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SYNOPTIC: Conceptual Design of a 2-Mw$_t$ (375 kw$_e$) Nuclear-Electric Space Power System,
John H. Pitts and Carl E. Walter, Lawrence Radiation Laboratory, University of California, Livermore, Calif.; *Journal of Spacecraft and Rockets*, Vol. 7, No. 11, pp. 1282–1286.

Spacecraft Electric Power Systems

Theme

Described is a nuclear space power system containing an integral reactor-boiler unit which is coupled together with heat pipes. Computational methods and operating characteristics are summarized.

Content

An analytical study of nuclear-electric power for space applications resulted in the conception of a system, shown in Fig. 1, which contains an intergral reactor-boiler unit. This unit (see the schematic of Fig. 2) uses 756 sodium heat pipes in lieu of a conventionally pumped primary loop. The reactor-boiler is separated from all other components of the system by a nuclear shadow shield composed of two layers of lithium hydride separated by a layer of tungsten. Lightweight heat-pipe radiators reject waste heat. A single electromagnetic pump, operating at a temperature no higher than is required for heat rejection, is used to circulate potassium working fluid in the power conversion loop. A low system specific mass of 10 kg/kw$_e$ and an over-all thermal efficiency of 18% are achieved. High reliability is expected.

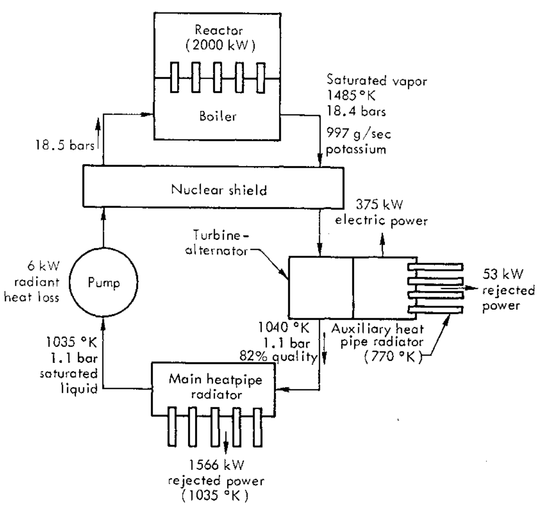

Fig. 1 System schematic.

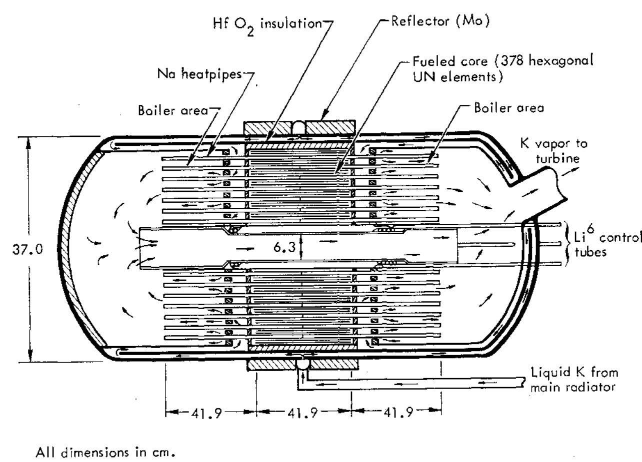

Fig. 2 Schematic diagram of integral reactor-boiler.

The reactor uses uranium nitride (UN) as the fuel, an alloy of 75% tungsten and 25% rhenium (W-25% Re) as the structural material, and sodium as the interstitial bonding agent and heat-pipe fluid. The fuel is enriched with U^{235} in two radial zones. UN was chosen for the fuel because of its high density, good thermal conductivity, high melting point, and excellent physical properties. Reactivity is regulated with a dual control system consisting of a 2-cm thick, axial translating side reflector and centrally located, in-core liquid Li^6 control circuits. Reactivity can be controlled with either control system, thereby providing redundancy.

The reactor was designed using a composite computer code which considers, in a single pass, nuclear performance, structural component sizes, expansion due to swelling and thermal effects, and production of daughter fissile species. Small perturbations can be made with a high degree of numerical consistency, and complex interactions can be studied in detail.

The nuclear shield was designed for unmanned missions so that a payload placed 10 m from the near face of the reactor would receive a total dose of 10^{13} nvt for neutrons and 10^6 R for gamma rays over a 20,000-hr operating life. Point-kernal techniques were used to determine the required thickness of the various shield layers to give minimum mass. Even so, the mass of the shield is 56% of the total system.