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PRELIMINARY SURVEY
REACTOR FORMATION OF RHENIUM-TUNGSTEN ALLOY

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PRELIMINARY SURVEY. REACTOR FORMATION OF RHENIUM-TUNGSTEN ALLOY

by

L. W. Lang
and
R. H. Meichle

IRRADIATION PROCESSING DEPARTMENT

November 11, 1963

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PRELIMINARY SURVEY - REACTOR FORMATION OF RHENIUM-TUNGSTEN ALLOY

INTRODUCTION

In response to a Commission request, this document considers the costs of rhenium formation as produced by irradiating tungsten. Two isotopic compositions of tungsten are considered for the study.

SUMMARY AND CONCLUSIONS

The cost for reactor-formed rhenium appears to be prohibitively high--something in excess of $20 per gram, as shown in Table No. 1. This cost would exist for tungsten containing 90 percent 186, 9 percent 184, and 1 percent tungsten 182 and 183. The cost of alloy made from natural isotopic compositions of tungsten would be higher by a factor of 3, and would take prohibitively long to produce significant quantities of rhenium. Thus, detailed numbers are not shown or considered for the natural isotopic composition of tungsten.

DISCUSSION

Tungsten of natural isotopic composition contains 26 percent tungsten 182, 14 percent 183, 31 percent 184, and 28 percent 186. The cross section of 186 is 32 barns but a substantial cross section also exists for the 182 and 183 isotopes. The cross section for tungsten 184 is relatively small.

The conversion ratio versus the flux rate is shown in Figure No. 1 for a flux of 4.5×10^{13} and 6.0×10^{13}. By using a thin coating of tungsten on the process tubes a flux value of 6.0×10^{13} can be achieved through the deposited tungsten. Extra neutrons required for the irradiation would be furnished by slightly enriched uranium fuel charged in the tungsten-bearing tube. Because of the large tungsten cross section, this appears to be the most advantageous placement. Were the tungsten charged in an empty fuel column as a target element, ten or more enriched uranium columns would be required to support the reactivity and the flux in the tungsten would be considerably reduced from that obtained by the thin coating.

The production rate for rhenium does not reach 25 percent, as suggested as a minimum alloy of merit. Present aluminum process tubes may require replacement every six years and thus would not be appropriate for rhenium alloys above 20 percent. Although higher flux levels would be obtained by different charging stratagems, gross quantities of material could not be irradiated and lower conversion rates would be entailed. The conversion of rhenium to osmium is indicated in Table No. 1. It is assumed that the osmium would be removed as an alloy impurity and thus the only effect, as far as the irradiation is concerned, is one of neutron loss. With increasing osmium content and irradiation time, the neutron economy is reduced from increased useful atom production to production

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in which a slight loss occurs due to osmium formation. The approximate costs of production of alloys containing 5, 10, 15, and 20 percent rhenium are shown in Table No. 1. These cost estimates are based on raw material costs and fabrication and separation costs of $.41 per gram of alloy. No extensive cost research was carried on to refine these particular numbers inasmuch as the reactor costs may discourage further investigation.

The irradiation process is shown in Figure No. 2. The calculation of the buildup of rhenium-tungsten alloy and osmium was made using conventional buildup and burnout equations. The neutron flux and amount of tungsten that can be irradiated per column of .947 slightly enriched uranium was obtained from MOFDA, a lattice physics P-3 computer code. The calculations were made assuming the reactivity of the enriched uranium-tungsten lattice was equivalent to that of a natural uranium lattice. Calculations were made for both small and K reactors. The rather small differences between the two reactors were averaged as was the cost of neutrons.

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Table No. 1

COSTS FOR REACTOR FORMED RHENIUM

	One kg of 5% Rhenium-Tungsten	One kg of 10% Rhenium-Tungsten	One kg of 15% Rhenium-Tungsten	One kg of 20% Rhenium-Tungsten
Grams Rhenium	50	100	150	200
Grams Osmium	3	15	35	87
Irradiation Time/Days	350	820	1 350	2 100
Grams Pu Loss	41.4	89.8	144.5	224.2
Cost $/kg Alloy				
Raw Material, Fabrication, and Separation	411	416	424	446
Irradiation	1 000	2 160	3 500	5 400
Cost/kg Alloy	$1 411	$2 576	$3 924	$5 846
Reactor Capability kg Alloy/Year	12 000	5 500	3 500	2 200

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Figure 1

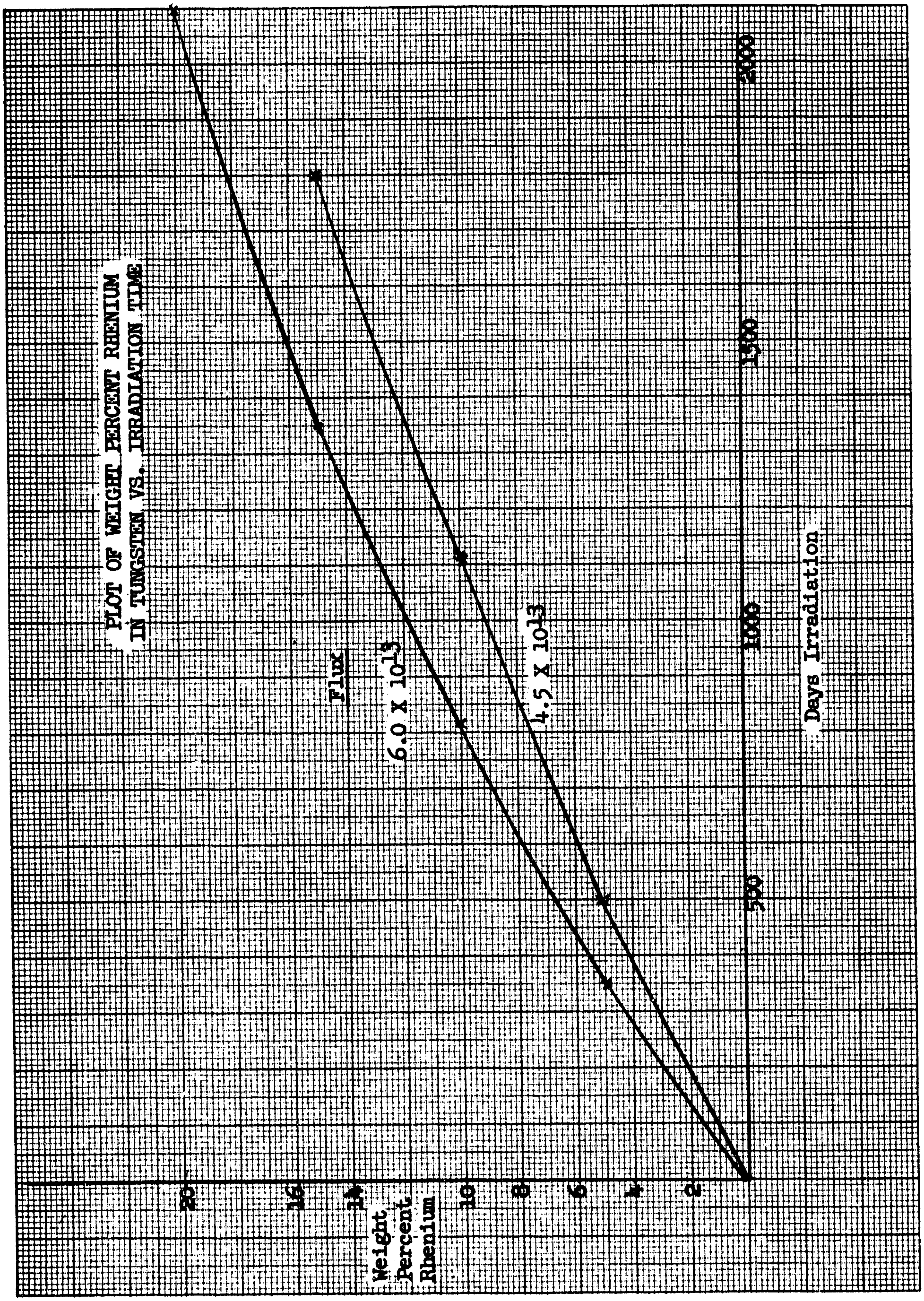

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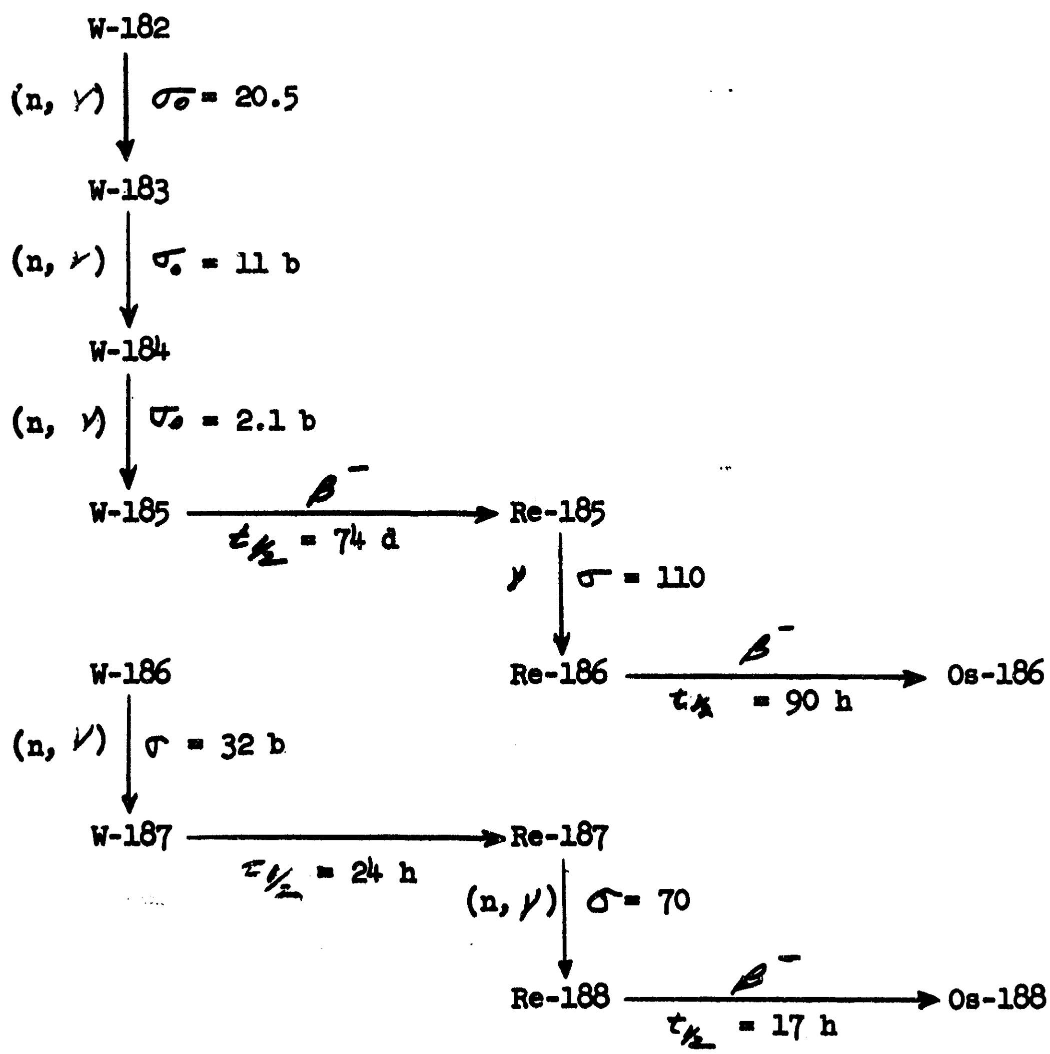
Figure 2

PRINCIPAL NUCLEAR REACTIONS
TUNGSTEN-RHENIUM



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