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SUBJECT

Second Partial Report on Liquid Thermal Diffusion

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NAVAL RESEARCH LABORATORY

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SERIAL No. 7

January 7, 1943

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NAVY DEPARTMENT [redacted]

Report

on

Second Partial Report on Liquid
Thermal Diffusion

[redacted]

NAVAL RESEARCH LABORATORY
ANACOSTIA STATION
WASHINGTON, D.C.

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Prepared by: Philip H. Abelson, Physicist

Reviewed by: Ross Gunn, Superintendent
Mechanics & Electricity

Approved by: A. H. Van Keuren, R. Admiral, U. S. N.
Director

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1. On the basis of information available on December 20, 1942 a progress report on Liquid thermal diffusion research was prepared. New experimental results now available render certain phases of the report obsolete.

2. The new work throws further light on optimum wall spacing and operating temperature. The apparatus used was a 36 foot column built according to a previously described design.

3. One of the new experiments was made under the following conditions:

Spacing	Temp. of Steam at hot wall	Cold Wall circ.Temp.	Hold up of Col.	Power cons.
.25 mm.	213°C.	65°C.	1750 grams.	21,500 cals/sec

Results obtained are given in the following table:

Time	Separation Factor
1 day	1.153
2 1/6 days	1.255
7 days	1.317*
Equil.	1.320*

*Calculated

4. In the following table are listed results from columns of various spacings when run at a hot wall steam temperature of 213°C and a circulating water temperature of 62-65°C.

Spacing	Equilibrium Separation Factor	Time One half Equilibrium	Hold up	Power Cons.
.14	1.12	13 hours	1100 grams	40,000 cal/sec
.20	1.205	15 hours	1500 "	32,000 " "
.25	1.320	23 hours	1750 "	21,500 " "
.38	1.108	8 hours	2300 "	21,000 " "
.53	1.023	8 hours	3200 "	16,000 " "
.66	1.013		3800 "	12,000 " "

5. While it is clear that a substantial improvement has been made, there is no reason to believe that the optimum wall spacing has been attained.

6. Perhaps the most important result was obtained in a run employing a 36 foot column under the following conditions:

[redacted]

Spacing	Temperature of Steam at hot wall	Cold Water circ.Temp.	Hold-up of Col.	Power Consumption
.25	237.5°C	65°C	1700 grams	25,400 cals/sec.

Results obtained are given in the following table:

Time	Separation Factor at top	Separation Factor at bottom	Total Separation Factor
1 1/6 days	1.098	1.089	1.196*
2 5/6 days	1.138	1.171	1.333*
7 days	1.148*	1.265*	1.453*
Equilibrium	1.149*	1.281*	1.472*

*Calculated

7. A glance at the figures shows an interesting inconsistency. The separation at the bottom showed a larger gain over 1 1/6 days (92%) than the top (41%) for samples taken at the end of 2 5/6 days. This type of inconsistency is not generally experienced in a normal run.

8. Shortly after the first set of samples had been withdrawn, the experiment was interrupted due to failure of the boiler fuel supply. The apparatus was shut down according to routine in such a way as to cause no flow in or out of the column. However, in cooling, the UF_6 in the column flowed toward the bottom. When cold the material which filled the column during operation then only filled the lower 30 feet. On resuming operations the column was heated in such a way that the UF_6 next to the hot wall melted first. Since UF_6 expands by 20% on melting, a large degree of mixing of the top material occurred. This effect, which is difficult to avoid, is not present to any extent at the bottom.

9. In view of the probability that the explanation accounts for the inconsistency the following revised results are given.

Time	Separation Factor at Top	Separation Factor at Bottom	Total Separation Factor
1 1/6 days	1.098	1.089	1.196*
2 5/6 days	1.187*	1.171	1.390*
7 days	1.290*	1.265*	1.632*
Equilibrium	1.307*	1.281*	1.674*

* Calculated

10. It is of interest to compare the two results obtained under the following conditions:

[redacted]

Spacing	Temp. of Steam	Temp. at hot Surface of UF_6	Temp of Circ. Water	Time for One-half Equil.	Equil.Sep'n Factor
.25 mm	213.5	193	65	23 hours	1.32
.25 mm	237.5	216	65	1 - 2 days	1.47 - 1.67

11. The increase in separation factor obtained with a relatively slight change in hot wall temperature is important. It is obvious that the hot wall temperature is a crucial variable indeed. Exploration of the potentialities for increase in separation factor may lead to still larger values. Experiments have been conducted to determine the limiting value of the hot wall temperature. The question of the effect of the critical temperature (232°C) has been considered in a preliminary way. Experiments have been made determining density of UF_6 as a function of temperature and pressure. Although the critical density is about 1.6 gm/cm^3, gaseous UF_6 at a density of 2.1 has been readily handled.

12. Another question is the stability of UF_6 at the elevated temperatures in the presence of suitable container materials.

13. A number of experiments have been conducted in the past employing nickel in the presence of fluorine and UF_6. These all indicate that a hot wall temperature of 400°C would not be excessive. No real obstacle can be seen to conducting an experiment employing a combination of gaseous and liquid diffusion at a hot wall temperature of 400°C and a cold wall of 65°C.

14. The attainment of optimum spacing and hot wall temperatures would by no means exhaust the potentialities for improvement of the method. We have already learned that too low a cold wall temperature can lead to a strongly diminished separation and a temperature above 65°C may prove advantageous. Yet to be investigated are the potential benefits to be gained by more accurate centering of the hot wall with respect to the cold wall.

15. The effect of the new experiments is to lower substantially our estimates of the cost of a 1 Kg/90% U235 plant from the previously quoted figure of $25,000,000. In view of the research program currently in progress at the Naval Research Laboratory and the obviously potentialities for apparatus improvement a further reduction at an early date is not unlikely.

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