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MEASUREMENTS ON $\sigma_f(49)/\sigma_f(25)$ AND THE VALUE OF $\sigma_f(49)$ AS A FUNCTION OF NEUTRON ENERGY

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ABSTRACT

The relative fission cross section of 49 to 25 has been determined as a function of neutron energy in the range 0.08 to 1.5 Mev. The results show a marked dependence of neutron energy. The values of $\sigma(49)$ are plotted as a function of neutron energy on the basis of the measured value of $\sigma_f(49)/\sigma_f(25)$ for thermal neutrons and the Wisconsin measurements of $\sigma(25)$.

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MEASUREMENTS ON $\sigma_f(49)/\sigma_f(25)$ AND THE VALUE OF $\sigma_f(49)$ AS A FUNCTION OF NEUTRON ENERGY

Measurements of $\sigma_f(49)/\sigma_f(25)$ have been performed by several observers for neutrons of thermal energies.[1] We have reported in a previous publication[2] measurements of this ratio with two different geometries of paraffin surrounding different fission comparison chambers. If one accepts the value of 21,300 years for the half life of 49, our measurements result in a value of $\sigma_f(49)/\sigma_f(25) = 1.83 \pm 3\%$ for C neutrons.

Segrè and Wiegand[3] have made measurements of the above ratio with neutrons of other than thermal energies. They found that $\sigma_f(49)/\sigma_f(25)$ was $1.14 \pm .13$ for 220 kv neutrons emerging from a Be block irradiated by a Y source. In view of this unexpected and important difference from the value obtained by Heydenburg[4] with neutrons of .650 Mev energy, namely, $\sigma_f(49)/\sigma_f(25) = 1.76$ when corrected to the accepted thermal value, it appeared that further measurements were necessary.

In order to extend measurements of the relative cross sections to energies other than thermal it is necessary to use more massive foils of 49 which are not necessarily "thin" for the emission of fission fragments. The <u>effective</u> mass of the 49 sample used in these experiments was found to be 17.2 micrograms by measuring the relative fission rates of this sample and a 17.9 microgram <u>thin</u> foil of 25 simultaneously irradiated by slow neutrons. These foils were mounted back to back on opposite sides of the high voltage electrode A (see Fig. 1) of an ionization comparison chamber containing air at atmospheric pressure. In this aluminum comparison chamber,

1 Chamberlain, Kennedy, Segre, Wahl - CN-469
2 Williams - LA-25
3 Segre and Wiegand - LA-21
4 Heydenburg and Meyer - CF-626

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guard rings B extended the uniformity of the field to the collecting plates C. The plate separation was 6 mm resulting in a collecting field of approximately 2000 volts/cm.

Observations of the fission rates with thermal neutrons were made with and without a Cd shield covering the chamber. This shield reduced the fission rate to one per cent of the unshielded value. The geometrical arrangement of the target and ionization chamber used in the high-energy observations is shown to scale in Fig. 2. In the case of thermal-neutron measurements, the ionization chamber was situated approximately 3 inches from the target and a block of paraffin approximately 18 inches on a side surrounded both the chamber and the target.

The source of neutrons used in the higher-energy measurements was a 60 kv thick lithium target bombarded with controlled-energy protons accelerated in a Van de Graaff generator. The samples of fissionable material subtended an angle of 12° degrees at the target. The variation in angle subtended by the foil surfaces introduced a further uncertainty in the neutron energy incident upon them. Since the yield of neutrons and their energy as a function of proton energy and angle of emission is known for the Li (p,n) reaction it is possible to calculate the average neutron energy effective in any set of observations. The maximum variation of neutron energy from this average is $37\frac{1}{2}$ per cent for the lowest energy value, 80 kv, principally due to the target thickness. The variation is 6 per cent for the average neutron energy of .565 Mev and 3.2 per cent for the highest energy value 1.46 Mev.

Observations of the relative fission rate from the samples of 49 and 25 in the Cd-covered comparison chamber were made for various average neutron energies. The usual precautions of bias settings to give

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zero background and to count all the fission particles were taken. At each energy the position of the samples was reversed in space and simultaneously the two linear amplifiers were interchanged. In general the values of the relative fission rates observed under these two conditions differed by less than ten per cent. The geometric mean of the normal and reversed-position ratios was taken to represent the proper value.

The values of $\sigma(49)/\sigma(25)$ were calculated from these observations and the previously determined effective masses of the samples. The observed ratio is shown in Fig. 3. The errors shown in this figure are calculated from the statistics of the number of fission fragments counted in each case except for the highest-energy point. In this case some of the error arises from uncertainty of the amount of 28 present in the 25 sample since at this neutron energy approximately 1/3 of the fissions were of the 28 in the sample.

It is clear from Fig. 3 that there is a marked change in the relative cross sections of 49 and 25 in the neighborhood of 550 kv. It is also apparent that the relative cross section is practically constant at approximately 92 per cent of the thermal value for energies above 1 Mev. The interesting region between thermal energies and 80 kv remains to be investigated.

From these data we have calculated $\sigma(49)$ as a function of neutron energy by multiplying the values of $\sigma_f(49)/\sigma_f(25)$ of Fig. 3 by $\sigma(25)$. The values of $\sigma(25)$ used are the coincidence-proportional-counter data of Hanson. (CF 618).

Fig. 4 shows the values of $\sigma(49)$ as a function of neutron energy. It should be noted in this figure that the indicated errors are those due only to uncertainties in $\sigma_f(49)/\sigma_f(25)$ and do not include the

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uncertainties in $\sigma_f(25)$. The left-hand scale gives the cross section based on the values for $\sigma_f(25)$ obtained from the coincidence-proportional calibration. The scale on the right-hand side is obtained from the manganese-bath calibration for the cross section of 25.

This curve indicates a pronounced minimum for $\sigma(49)$ in the 400 kv neutron energy region. The reality of this minimum is readily established by attempting to draw a curve through the experimental points of Fig. 3 which would minimize as much as is reasonable the magnitude of the break in $\sigma_f(49)$ $\sigma_f(25)$. Any such distortion will not erase the minimum exhibited in Fig. 4. The earlier observations of Heydenburg and Meyer and of Segre and Wiegand are confirmed by those reported here and serve to substantiate the present conclusions.

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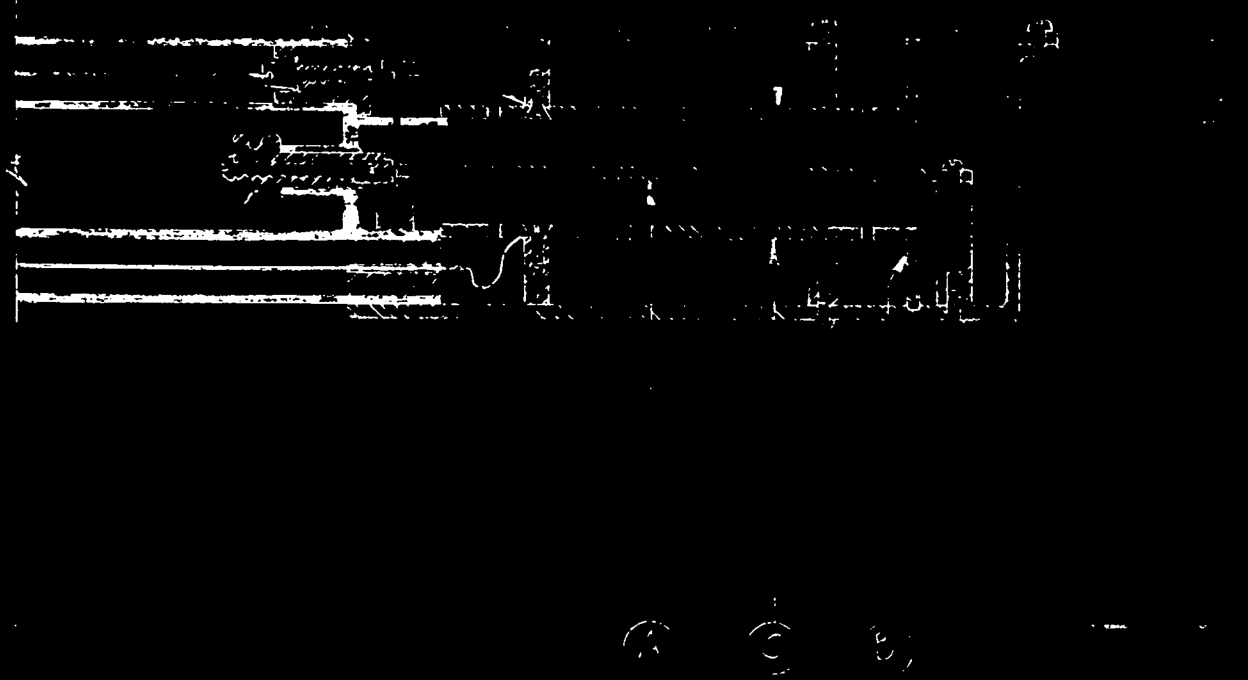

FIGURE 1
Scale: Full Size

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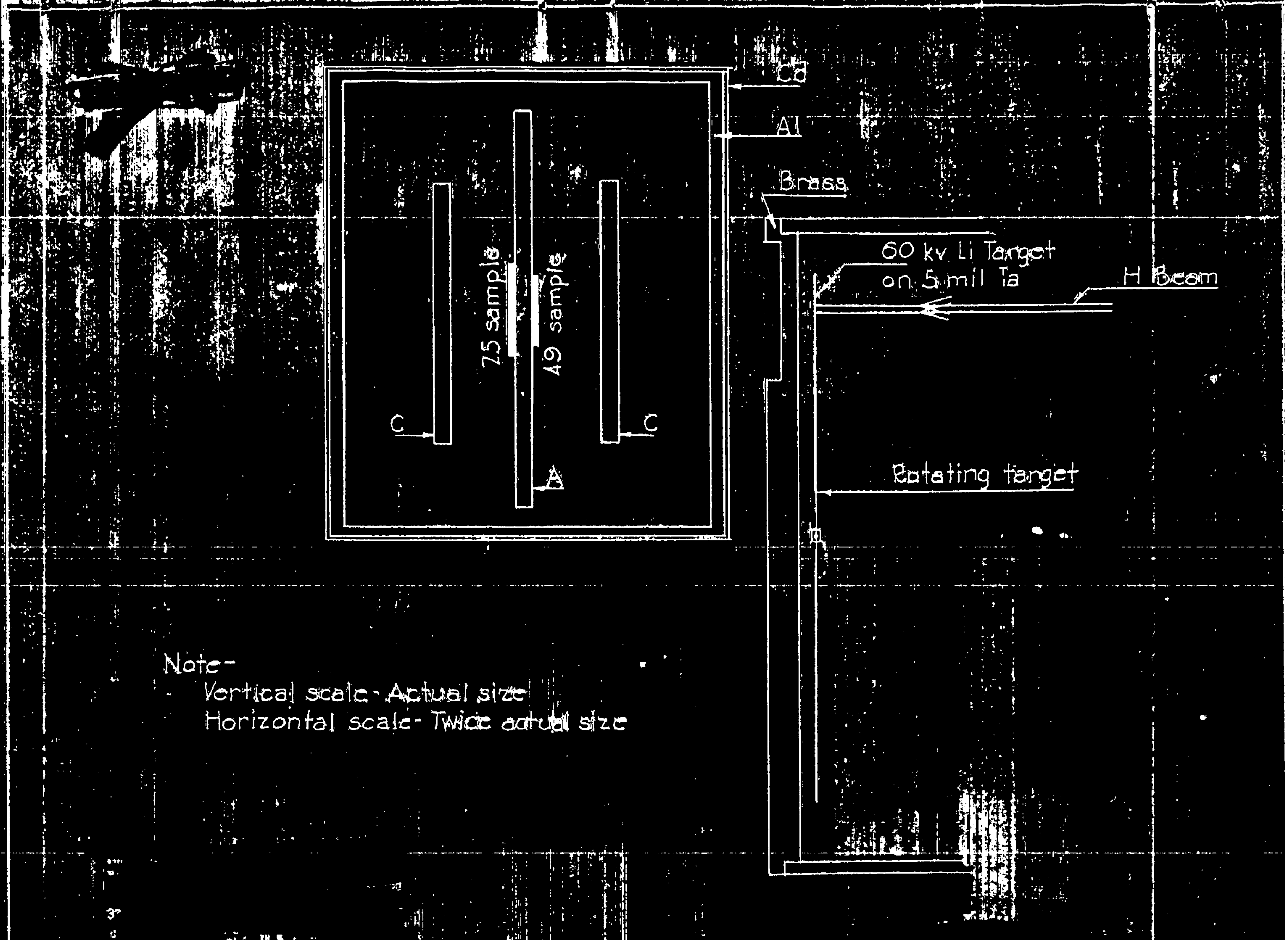

FIGURE 2

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FIGURE 3

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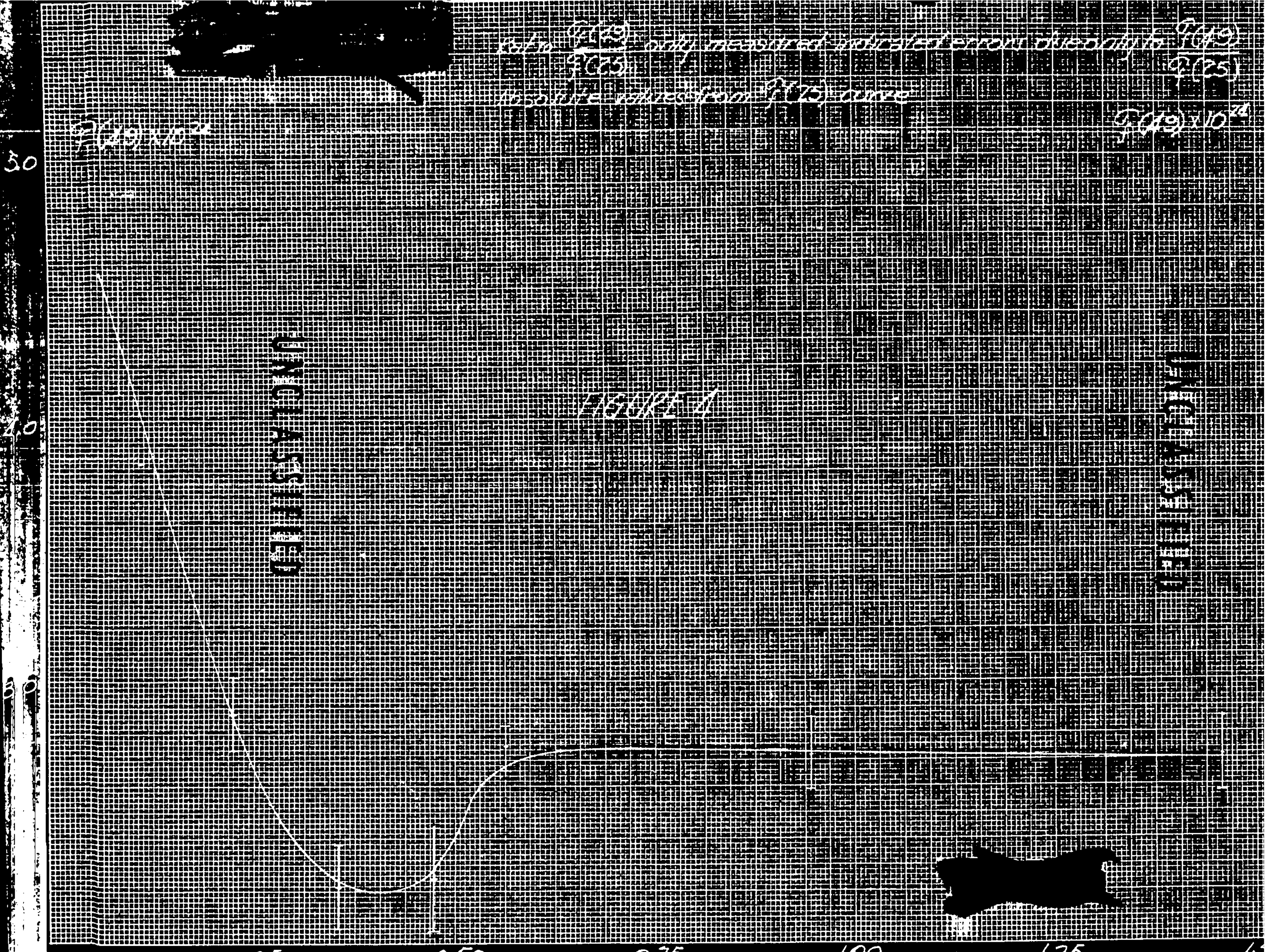

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