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TITLE
A PRELIMINARY STUDY OF PRODUCTION OF TUNGSTEN-RHENIUM ALLOYS IN N-REACTOR

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A PRELIMINARY STUDY OF PRODUCTION OF TUNGSTEN-RHENIUM ALLOYS IN N-REACTOR

Feasibility and cost data are supplied herewith for the production of tungsten-rhenium alloys from tungsten targets in the N-Reactor. The two types of target elements assumed were: a) tungsten containing 90 a/o tungsten-186, 9 a/o tungsten-184 and 1 a/o tungsten-183 and 182, and b) tungsten of natural isotopic composition (28.4 a/o tungsten-186, 30.6 a/o tungsten-184, 14.4 a/o tungsten 183, and 26.4 tungsten-182). As per instructions, it is assumed that the average thermal neutron capture cross section for the tungsten-186 is 32 barns.

The production and costs of rhenium will be based on the assumptions as follows:

1) The production chain is limited to:

$$W^{186} + n \longrightarrow Re^{187} + n \longrightarrow O_s^{188}$$

$$(\sigma_c = 32 \text{ barn}) \qquad (\sigma_c = 66 \text{ barn})$$

And it is further assumed that:

a) No contribution to rhenium-187 production from tungsten isotopes of mass less than 186 i.e., from tungsten-182 to tungsten-185.

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b) All tungsten-187 formed by the (n,γ) process in tungsten-186 is transformed immediately to rhenium-187 without loss, i.e., neutron absorption in the intermediate product tungsten-187 has been omitted in our formulation.

c) The (n,γ) process in rhenium-187 leads directly to osmium-188, rather than going through the intermediate product rhenium-188.

d) The thermal cross-sections are used instead of effective cross-sections.

2) The neutron thermal flux in the flux trap is assumed to be three times the normal reactor thermal flux.

3) The plant factor is assumed to be 84 per cent.

4) The cost of rhenium is based on "opportunity costing".

5) The costs for post irradiation treatment such as separation (mechanical or chemical), storage charges and transportation are not included.

6) The burnout values for the uranium are based on HAN-85315, dated June 10, 1963. This schedule was used for the current AEC ten-year cost study.

The conceptual target design for use in the process tubes consists of a small diameter rod clad in zirconium. A more detailed study would probably reveal that there is no need for the cladding.

The formation of rhenium-187 and osmium-188 versus the exposure in the N-Reactor is shown in Figure 1. The exposures at different irradiation periods are based on using flux traps that increases the thermal flux by a factor of three above the normal N-Reactor thermal flux. The maximum atom per cent of rhenium-187 for the enriched tungsten-186 target reached after 12.5 years of irradiation is 21.6. The unit cost for this material, as shown in Figure 2, is much greater than $1.50 per gram of rhenium-187. The costs for the rhenium includes fuel fabrication costs, burnout charges, charges for reactor space, and irradiation operating costs. We must iterate that these figures are based on the assumptions listed above. Since there is little incentive for the production of tungsten-rhenium alloys containing less than 25 atom per cent rhenium, especially if the processing time is in excess of 12 years, this study is only of academic interest. For a more reasonable irradiation period such as two years, the atom per cent of rhenium-187 and osmium-188 are 9.4 and 0.4, respectively. The unit cost is about $73 per gram of rhenium-187. Based on a toll charge arrangement with the base load being charged to the plutonium production, the unit cost would be about $36 per gram of rhenium. Figure 2 shows the relation of unit costs for the higher enriched tungsten-186 target versus both atom per cent of rhenium-187 and reactor residence times.

Figure 3 gives the production for rhenium-187 produced from natural tungsten. The maximum atom per cent of rhenium-187 for a natural tungsten target is only 6.8.

As a matter of interest, if one was to load the graphite cooling cross channel with limited quantity of tungsten, some flattening of the reactor from the front to rear could be achieved. Also, the tungsten is compatible with the environs of the cooling channels. The tungsten, as a wire without cladding, therefore could be placed in the channel with no other costs than that necessary to place the tungsten wire into the channel and to pay for the absorbed neutrons. Hence, the charges for reactor space is not applicable. Preliminary estimates of the unit costs with the target in the cooling channel for a two year exposure period is about $30 per gram of rhenium. The rate of rhenium production and the composition of the target after irradiation would be about the same as that produced in the process tube because the flux level in the graphite cooling channels is not much different than that in the flux trap.

Based on assumptions given in the reference letter, the irradiation period necessary to achieve the maximum atom per cent of rhenium of 21.6, which is below the percentage of real market-interest, is prohibitively long for a product that has a market value of about $1.50 per gram. Consequently, the product costs were treated on a cursory basis because any error in the cost figures would not materially change the conclusion.

If, after your review of this subject, it is concluded that additional data or more refinement is deemed necessary let us know.

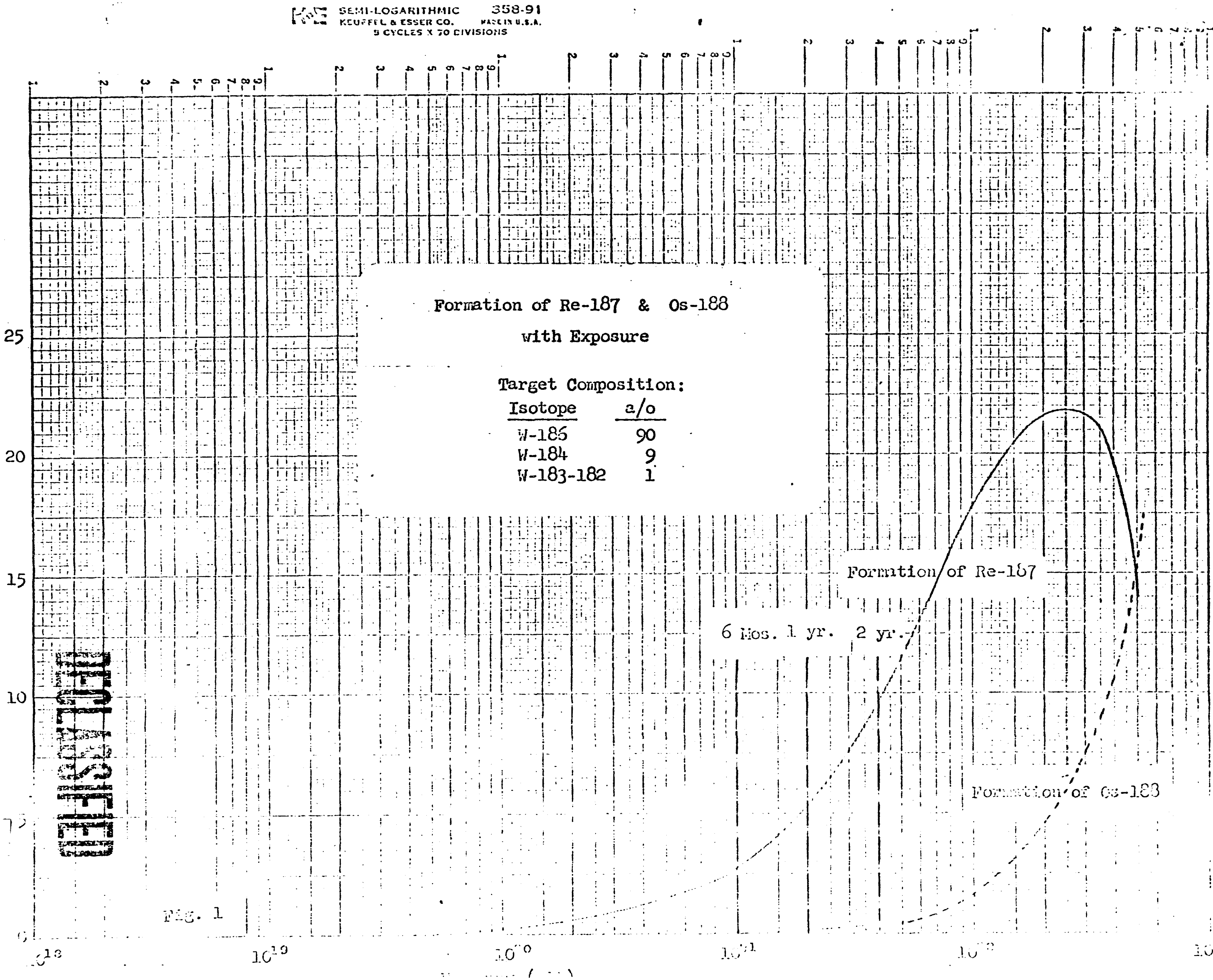
SEMI-LOGARITHMIC 358-91
KEUFFEL & ESSER CO. MADE IN U.S.A.
5 CYCLES X 70 DIVISIONS
Formation of Re-187 & Os-188
with Exposure
Target Composition:
Isotope a/o
W-186 90
W-184 9
W-183-182 1
Formation of Re-187
6 Mos. 1 yr. 2 yr.
Formation of Os-188
25
20
15
10
5
0
10^{18}
10^{19}
10^{20}
10^{21}
10^{22}
10^{23}
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Fig. 1

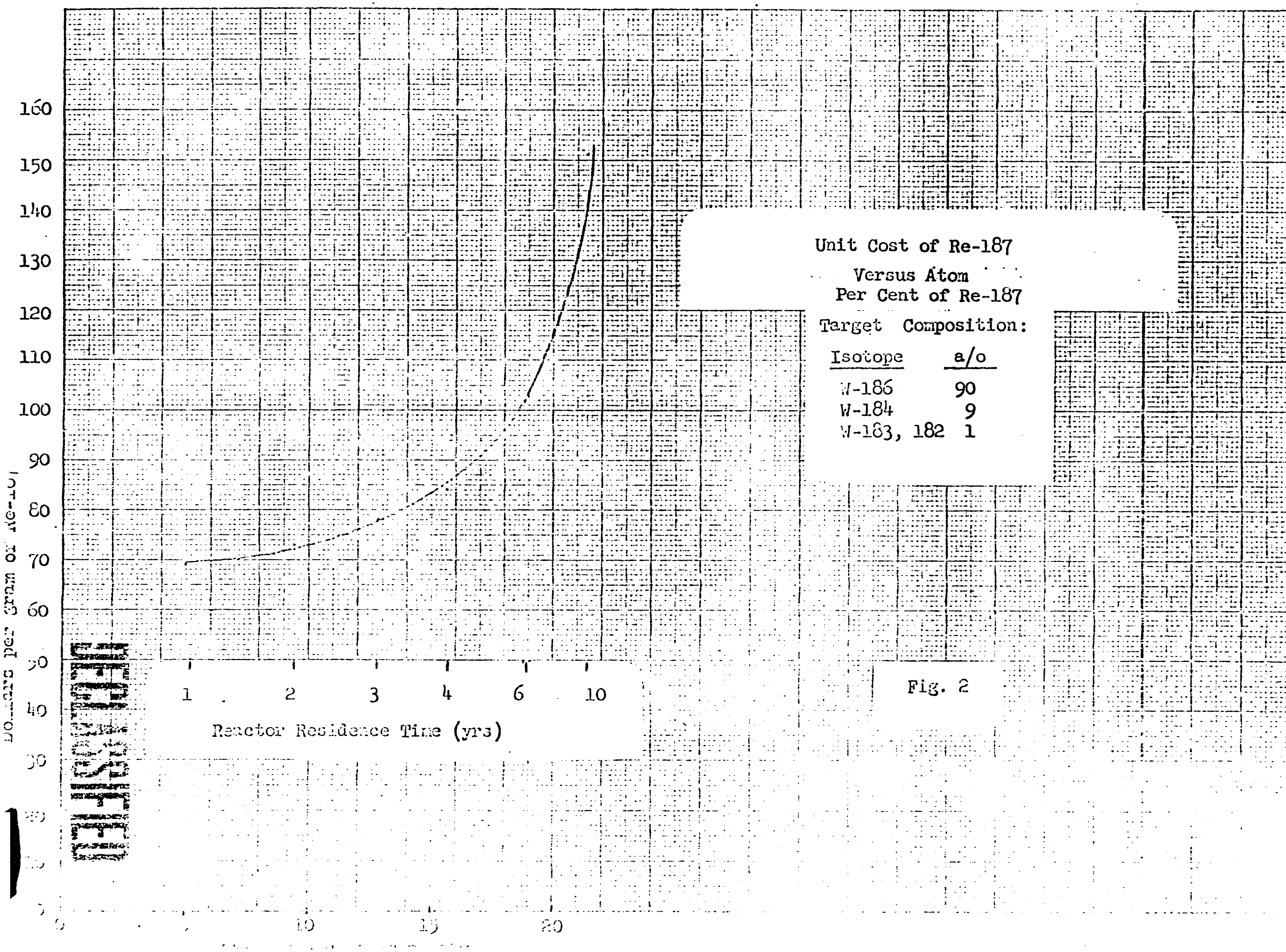
Unit Cost of Re-187
Versus Atom
Per Cent of Re-187
Target Composition:
Isotope a/o
W-186 90
W-184 9
W-183, 182 1
Reactor Residence Time (yrs)
1 2 3 4 6 10
Dollars per Gram of Re-187
160 150 140 130 120 110 100 90 80 70 60 50 40 30
0 10 15 20

Fig. 2

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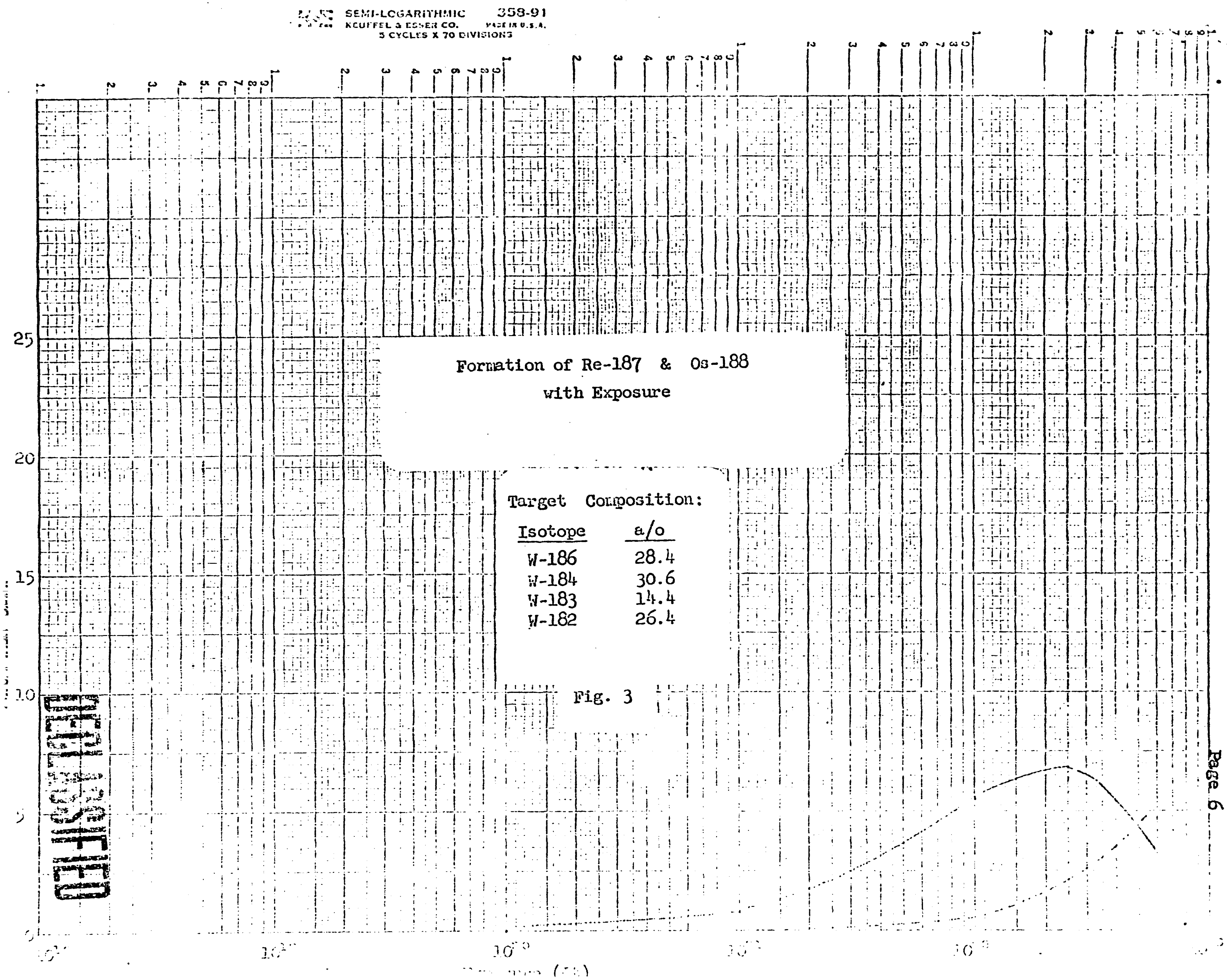

Formation of Re-187 & Os-188 with Exposure

Target Composition:

Isotope	a/o
W-186	28.4
W-184	30.6
W-183	14.4
W-182	26.4

Fig. 3

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Centimeter

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 mm

1 2 3 4 5

Inches

1.0 1.1 1.25 1.4 1.6 1.8 2.0 2.2 2.5 2.8 3.2 3.6 4.0 4.5 5.0 5.6 6.3

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