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Uranium Enrichment

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Preface

Due to its fissile properties, the light uranium isotope ^{235}U is an important ingredient of the fuel used in nuclear reactors for power production. Uranium fuel enriched in ^{235}U is used in most power reactors. Concentrations of ^{235}U up to a few percent are required for such applications, while highly enriched ^{235}U is used especially in nuclear weapons.

Uranium enrichment technology has obviously military implications even if current developments are aimed at civilian goals. This is why information in this area is largely classified and only some aspects of enrichment technology can be treated in open literature.

Separation processes can be more or less selective. High selectivity does not lead necessarily to the best plant economy. The combination of investment and power costs may well favour less selective processes. When selectivity is low, the process material must be submitted to the enrichment operation in a large number of subsequent steps (stages) to reach the wanted product concentration. The smallness of the single-stage separation effect and the rarity of the ^{235}U isotope in the feed material lead to very large plant dimensions.

The selection of operating conditions, the determination of stage sizes and the connection of stages to form a separation plant (cascade) can be determined on the basis of the, so-called, cascade theory which is an important instrument for optimization studies.

This book is an attempt to give an up-to-date picture of uranium isotope separation science and technology in the field of industrial applications and laboratory investigations. The authors contributing to the book have tried to be as exhaustive as allowed by classified or proprietary information limitations.

Cascade theory, as treated by B. Brigoli, gives the reader the basic concepts for the mathematical treatment of separation processes. The relevant chapter includes an original presentation of ideal nonsymmetric cascades.

Gaseous diffusion, which is the main industrial process for uranium enrichment today, has been illustrated extensively by D. Massignon. Apart from some industrial and engineering aspects of diffusion plants, the author has treated in depth the gas flow through the porous barriers and the relevant separation effects.

The chapter on centrifugation by Soubbaramayer, covers essentially the conceptual and theoretical aspects of the process. As a matter of fact, the technical details of centrifuges are classified. The gas flow and separation phenomena in a countercurrent centrifuge have been treated extensively in the past. A thorough review on the subject has been published in 1972 by D. Olander. However, since that time a further understanding of flow patterns and boundary phenomena in rotational fields has been attained. Soubbaramayer gives a full account of the newest studies. He also shows how to determine the centrifuge parameters so as to maximize the separation power.

The separation nozzle process is now facing the demonstration phase. E. W. Becker has contributed an overall description of the method including both the physical principle and the technical aspects. The trends of further investigation in this area are also briefly described.

The two last chapters in the book are devoted to new uranium enrichment methods. C. P. Robinson and P. Jensen review the laser methods in which separation is obtained through selective photoexcitation of uranium atoms or molecules. Finally F. Boeschoten and N. Nathrath report on separation experiments with rotating plasmas and briefly describe some advanced concepts like using ion cyclotron resonance effects to achieve isotope separation. Both laser and plasma methods are still at the laboratory stage.

Brussels, February, 1979 *S. Villani*

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