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THE SPALLATOR - ACCELERATOR BREEDER

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Informal Report

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We have been interested for some time in a concept for breeding nuclear fuel, as an alternative to the LMFBR. The concept involves the use of spallation neutrons produced by interaction of a high energy proton (1-2 GeV) from a linear accelerator (LINAC) with a heavy metal target (uranium). The spallation neutrons are absorbed in natural fertile material (uranium or thorium) to produce fissile material (Pu-239 or U-233). This machine has been variously called an "accelerator-breeder", an "electric breeder", and a "spallator". Over the years, several spallator concepts have evolved.

The principal spallator concept is based on generating fissile fuel for use in LWR nuclear power plants, thus assuring a long-term fuel supply for the nuclear industry. The spallator, as we envision the unit, is an energy self-sufficient machine producing only fissile fuel on demand. As shown in Figure 1, the spallator functions in conjunction with a reprocessing plant to regenerate and produce the Pu-239 or U-233 for fabrication into fresh LWR reactor fuel elements.

Advances in proton accelerator technology at Brookhaven and other national laboratories has provided a solid base for predicting performance and optimizing the design of a reliable, continous wave, high-current LINAC required by a fissile fuel production machine. Figure 2 indicates the various sections of the LINAC equipment.

Neutron multiplication in the target relies on spallation and fast fission of the heavy elements. Based on earlier experiments at the BNL cosmotron and on high energy Monte Carlo and neutron transport caluclations, the neutron yield and fissile production rate have been determined. Evolution of target design at Brookhaven maximizes fissile production rate while relying on near term reactor technology. One reference design, shown in Figure 3, utilizes solid fertile material with light water as a coolant in a tight lattice. The target assembly operates in a subcriticel mode. The target is designed to produce enough thermal energy to provide power for the LINAC. One set of reference design parameters are given in Table 1. A single 600 MW, 300 Ma-2GeV proton beam LINAC acting on a uranium spallation target could produce enough fuel to supply nine 1000 MW(e) LWR power reactors on a continous basis. The estimated economics of the system indicates a competitive position with the LMFBR. The advantage of the spallator is that it can sustain conventional LWR and GCR thermal reactor economies.

To implement this technology, requires demonstration of the reliability of high-current continous wave accelerator components, accurate measurement of neutron multiplication in spallation target lattices, and measurement of thermal and hydraulic characteristics of target assemblies.

Small international programs on spallator technology exist in Canada, Japan, Germany, and the Soviet Union.

Selected References

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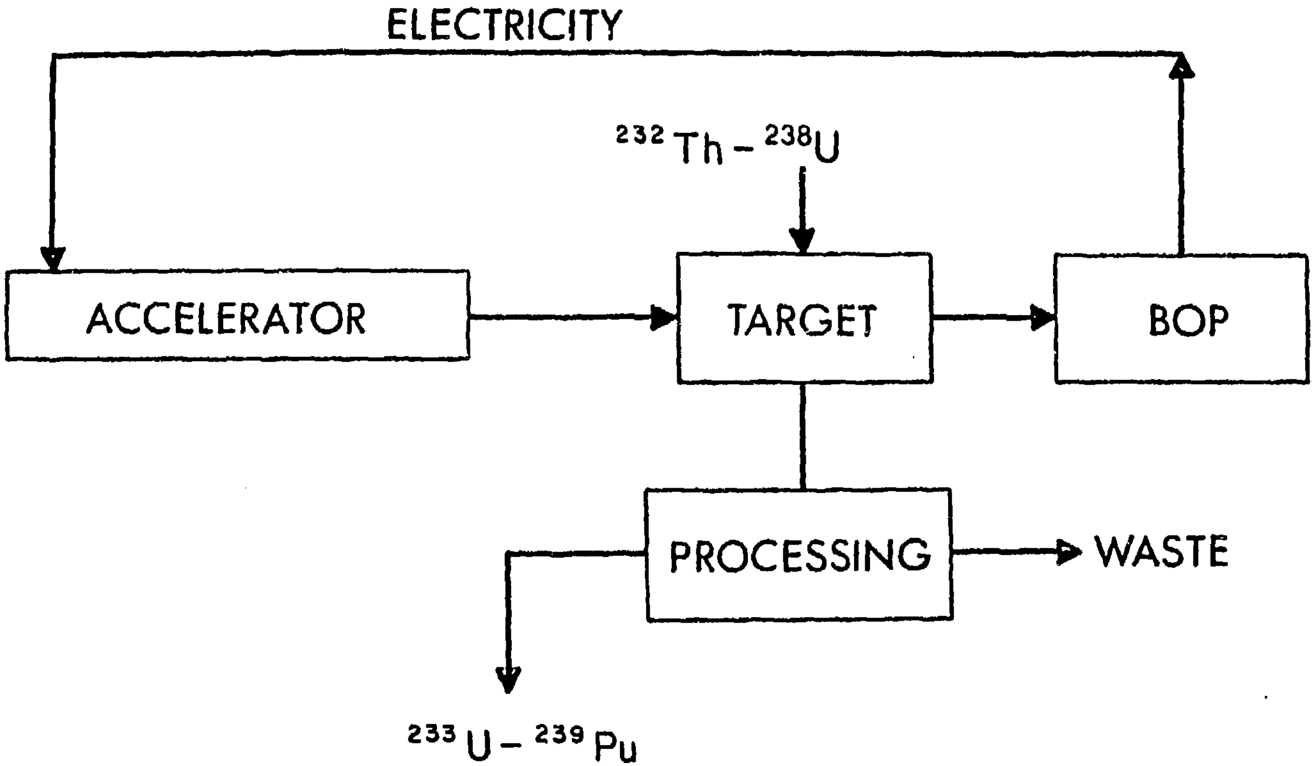

FIGURE 1. ACCELERATOR BREEDER SYSTEM.

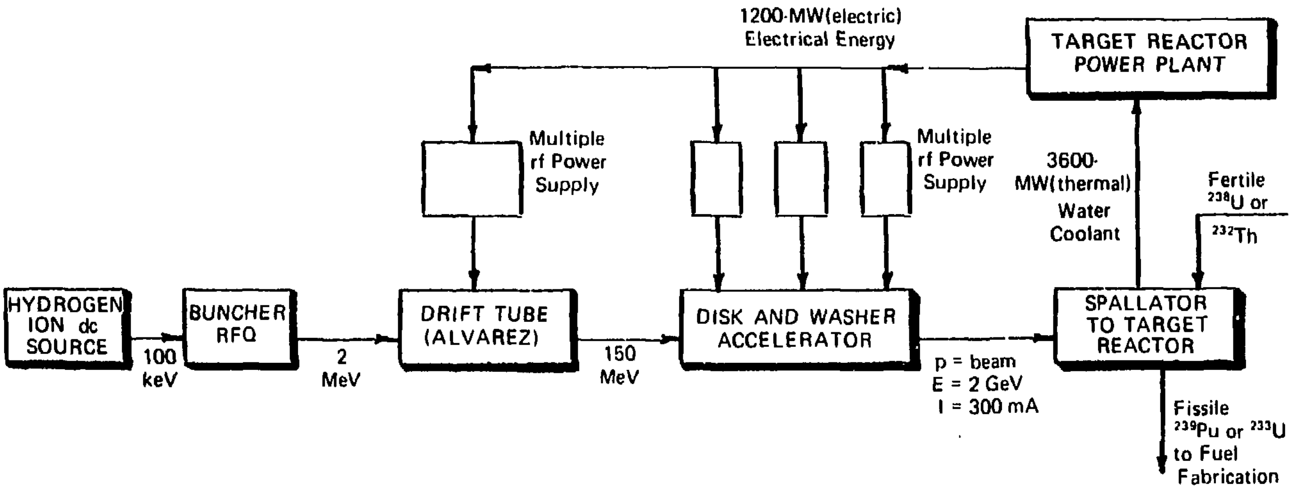

FIGURE 2. THE LINAC FOR THE SPALLATOR.

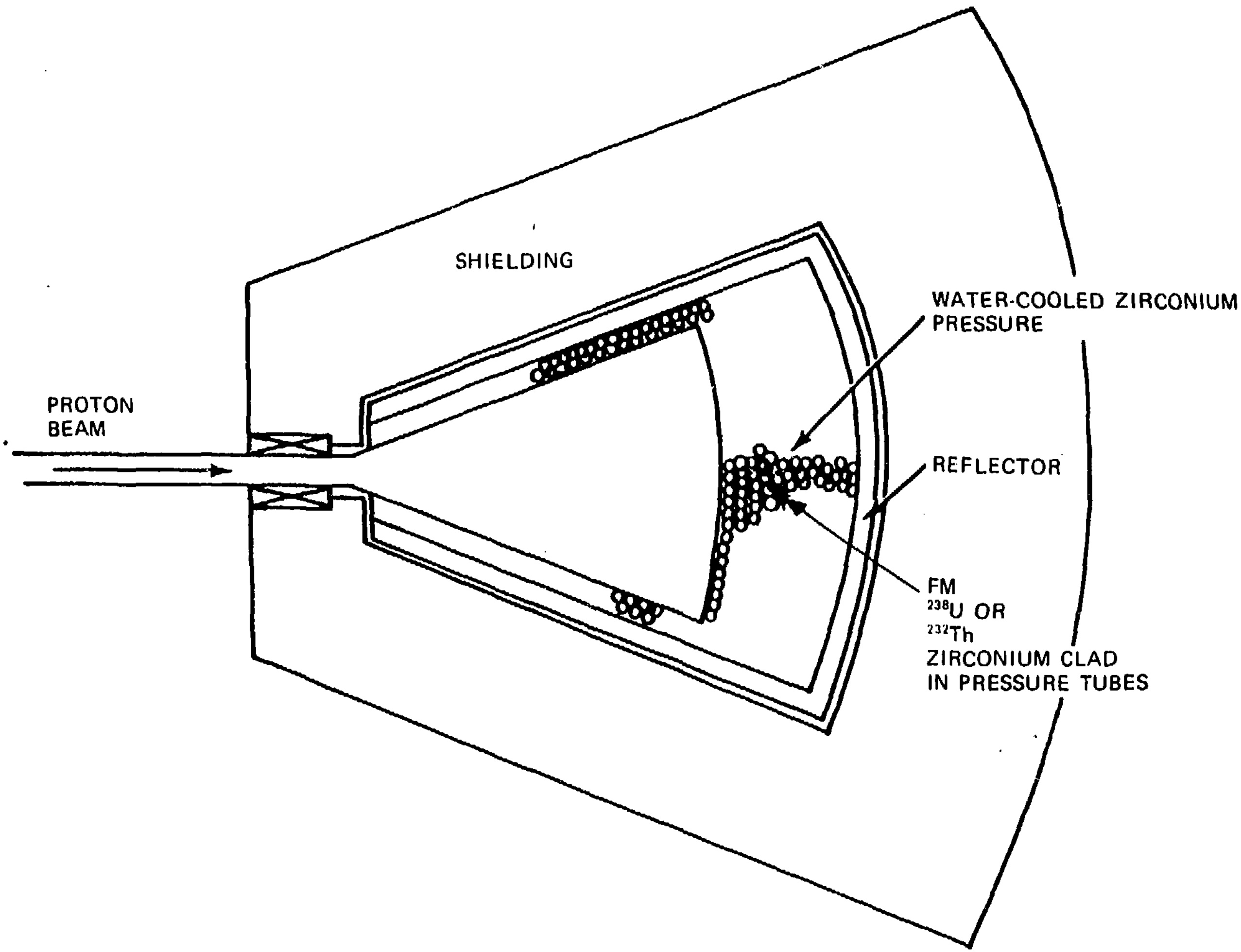

FIGURE 3. THE SPALLATOR TARGET DESIGN.

TABLE I

The Spallator—Accelerator Spallation Reactor—Production Capacity and Design Characteristics

Proton energy	2 GeV
Net fissile atom yield for UO_2/Zr clad–H_2O cooled	94 fissile atom/GeV·proton
Current cw	300 mA
Beam power	600 MW
Accelerator efficiency	50%
Power to accelerator	1200 MW(electric)
Power generated in target	3600 MW(thermal) (self-sufficient)
Plant factor	75%
^{239}Pu FF production rate	3300 kg/yr
FF needed for 1 to 1000-MW(electric) LWR 75% power factor and 0.6 C.R.	360 kg/yr
Number of 1000-MW(electric) LWRs supported	Nine