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GRAPHS SHO[redacted]G NEUTRON CROSS SECTIONS AS FUNCTIONS OF A, Z OR N

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GRAPHS SHOWING NEUTRON CROSS SECTIONS AS FUNCTIONS OF A, Z OR N

G. Haines and K. Way

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The accompanying graphs were prepared from the neutron cross section data of Tables of Neutron Cross Sections, Mon P-405, October 1947, and Mon P-405 Supplement and Errata, April 1948. A, Z, and N stand for atomic number, proton number, and neutron number respectively. References to sources of data are given on the graphs.

Activation cross sections for fast neutrons of two different energy regions are shown in Figure 1 as a function of neutron number. The dips at neutron numbers 50, 82 and 126 have been commented on by Dr. Maria Mayer, Phys. Rev. 74, 235 (1948) in connection with other evidence that nuclei with these neutron numbers have particularly tight bindings and that the 51st, 83rd or 126th neutrons are rather weakly bound.

Figure 2 shows γ ray yields from bombardment with 2.4 mev neutrons which are presumably roughly proportional to inelastic scattering cross sections. The atomic number A of the most abundant isotope of the element investigated has been chosen as abscissa. This curve shows a striking resemblance to Hughes curve (CP-3750) for fast activation cross sections. Nuclei with 82 and 126 neutrons again show abnormally small cross sections as is to be expected if formation of the compound nucleus is less probable for nuclei with these neutron numbers than for their neighbors. No anomaly appears at neutron number 50 (Zr^{90}_{40}).

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Figures 3 and 4 show total cross sections as functions of the "most abundant A" for neutron energies of 2.5 mev and 14 mev respectively. Comparison of these two figures shows that as the neutron energy increases the cross sections decrease slightly and the curve tends to smooth out. For 90 mev neutrons Cook et al, Phys. Rev. 72, 1264 (1947) have recently found cross sections very nearly proportional to the geometrical area of the nucleus. Cook's values are slightly lower than those of Amaldi.

Figure 5 shows thermal neutron absorption cross sections of elements as function of charge number Z. Such cross sections are, of course, averages of isotopic cross sections for all stable nuclei with the same Z in which the cross section for each nucleus is weighted with its relative abundance. There is a general trend toward large cross sections as Z increases. This is to be expected if the cross section is determined chiefly by the nearness of an energy level of the compound nucleus to the energy state produced by neutron capture, i.e. by the difference $|E_r - E_B|$ where E_r is a resonance energy and E_B is the binding energy of a neutron to the target nucleus. As the atomic number increases the level density near E_B increases, the chance for a small $|E_r - E_B|$ increases and the probability of large cross sections grows correspondingly greater.

One would expect peaks and dips to occur at random on the general rise. Figure 5 shows no pronounced pattern. It is a little surprising, however, to find that two of the dips occur in the region of proton numbers 50 and 82.

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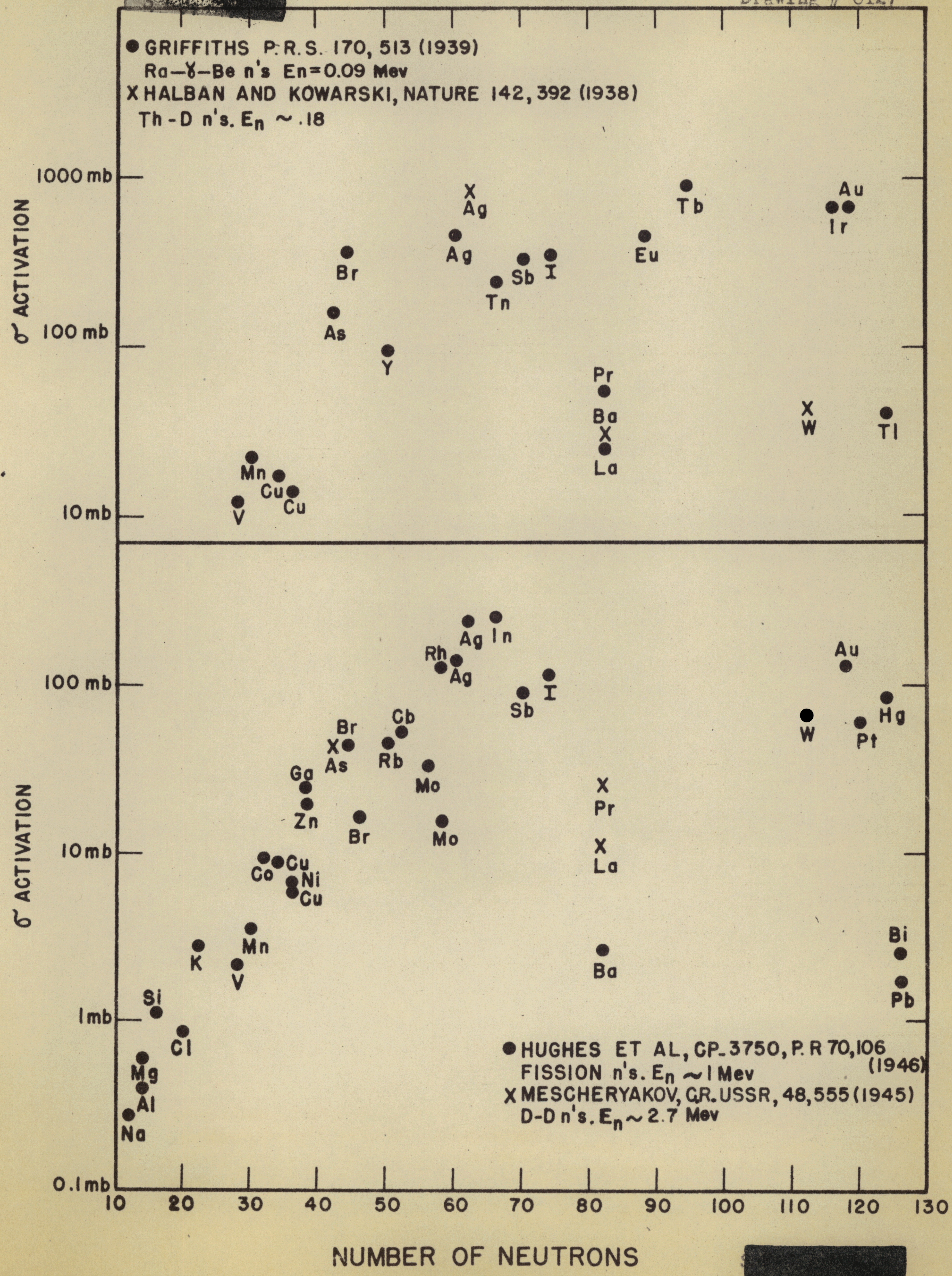
These dips still appear when isotopic cross sections are plotted against Z as in Figure 6. Some of the isotopic values are due to mass spectrographic depletion measurements, others to activation data. Figure 6 shows the values of all known individual cross sections for each value of Z. Most of the peaks and dips of Figure 5 are considerably blurred but the pronounced minima just above 50 and 80 remain. Additional measurements may show that these do not exist or that they are connected with the neutron numbers 82 and 126.

If the binding energies of the 51st, 83rd or 127th neutrons are actually abnormally low, the excited state of the compound nucleus will be in a region of lower than normal level density. The chance of finding a small value of $|E_r - E_B|$ will, therefore, be smaller than usual and so one would expect a greater probability for low absorption cross sections for nuclei with 50, 82, or 126 neutrons.

Figure 7, which shows isotopic cross sections plotted against neutron number, indicates that this expectation may be fulfilled. There are not yet, however, enough data to allow any clear cut conclusions.

[redacted] FIG.1 Drawing # 6127



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UNCLASSIFIED FIG. 2 Drawing # 6128

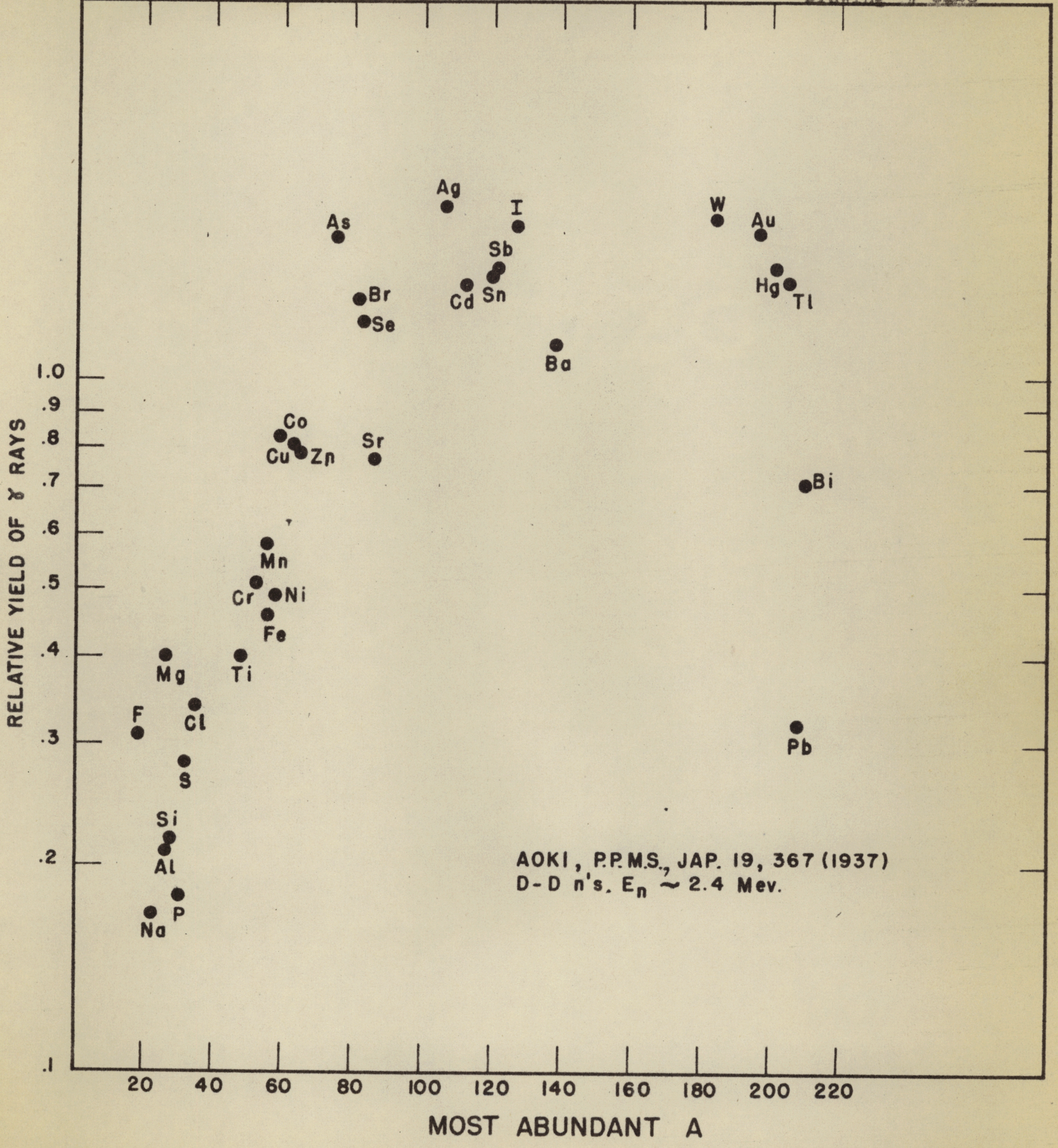

FIG. 3

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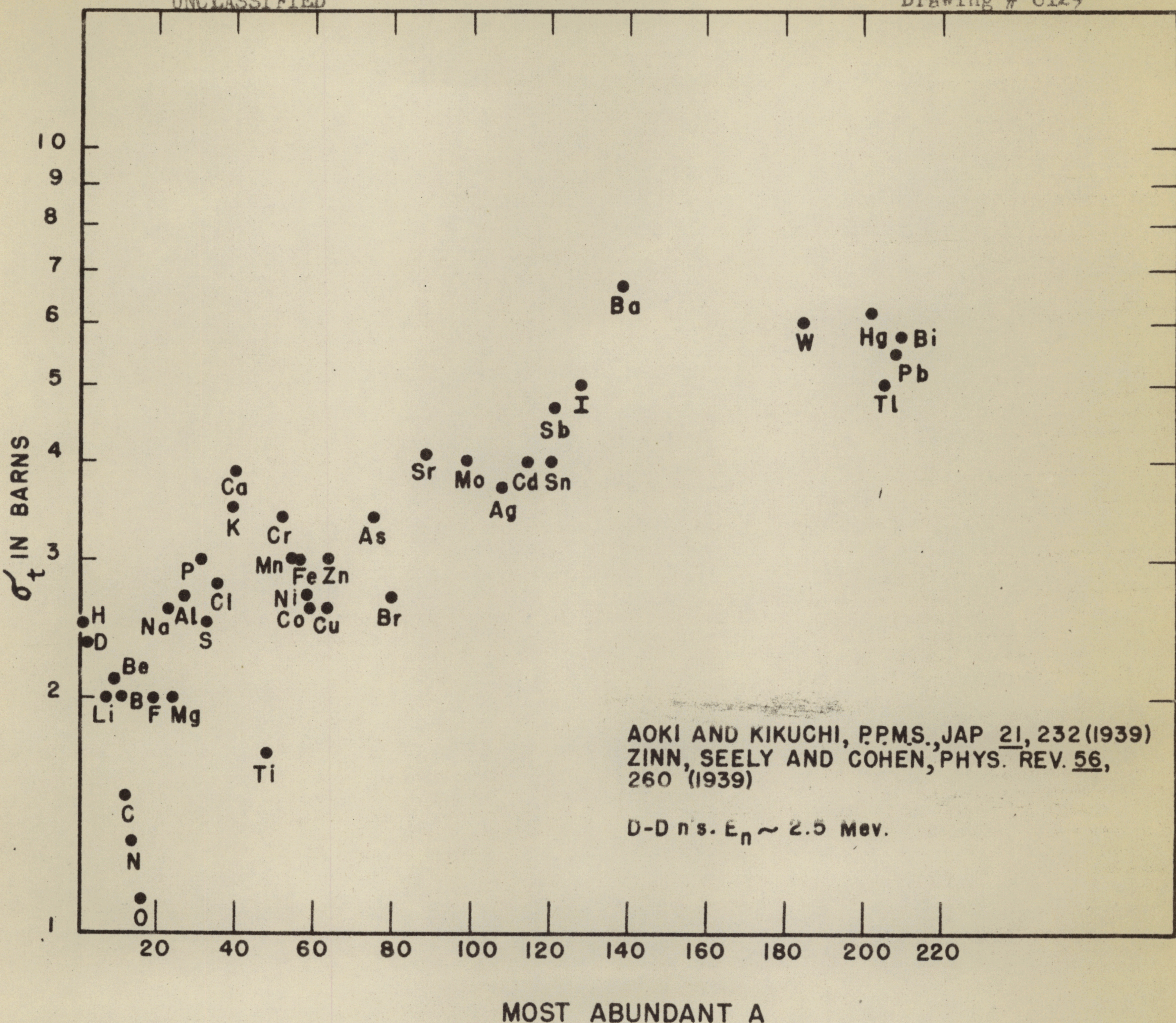
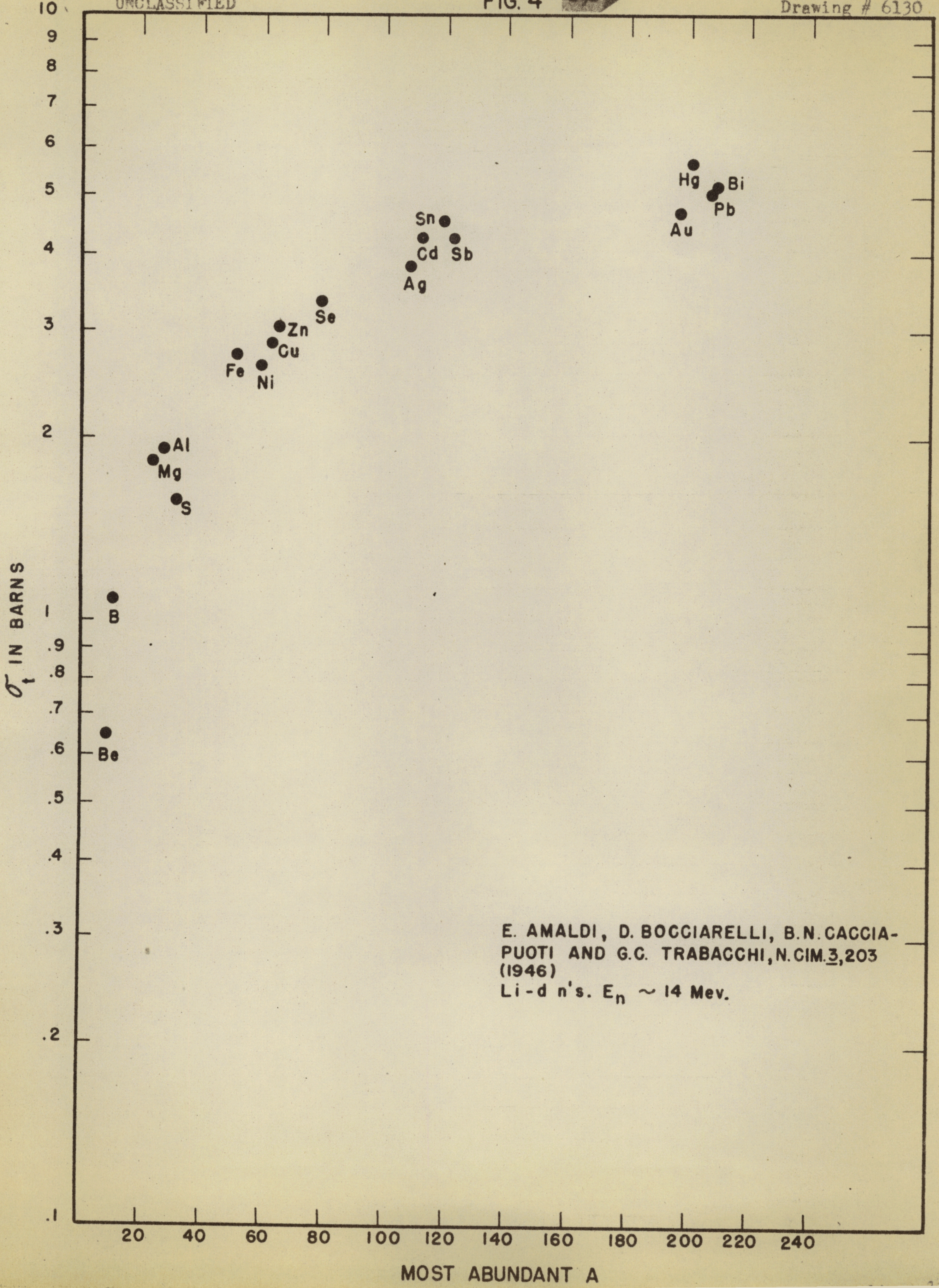
Drawing # 6129




10
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σt IN BARNS
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60
80
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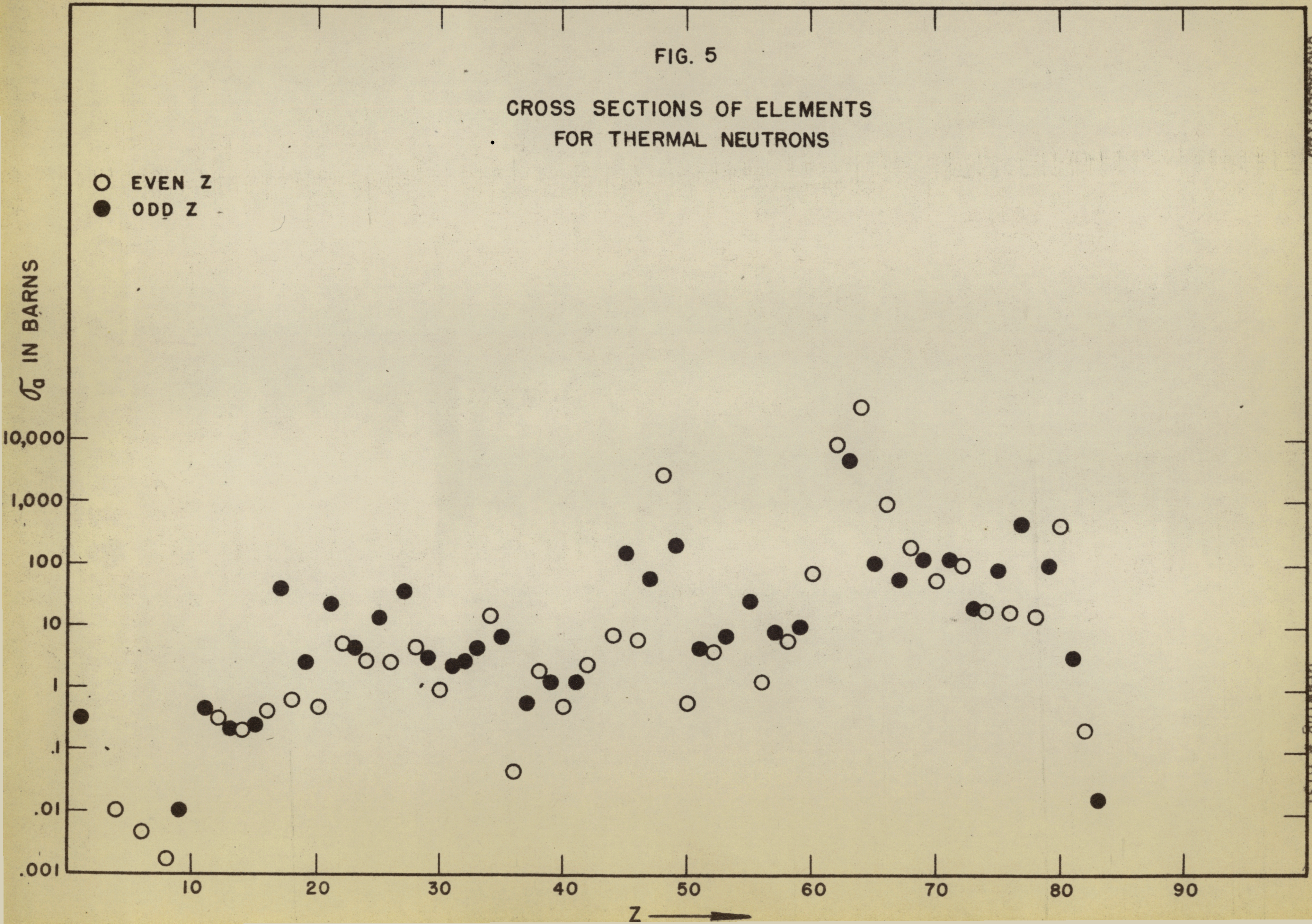
180
200
220
240
MOST ABUNDANT A
Hg
Bi
Pb
Au
Sn
Cd
Sb
Ag
Se
Zn
Cu
Fe
Ni
Al
Mg
S
B
Be
E. AMALDI, D. BOCCIARELLI, B.N. CACCIA-
PUOTI AND G.C. TRABACCHI, N. CIM. 3, 203
(1946)
Li-d n's. En ~ 14 Mev.



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Drawing # 6131

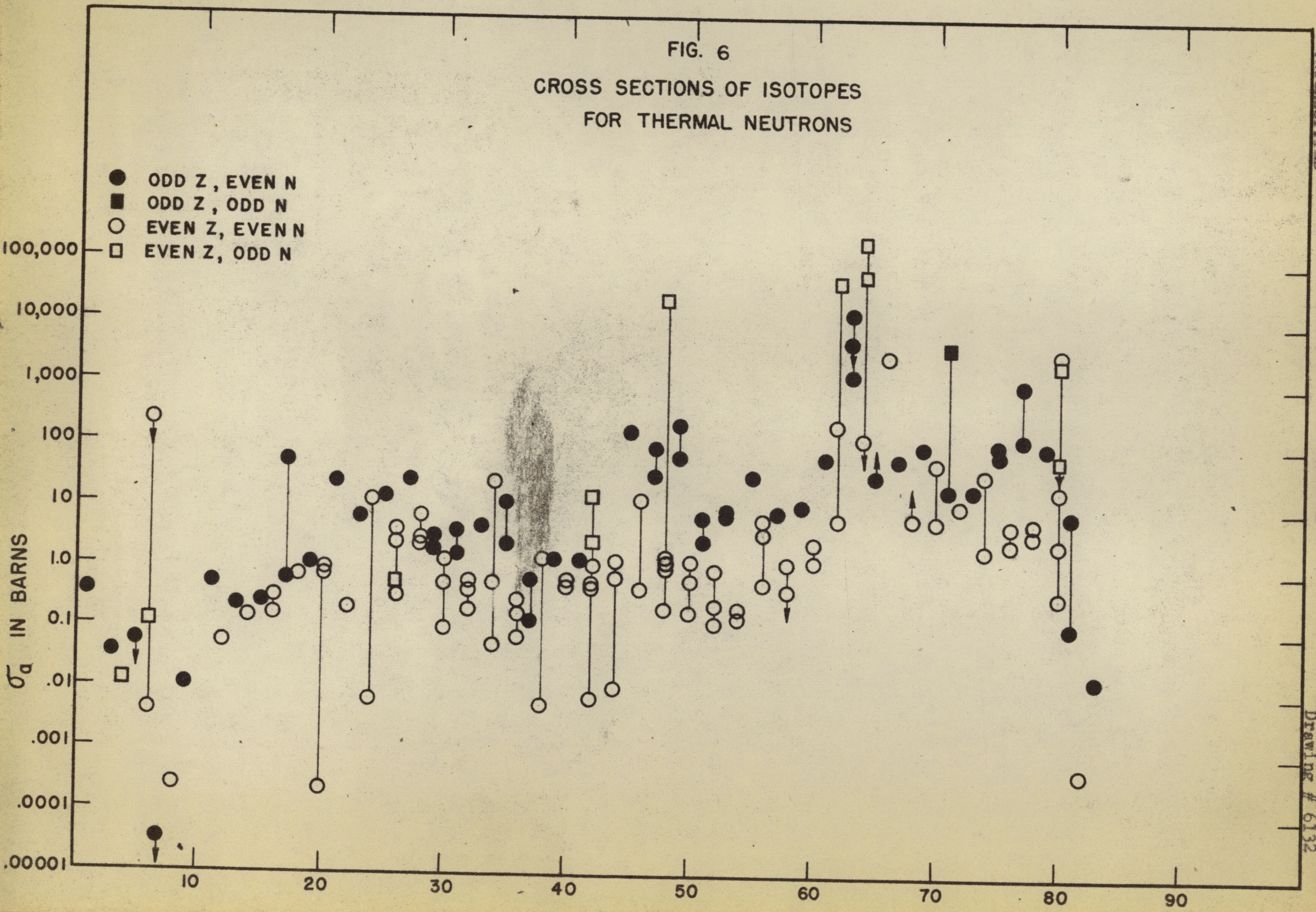

FIG. 6
CROSS SECTIONS OF ISOTOPES
FOR THERMAL NEUTRONS

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Drawing # 6132

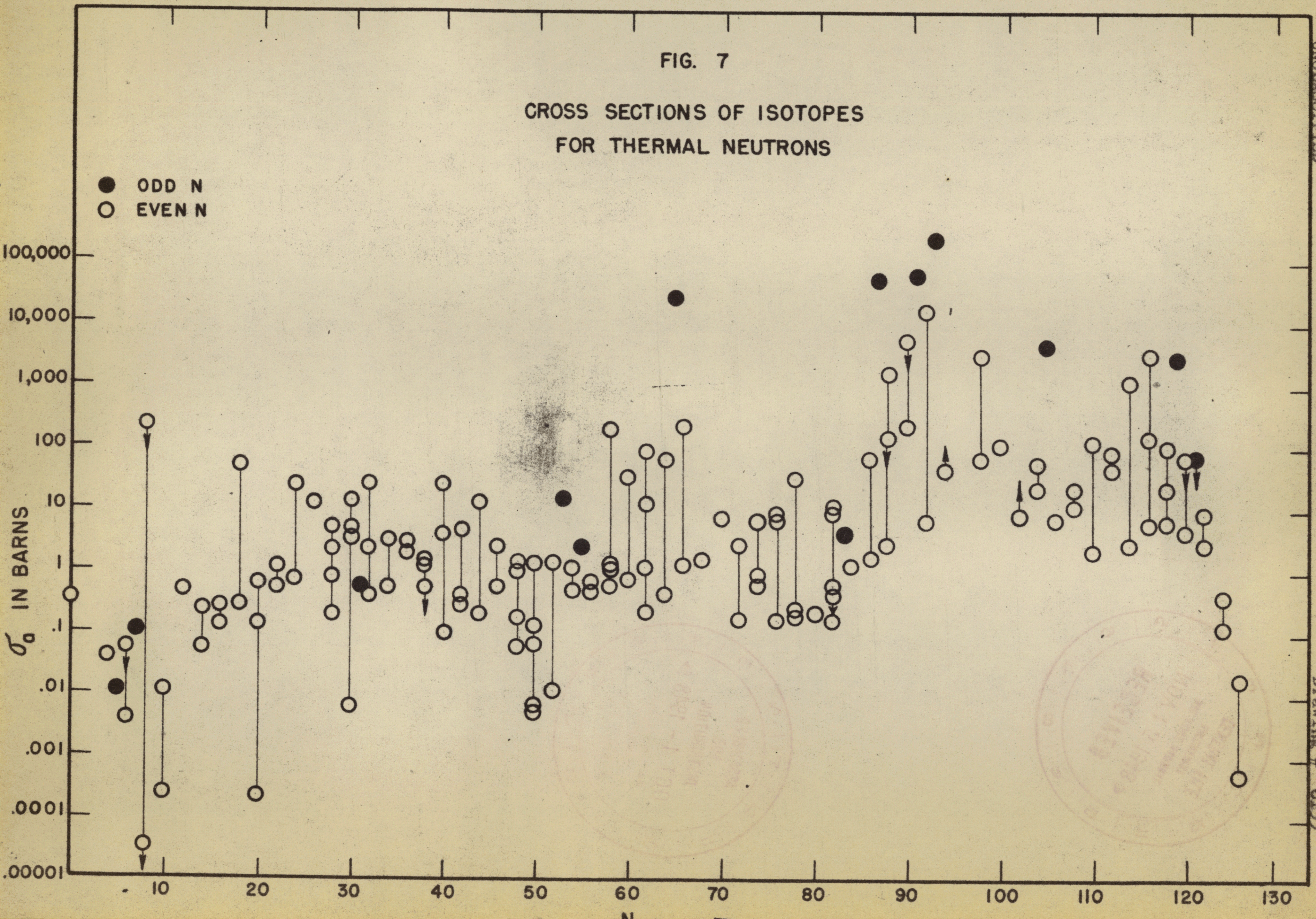

FIG. 7

CROSS SECTIONS OF ISOTOPES FOR THERMAL NEUTRONS

Drawing # 6133