TRANSMUTATION OF TRANSURANIUM ELEMENTS BY A METALLIC FUEL FBR

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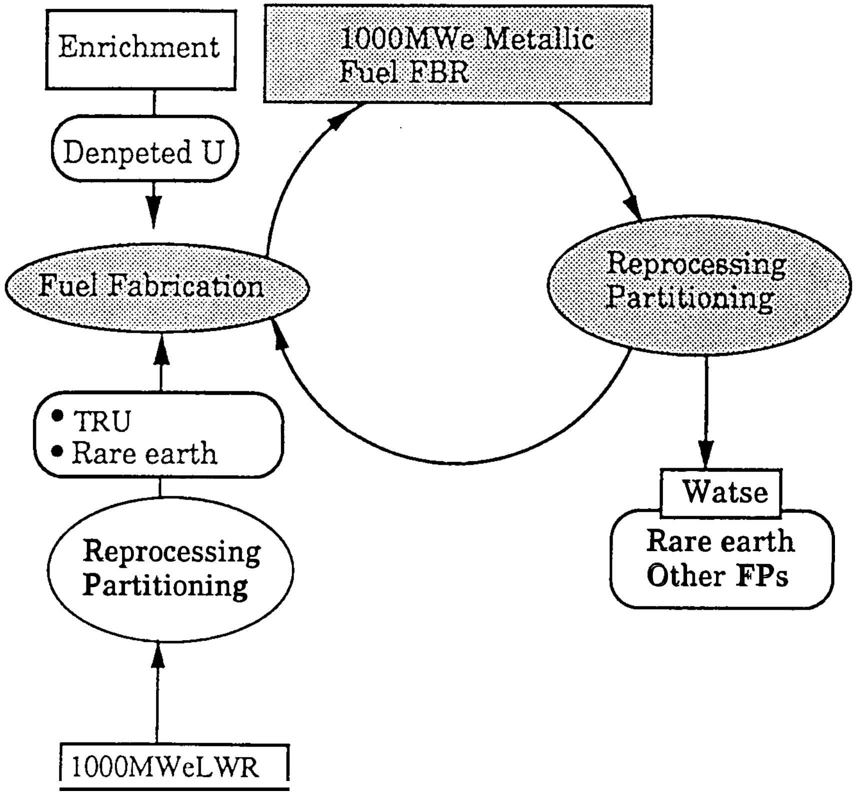


Fig. Scheme of TRU partitioning and transmutation with metallic fuel FBR recycle

TRANSMUTATION OF ACTINIDES

Concept : Burning in a Commercial FBR with Metallic Fuel under Development.

> Based on the Alloy of U-Pu-MA*-Zr with some amount of impurities.**

Subject :
- Analysis of Transmutation Rate of MA by simulation Code and Design Study of Fuel with MA including Core Analysis.
- Fabrication and Characterization Studies of Fuel Alloy and Irradiation Study with PIE .

* : MA : mainly Np, Am, Cm

** : The Amount of Impurity depends on the refining efficiency of Pyrochemical Separation

Analysis of Transmutation Rate of IVIA

— Development of the Analysis Code that can treat complicated Nuclear Transformation of TRUs.

CITATION-TRU Code

— Analysis of Transmutation Rate by the CITATION-TRU Code .

Ex. Metallic Fuel vs. Oxide Fuel (MOX)

Metallic Fuels with TRUS vs. with TRUS + REs

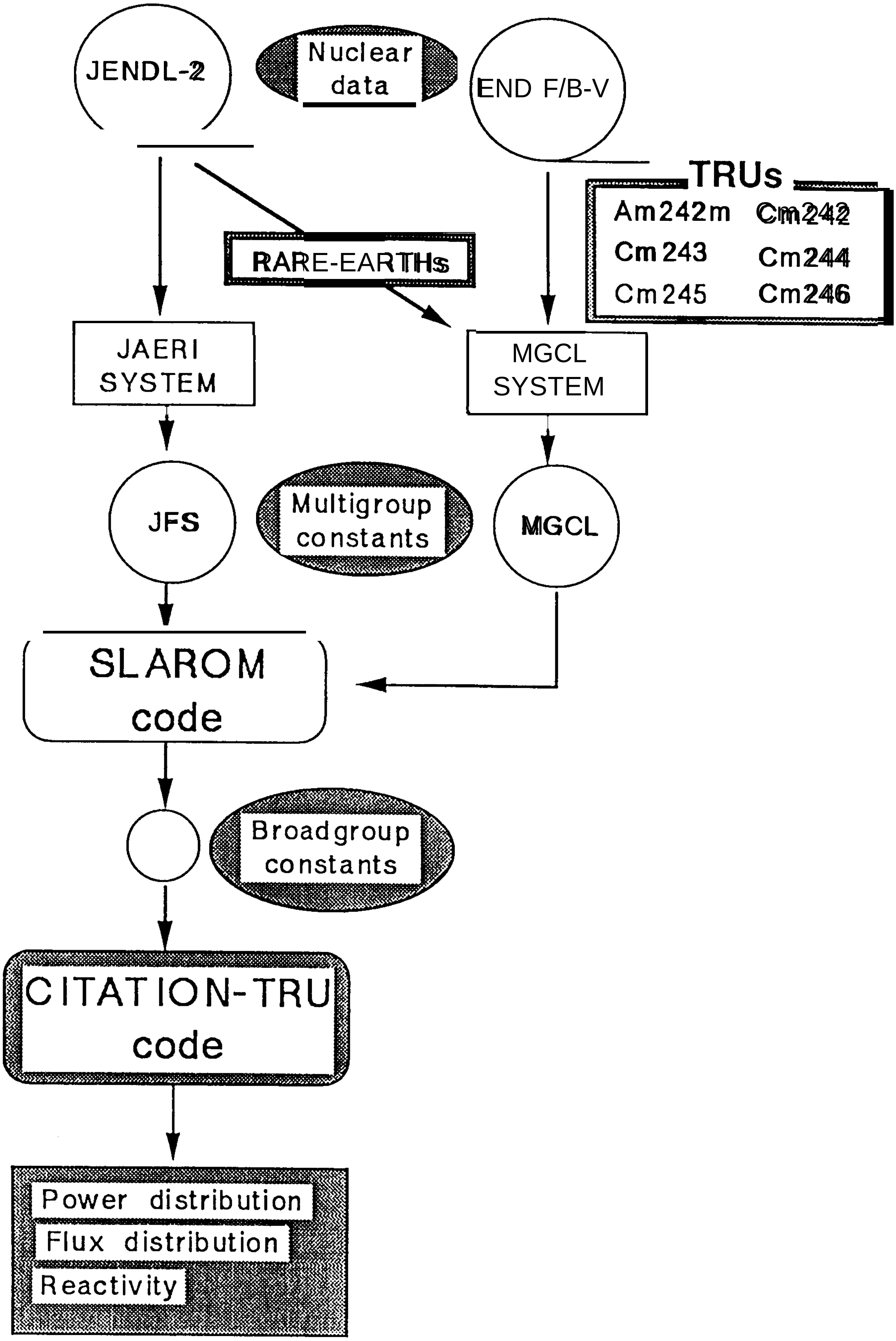


Fig. Calculation flow

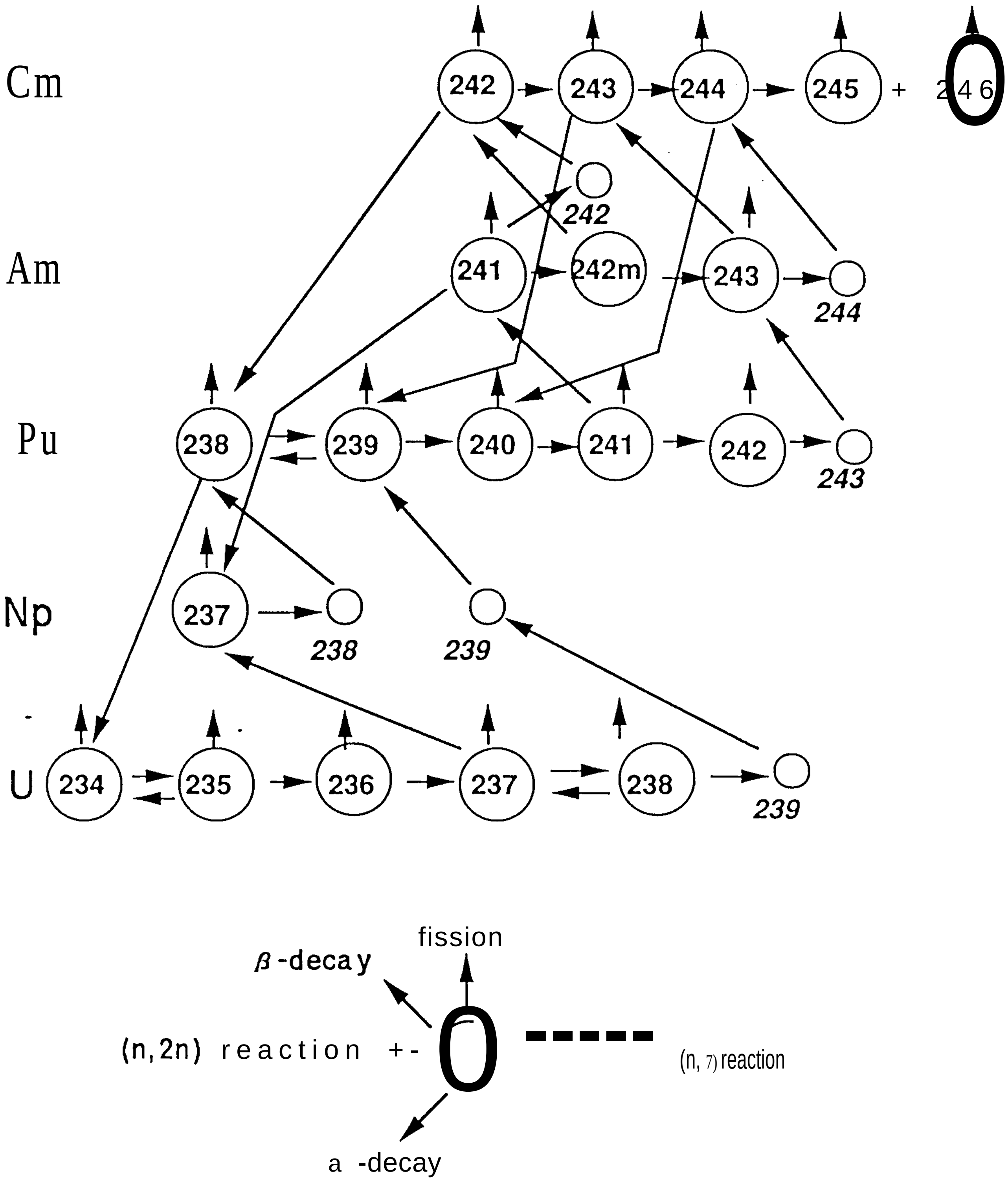
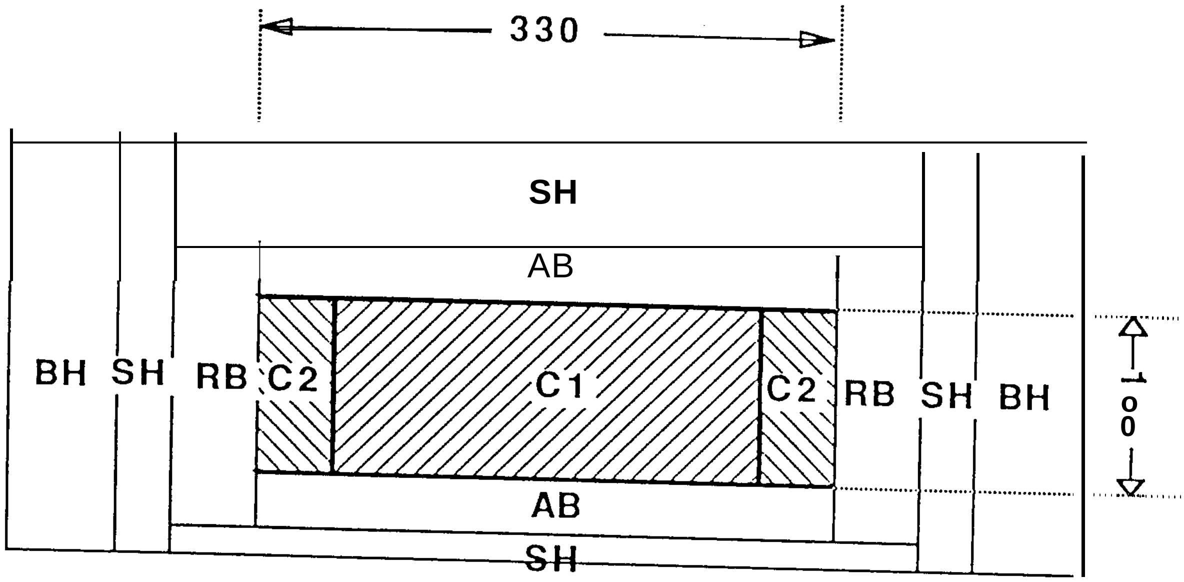


Fig. Burn-up chain of heavy metal

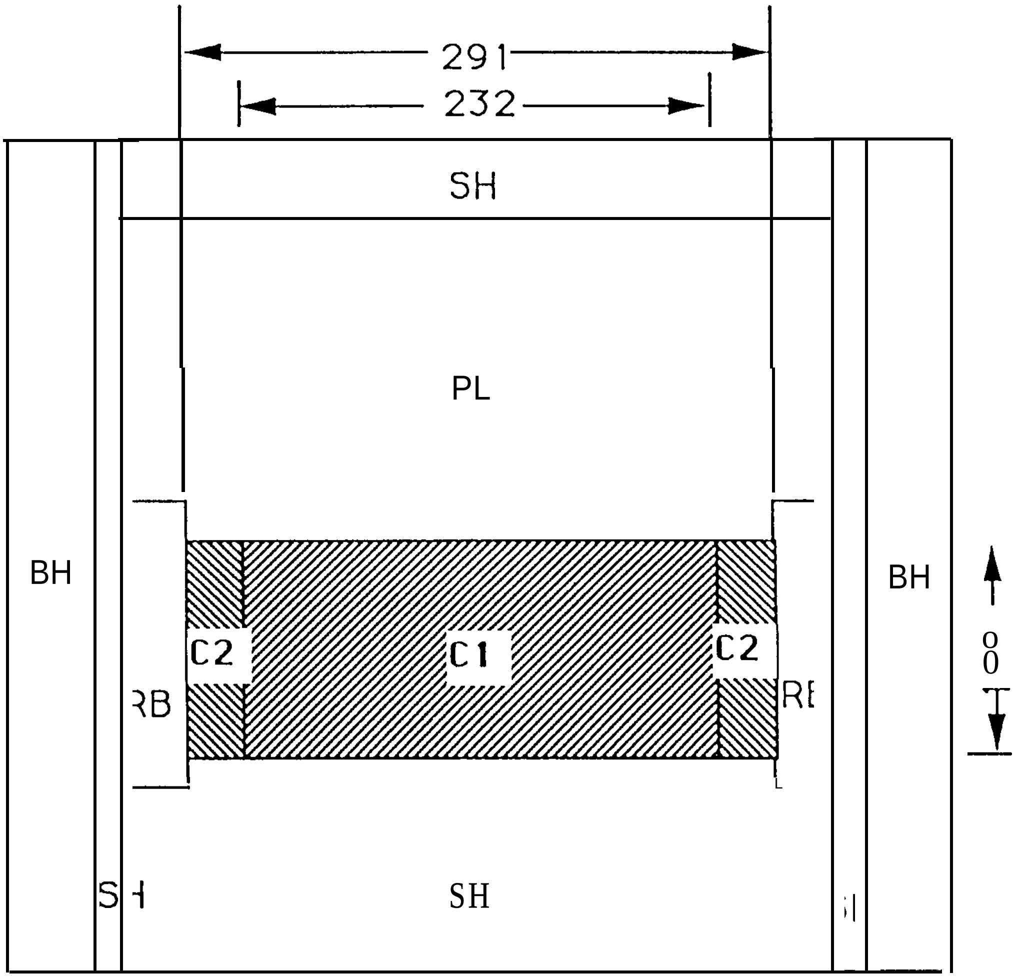


cl) INNER CORE
C2) OUTER CORE
RB) RADIAL BLANKET
AB) AXIAL BLANKET
SH) SUS316 SHIELD
BH) B4C SHIELD

Unit(cm)

Fig. 1000MWe MOX fuel FBR design

Homogeneous core with two Pu-enrichment regions. Refueling interval: 1year, Fuel loading:3 batches. TRU loading: uniform distribution in fuel.



Cl) INNER CORE
C2) OUTER CORE
RB) RADIAL BLANKET
PL) GAS PLENUM
SH) SUS316 SHIELD
BH) B4C SHIELD

Unit(cm)

- Operational cycle :1 year
- Fuel exchange of inner and outer core :3 batch

Fig. 1000MWe metal fuel FBR design

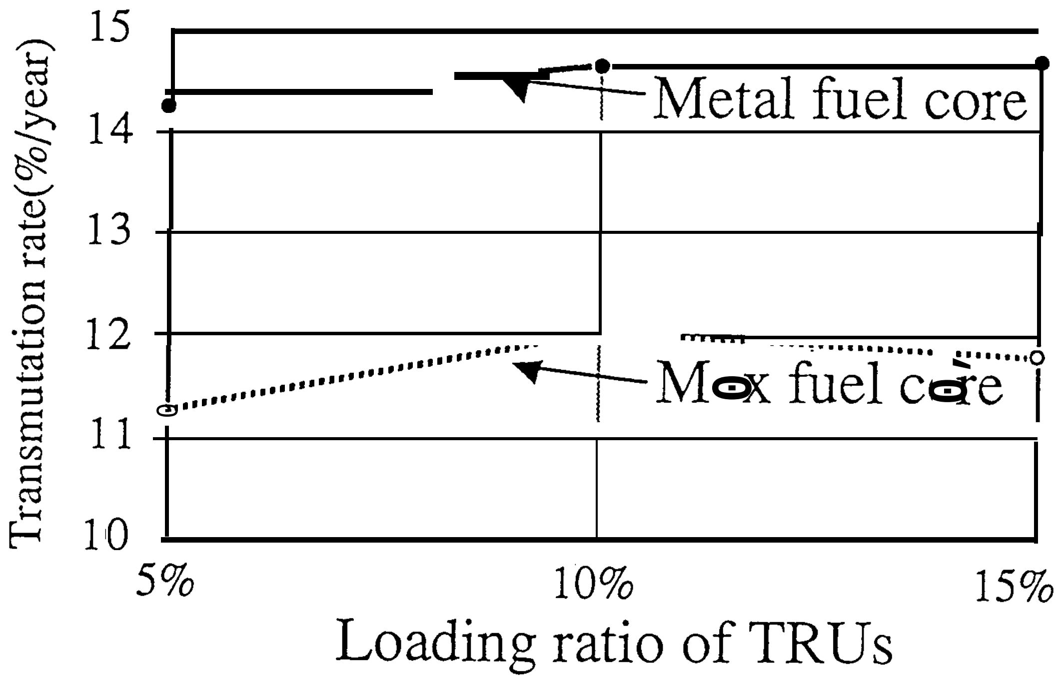


Fig. Transmutation rate of metal fuel core and Mox fuel core

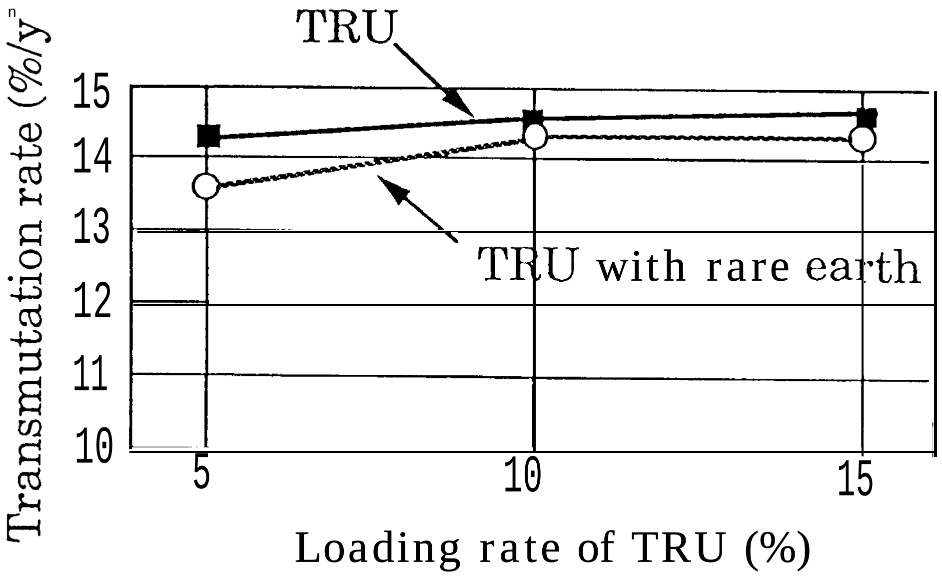
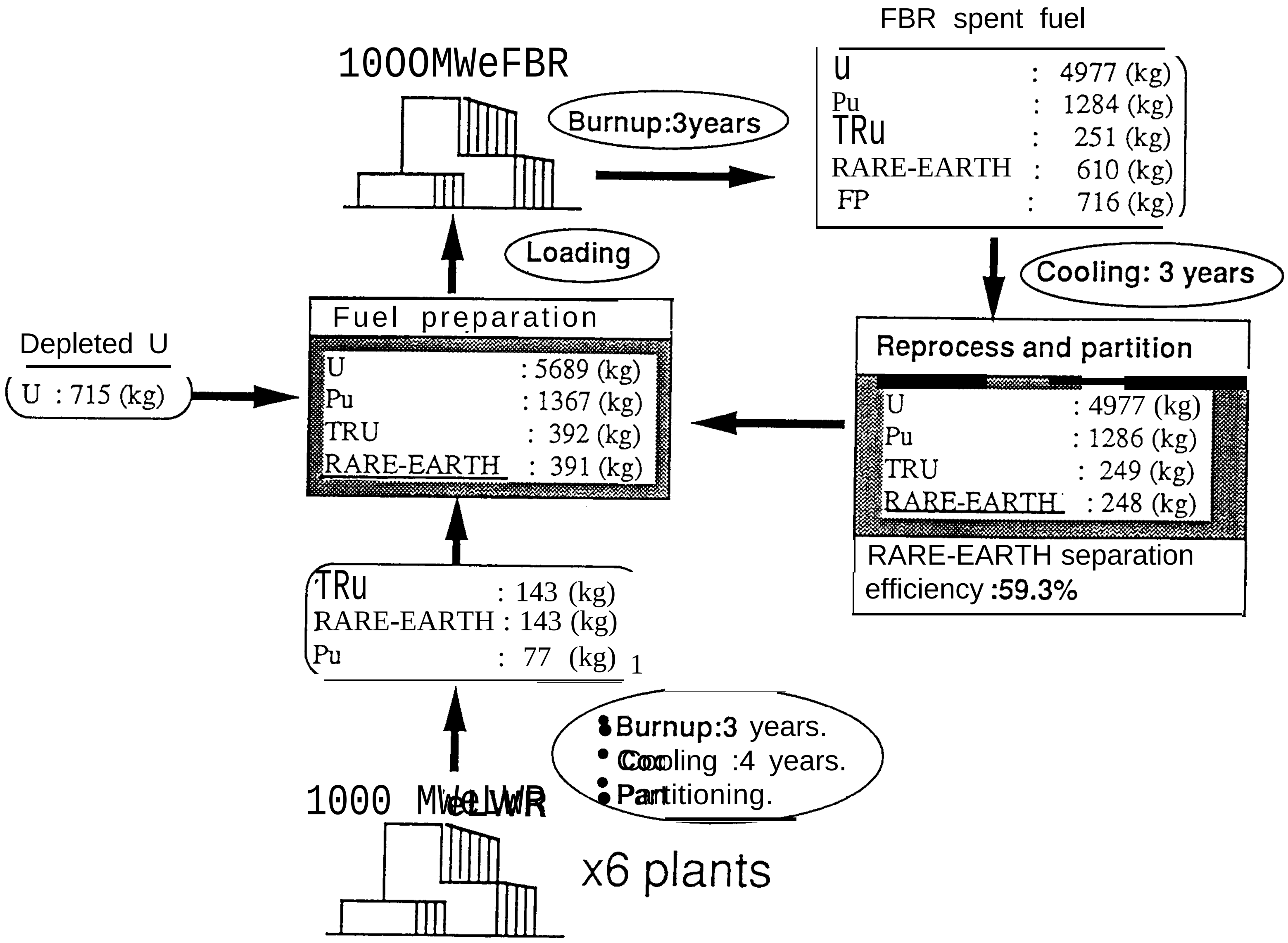


Fig. Transmutation rate of TRU with and without rare earth



(b) TRUS with RARE-EARTH

Fig. FBR equilibrium recycle (TRUS 5%,REs 5%)

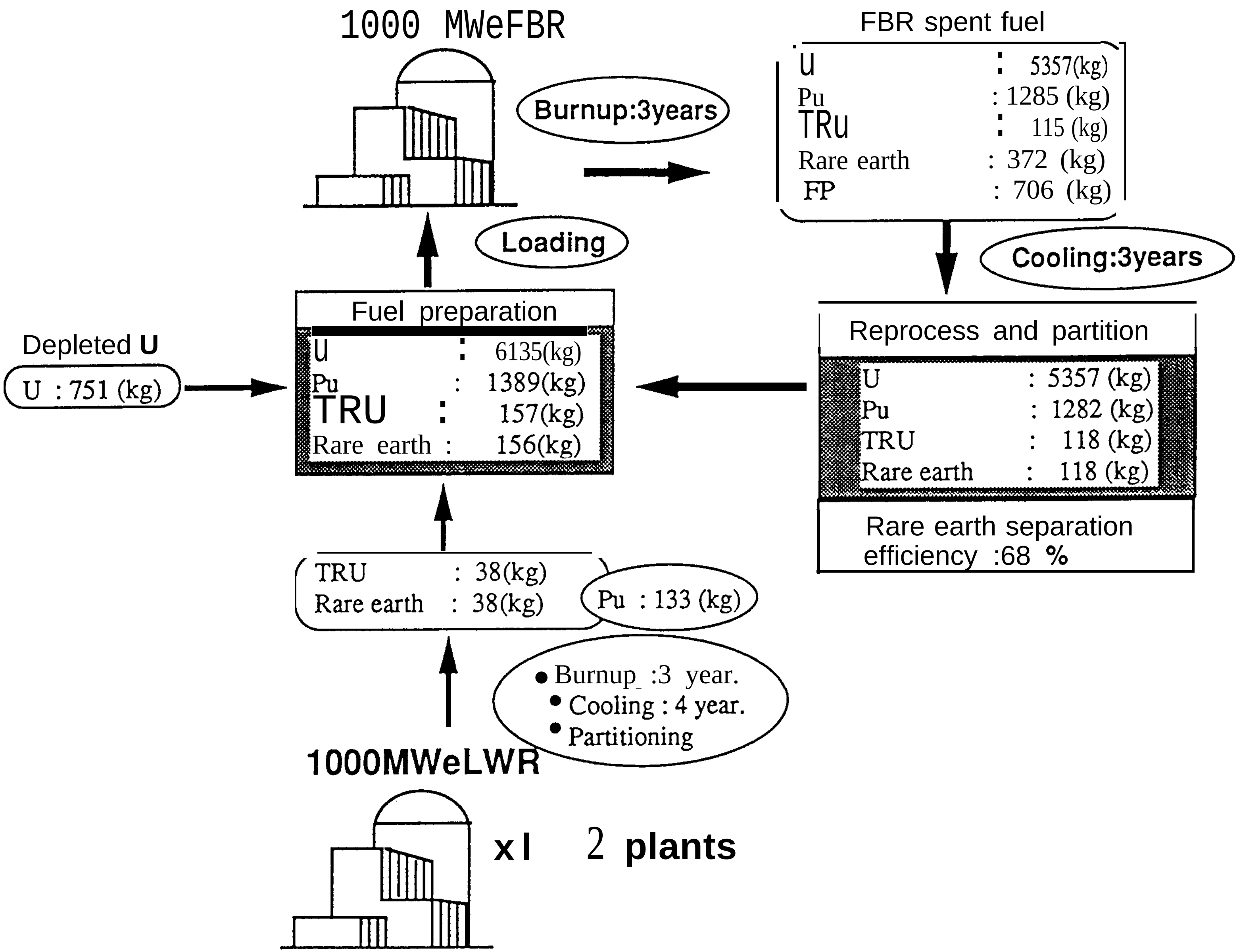


Fig. FBR equilibrium recycle (TRU 2 %, Rare earth 2 %)

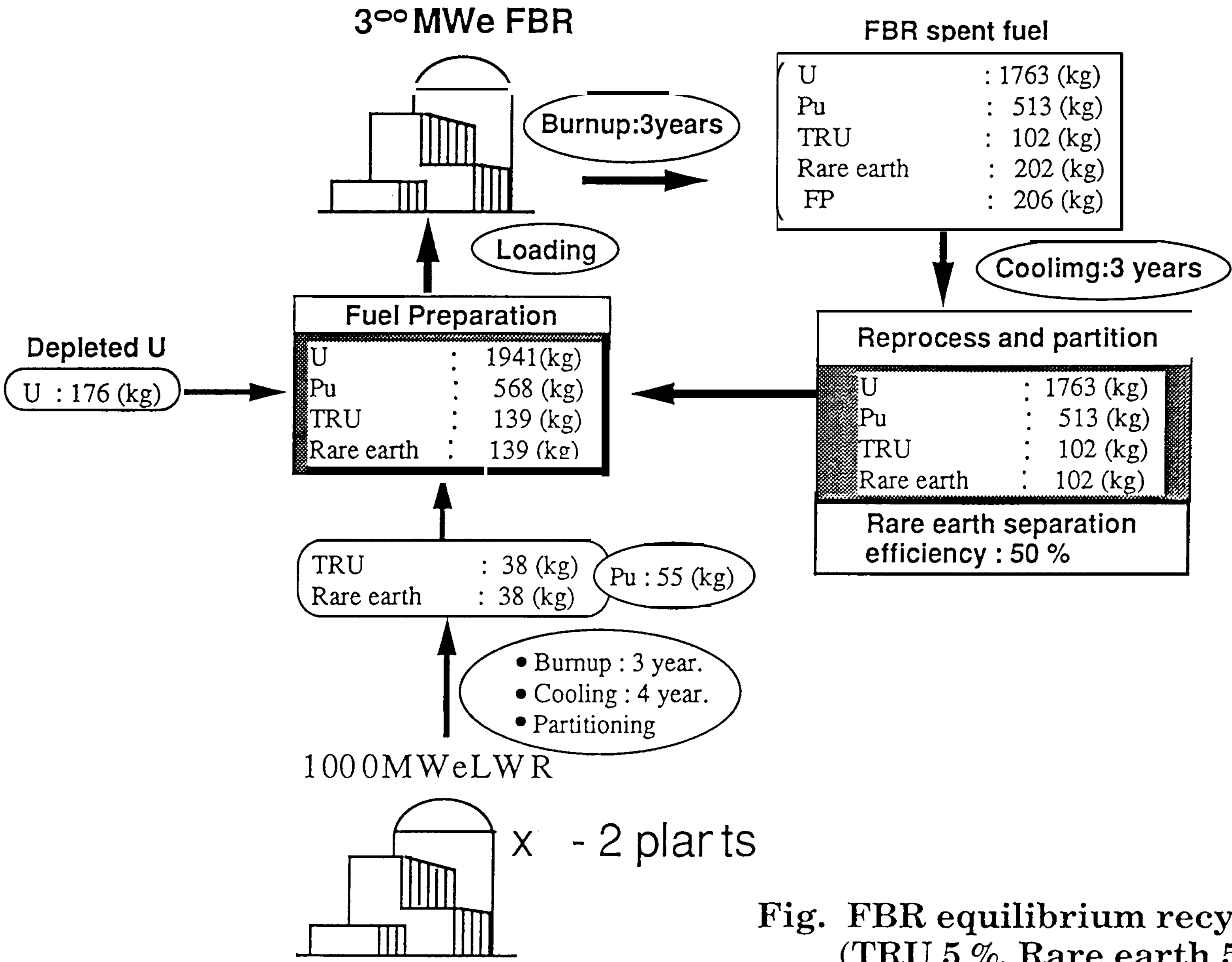


Fig. FBR equilibrium recycle (TRU 5 %, Rare earth 5%)

MICROSTRUCTURE OF FUEL ALLOY WITH MINOR ACTINIDES

Preparation of Actinides

Np Metal

$$NpO_2 + 2\,Ca \xrightarrow{CaCl_2} 2\,CaO + Np\uparrow$$

Pu Metal

$$PuC + Ta \longrightarrow TaC + Pu\uparrow$$

$$PuO_2 + Th \longrightarrow ThO_2 + Pu\uparrow$$

Am Metal

$$Am_2O_3 + 2\,La \longrightarrow La_2O_3 + 2\,Am\uparrow$$

Cm Metal

$$CmO_2 + Th \longrightarrow ThO_2 + Cm\uparrow$$

Table Alloys Fabricated for Metallographic Analysis

		U	Pu	Zr	Np	Am	Ce	Nd	Y
CR1 CR2	U- Zr - Y - Nd - Ce	62.7		7			5.2	16.1	1.04
CR6	U- Pu-Zr-Np-Ce-Nd	45	19.3	10.7	9.7		3.7	11.6	
CR7	U- Pu - Zr - Np - Ce - Nd	68.9	18	10	1.2		0.5	1.4	
CR3	Pu - Am		50			50			
CR4	u - Am	90				10			
CR5	Np -Am				67	33			
CR8	U- -Np	40			60				
CR11	U- Pu-Zr-Np-Am-Ce-Nd	68	18	10	1.2	0.8	0.5	1.4	

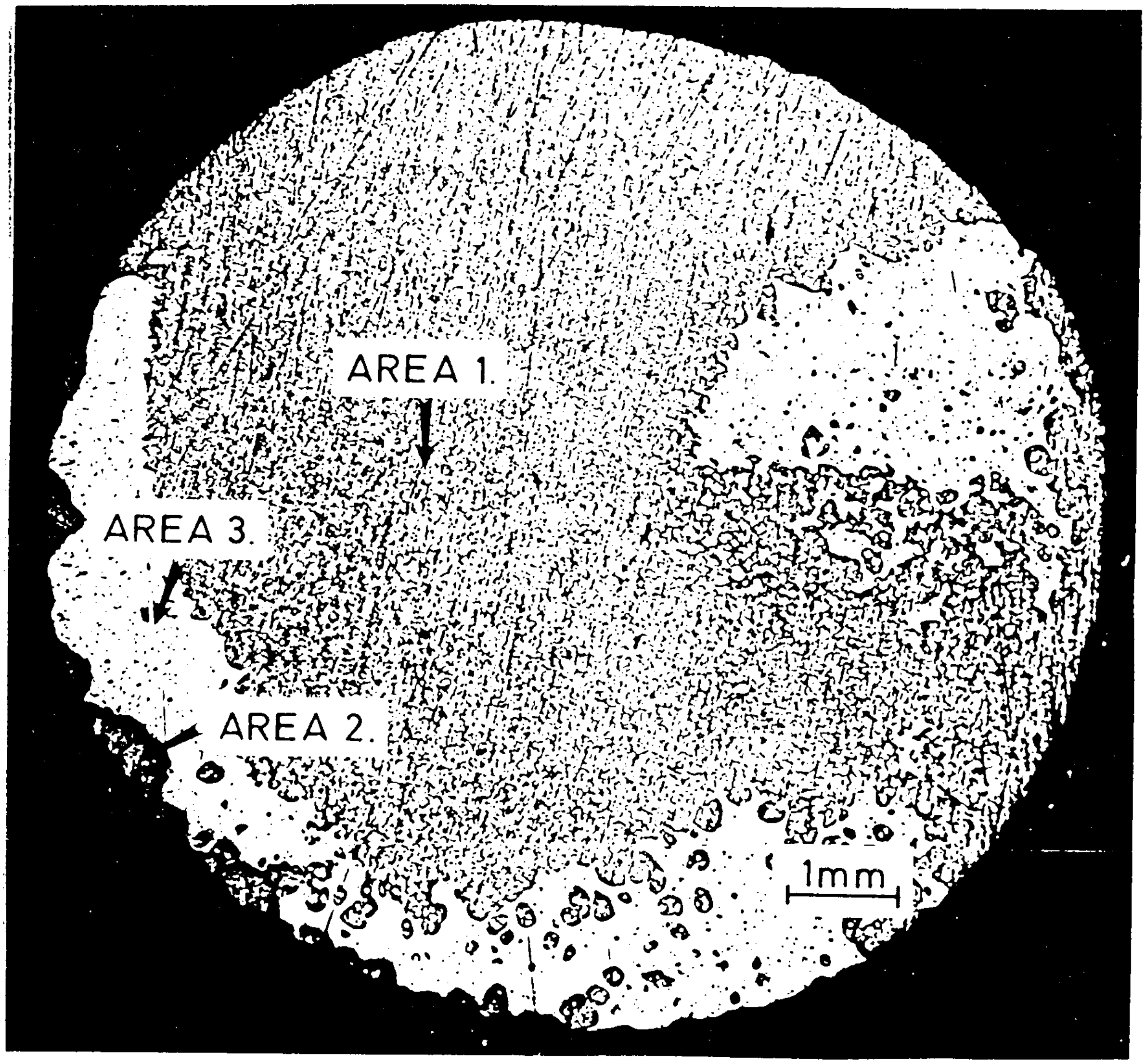


Fig. 15 ***Photomicrograph*** *of specimen CR 1*

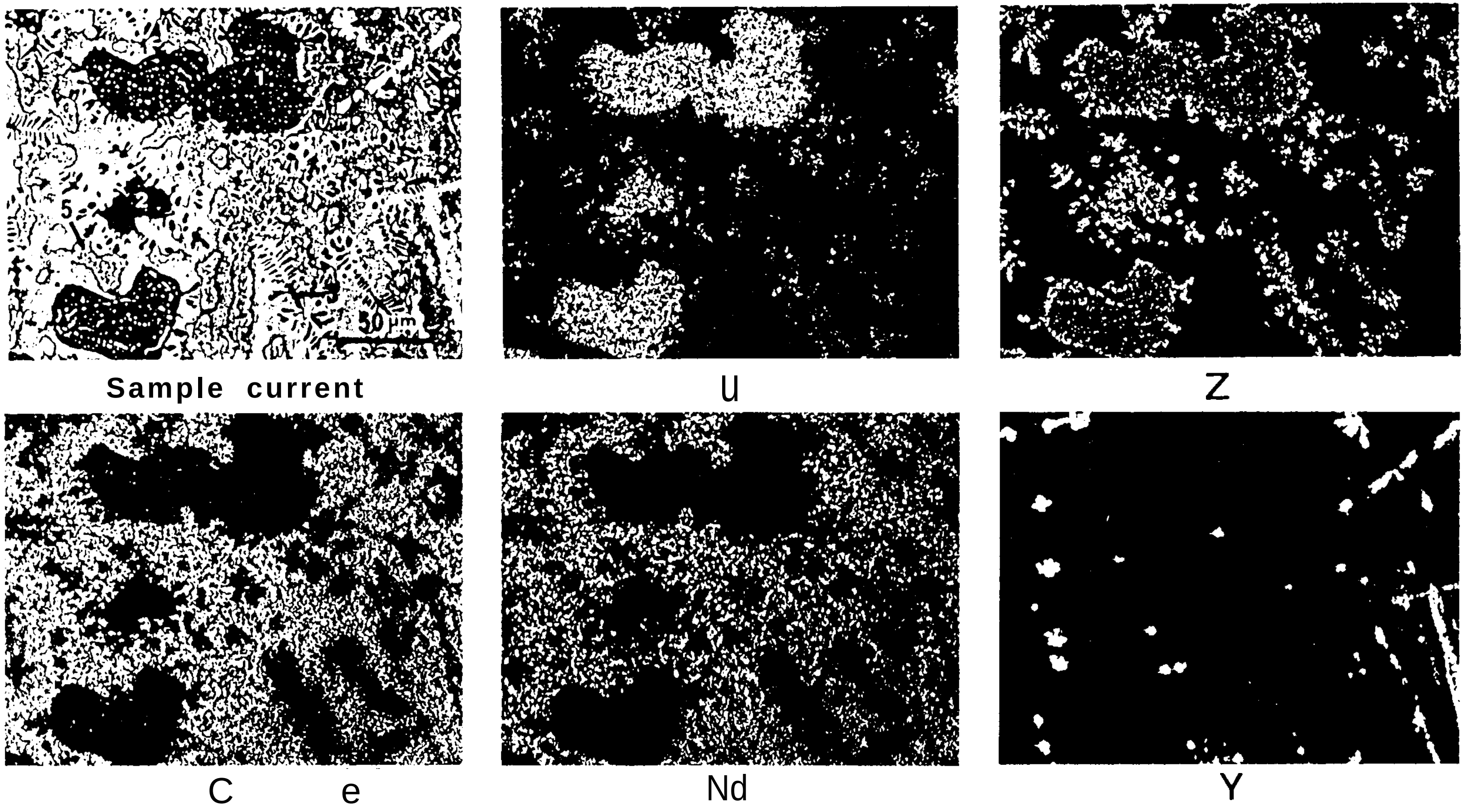


Fig. 16 *Electron absorption and X-ray scanning micrographs showing the microstructure and components of the phases in area 1 of specimen CR 1.*

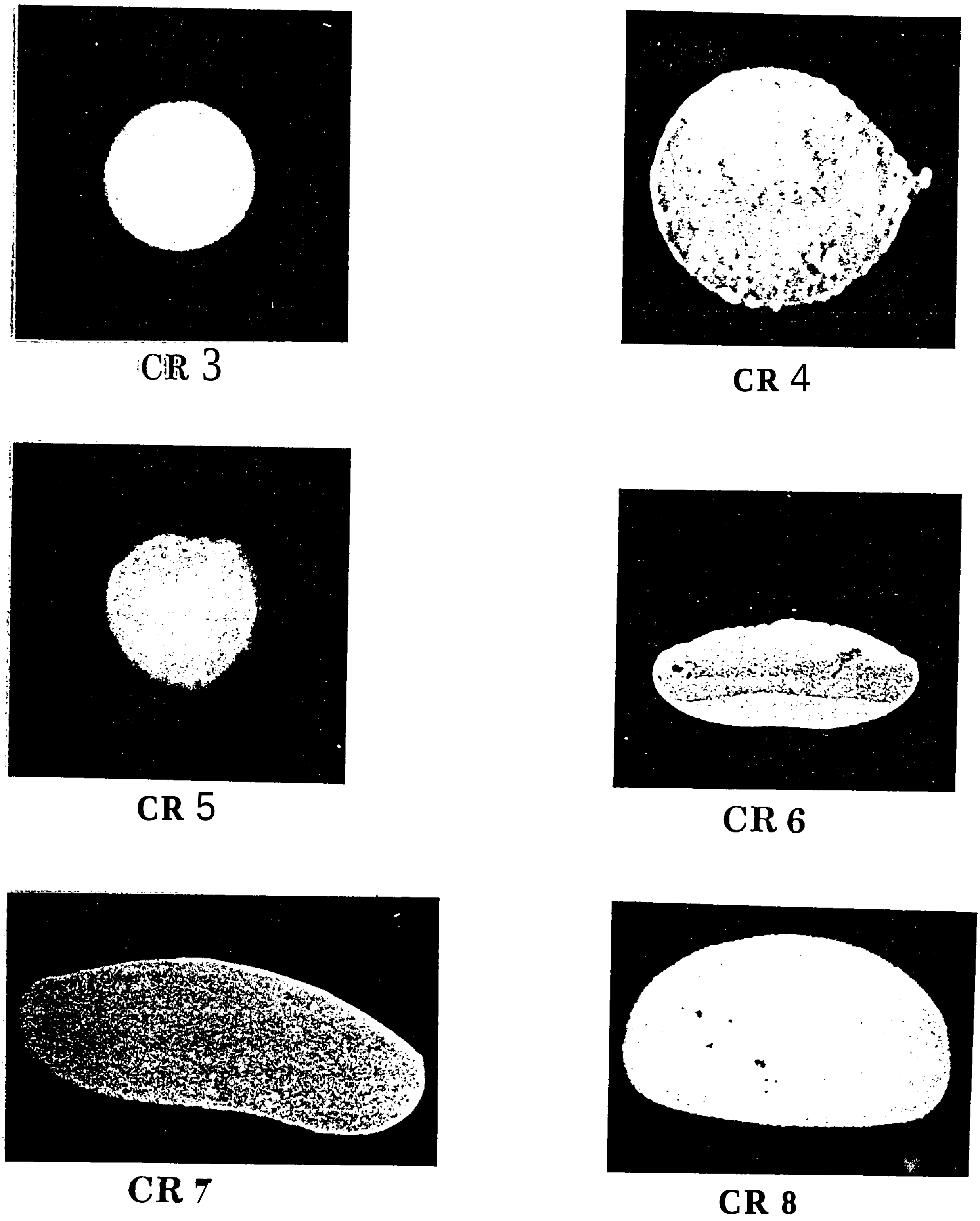
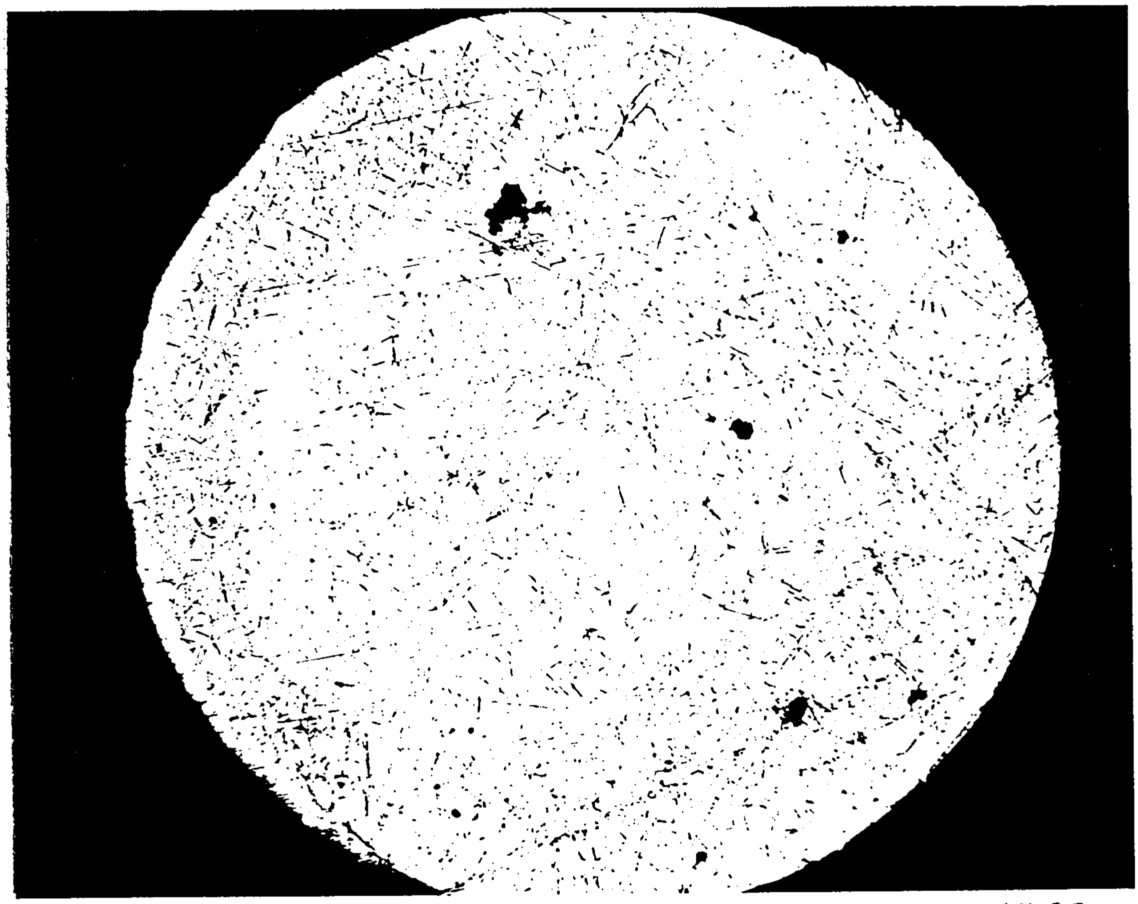


Fig. 1 1 *Specimens CR 3 to CR 8 as revealed by α-autoradiography. White spots correspond to high α-activity.*

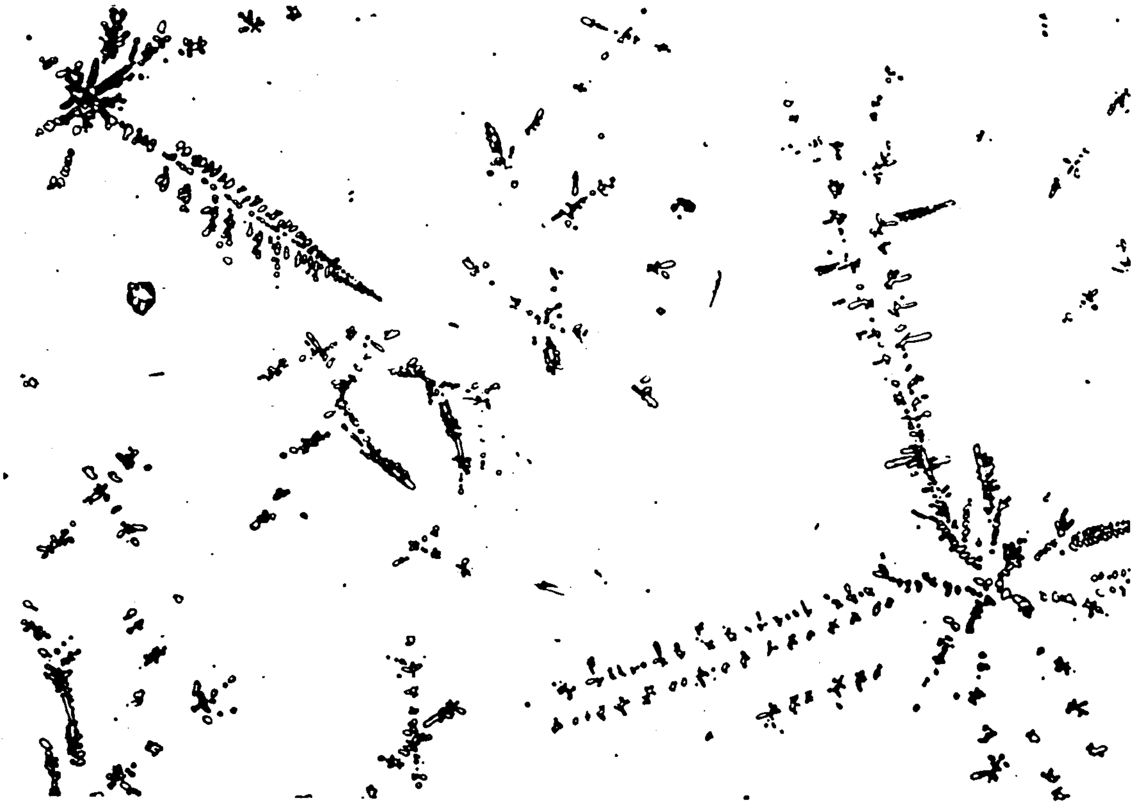
Specimen Nr: CR 3	Composition (wt%)	U	Pu	Zr	Ce	Nd	Np	Am
		-	~50	-	-	-	-	~50



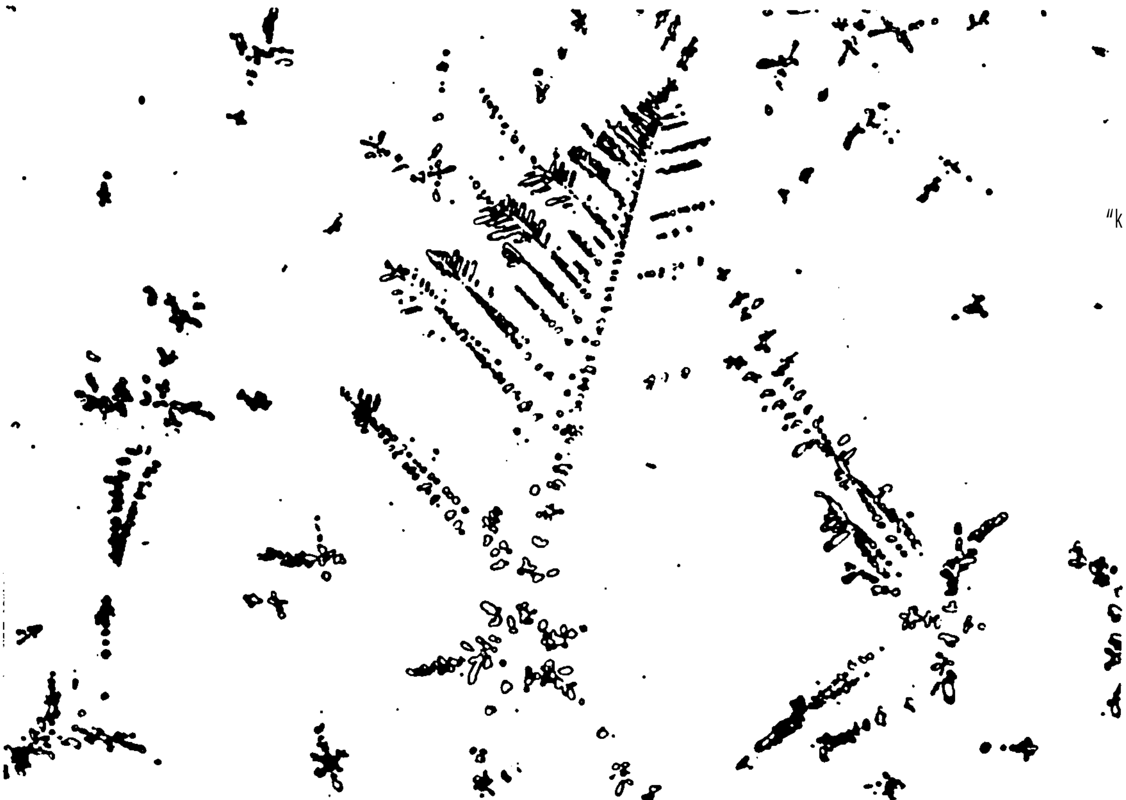
X 20

Specimen Nr: CR 3 Composition (wt%)

U	Pu	Zr	Ce	Nd	Np	Am
	-50	-	-	-	.-	~50

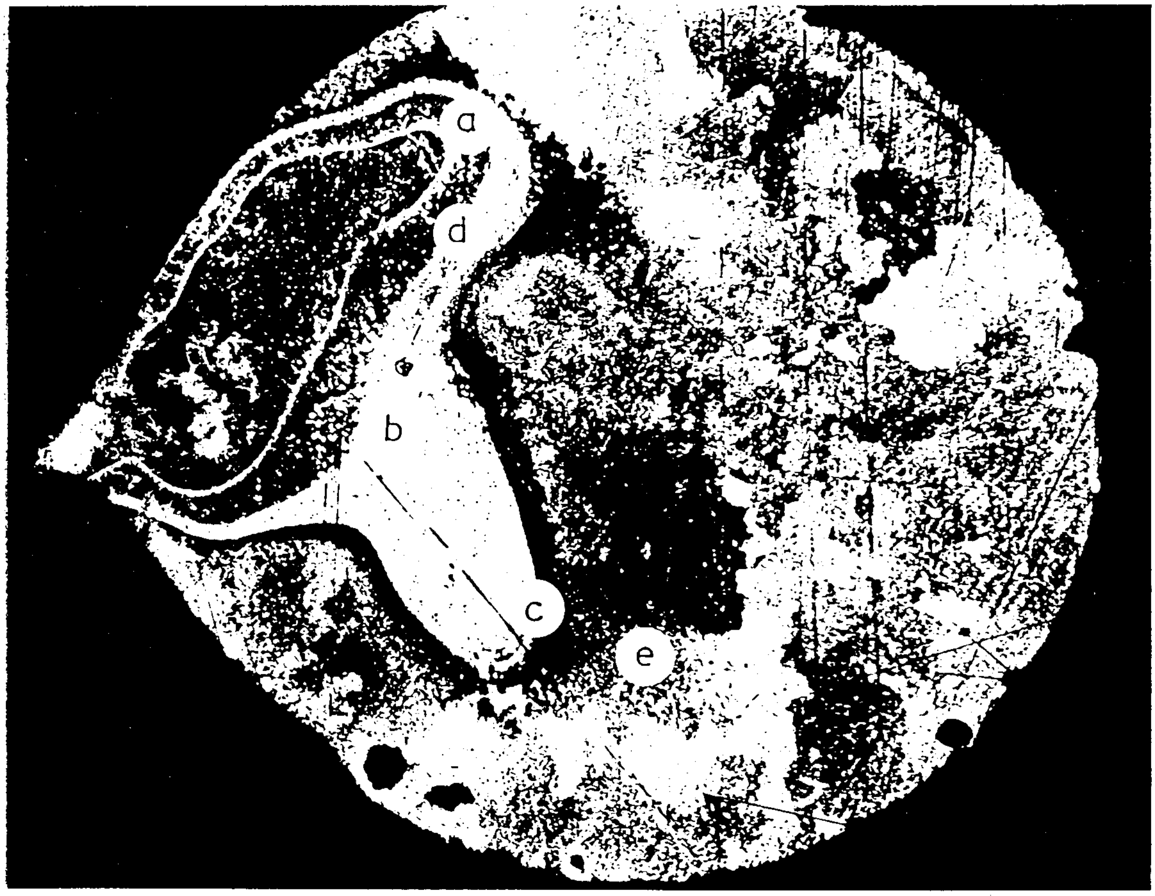


x 1000



x 1000

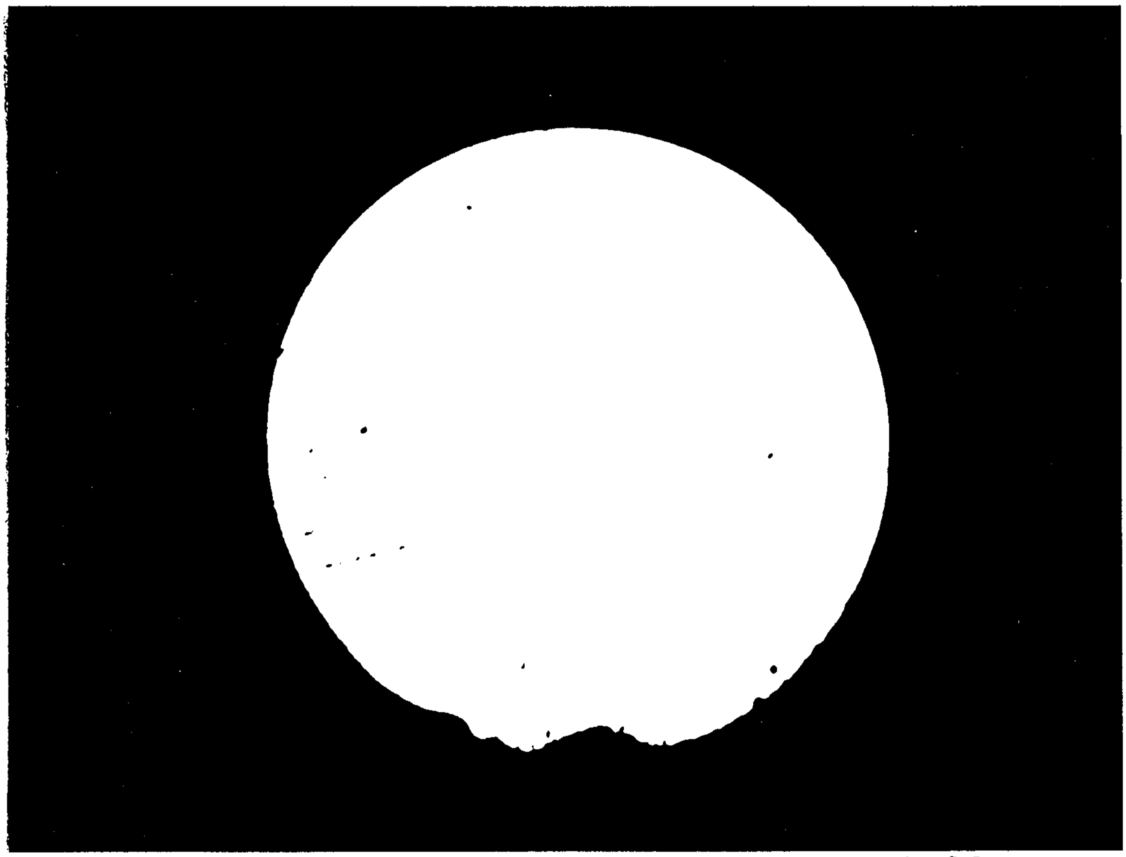
Specimen Nr: **CR 4**	Composition (wt%)	U	Pu	Zr	Ce	Nd	Np	Am
		-90	-	-	-	-	-	-10



x 20

Specimen Nr: C R 5 Composition (wt%)

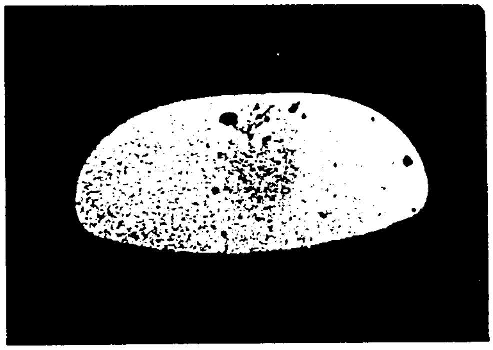
Pu	Zr	Ce	Nd	Np	Am
				--67	-33



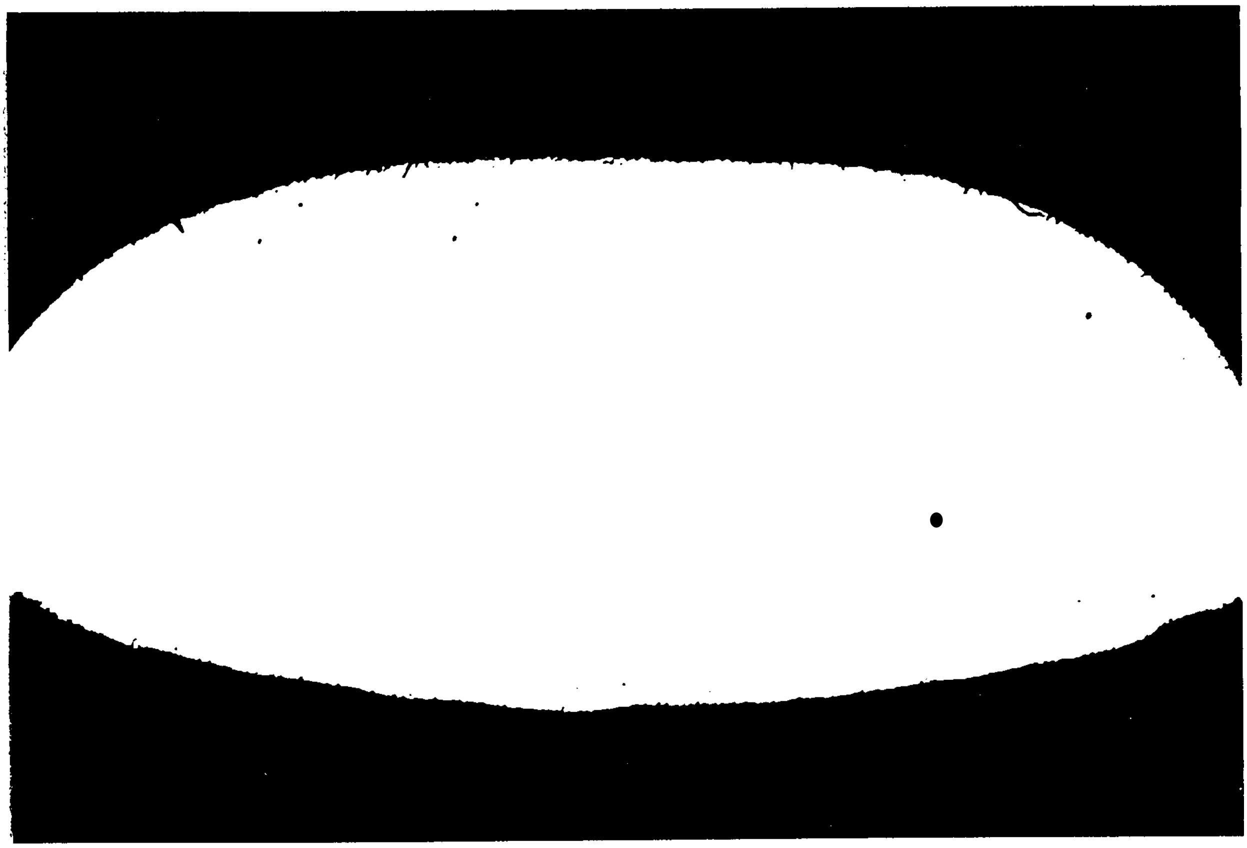
X 20

Specimen Nr: **CR 11** Composition (wt%)

U	Pu	Zr	Ce	Nd	Np	Am
68.1	18	10	0.5	1.4	1,2	0.8



a autoradiograph



X 0

Specimen Nr.: CR 11 Composition (wt%)

U	Pu	Zr	Ce	Nd	Np	Am
68.1	18	10	05	1.4	1.2	0,8

x 500

X 1000

Summary

1. **The actinides are miscible in the molten state.**

2. **Neighboring actinides in the periodic table exhibited the best miscibility. (e.g. U - Np and Pu - Am)**

3. **Dendrite formation was stronger for Np -Am and in the case of U - Am large crystals were formed.**

4. **U - Pu - Zr alloy with minor actinides and rare earths of 2 wt% in each shows homogeneous microstructure with small particles having Am and rare earths along the grain boundary.**

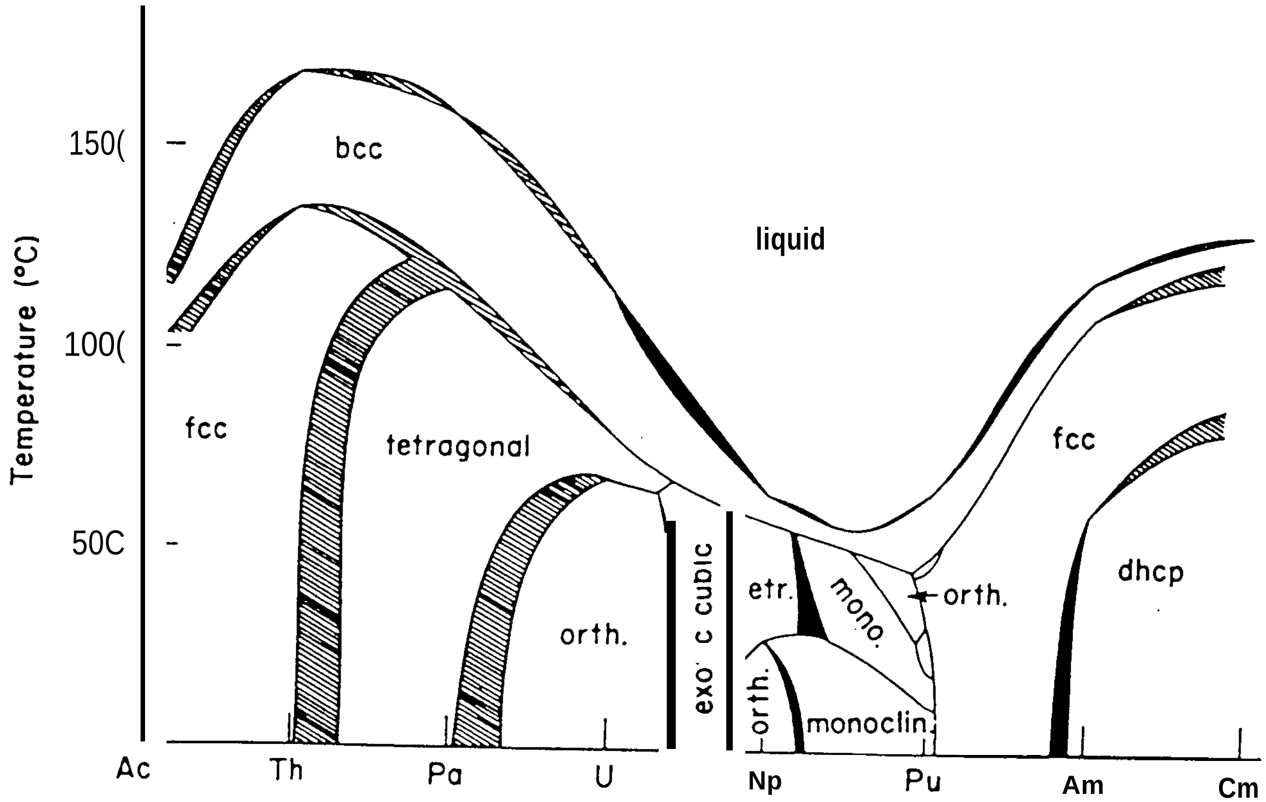


Fig. 19.1 *Schematic binary phase diagram of the actinide metals. (After Smith and Kmetko* [31].)