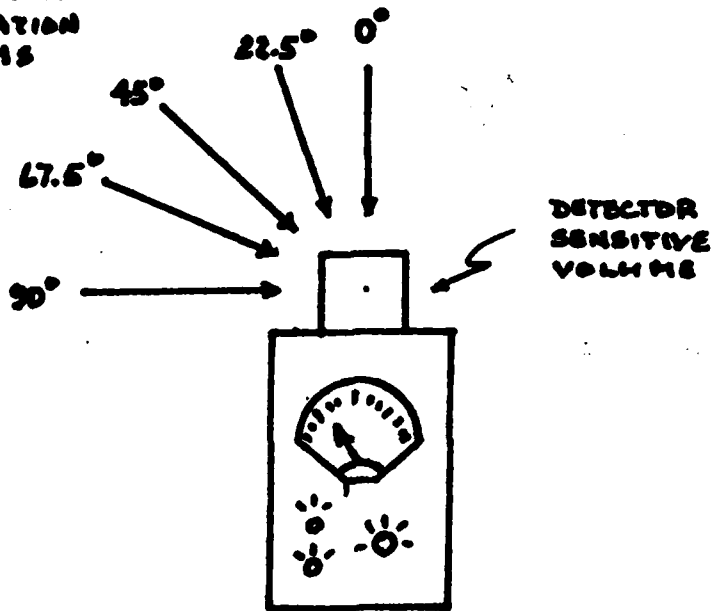
Feature	Specification
Battery Life.	"D" Cells-mR/hr range: 150 hours at 24 hrs/day 210 hours at 8 hrs/day R/hr range: 85 hours at 24 hrs/day 120 hours at 8 hrs/day 22.5 volt batteries - shelf life approximately 1 year.
Zero AdjustCan be properly adjusted in a radiation field.
Warm-up Time.	Less than one minute.
Environmental Effects:	
Temp. Range	20°F + 120°F (-29°C to + 49°C)
Humidity Range.	0 to 95% non condensing. Pressure dependent due to detector being unsealed air ionization chamber.
Geotropism.Negligible, Less than two minor divisions on Meter scale.
Response to Other Radiation:	
Minimum Energy to Penetrate Chamber	Alpha-305 MeV Beta -70 keV
Zero Drift with Temperature . .	6% per 10°C on 3mR/hr and 3R/hr range; 2% per 10°C on 10 mR/hr and 10 R/hr range; 0.6% per 10°C on 30 mR/hr range and 30R/hr range. Can be completely eliminated by rezeroing.
Collection Efficiency	See Figure 1.
Check Source.	0.07 Microcuries of Depleted Uranium (238U).

Irradiation Technique

Technique	KVCP	Total Filtration	1st HVL	Homogeneity Factor	Effective Energy
LFD	20	1 mm Be	.071 mm Al	.76	9 keV
LFI	50	1 mm Be 1 mm Al	1.02 mm Al	.66	21 keV
MFG	100	5 mm Al	5.03 mm Al	.73	42 keV
MFI	150	5 mm Al 0.25 mm Cu	10.2 mm Al	.89	64 keV
HFG	150	4 mm Al 4 mm Cu 1.5 mm Sn	16.9 mm Al	N/A	120 keV
Cs-137	N/A	N/A	10.8 mm Cu*		662 keV

*Calculated HVL

INCIDENT
RADIATION
BEAMS



ANGULAR DEPENDENCE GEOMETRY
Survey METERS

Energy/Angular Dependence* of Victoreen Mod 470A, SN 2017

Effective Radiation Energy (Technique)		Angle of Incident Radiation Beam				
		0°	22.5°	45°	67.5°	90°
9 keV (LFD)	Cap on	.25	.25	.20	.15	.17
	Cap off	1.00	1.10	1.10	1.12	1.07
26 keV (LFI)	Cap on	.87	.93	.85	.80	.78
	Cap off	1.10	1.15	1.17	1.17	1.15
42 keV (MFG)	Cap on	.98	1.05	1.10	1.00	1.00
	Cap off	1.00	1.10	1.17	1.15	1.15
64 keV (MFI)	Cap on	1.07	1.15	1.12	1.05	1.00
	Cap off	1.07	1.20	1.20	1.20	1.15
120 keV (HFG)	Cap on	1.11	1.14	1.13	1.11	1.07
	Cap off	1.11	1.15	1.19	1.17	1.19
662 keV CS-137	Cap on	1.00	1.00	1.05	1.10	1.10
	Cap off	.89	.85	.83	.80	.80

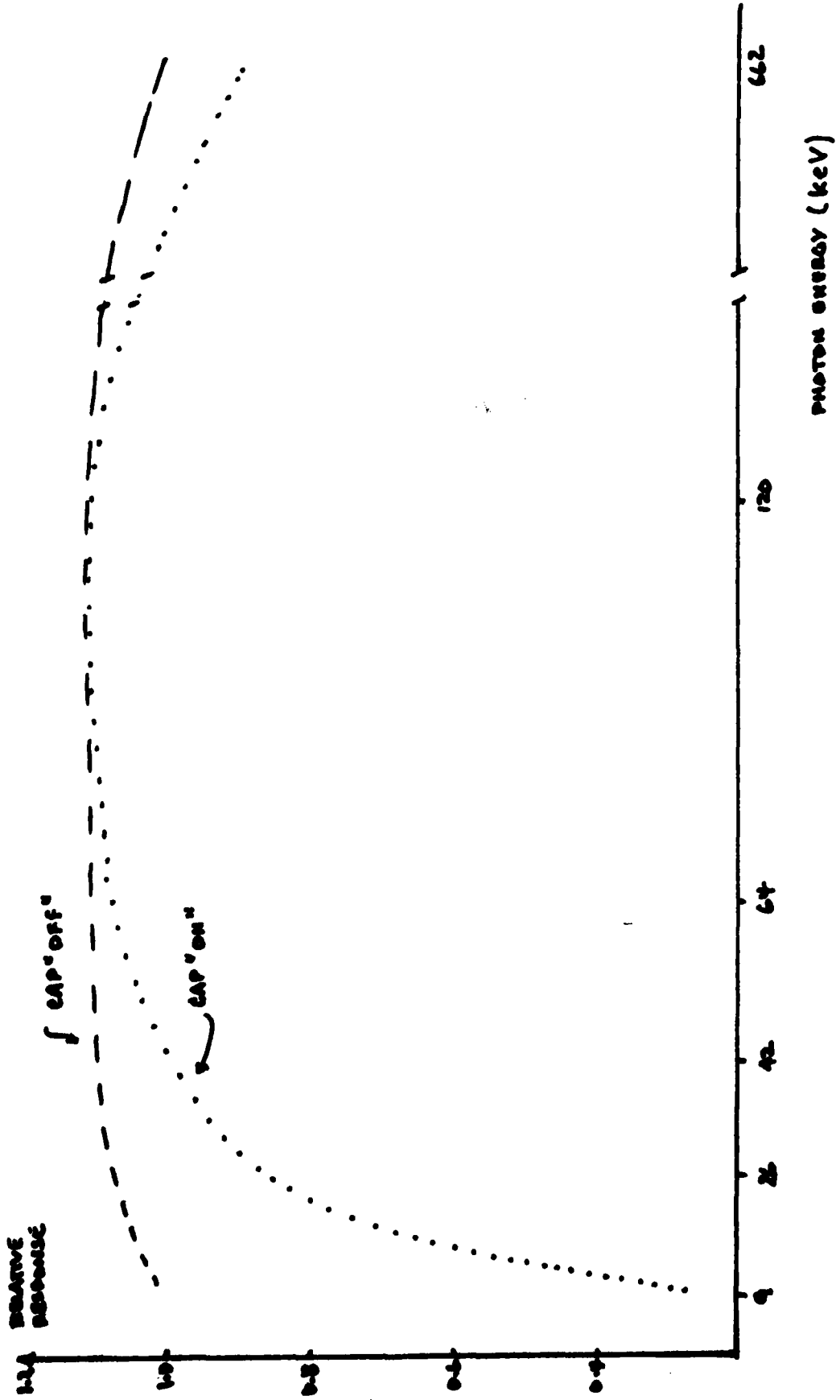
Measured Values Expressed As Ratios
of Actual Value (Measured/Actual)

Energy/Angular Dependence* of Victoreen Mod 471, SN 134

Effective Radiation Energy (Technique)		Angle of Incident Radiation Beam				
		0°	22.5°	45°	67.5°	90°
9 keV (LFD)	Cap on	.50	.40	.37	.40	.50
	Cap off	.97	.70	.60	.50	.50
26 keV (LFI)	Cap on	.95	.93	.90	.90	.97
	Cap off	.95	.95	.95	.99	1.02
42 keV (MFG)	Cap on	.95	.99	.95	.95	1.00
	Cap off	.95	1.00	1.00	1.00	1.02
64 keV (MFI)	Cap on	.98	1.00	1.00	1.00	1.00
	Cap off	.98	1.05	1.05	1.05	1.05
120 keV (HFG)	Cap on	1.03	1.07	1.07	.91	.95
	Cap off	1.03	1.07	1.09	.93	.95
662 keV (Cs-137)	Cap on	1.00	1.00	1.00	1.00	1.00
	Cap off	1.00	.95	.95	.95	.95

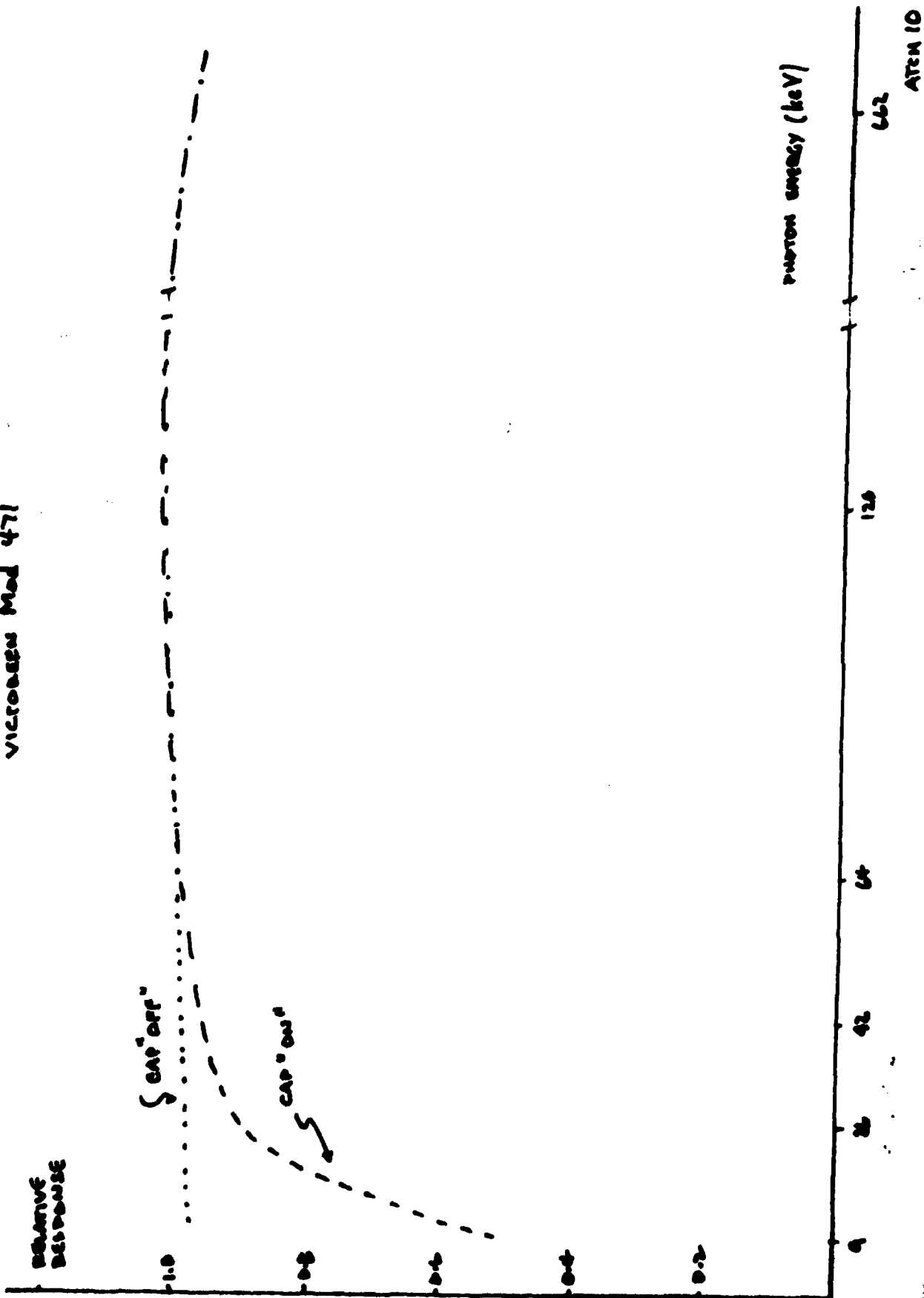
*Measured Values Expressed as Ratio of Actual Value (Measured/Actual)

VICTORESEN Nos 470A

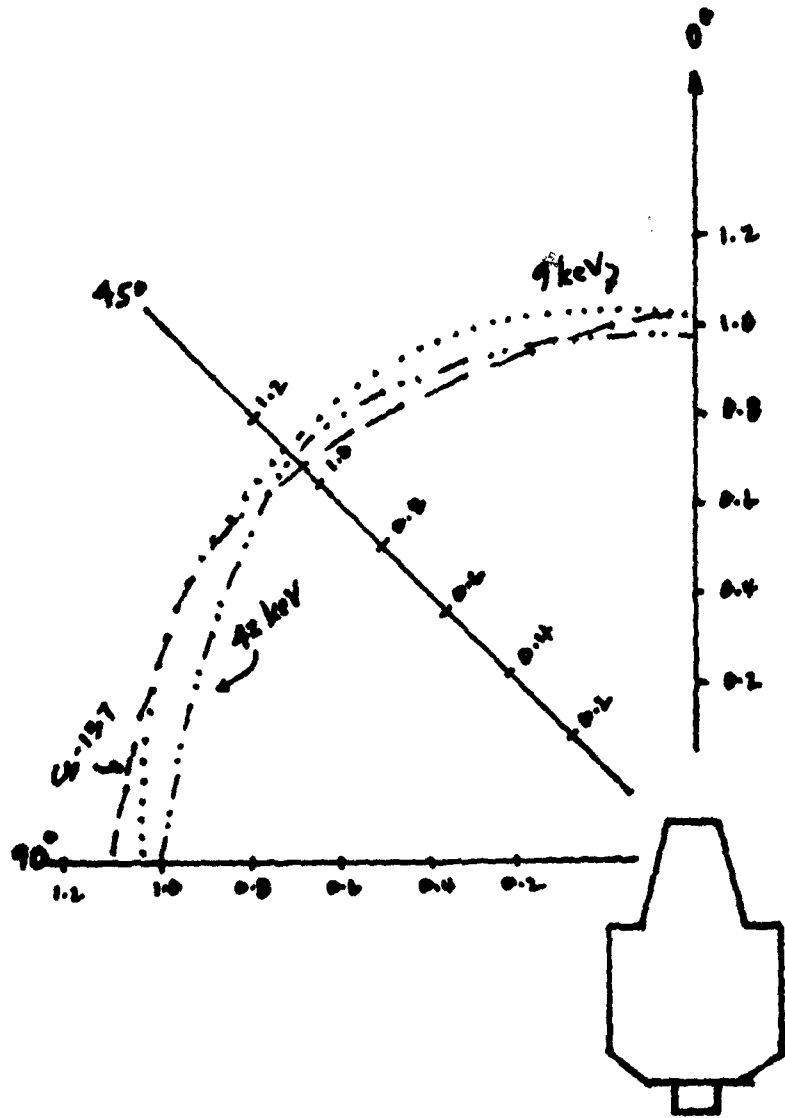


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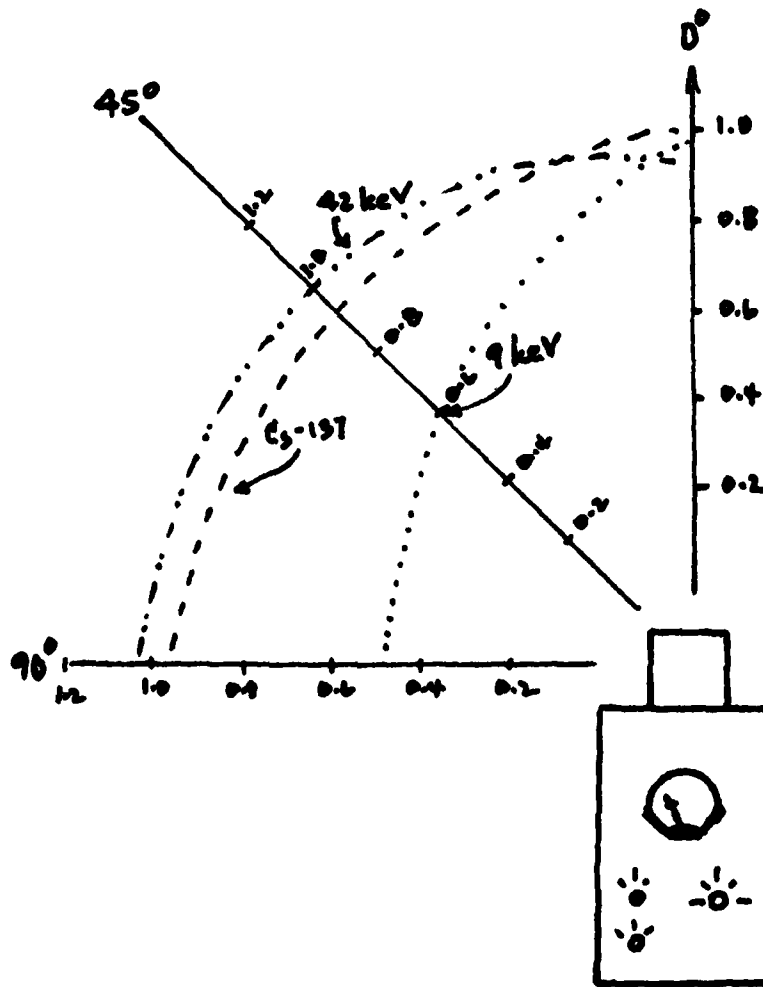
VICORGEN Mod 471



VICTOREEN Mod 470A - Angular Dependence



VICTOREEN Mod. 471 - ANGLE DEPENDENCE



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