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FISSION CROSS SECTION OF URANIUM 235 FROM 20 TO 500 KEV

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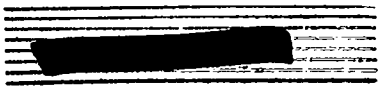
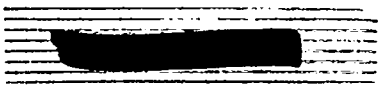


ABSTRACT

With a redesigned and calibrated long counter, relative measurements of the fission cross section of 25 between 500 and 30 Kev have been made. Using these data, and also all the available data obtained in other investigations, a curve has been drawn which represents the best knowledge concerning the 25 fission cross section to date between 20 and 500 Kev. This curve is meant to supersede the curve found in LA-150.



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FISSION CROSS SECTION OF URANIUM 235 FROM 20 TO 300 KEV

The fission cross section of 25 as a function of neutron energy has been reported in LA-150. Since then, however, several experiments have been performed [1)2)3)] in the energy region below 500 Kev which do not agree with the published values. These latter experiments all give results in the neighborhood of 20% lower than the LA-150 cross section.

The LA-150 cross section was based principally on comparison of 25 fission rate with counting rate of a long counter, whose sensitivity as a function of neutron energy was thought to be constant. Measurements with a compensated hydrogen-recoil ionization chamber[4)] confirmed the long-counter data, and two points by Hall, Koontz, and Rossi[5)] at 340 and 460 Kev were in general agreement, although somewhat high.

In view of the discrepancies, the sensitivity of the long counter (the "5 x 5") which had been used, was re-examined, using various degraded and undegraded natural neutron sources. The sources used were: Mock fission[6)] No. 3, average energy about 2.2 Mev, mock fission No. 3 immersed in D_2O, about 400 Kev; a Ra-Be source, about 5 Mev; and an Sb-Be(γ,n) source, about 22 Kev. The response of the 5 x 5 long counter to these sources was compared to the response of Hanson's 15" long counters, which, as elsewhere described[6)] had already been calibrated with the same sources. It was found that the sensitivity of the 5 x 5 fell off quite rapidly (about 20%) between 500 and 30 Kev.

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1) R. F. Taschek, C. M. Turner, LA-445
2) A. O. Hanson and L. W. Seagondollar, LA forthcoming
3) D. H. Frisch: LA forthcoming
4) C. L. Bailey: LA forthcoming, also LA-150.
5) P. G. Koontz: LA-128
6) C. L. Bailey, A. O. Hanson, James Hush, and J. H. Williams, Multiplication of 25 and 49 Spheres (LA forthcoming).

[redacted]

Since in LA-150 a flat response was assumed for this counter, one was led to underestimate the neutron flux at low energies and thus overestimate the fission cross section. Therefore it seems well indicated that the LA-150 cross section must indeed be too high in the lower-energy region.

The 5x5 long counter was therefore rebuilt. Its active element was made a BF_3 - filled proportional counter, and its sensitivity for low energy neutrons was increased by drilling several holes, 5 1/2" deep, and 1" diameter, in the paraffin surrounding the BF_3 counter. The present 5x5 design is shown in Fig. 1.

The response of the new 5x5 to neutrons of various energies was next measured in the same way as just described; it was now found that the counter was much more nearly flat at low energies. The sensitivity as a function of neutron energy of the new counter is plotted in Fig. 2. This sensitivity curve was taken into account in evaluating the observations with the new counter.

Using the rebuilt 5x5, measurements of the 25 fission cross section were then made. The 5x5, and a small fission counter, were exposed to the Li(p,n) neutrons from a Li target of 5 to 10 Kev stopping power for protons, on the short electrostatic generator. The geometry is shown in Fig. 4. Data at the following energies were taken at 45°: 500, 350, 200, 150, and 100 Kev. At 120°, measurements were made at 200, 150, 100, 60, and 30 Kev. The procedure was to measure the relative counting rates of the 25 counter and the 5x5 at the various neutron energies, under the assumption that the two detectors receive neutrons of the same mean energy. In every case enough counts were recorded to reduce the statistical error to about 2 o/o.

The observed ratios are given in Table I, against the mean neutron energy as given by the angular spread of the detectors and the target thickness. For 45°, the cross section was normalized to 1.42 barns at 500 Kev. This choice of normalization value seems the most reasonable when all the available data in the region above and around 500 Kev are taken into account. For 120° values, the normalization was to the value observed at 45°. The normalization could not all be to 500 Kev, because the counters had to be placed at somewhat different distances at the two angles. The "overlap" observations at 150 and 100 Kev, as taken at the two angles, are in good agreement.

Background neutrons which would affect the ratio of 25 to 5x5 might be of three kinds: neutrons scattered from the walls of the room, scattered from the target material, or scattered from one detector into the other. Tests were made for all these effects, and it turned out that although some background of each kind was present, the effect on the ratio as a function of energy was in general negligible, mostly because only relative measurements of the cross section were made. A small correction of a fraction of one percent (see Table I) for room neutrons were made in the 45° data.

The cross sections as finally listed in Table I include a correction for the sensitivity of the 5x5, as taken from Fig. 2. The values are plotted in Fig. 3. The errors are largely due to the uncertainty in the calibration of the 5x5

These results are first of all to be compared with those in LA-150. The latter are certainly too high at least as far as the long-counter data are concerned, for the reasons already given; the compensated ionization chamber results, since they agree with the old long-counter data, must also be too high.

The reason may perhaps be found in the decrease of the energy loss of proton recoils per ion pair with decreasing neutron energy. The point of Hall, Koontz, and Rossi[5] at 340 Kev seems to be high, but their values at 460 and 590 Kev were given weight in drawing the curve through 500 Kev.

The other measurements to be compared are the following:

A. Be^7-activity method of determining neutron flux[4]: points at 250 and 54 Kev.

B. Mn-bath method[1]: point at 250 Kev.

C. Determination with an Sb-Be (γ,n) neutron source[2]: point at 22 Kev.

D. Measurement with a proton-recoil proportional counter by the "threshold tickle" technique[3]: point at 34 Kev.

These points are all included in drawing the curve between 500 and 30 Kev, since there seems to be no reasons to feel that any of them are invalid. The data from A, B, C, D, are recorded in Table I and plotted in Fig. 3. It is seen that in general the agreement between these and the new 5x5 data is fairly good.

The 25 cross section as given in LA-150 is therefore deemed obsolete below 500 Kev. The curve which is dealt to represent the present best value of δ_{25} below 500 Kev is presented in Fig. 3, and is the consensus of opinion of all the people whose work has been mentioned here.

TABLE I

E_n - Kev (mean)	Ratio of bounting rates 45°	25 fission counter / 5x5 long counter 120°	Corrections to σ_{25} for 5x5 sensitivity	Corrections to σ_{25} for background (45° only)	LA-417 45°	LA-417 120°	σ_{25} in barns other measurements (see page 4) A	B	C	D
494	6.26		0		1.42					1.42 ±.04
344	6.72		- 2%	+ 0.4 %	1.51					
250							1.50 ±.10 %	1.54 ±.5 %		
195	7.25	6.61	- 4 %	+ 0.8 %	1.60	1.60				
145	8.30	7.68	- 5 %	+ 0.9 %	1.80	1.82				
95	9.49	8.60	- 6 %	+ 1.0 %	2.05	2.03				
57		9.93	- 7%			2.32				
34							2.30 ± 5 %			2.17 +0.4
27		10.94	-7%			2.56				
22									2.7 ± 7 %	

Margin of error in points with new 5x5:

344 Kev	± 4%
195	5 %
145	6 %
95	6 %
57	8 %
27	9 %

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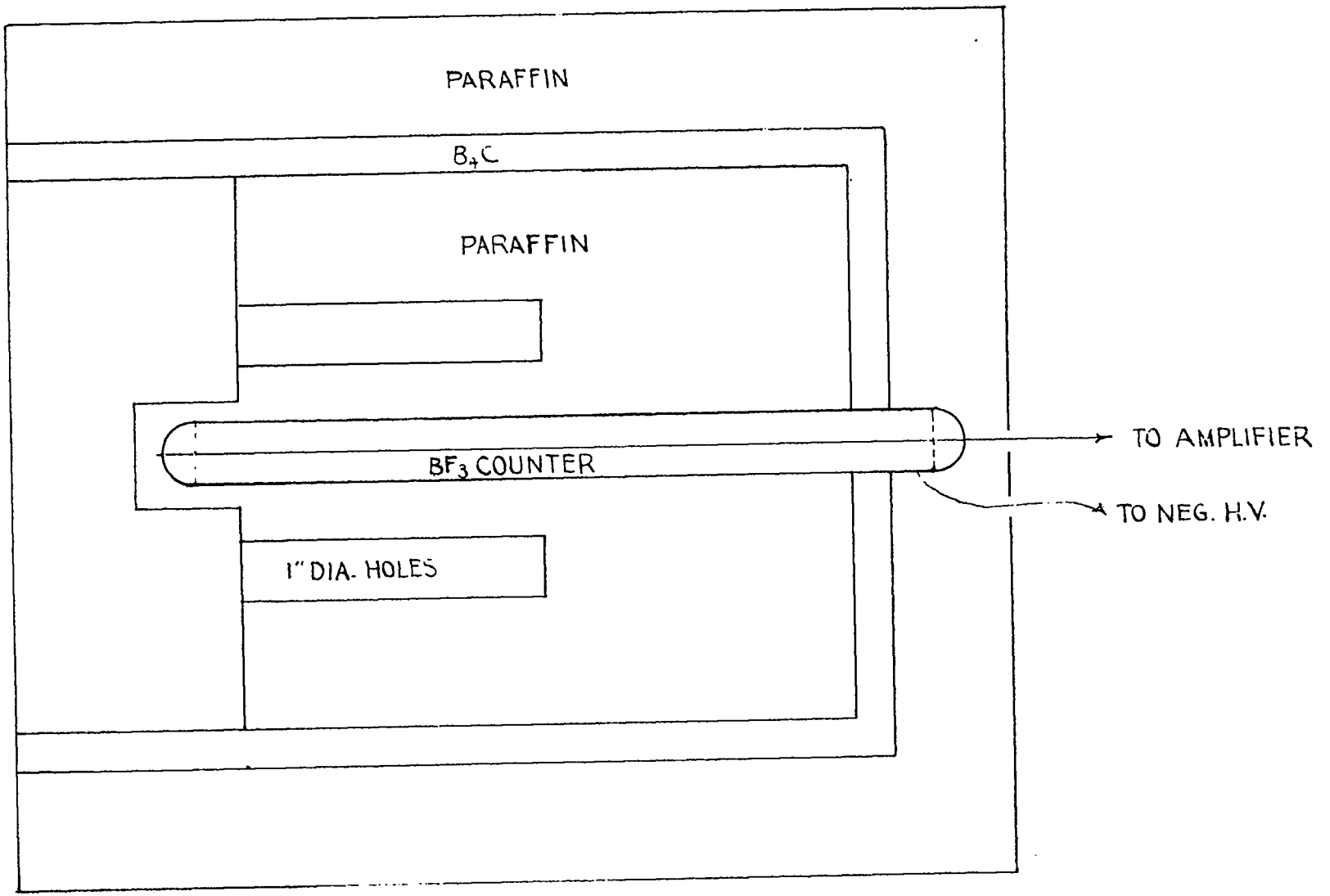

FIG. 1

PRESENT 5x5 DESIGN

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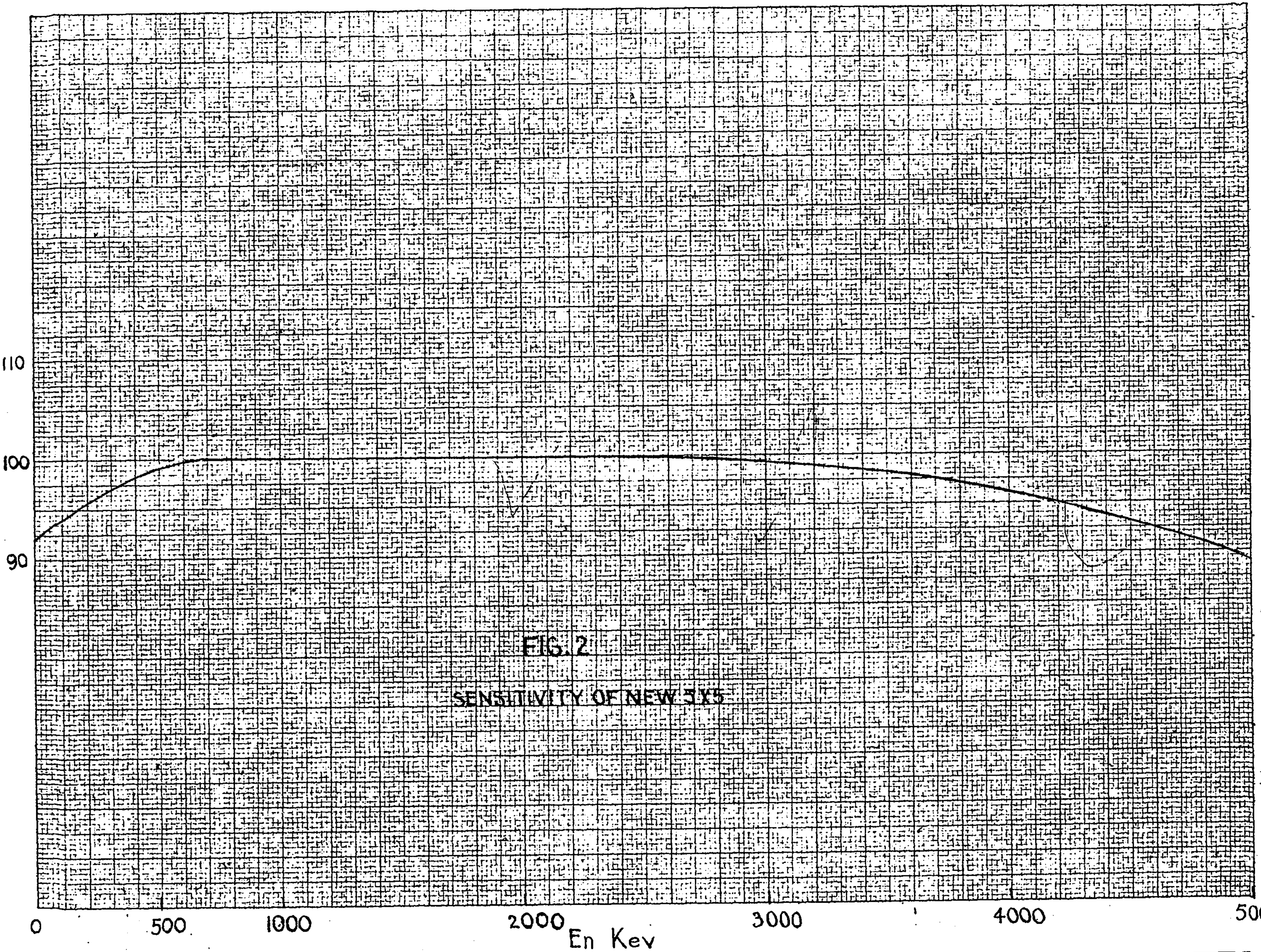

FIG. 2

SENSITIVITY OF NEW 5X5

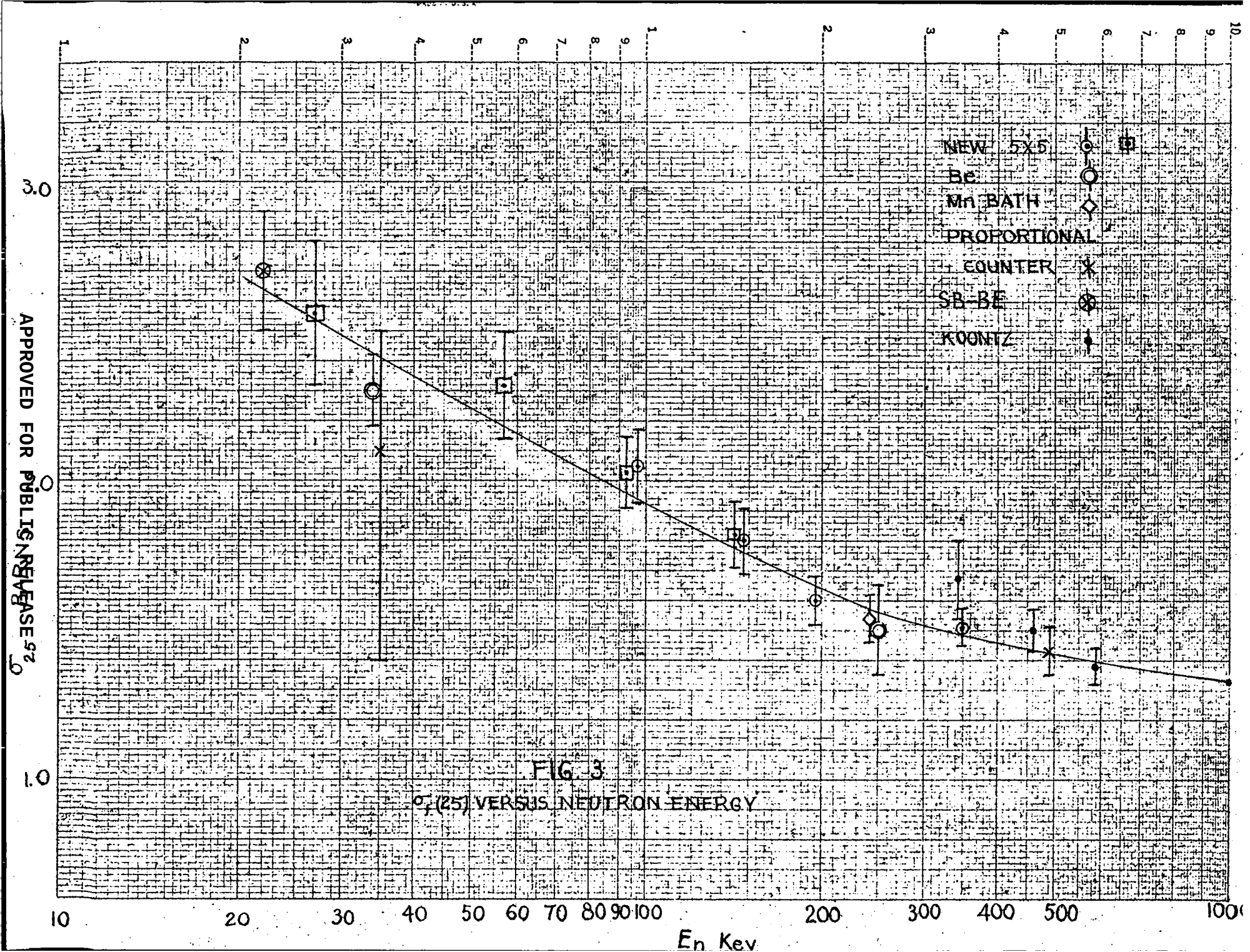

FIG 3

$\sigma_f(25)$ VERSUS NEUTRON ENERGY

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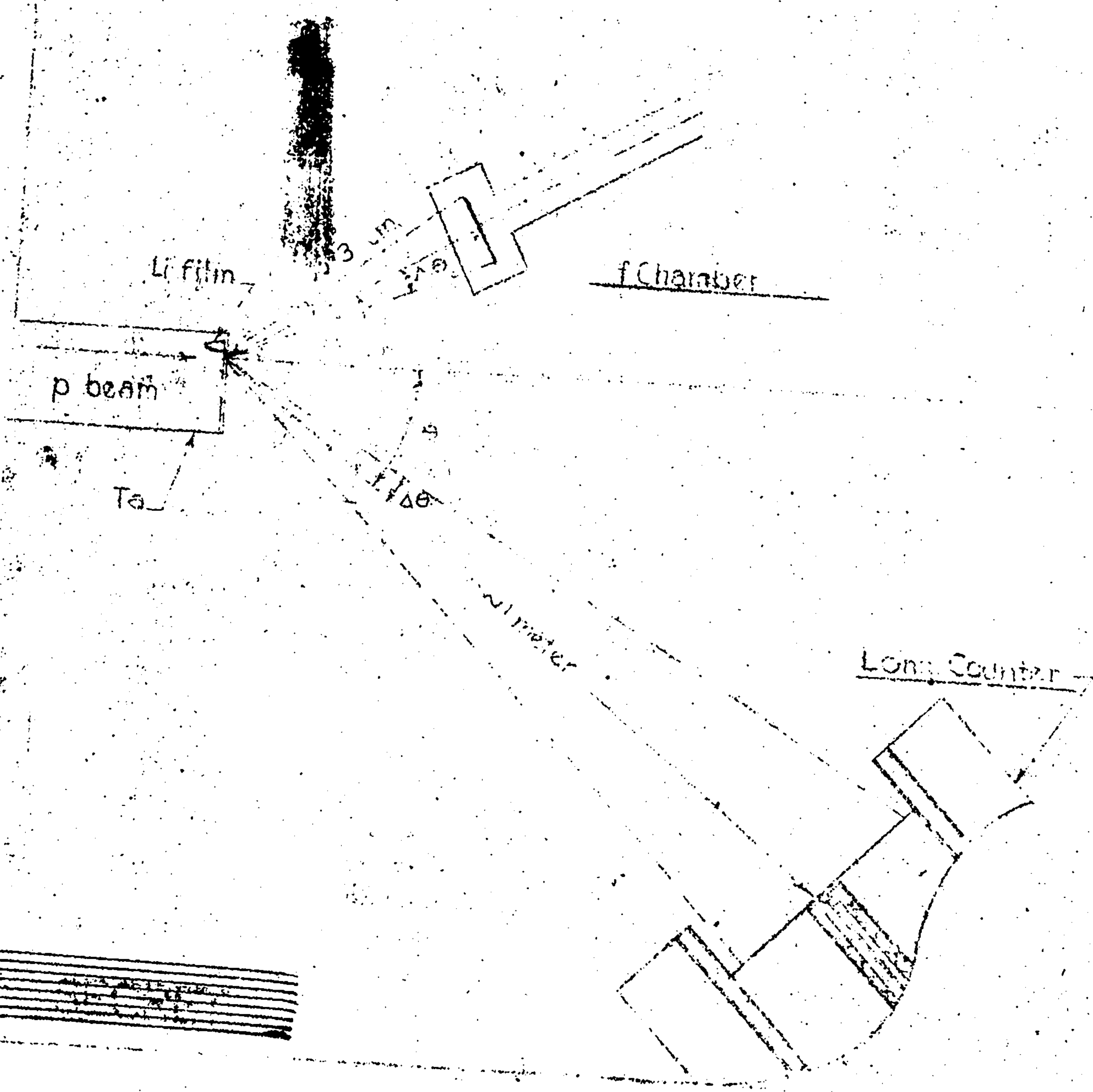

Fig. 4

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