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SPATIAL AND ENERGY DISTRIBUTION OF NEUTRONS IN 25 METAL CRITICAL ASSEMBLIES

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ABSTRACT [redacted]

The distribution of neutrons was studied in critical assemblies consisting of 25 tamped with WC and Fe, with WC alone, and with Tu. An indication of the energy distribution of the neutrons is obtained by the use of various fission chambers and detecting foils.

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SPATIAL AND ENERGY DISTRIBUTION OF NEUTRONS IN 25 METAL CRITICAL ASSEMBLIES

As a check on the theoretical calculations of the spatial and energy distribution of neutrons in a 25 metal critical assembly, various neutron detectors were activated in critical assemblies at Omega. The following detectors were investigated:

1. 25 fission was studied both by use of a small ionization ("fission") chamber of the "spiral" type and by measuring in a Geiger counter the gamma activity resulting from fission in a foil of 25 metal. The chamber was kindly supplied to us by the members of group R-3, who also assisted in its operation as well as in the interpretation of the results obtained therefrom.

2. 28 fission. A spiral chamber and foils were both used for this measurement. Fission in 28 has an effective energy threshold of ~ 1.4 Mev.

3. 37 fission was studied by the use of a spiral chamber. Fission of 37 has an energy threshold of about .4 Mev.

4. Au activity induced by the (n,γ) reaction was measured by the use of gold foils. These were activated in the assembly, and the resulting β activity measured in a Geiger counter. The cross section for this reaction is supposed to vary approximately as $1/E$ in the 100-500 Mev region, and hence this detector should be more sensitive to the low-energy part of the neutron spectrum than the 25 detector.

5. W activity, due to an (n,γ) reaction, was studied. The energy dependence of the cross section for this reaction is not known.

6. $Mn(n,\gamma)$ was investigated. The cross section for this reaction

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was presumed to vary with neutron velocity as $1/v$, though it has never been measured for the neutron energies involved. The experiment indicates that the $1/v$ assumption is probably false.

The spiral chambers were about 3/8" in diameter and 3/8" long. These were completely surrounded, in the critical assembly, by the materials appropriate to their position, so as to minimize the perturbation introduced by the hole made by the chamber.

The foils were 1/2" square, and placed, flat, in the central plane of the critical assembly. Thus, the activity of a foil represents an average over a square 1/2" on a side; the position of a foil was taken as the position of the center of the foil (the same was true for the chambers). This places a limit on the resolution of these measurements.

The irradiations were made by stacking a slightly super-critical assembly and allowing the power to rise to a level sufficient to activate the detectors the desired amount; the assembly was then run exactly critical for five minutes, after which the assembly was made sub-critical by the removal of sufficient tamper material. The foils were stacked into the assembly, and afterwards removed and "counted" in Geiger counters. Thus, all the foils to be compared received the same irradiation.

A removable channel was provided for the chamber measurements, into which the chamber, completely surrounded by the appropriate materials, could be introduced at any desired position. The ratio of counting rate of the chamber to the counting rate of a fixed "monitor" was always taken, so that all the chamber measurements may be said to have been made at the same power.

Spatial distributions were measured in a number of assemblies.

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I. 25-WC-Fe Assembly: The 25, 28, and 37 fission rates were compared by the use of the spiral chambers. The results of these measurements, in counts per mg. of material at an arbitrary power are shown in Fig. 1. In the same assembly, the 25 and 28 fission activities were measured by foils. The results of these measurements are shown in Fig. 2. The curves are normalized to a value of 1 at the center of the 25 core. A rough calibration of the foil activities in terms of fissions per mg can be obtained by using the chamber measurements. However, since the correction for the hole made by the chamber is somewhat uncertain and probably different for the two materials, it would be desirable to obtain an absolute calibration for the foils. This has not yet been provided, though it is intended to do so in the near future by irradiating both a 25 and a 28 foil simultaneously in a flux of "fission" neutrons, produced by irradiating a sandwich of the foils inside 25 metal in a cavity in the thermal column of the water boiler.

II. 25 - WC Assembly:

25, Au, and W foils have been irradiated in this assembly. Their activities are shown in Fig. 3. Again, they are all normalized to a value of 1 at the center. To compare directly the average cross sections of 25 and Au, two such foils were irradiated for five minutes in the same thermal neutron flux in the water boiler thermal column, and their activities compared. From a knowledge of the thermal neutron cross sections for 25 fission and Au (n,γ) (549 b and 105 b respectively) one obtains for the ratio of $\overline{nv\sigma}(25)$ to $\overline{nv\sigma}(Au)$ at the center of this critical assembly, the value 9.65.

III. 25-Tu Assembly:

25, 28, Au, and Mn foils were irradiated. The activities are shown in Fig. 4, where the activities at the center are again normalized to 1. Using

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the above discussed intercalibration, the value of $\overline{nv\sigma}(25)/\overline{nv\sigma}(Au)$ at the center is found to be 10.4.

In the thermal-neutron intercalibration of the 25 and Au foils, the same foils as had been irradiated in the metal critical assemblies were used. The 25 foils were not thin - having a transmission, for a thermal neutron beam falling perpendicularly upon them, of about 72 per cent. The gold foils had a corresponding transmission of 92 per cent. We have assumed the activities per mg to be 75 per cent and 93 per cent respectively of the activities per mg of infinitesimally thin foils irradiated at the same place in the graphite thermal column of the water boiler.

The intercalibration of the 25 and 28 foils was carried out as follows. 25 and 28 foils were irradiated with 25 fission neutrons. The foils were covered with 0.8 mm Cd and sandwiched between 3 mm 25 blocks and placed in the cavity of the graphite column of the Omega water boiler. The foils were at least 10 inches from graphite. The resulting γ activity was counted in the same geometry and with the same Geiger counter as the foils irradiated in the critical assemblies.

The ratio of activities of the 28 and 25 foils was the same at the center of the 25 core for both the WC-Fe tamper and the Tu tamper. The 28/25 ratio for the critical assembly neutrons at the center of the core divided by the 28/25 ratio for fission neutrons, (i.e. $\dfrac{\overline{(nv)_A\sigma_{28}}/\overline{(nv)_A\sigma_{25}}}{\overline{(nv)_f\sigma_{28}}/\overline{(nv)_f\sigma_{25}}}$, where $(nv)_A$ refers to the critical assembly and $(nv)_f$ to the fission spectrum) is 0.62. This is for 1 mg of pure 28 and 1 mg of pure 25. $\overline{(nv)_A\sigma_{28}}/\overline{(nv)_A\sigma_{25}} = 0.125$ and

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$\overline{(nv)_f\sigma_{28}}/\overline{(nv)_f\sigma_{25}} = 0.20$. Since the general fission decay is not the same for 25 and 28, these two values are dependent on the counting set up. For a 5 minute irradiation and counting through 1/32" Cd absorber, the ratios are the same from 10 to 120 minutes after activation.

The graphs of the 25 fission distribution are not corrected for the 26.4 per cent of 28 in the foils. This correction is 4 per cent at the center of the core, but drops off rapidly in the tamper. The 28 foils contain about 1 part in 3000 of 25 and no correction is necessary.

Since it is felt that these results should be made available without delay, we have not included the results of contemplated intercalibrations by fast neutrons from the W long tank and of relative activations of the P(n,p), Al(n,p), Al(n,α) and Ag(n,2n) reactions in the various critical assemblies, which will be reported in addenda to this report as soon as they become available.

The comparison of our experimental distributions with theoretical calculation is being carried out by members of Serber's and Weisskopf's groups in the theoretical section.

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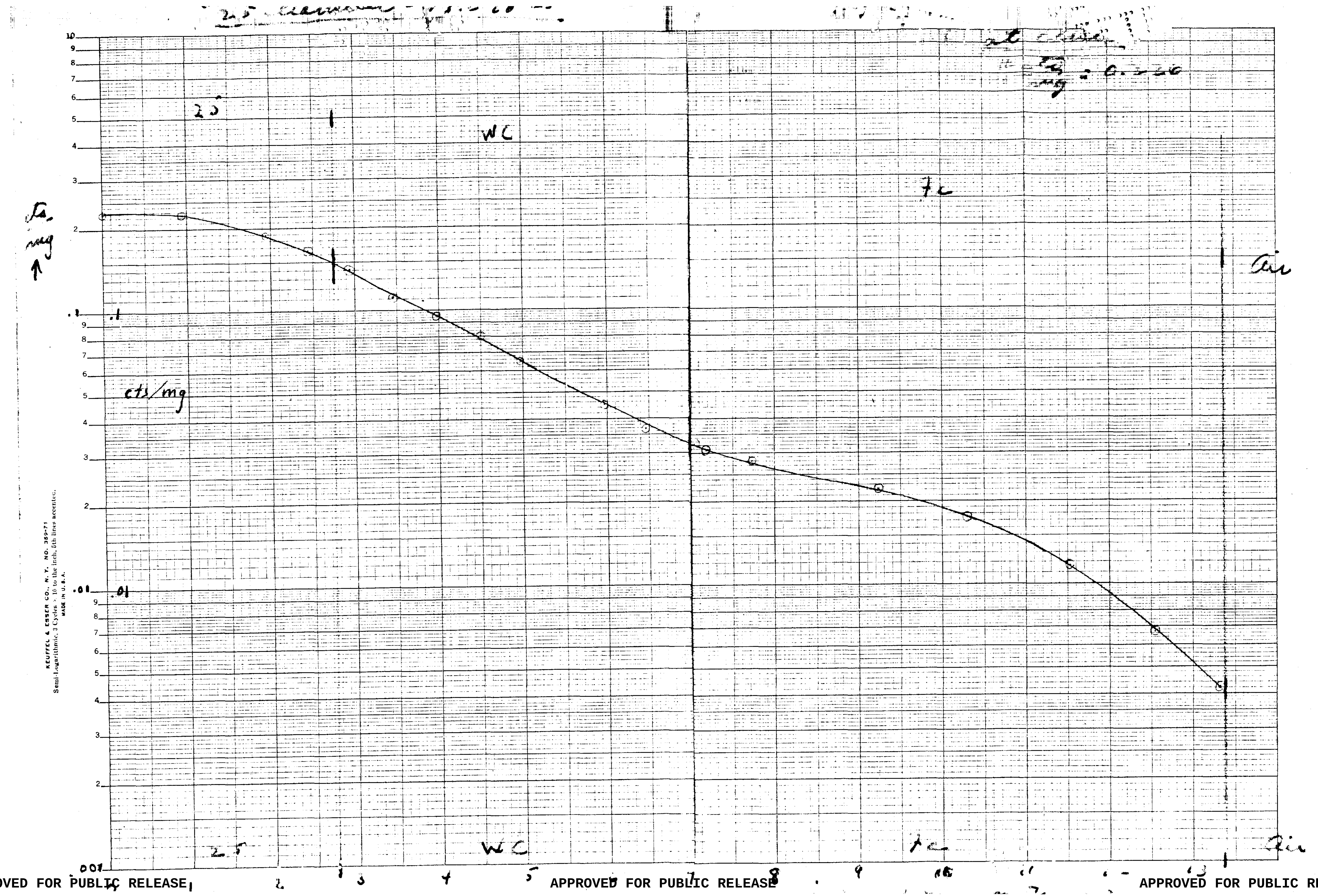
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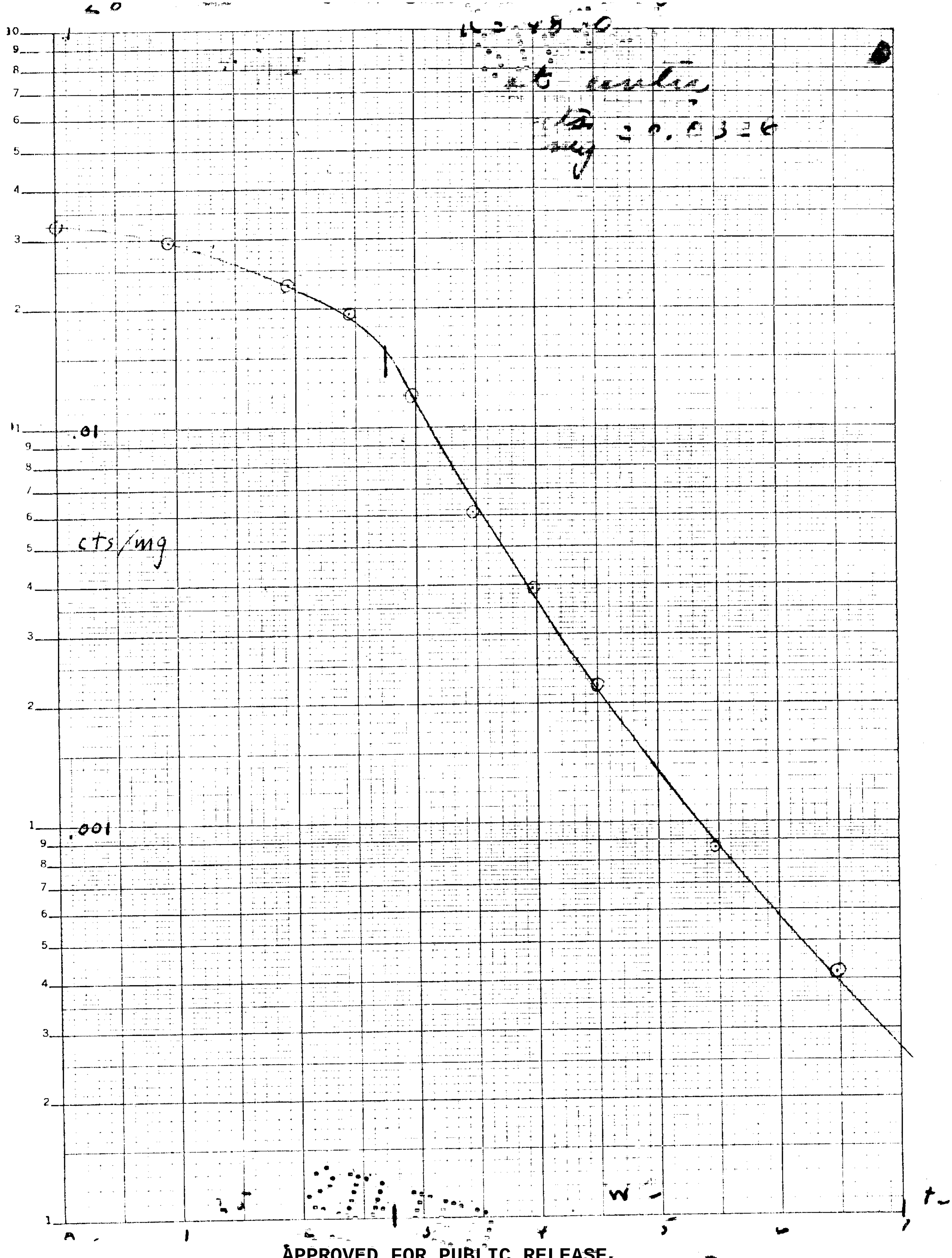

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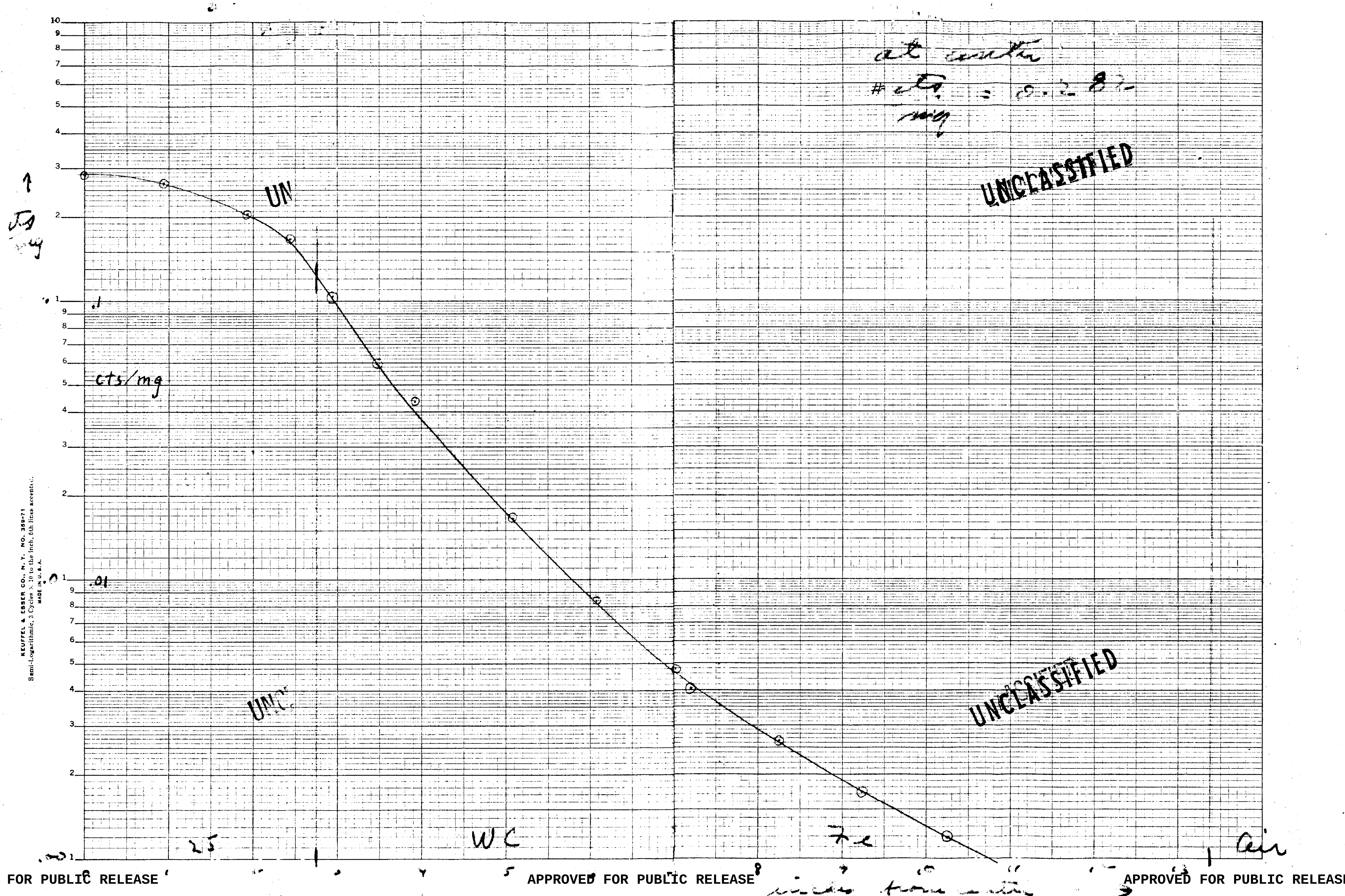

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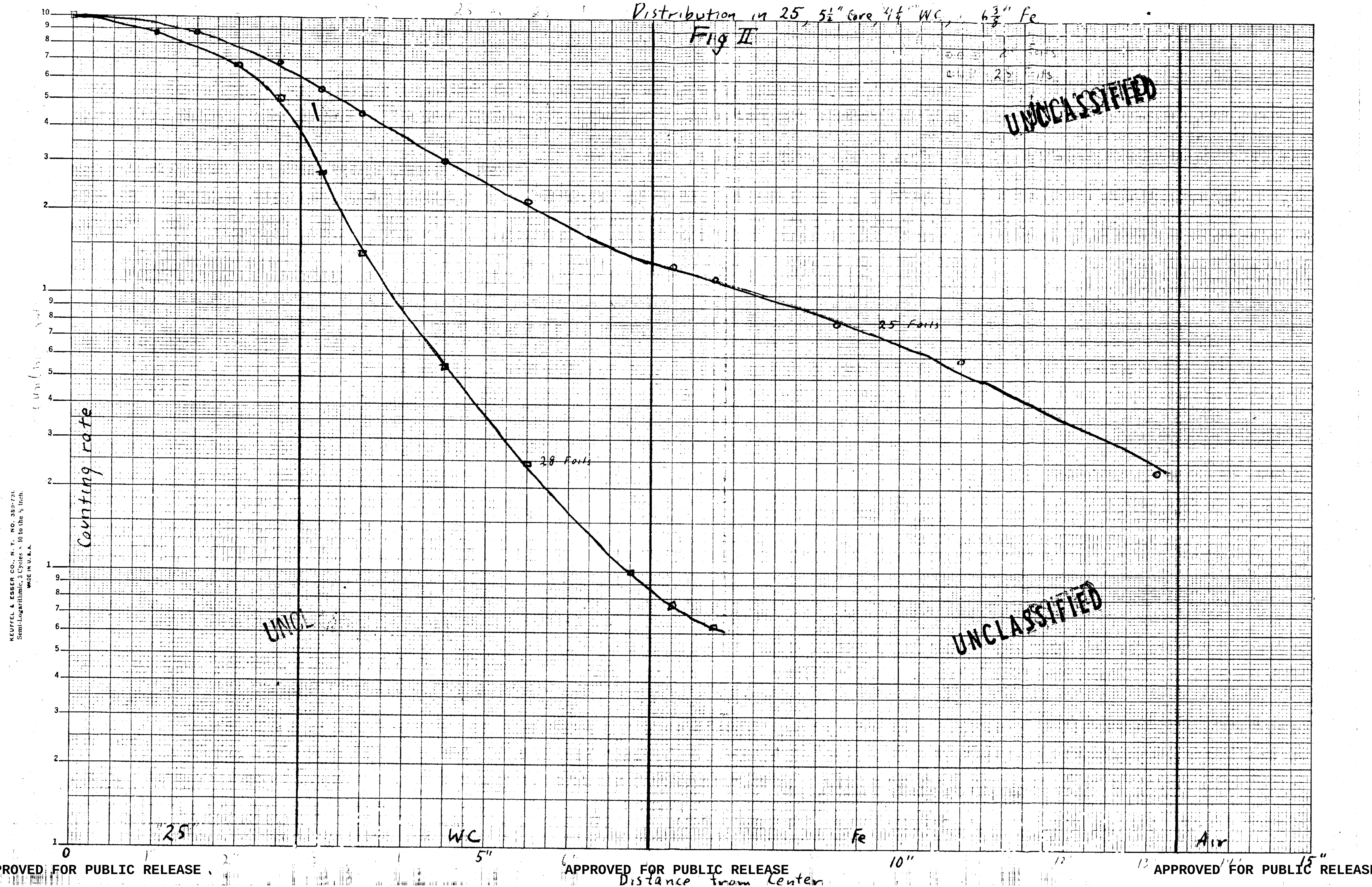

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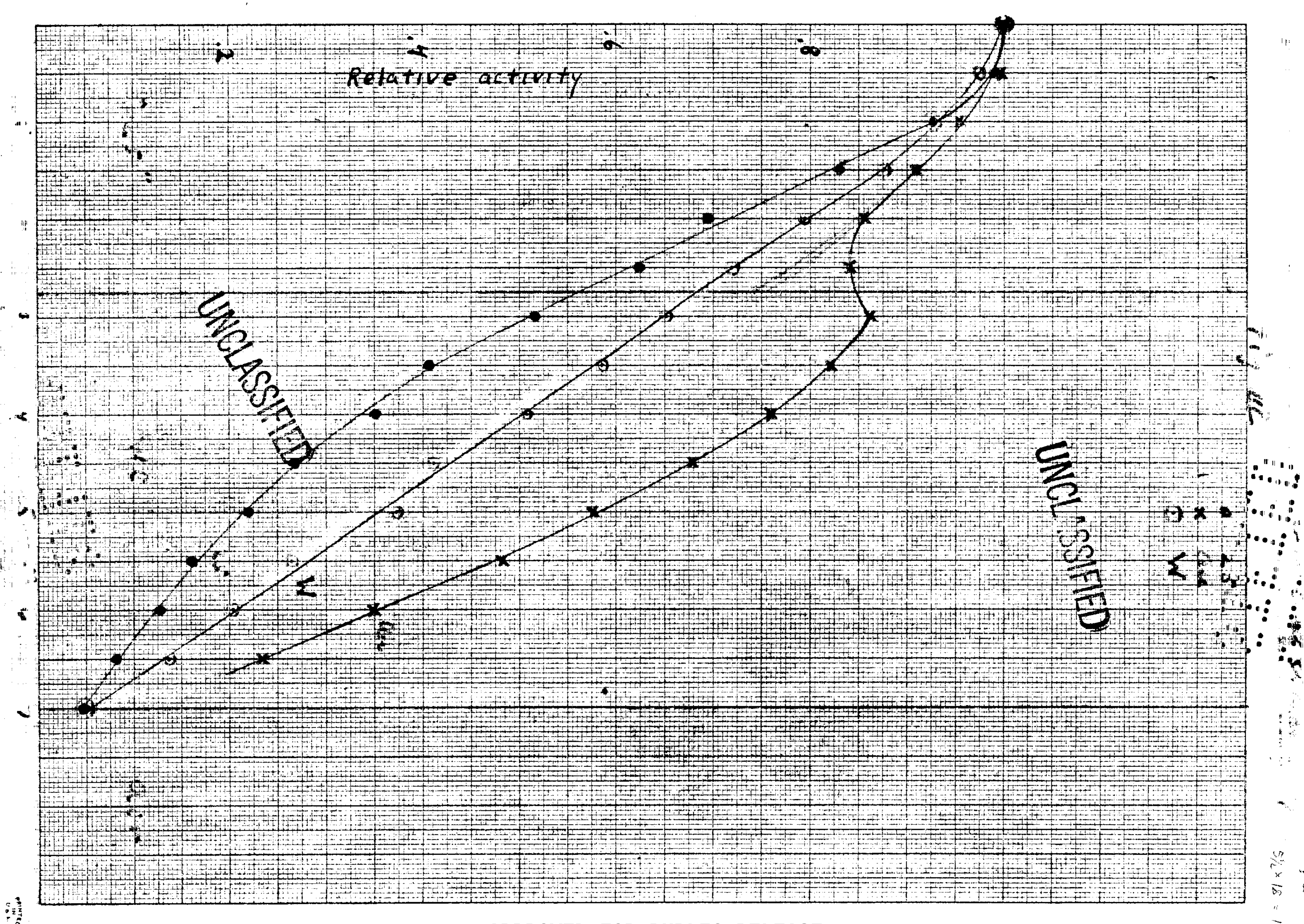
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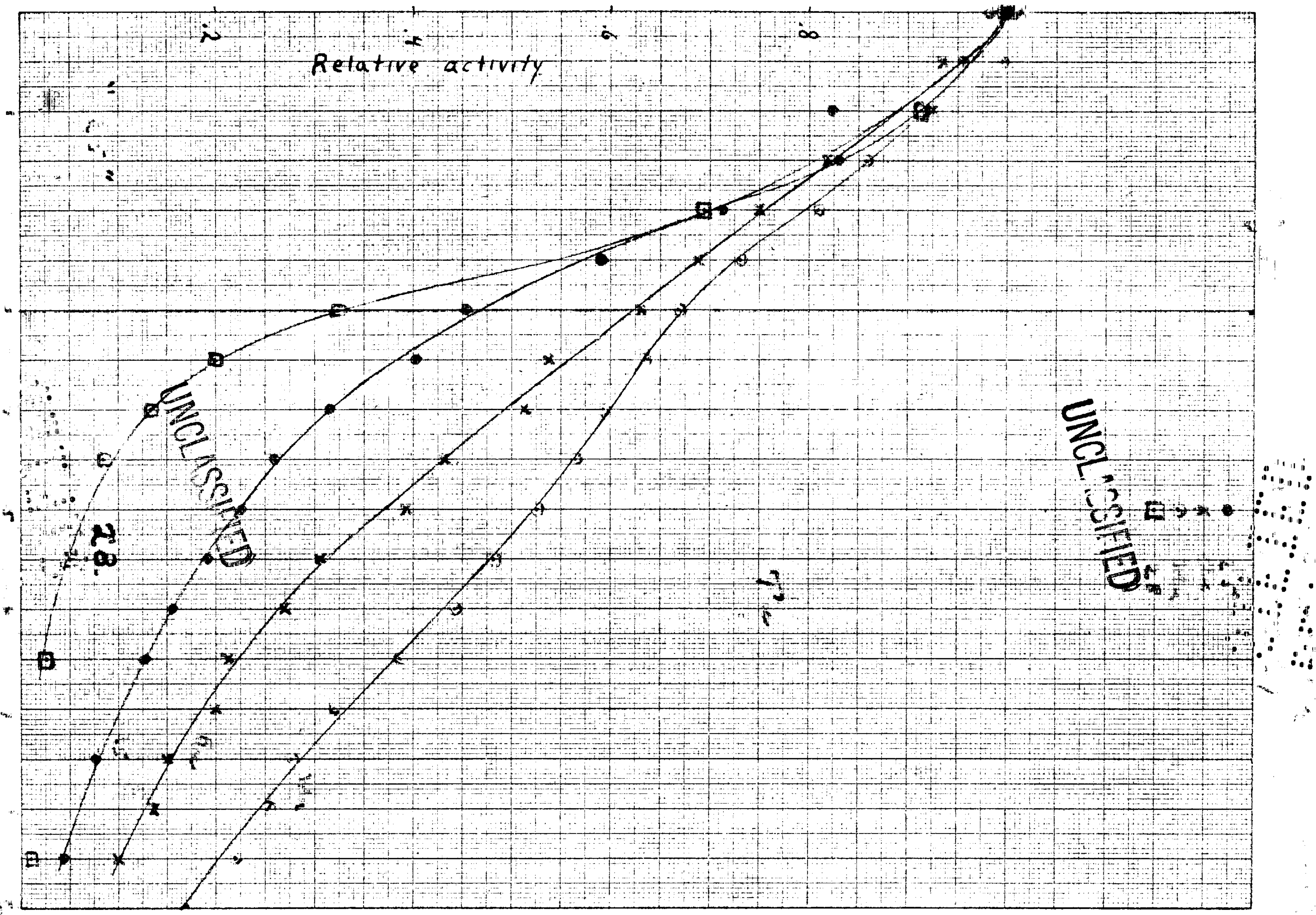
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