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R & D PROGRAM ON ELECTRONUCLEAR PRODUCTION OF FISSILE MATERIAL

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R & D PROGRAM ON ELECTRONUCLEAR PRODUCTION OF FISSILE MATERIAL

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If the electronuclear production of fissile material (^{239}Pu and/or ^{233}U) is to be pursued seriously the following activities would seem to be appropriate.

1. ^{239}Pu Production in Depleted Uranium by 460 MeV Deuterons from the 184" Cyclotron

- a. Assemble a mock-up of the production secondary target of depleted uranium (~ 90 tons) with provision for depleted uranium foils distributed throughout the assembly to measure ^{239}Np activity. The assembly should be designed to allow easy insertion and removal of test foils without unstacking the uranium. Runs of about five or six 24-hour days would reach near-equilibrium levels of activities in the foils. Comparison of actual ^{239}Np yields with calculated yields would provide the assurance needed to predict accurately the production of ^{239}Pu from a full-scale installation. These experiments should compare production using a lithium primary target (as shown in Fig. 1) with that using a uranium primary target and compare alternative secondary-target configurations.
- b. Similar runs using a thorium secondary target for production of ^{233}U should also be considered, although this process would appear to be less productive and require longer bombardment times than the ^{239}Pu experiments.

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- c. The 740 MeV proton beam of the 184" cyclotron would be ideal for checking the relative yield of protons versus deuterons. Light metal primary targets such as lithium and beryllium would probably not produce interesting yields using protons. But heavy targets such as lead, thorium and uranium would be more promising.

2. Nuclear Theory of the Electronuclear Process

A theoretical effort aimed at a good understanding of the primary and secondary target nuclear cascades, which produce the low energy "source" neutrons in the secondary target, should be carried on concurrently with the experimental nuclear program. These "source" neutrons are then to be put into a multigroup code to determine the fissions and capture events and the distribution of ^{239}Pu produced in the secondary target. When the predicted and measured total production and distribution are brought into reasonable agreement for the experimental assembly, production in the full-scale system can be predicted with confidence. Two nuclear theorists working on the cascade processes and one neutronics expert working on the fission and capture distributions together with computing support should achieve the needed understanding of the process. This effort should facilitate parametric studies leading to an optimum choice of deuteron energy and target configuration.

3. Accelerator Design and Injector Development

Beam dynamics in Alvarez cavity-type accelerators is much better understood and high-power electronics systems much improved since the MTA program was terminated. However, little effort has been expended on CW

beam-current injection. Development of a system capable of injecting a 0.3 to 0.5 A steady-state beam of deuterons at 800 to 1,000 keV with measured emittance matching the requirements of the accelerator and with optimized rf bunching would provide a firm basis for beam dynamics calculations to optimize the design of a production accelerator.

The efficiency of the accelerator (beam power/60 Hz input power) depends critically upon the 60 Hz to rf conversion efficiency. Using the best amplifier tubes now available for 50 MHz (the Eimac X2170 or the RCA 4648) the attainable conversion efficiency may not exceed 0.50. However, by developing a tube specifically for this application and optimizing the modulator-driver circuitry appropriate for the tube, an overall conversion efficiency of 0.65 to 0.70 can probably be achieved. The total power required to drive a high-current 500-MeV deuteron accelerator is in the range of hundreds of megawatts so that such an rf tube development, though expensive, would be fully justified by the anticipated saving in power to drive the accelerator.

4. Target and Process Design Studies

Based upon theoretical and experimental investigations of the yield of ^{239}Pu and ^{233}U from high-energy particle bombardment, realistic production target design studies should be carried out. These studies should include parametric variations to optimize production cost, detailed design studies of remote handling of exposed fertile material, neutronics calculations of the distribution of fissile material produced in the target assembly, extraction of fissile from the exposed fertile material, and the conversion of the thermal power developed in the target assembly into electric power.

EXPERIMENTAL TARGET ASSEMBLY

FIG. 1

Distribution

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