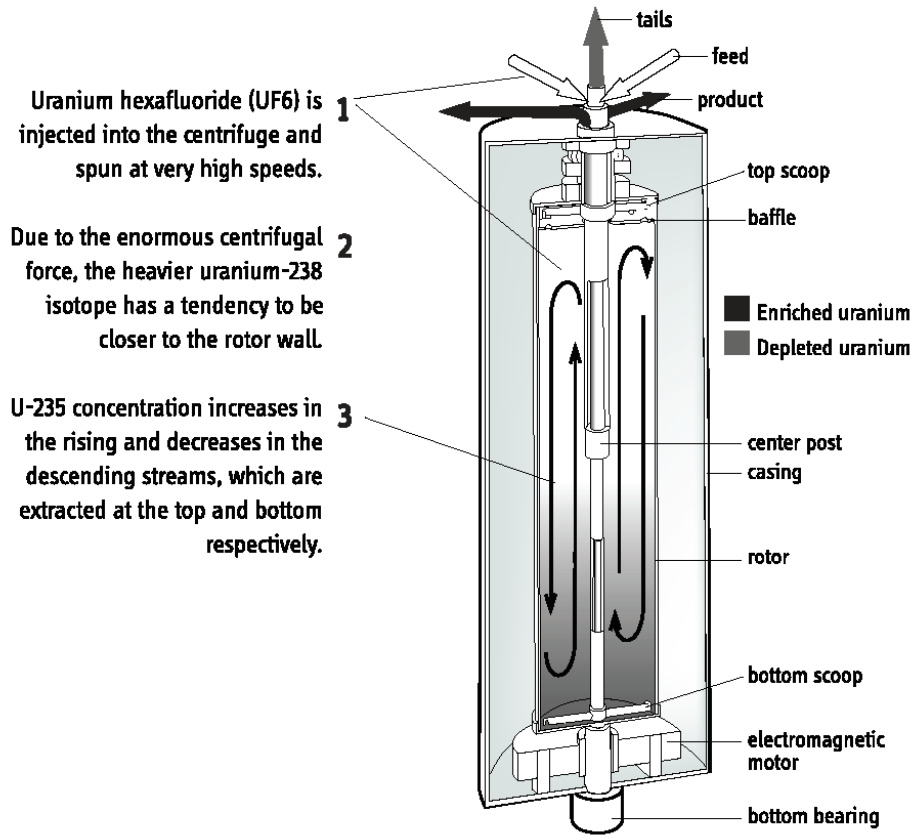

Figure 3.2 - The gas centrifuge for uranium enrichment and its large-scale use in an enrichment facility. The possibility of using centrifuges to separate isotopes was raised shortly after isotopes were discovered in 1919. The first experiments using centrifuges to separate isotopes of uranium (and other elements) were successfully carried out on a small scale prior to and during World War II, but the technology only became economically competitive in the 1970s. Today, centrifuges are the most economic enrichment technology, but also the most proliferation-prone.[46]

Source: *IPFM Global Fissile Material Report 2006: Developing The Technical Basis For Policy Initiatives To Secure And Irrversibly Reduce Stocks Of Nuclear Weapons And Fissile Materials*, International Panel on Fissile Material, 2006, p.25.

Successful Indigenous Centrifuge Enrichment Programs

Country	*Program Initiation*	*First Demonstration Facility**	*Operational Time to First Demonstration Facility (yrs)*	*First Full Scale Facility***	*Time to first full scale facility*
Soviet Union	1945	1953	8	1957	12
Urenco	1960	1971	11	1973	13
Japan	1971	1979	8	1982	10
Pakistan	1974	1980	6	1984	10
Brazil	1980	1990	10	2002	22
India	1975	1985	10	1992	17
Iran	1987	2004	17	na	na

*Linked cascades of 100 or more centrifuges producing enriched uranium
**Facility producing 5,000 or more swu/yr
M.D. Zentner, G.L. Coles, R.J. Talbert, *Nuclear Proliferation Technology Trends Analysis*, PNNL-14480, September 2005, pp.20.

Maximum peripheral speeds for thin- walled cylinders

Material	*Tensile strength, T (kg cm-2)*	*Density ρ (g cm-3)*	*T/ρ (×10³)*	*Approximate maximum peripheral speed (m s-l)*
Aluminum alloy	5 200	2.8	1.9	425
Titanium	9 200	4.6	2.0	440
High-strength steel	17 000	8.0	2.1	455
Maraging steel	22 500	8.0	2.8	525
Glass fiber resin	7 000	1.9	3.7	600
Carbon fiber resin	8 500	1.7	5.0	700

S. Whitely, "The Uranium Ultracentrifuge," *Phys. Technol.* 10 (1979) p.28.