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THE LINEAR ACCELERATOR FUEL ENRICHER REGENERATOR (LAFER) AND FISSION PRODUCT TRANSMUTOR (APEX)

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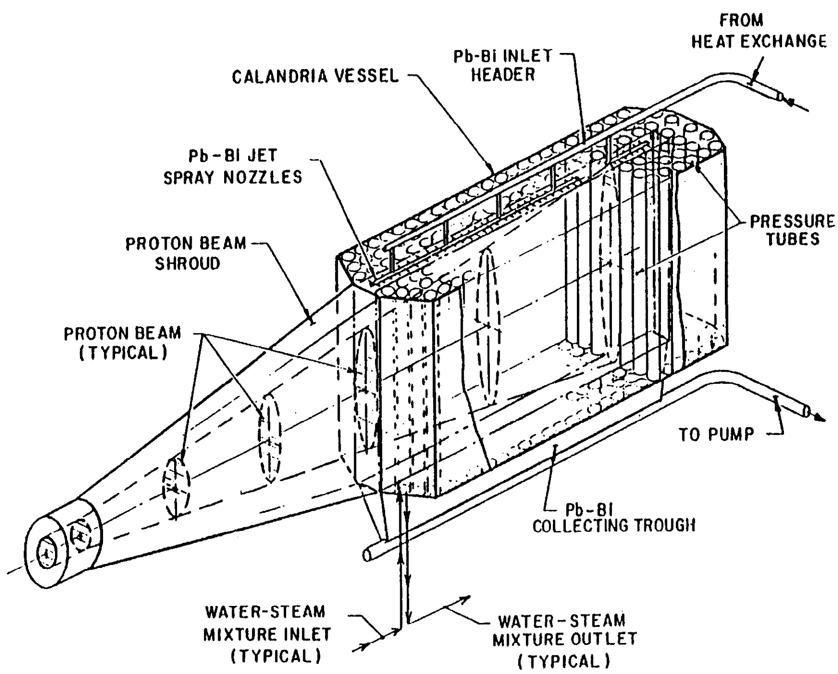
Abstract

Two major problems face the nuclear industry today; first is the long-term supply of fissile material and second is the disposal of long-lived fission product waste. The high energy proton linear accelerator can assist in the solution of each of these problems. High energy protons from the linear accelerator can interact with a molten lead target to produce spallation and evaporation neutrons. The neutrons can be absorbed in surrounding light water power reactor (LWR) fuel elements to produce fissile Pu-239 or U-233 fuel from fertile U-238 or Th-232 in-situ. A schematic of the target assembly for enriching PWR fuel elements is shown in Figure 1. The enriched fuel element is used in the LWR power reactor until reactivity is lost after which the element is regenerated in the linear accelerator target blanket assembly and then the element is once again fissioned in the power LWR.[1] In this manner the natural uranium fuel resource can supply an expanded nuclear power reactor economy without the need for fuel reprocessing, which satisfies the administration's policy of non-proliferation. Furthermore, the amount of spent fuel elements for long-term disposal is reduced in proportion to the number of fuel regeneration cycles. The limiting factor is the burnup damage to the fuel cladding. A 300 ma-1.5 GeV (450 MW) proton linear accelerator can produce approximately one ton of fissile (Pu-239) material annually which is enough to supply fuel to three 1000 MW(e) LWR power reactors.[2] With two cycles of enriching and regenerating, the nuclear fuel resource can be stretched by a factor of 3 without the need for reprocessing. The U-235 enrichment separative work requirements are reduced by a factor of 4 and the volume of spent fuel to be stored is reduced by a factor of 2. Current estimates indicate that the LAFER fuel cycle would increase the cost of power by about 30% compared to present LWR power costs which is in the range of cost increases projected for the breeder reactor (LMFBR). As the natural uranium fuel resource becomes depleted, the LAFER becomes more competitive. Although viewed as a backup technology, the LAFER, on the one hand, is an alternative to the breeder reactor and on the other hand, it is also an alternative to isotope enrichment, i.e., U-235 separation either by gaseous diffusion, by gas centrifugation or by laser separation. The LAFER insures a long-term LWR power economy.

The fuel cycle can also be designed so that only stable fission products are removed from the fuel while the long-lived fission products remain contained in the fuel cycle thus eliminating the need for long term waste management (APEX cycle). The transuranics and fission products are fissioned, decayed, and transmuted within the LAFER-APEX fuel cycle.

The use of the linear accelerator in the nuclear fuel cycle both as a fuel producer and as a fission product management tool, appears to be the missing link in the development of long-term nuclear fission power. The technology of LINACs has advanced so that it is currently used as a highly reliable research tool. There is every reason to believe now that the LAFER can be designed and built as a high capacity reliable production tool. It is thus recommended that a strong effort be mounted for its early implementation.



PWR-TYPE TARGET ASSEMBLY

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1) M. Steinberg, et al, "Electronuclear Fissile Fuel Production, LAFR and LAFP", BNL 24356 (April 1978).
2) P. Grand, et al, "Conceptual Design and Economic Analysis of a Light Water Reactor Fuel Enricher/Regenerator", BNL 50838 (in press).

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