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Pratt & Whitney Aircraft is conducting for the Atomic Energy Commission at the CANEL facility in Middletown, Connecticut a research and development program leading ultimately to the operation of a high temperature, compact, liquid-metal-cooled reactor suitable for 10,000 hour operation in space flight environment. Successful completion of this program represents a large forward step in reactor, materials, and engineering technology. Such technology will eventually have a significant impact on many power programs but will very probably not be ready for the civilian reactor program within the next five years.

The first major objective of the SNAP-50 reactor development program at CANEL is the engineering, design, development, construction, and operation of a very high temperature, lithium-cooled reactor experiment (LCRE) in the spring of 1965. Work on this experiment concept was initiated in May of 1961 prior to the establishment of the SNAP-50 program in response to the Atomic Energy Commission requirement for the continuing development of the broadly applicable high temperature reactor technology born under the ANP program. The second objective is the design, development, and test of the prototype reactor and primary liquid metal loop for a nuclear electric space powerplant of one megawatt electrical output. The design of the reactor for the first experiment is based upon a fuel element consisting of pins containing uranium dioxide, beryllium oxide ceramic fuel in a columbium-zirconium alloy jacket. The 13-1/2 inch diameter core containing 1651 of these pins is cooled by lithium-7. The reactor pressure vessel structure and primary loop are constructed of columbium-zirconium alloy. The reactor is reflected

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on the enas by beryllium oxide and around the periphery of the core by beryllium metal cooled by NaK. The thermal power output of the reactor is ten megawatts for a design life of 10,000 hours at a lithium outlet temperature of 2000°F.

The physical and mechanical properties as well as the corrosion characteristics of the reactor structural material, columbium-zirconium alloy, are well in hand. A large number of creep and stress rupture tests have been performed on this material in lithium. A number of corrosion loops simulating reactor primary loop conditions have been operated successfully with no evidence of mass transfer over periods of time as long as 2000 hours, and a large corrosion loop is still running at 2000°F maximum lithium temperature with no external evidence of mass transfer or leakage after 7800 hours of operation.

The uranium dioxide, beryllium oxide ceramic fuel has been under development in the pin configuration at CANEL for approximately four years. A large number of successful in-pile irradiation tests of fuel pin samples have been completed. Sufficient data on fission gas released from the ceramic fuel material have been accumulated to insure confidence in the design of the fuel pin as a fission gas container. In addition, a vigorous program on the development of uranium carbide as an advanced reactor fuel in a similar pin configuration is under way.

The design of the reactor for the lithium-cooled reactor experiment is essentially completed. Development work on reactor components is in progress. The primary lithium pump and the secondary NaK pump for the reactor experiment are on test and running well. A number of pump mechanical and seal development tests are in progress. A liquid metal system duplicating in full scale the most important elements of the reactor heat rejection system and including the primary pump, the regenerator, the lithium-to-NaK heat exchanger, the secondary pump, the secondary valves, and the heat dump is nearly

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completed. This system in which heating of the lithium in the reactor is simulated electrically will go on test by mid-summer of this year.

No major technical feasibility problems remain to be solved prior to operation of the LCRE. The success of this experiment, however, depends upon extremely rigorous quality control throughout manufacture and assembly, particularly of the columbium alloy components. Contamination of columbium alloy by atmospheric gases and other impurities may render the alloy subject to attack by lithium with resulting leakage of this liquid metal. Extreme vigilance must be exercised wherever high temperatures are involved in the processing of this material; for example, in welding and annealing, to insure freedom from contamination. This problem is well understood and the facilities and experience required for successful fabrication are at hand.

The ultimate objective of the reactor program at CANEL is the development of a Rankine cycle nuclear electric powerplant for the generation of electric power for propulsion and auxiliary requirements in a space vehicle. The booster requirements for launching such a vehicle place extreme emphasis on minimum specific weight of the nuclear electric powerplant. Two aspects of the reactor technology described here make it uniquely adaptable to this application. First, the lithium-cooled reactor is extremely compact and has a very low specific weight. Secondly, the very high lithium outlet temperature attainable minimizes the powerplant radiator weight, an extremely important factor in the over-all weight of the powerplant.

The LCRE program is now entering the construction phase. Procurement of material for fabrication of the reactor has been initiated and some parts are in fabrication. Development of reactor and external system components will continue for approximately two years. Assembly and installation of the experiment at the National Reactor Testing Station in Idaho will begin late in 1963. Test operation is scheduled to begin in the
spring of 1965 and the test is programmed for 10,000 hours of full power operation. The total estimated cost of this experiment through operation is approximately $64,000,000.

Engineering design studies of the prototype reactor and primary system for the SNAP-50 Rankine cycle nuclear electric space powerplant have just begun. Engineering, research, and development work to support these studies is being initiated. Nuclear power testing of the prototype reactor and primary system is scheduled to begin late in 1966. The total cost of this program through beginning of nuclear testing is estimated to be approximately $95,000,000. The ultimate objective of this program is the development of a flight powerplant for first launch in the late 1960s.

While the principal application for the technology currently under development at CANEL is presently the Rankine cycle space nuclear electric plant, it is recognized that this compact, high temperature reactor technology may ultimately have a wide spectrum of application including the central power station. The particular reactor concept presently under development at CANEL is certainly not optimum for central station power generation either in size or configuration. Little is known about the cost of energy generation associated with such a high temperature reactor system. On the other hand, the compactness of the system and the high cycle temperatures attainable with this technology, together with the extremely high degree of reliability which will be developed for the space application, may prove very attractive. It thus appears extremely important that studies be undertaken to determine the way in which this technology may be most effectively applied to the stationary power field.