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RELATIVE FISSION CROSS SECTION OF 23 FOR NEUTRONS

IN THE RANGE .025 TO 100 EV

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ABSTRACT

Measurements of the fission cross section of U_{233} relative to boron have been made as a function of energy in the interval extending from 0.025 to about 100 ev. The value of $\sigma_f(23)v$ remains essentially constant up to about 0.6 ev where it begins to rise to a resonance at 1.7 ev. Here it takes on a value greater than 7.5 times its thermal value. Above this resonance, it falls off again but the presence of several higher levels maintains the average value of $\sigma_f(23)v$ at about 4 times the thermal value. Most prominent indications of other resonances are at about 6, 19, and 100 ev.

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This experiment was undertaken in order to measure the relative variation of the fission cross section of U_{233}, (23), for slow neutrons by the time-of-flight method.

The methods employed for making these measurements have been discussed in detail in earlier reports concerned with measuring the cross sections of $25^{[1]}$ and $49^{[2]}$. In brief, the method is the following. By using the velocity spectrometer, a distribution curve is obtained which is a function of the time of flight (inversely proportional to the square root of the energy). This distribution curve represents a quantity which is proportional to the product of the neutron cross section of the detector and the time of flight distribution of the neutrons in the incident beam. By taking the ratio of the distribution curve obtained using a 23 fission detector to that obtained using a boron (1/v) detector, the relative variation of $\left[\sigma_f(23)v\right]$ is obtained as a function of neutron energy (v = neutron velocity, $\sigma_f(23)$ = cross section for fission). To determine the absolute value of $\sigma_f(23)$ it is necessary to measure the cross section at only one energy in the region of the velocity measurements.

The ionization chamber which was used in the experiment was the same as the one described in an earlier paper[3]. It is shown in Fig. 1. It consists of three adjacent coaxial sections. The axis of the combination is placed in the direction of the incident beam. The front and rear sections

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1) Anderson, Lavatelli, McDaniel, and Sutton. LA-82
2) Anderson, Lavatelli, McDaniel, and Sutton. LA-91
3) Anderson, McDaniel, and Sutton. LA-158

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are connected together electrically to compose the 23 detector. A total of about 4 mg of material containing 23 were available. Analyses of the material showed that about 16 per cent is normal uranium. This makes the 25 content amount to about 1.1 parts per 1000. Since the cross sections of 23 and 25 are of the same order of magnitude, it was evident that no difficulty would be encountered from the 25 content of the sample. The material was deposited electrolytically in the form of the oxide on platinum foils, and was divided equally between the two sections of the detector. The center section is a BF_3 parallel-plate detector. This section was filled to a pressure of about 3 cm with BF_3. Enough argon was then added to the section to bring the total pressure to 1 atmosphere.

A fast amplifier with a 0.1 μsec clipping time was used to detect the ionization produced in the chambers. No difficulty was experienced in obtaining a plateau in the 23 section of the chamber in the presence of the strong alpha activity of this element.

The measurements were made using a source-detector distance of 3 meters. The source which was used consisted of a tank, 5 cm thick, filled with a boron oxide solution (7 gm/l), and a filter of B_2O_3 containing 0.25 gm/cm^2. Because the measurements were taken at 3 meters, the chamber was located inside of the water tanks which surround the cyclotron. It was feared that there might be some slight leakage of thermal neutrons into the collimator through small cracks because of a large 25 ton carbon block which was located adjacent to the collimator. For this reason, the chamber was wrapped with 60 mils of Cd, leaving only the front of the chamber open.

Two sets of measurements were made in the region below 0.6 ev. In

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the first set, the Cd wrapping about the chamber was omitted. This may have made the measurements somewhat unreliable. The second set of measurements were made with the chamber wrapped in Cd. For the measurements above 0.6 ev, in addition to wrapping the chamber in Cd, the front face of the detector was also covered with 60 mils of Cd to permit a higher repetition rate to be used.

The usual normalization measurement [3] was made to relate the data taken with Cd over the front of the detector to that without the front covered. No normalization was made between the two sets of data taken in the lower energy region, but instead the weighted mean of the data taken without the chamber wrapped was adjusted to be equal to that for the chamber wrapped with Cd. The data taken with the unwrapped chamber was included simply to give additional evidence with regard to the shape of the cross section curve in the thermal region.

The results of the experiment are shown in Fig. 2, with the conditions of the experiment indicated in Table I. The ordinate of the graph is proportional to $\sigma_f(23)v$ or $\sigma_f\sqrt{E}$ arbitrarily normalized to unity at 0.025 ev. The abscissa is the logarithm of the time of flight. In Fig. 3, the corresponding curve is plotted on a logarithmic energy scale. The present accepted value [4] for $\sigma_f(23)$ is 550 ± 20 barns for 2200 m/sec (very nearly 0.025 ev). From this measurement, the value of $\sigma_f(23)v$ or $\sigma_f(23)\sqrt{E}$ can be obtained for 0.025, and from this the corresponding value at any energy in the range of the measurements may be computed.

The principal features indicated by the results are the following. The value of $\sigma_f(23)v$ remains essentially constant up to about

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4) H. L. Anderson and A. N. May, CP-2301
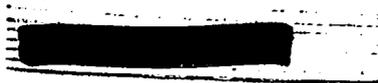
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0.6 ev where it begins to rise to a resonance at about 1.7 ev. It attains a value at resonance of at least 7.5 times greater than that at 0.025 ev. Immediately above the resonance it falls to a little less than twice the thermal value and then begins to rise again. Possibly three or more resonances are indicated to exist at higher energies. These seem to be located at about 5.8, 19, and 100 ev. Above about 5 ev and up to somewhat over 100 ev, the average value seems to be about 4 times the thermal value. The resonance at 1.7 ev is best resolved, but even this is not well resolved.

These results are in reasonable agreement with those given by Anderson and Fermi[5] from their determination of the variation of cross section by making boron absorption measurements. They found increase of a factor of about 4.4 in the value of $\sigma_f(23)v$ in going from thermal energies to energies of the order of 10 volts and greater.

Since only 4 mg of material were available for our measurements, it was not possible to improve the resolution. About 5 times this much material can be used before any difficulty is encountered with alpha particle background. However by the use of recently developed techniques it should be possible to count as much as 120 mg of the material which would permit a considerable increase in the attainable resolution. This would correspondingly permit extension of the range of the measurements to somewhat higher energy.

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5) H. L. Anderson and E. Fermi, Nuclear Physics Research Report. C.F. 2161

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Table I.

EXPERIMENTAL CONDITIONS FOR RESULTS SHOWN IN FIG. 2

On Time μsec	Frequency c p s	Region	Symbol	Conditions
50	200	100 - 508 μsec/m	▭	No Cd.
100	200	100 - 450 μsec/m	△	Cd. around chamber
20	2500	46 - 100 μsec/m	⊙	Cd. around chamber Cd. over front
10	2500	3.3 - 40 μsec/m	▽	Cd. around chamber Cd. over front

For all measurements a source-detector distance of 3.0 m was used.
The source consisted of a tank filled with 7g/liter B_2O_3 water solution along with a filter of 0.25 g/cm^2 B_2O_3.
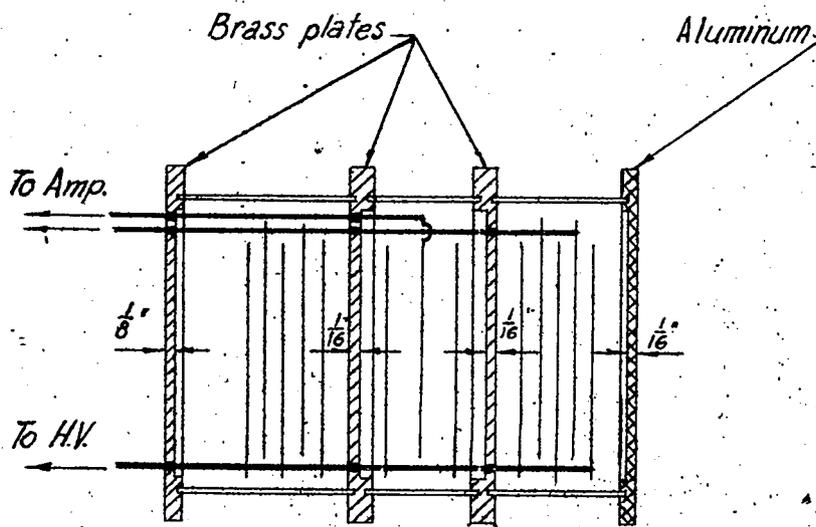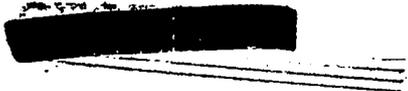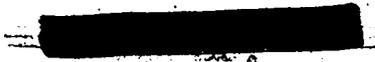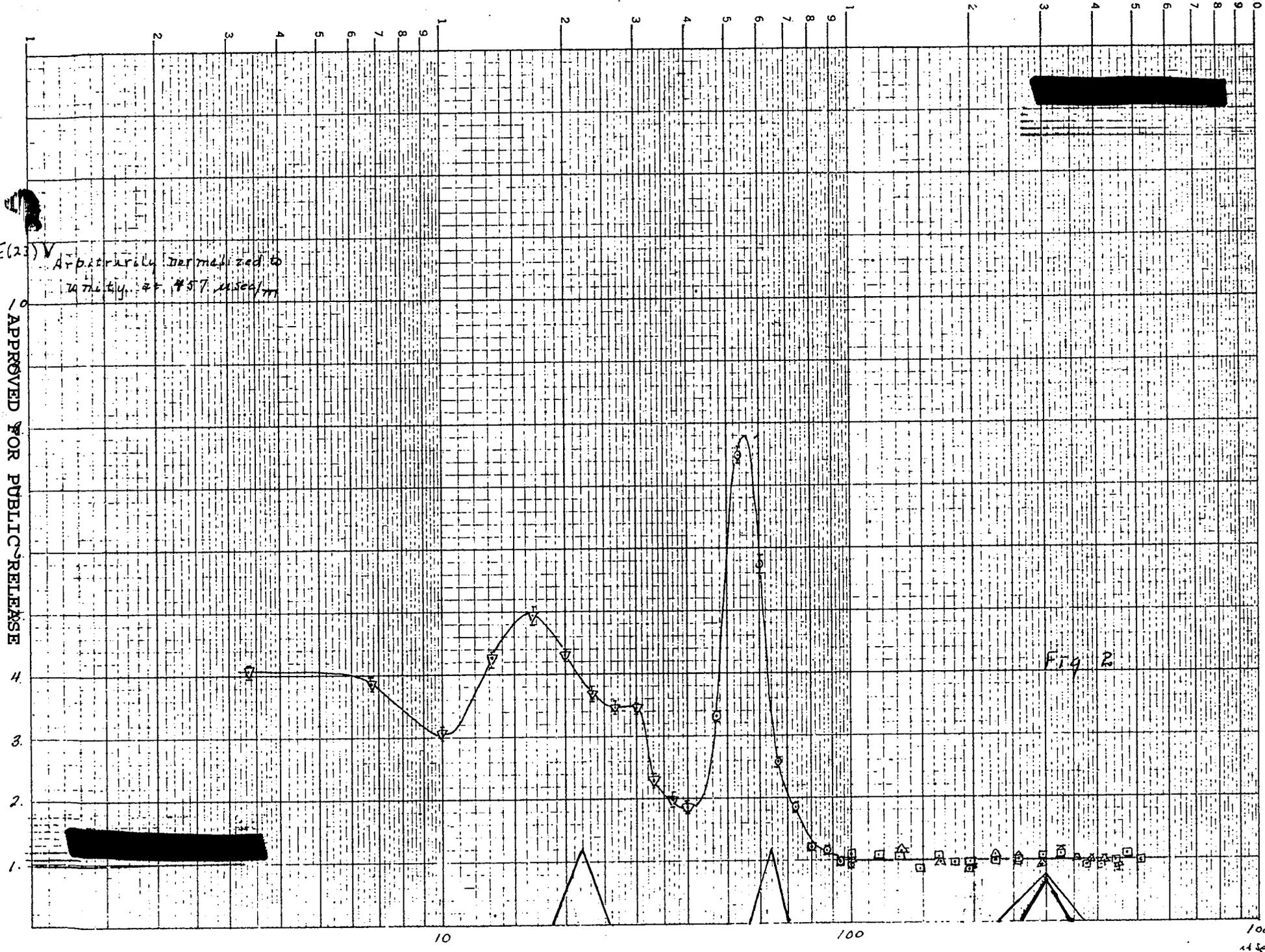
Fig. 1
THREE-DECK IONIZATION CHAMBER
$\frac{1}{4}" = 1"$

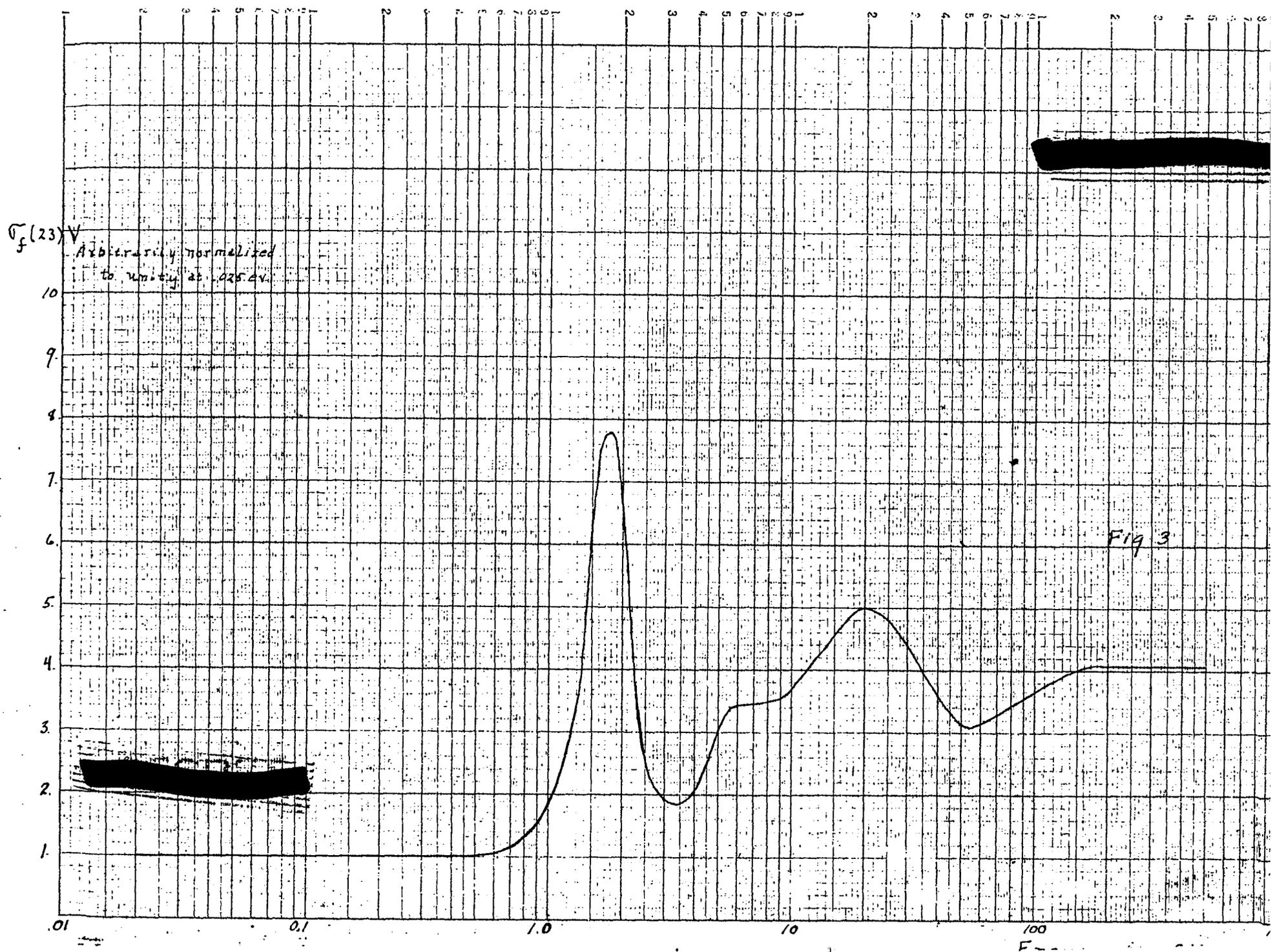$\overline{\nu}_f(25)$ V Arbitrarily normalized to
unity at .457 µsec/m

Fig. 2

Fig 3

$\sigma_f(23)\,V$ Arbitrarily normalized to unity at .025 ev.

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