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CAPTURE CROSS SECTIONS OF SEVERAL SUBSTANCES FOR NEUTRONS OF VARIOUS ENERGIES

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ABSTRACT

The relative capture cross sections of Th^{232}, I^{127}, In^{115}, Ag^{109}, and Ag^{107} for neutrons of various energies have been measured by comparing them with the fission cross section of U^{235} for neutrons of the same energies. Also, the capture cross sections of U^{238} reported in LA-179 have been extended to include 6-Mev neutrons.

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CAPTURE CROSS SECTIONS OF SEVERAL SUBSTANCES FOR NEUTRONS OF VARIOUS ENERGIES

The capture cross sections of U^{238}, Th^{232}, I^{127}, In^{115}, Ag^{309}, and Ag^{107} reported herein have been measured relative to the corresponding fission cross sections of U^{235} by essentially the same procedure as used for the capture cross sections of U^{238} which were reported in LA-179. The general experimental procedure was to irradiate samples of the above substances with Li (p,n) neutrons from the electrostatic generators of group R-2, the neutron beam being monitored by a U^{235} fission foil. The neutrons of 6-Mev energy were obtained from one of these generators which had been converted to operate as a D-D source. The fission monitoring apparatus was the identical equipment used before in the uranium runs and is described in the above-mentioned report. After being irradiated, the samples were beta counted. To obviate the necessity of making absolute beta counts, the ratio

$$\rho(En) = \sigma_r(En)/\,\sigma_f(25)_{En}$$

obtained for neutrons of various energies has been compared with the same ratio obtained with thermal neutrons in the graphite block of group R-1. If n_o is the initial number of beta disintegrations per atom of irradiated sample per unit time after infinite irradiation, and f_o is the number of fissions per atom of U^{235} in the monitor per unit time during the irradiation then

$$n_o/f_o = \rho(E_n) = \sigma_r(E_n)\,/\,\sigma_f(25)_{E_n} \quad \ldots\ldots(1)$$

However, since the efficiencies of the beta counters for the various samples used, the efficiency of the fission chamber, etc. are unknown, direct measurements of the specific beta activity and the specific fission activity do not give $\rho\ (E_n)$ directly but rather some quantity $A=\gamma\rho$. The quantity γ can be determined by a thermal irradiation

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from which A(thermal), as measured, is compared with accepted values of ρ (thermal). It follows, then, that

$$\rho(E_n) = \left[A(E_n)/A(th)\right] \rho(th) \ldots\ldots\ldots\ldots (2)$$

and finally $\sigma_r(E_n)$ is obtained by multiplying $\rho(E_n)$ by $\sigma_f(25)$ as obtained from LA-447 and LA-150. Table I contains the values of $\sigma_r(E_n)$ so obtained, as well as the values used for $\sigma_f(25)$. The results are plotted in Figs. 1, 2, 3, 4, 5 and 6.

Experimental Procedure

A. Preparation of Samples

The thorium was chemically purified to remove its beta-active decay products before each irradiation. It was found that the initial rate of growth of these activities is slow enough that a purification after irradiation was not necessary if the irradiation were made with neutrons of energy below the fission threshold. The purification procedure consisted of precipitating sulfides (with bismuth carrier) three times to eliminate the lead and bismuth isotopes. Four thorium basic acetate precipitations were then made by heating the thorium solution with saturated sodium acetate. The final basic acetate precipitation was dissolved in dilute nitric acid and thorium peroxyhydrate was precipitated. This was dissolved in a small amount of concentrated nitric acid and $Th(OH)_4$ precipitated, the latter being ignited to ThO_2. The entire purification requires from one-and-a-half to two hours. The purified ThO_2 was divided into two samples of approximately equal weights, one to be irradiated and the other to be beta-counted periodically throughout the experiment in order that proper corrections for the regrowth of decay products could be made.

The silver and indium samples consisted of foils of the metals 3.10 cm in diameter and of thickness 138 mg / cm^2 for the silver and 15 mg/cm^2 for the indium. The iodine was most conveniently used in the form of PbI_2, 3.93 gm of which were pressed into a pellet 2.55 cm in diameter and 7.58 mg/cm^2 thick.

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It should be noted here that by using the same samples of silver, indium, and iodine and the same weight of ThO_2 for all runs, and by reproducing counting geometries from run to run, the quantity η defined above is thus made constant for all energies and needs to be determined only once for each isotope.

B. Irradiation and beta-counting.

The irradiations were made in a manner described in detail in LA-179. The fission chamber was covered with cadmium to eliminate any effects due to a background of thermal neutrons. The silver foil, cadmium-shielded, was attached to the outside of the fission chamber and given two 40-sec irradiations (with subsequent beta counts) while the longer (usually 40-min) irradiation of the other samples was being made. The number of fissions from the monitor foil was recorded for each 40-sec interval.

The samples of silver, indium, and iodine were counted under a bell-jar mica-window-type Geiger counter. The thorium was mounted as a cylindrical layer around a Chicago-type aluminum wall Geiger tube by the same technique used on the uranium and described in the above-mentioned report.

C. Treatment of Data.

From the beta counts and the fissions observed during irradiation (with corrections for finite irradiation, decay of sample before counting, and geometrical factors arising from the fact that the samples and monit are different distances from the target), the quantity $A(E_n)$ may be calculated. This quantity, with the value of $\eta = A(th) / \rho\ (th)$ determined for each sample by a thermal run, is substituted in eqn. (2) to obtain $\rho(E_n)$. Finally, using the data for $\sigma_F(25)$ as taken from the reports LA-150 and LA-447, $\sigma_r(E_n)$ is obtained. The data for $\sigma_F(25)$ was taken entirely from LA-150 in preparing the report LA-179. Since better values are now available in the range from 20 Kev to 1000 Kev (LA-447), the corrected U^{238} cross sections are reported here although only the point at 6-Mev represents new work. In order that $\sigma_F(E_n)$ may be altered in accordance with any future changes of $\sigma_F(25)$, the values used for the latter are listed in Table I. For the same reason, the values accepted for the various thermal cross

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sections are also included. The neutron energies are given as the average energies at the center of the monitor, taking into account target thickness. The spread of energy is given as the total spread due to target thickness and angle subtended by the sample at the target.

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	235 U		238 U		232 Th		127 I		115 In		109 Ag		107 Ag	
Neutron Energy = E_n	σ_f barns	$\sigma_f\sqrt{E_n}$	σ_r barns	$\sigma_r\sqrt{E_n}$	σ_r barns	$\sigma_r\sqrt{E_n}$	σ_r barns	$\sigma_r\sqrt{E_n}$	σ_r barns	$\sigma_r\sqrt{E_n}$	σ_r barns	$\sigma_r\sqrt{E_n}$	σ_r barns	$\sigma_r\sqrt{E}$
Thermal + 5 1/2	545	86	2.56	0.404	6.03	0.953	6.80	1.07	143	22.6	51.3	8.11	25.3	4.00
3 $^{[illegible]}_{-3}$ Kev.	5.32	314			0.958	56.6	3.07	181	1.95	115	3.61	213	2.04	121
5^{+5}_{-2}	4.94	350	0.8[illegible]	57.7										
16^{+12}_{-7}	2.80	354			0.568	71.8	1.37	173	0.757	95.8	1.06	134	1.04	132
18^{+24}_{-13}	2.74	368	0.461	61.9										
33^{+35}_{-20}	2.44	444			0.574	104	1.05	191	0.695	126	0.856	156	0.703	128
40 ± 20	2.34	468	0.456	91.2										
6[illegible] $^{+40}_{-35}$	2.10	543			0.414	107	0.727	188	0.428	111	0.511	132	0.556	144
90 ± 30	1.97	591	0.262	78.6										
98 $^{+35}_{-30}$	1.94	606			0.363	113	0.593	185	0.406	127	0.635	198	0.[illegible]	19[illegible]
170 ± 25	1.70	700	0.189	77.9										
195^{+5}_{-20}	1.65	728	0.167	73.7	0.278	123	0.529	236	0.308	136	0.273	121	0.246	109
380 ± 20	1.47	906	0.132	81.3										
390^{+5}_{-20}	1.46	913			0.167	104	0.288	180	0.214	134	0.170	106	0.130	81.3
400 ± 25	1.46	924	0.131	82.9										
560 ± 30	1.40	1047	0.141	1.05										
615 ± 25	1.39	1090	0.140	110										
770 ± 30	1.36	1193	0.156	137										
1310 ± 40	1.30	1485	0.095	109										
2800 ± 200	1.30	2174	<0.04	<67										
5900 100	1.30	3156	0.019	46			0.0289	68	0.0237	58	0.096	233	0.0187	45

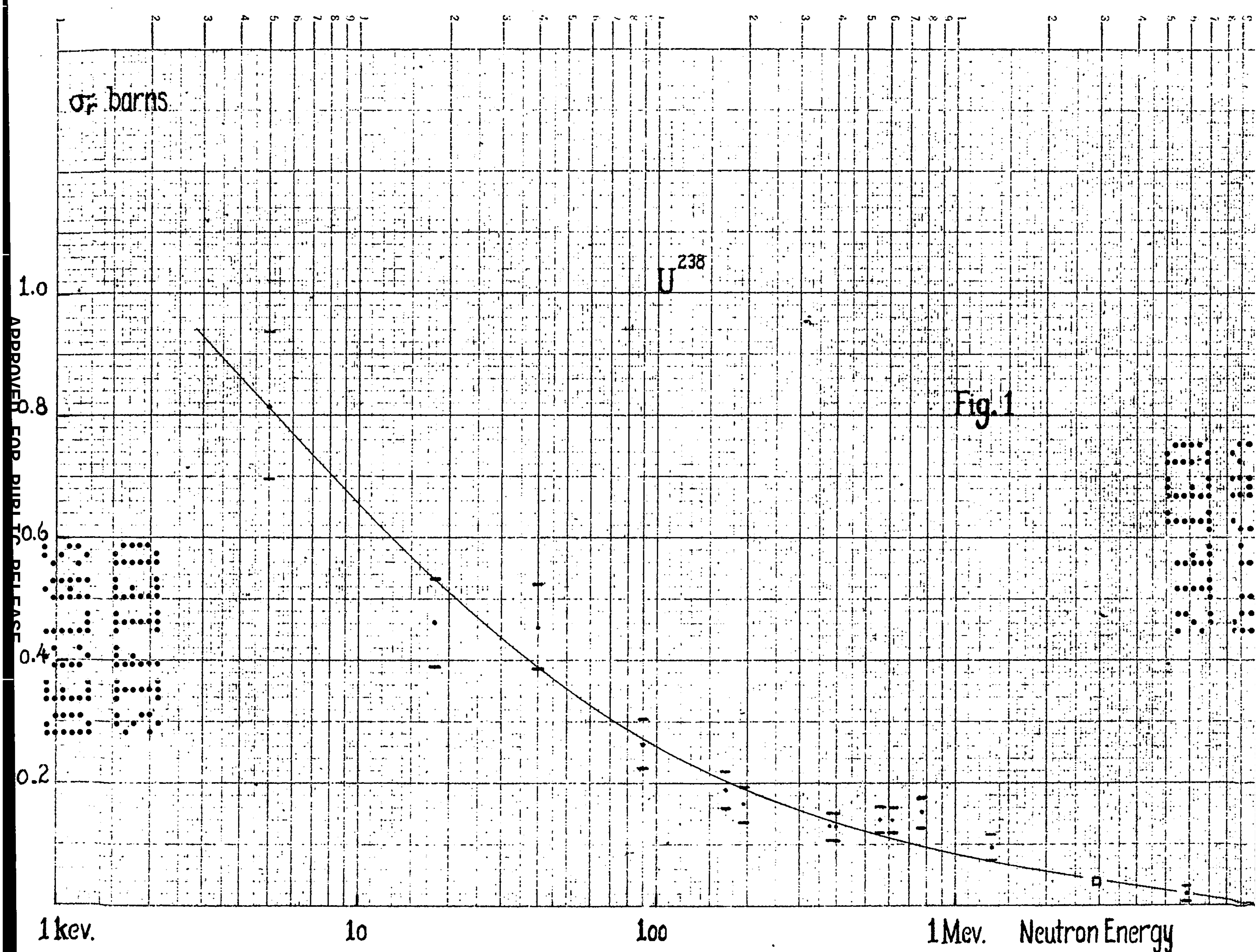

Fig. 1

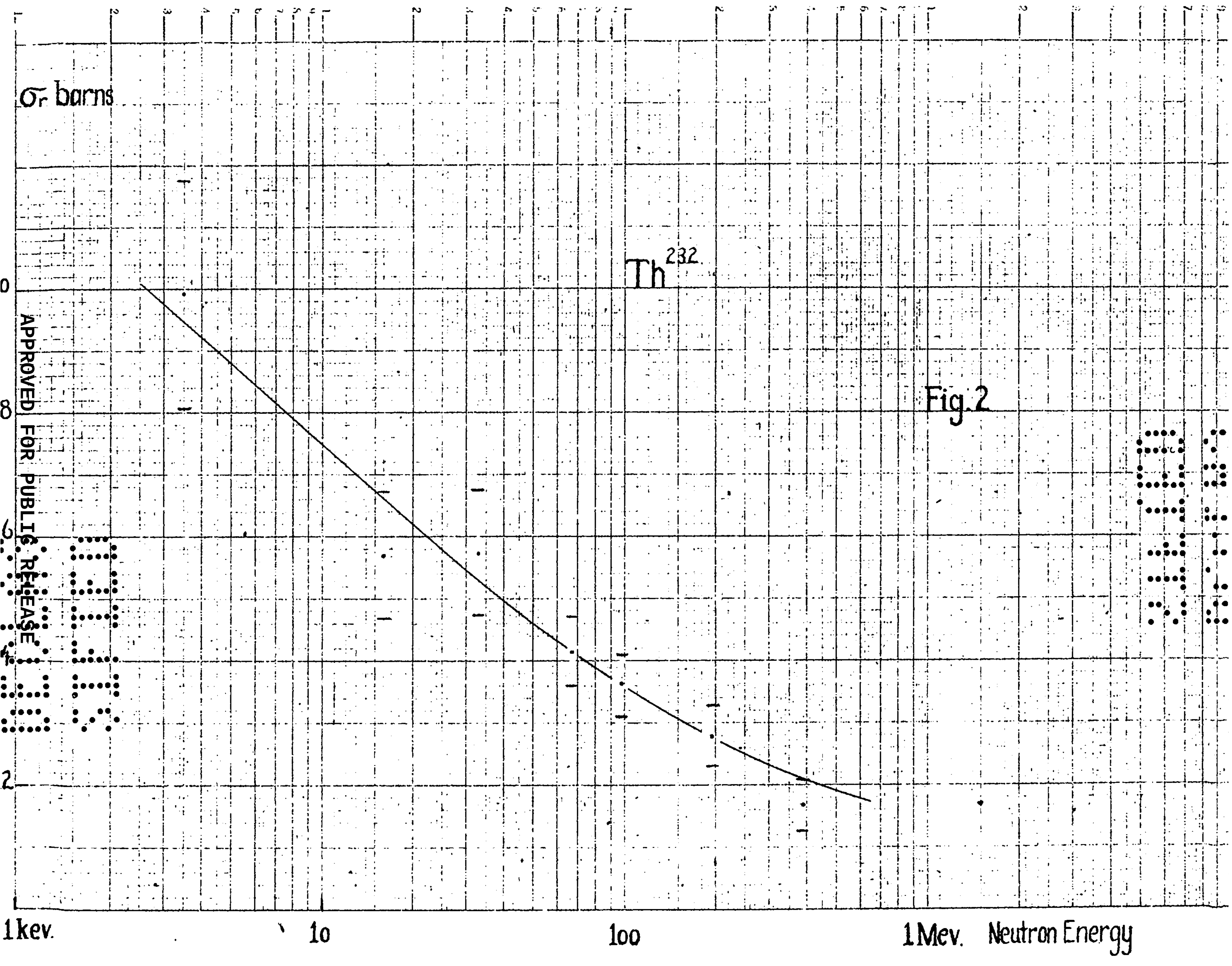

Fig.2

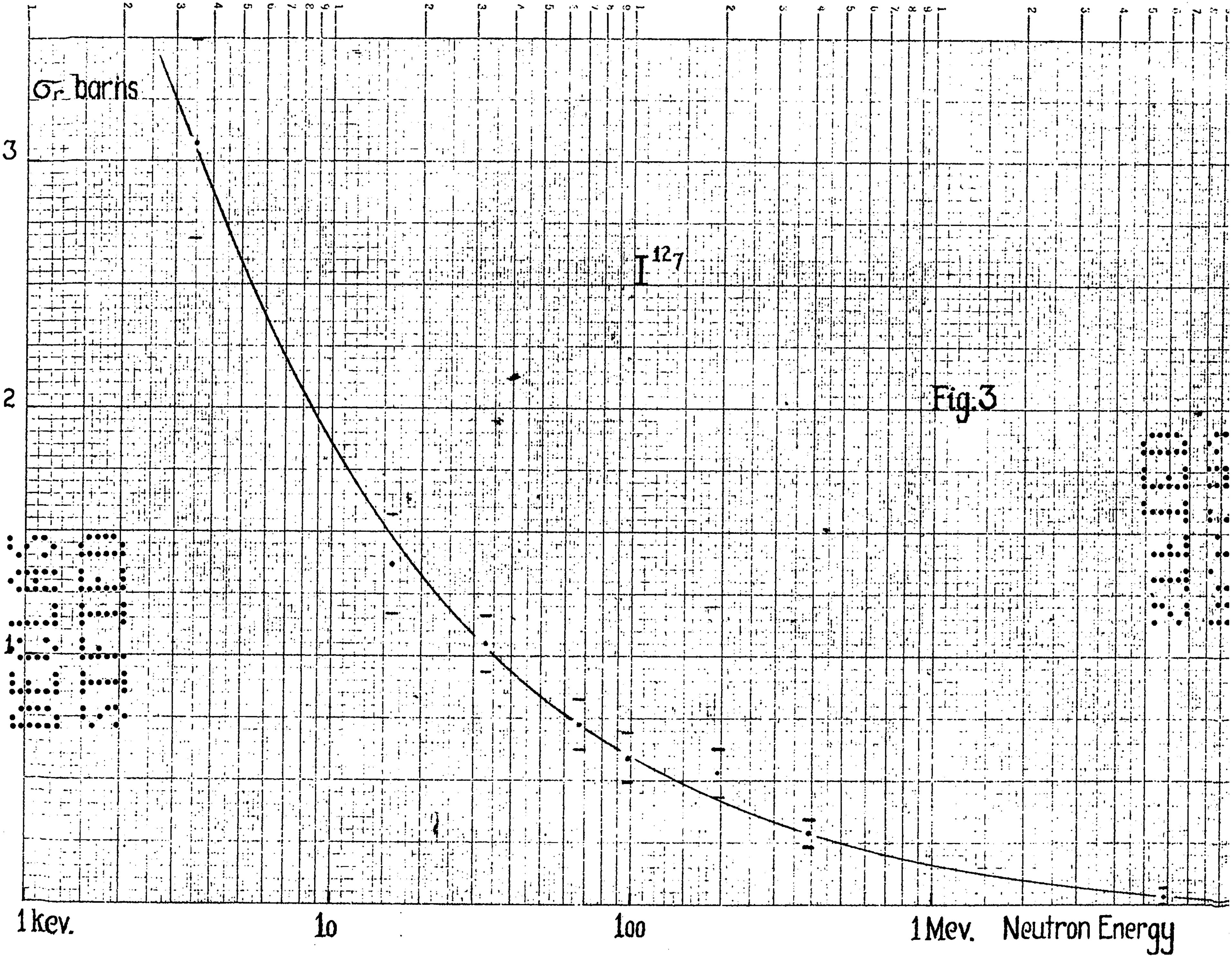
σ_r barns
3
2
1
I^{127}
1 kev.
10
100
1 Mev.
Neutron Energy
1
2
3
4
5
6
7
8
9

Fig. 3

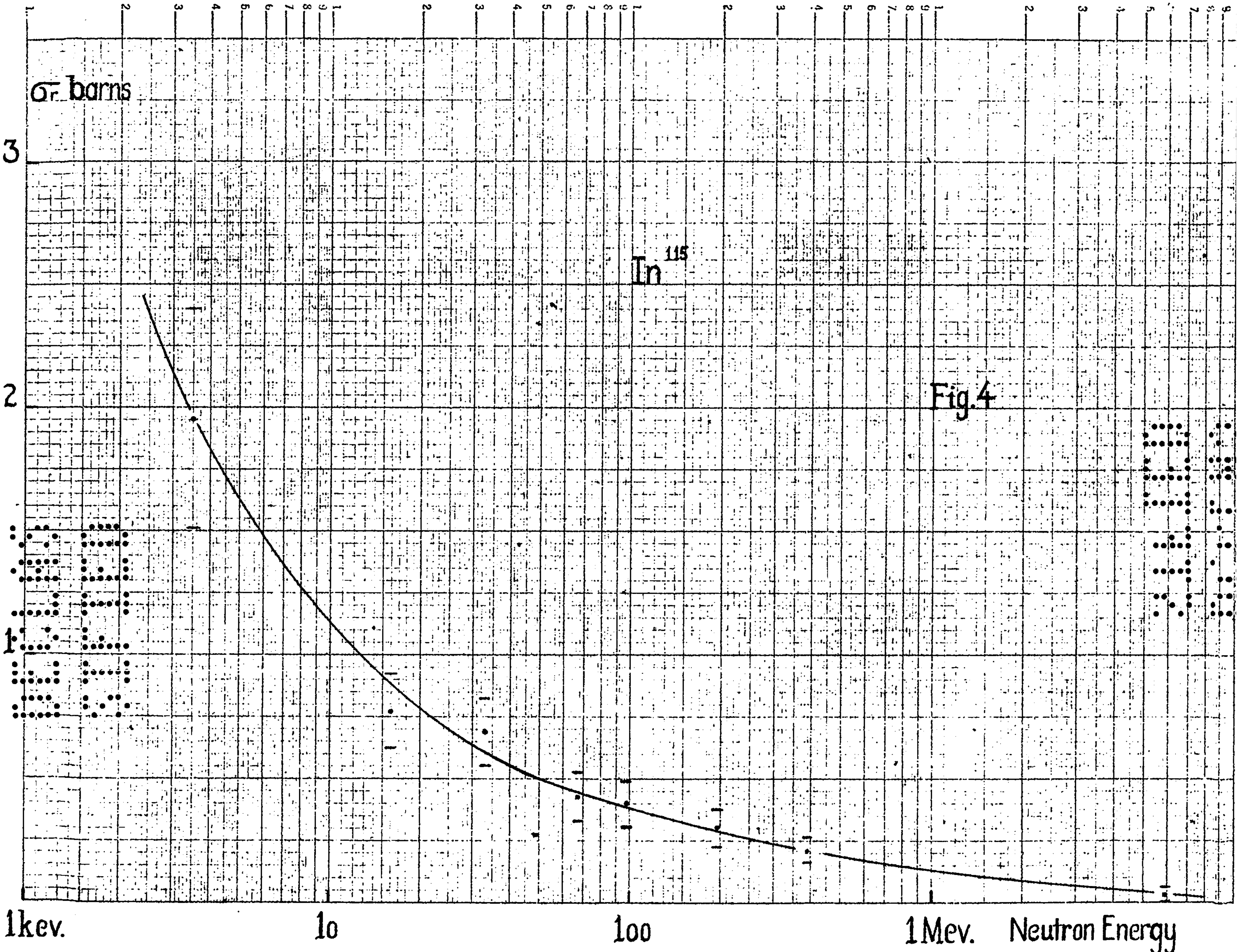

Fig.4

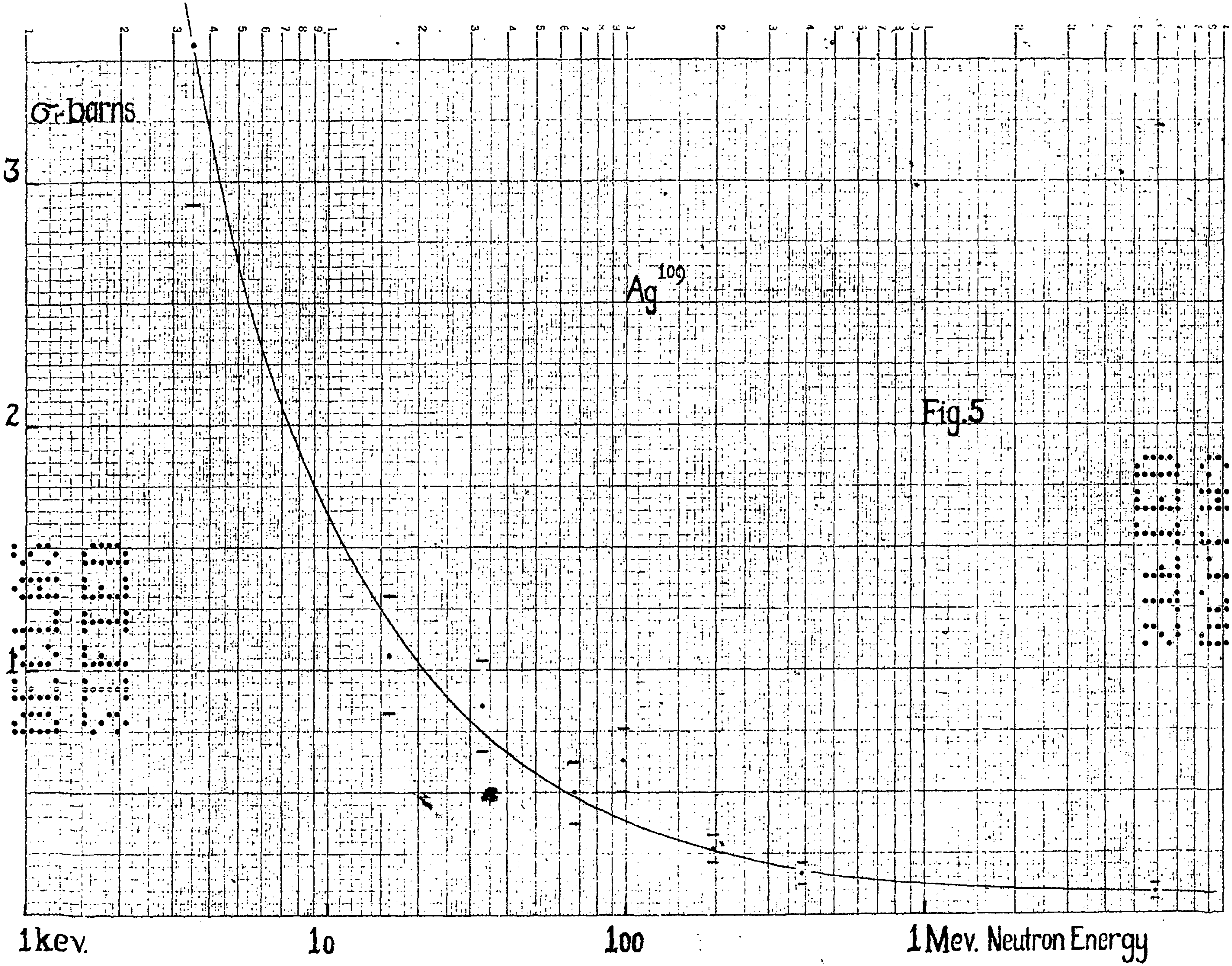

Fig.5

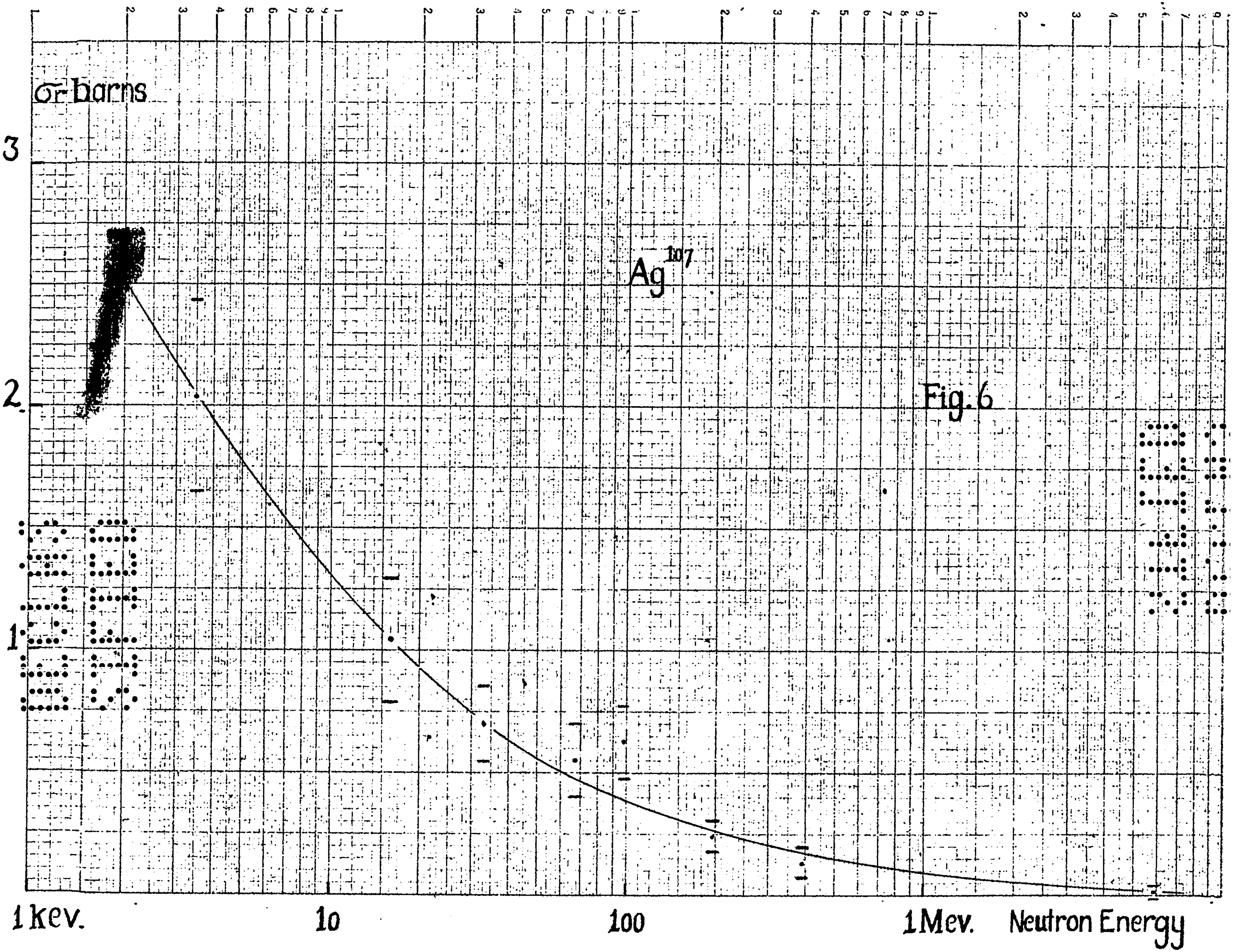

Fig. 6

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