Plum Brook's B-3 Stand Is Readied For New NERVA Program

As an important part of NASA's nuclear rocket research and development work, Lewis engineers in Cleveland and at Plum Brook Station have completed the first experimental program with Plum Brook's B-3 facility. They are now removing existing research hardware and overhauling the facility subsystems in preparation for a new series of approved investigations.

THE FIRST TESTS were conducted in December 1965. A total of 23 tests were performed during the first year program.

The recently concluded studies at the B-3 stand were organized as a full scale propellant feed system start-up test program for the NERVA (Nuclear Engine for Rocket Vehicle Application) project. An Aerojet Mark III, Mod 4 turbopump was used to supply liquid hydrogen to an unfueled KIWI B-1 reactor. Both dry pump and wet pump start-up tests were performed.

THE PURPOSE of the program was to define how to start a nuclear system in space. Nuclear power systems are not expected to be used as first stages in space missions; rather, they would serve as second or third stages and would be rocketed into space aboard first stages.

Because a nuclear system could not be brought to full power until hydrogen starts to flow through the reactor to cool it, and yet, the liquid hydrogen must not be allowed to enter the reactor core, a finite procedure must be followed to establish liquid hydrogen flow and then start generating power in the reactor.

THE RECENTLY concluded test program defined the required start-up procedure, including liquid hydrogen flow rates, time delay on the power cycle, and the application of power to the turbine.

These experiments were directed toward a definition of complete system performance and mechanical operating characteristics of centrifugal turbopumps by using a realistic feed system.

The in-flight feed system was simulated by mounting a turbopump directly under a large propellant tank which was a scale representative of a flight configuration.

The program ended in December with two wet pump bootstrap tests providing successful system start-up.

THE NEW TEST program will investigate a turbopump problem area of major concern in nuclear rocket development — liquid hydrogen pump cavitation. The heating by nuclear radiation of the liquid hydrogen propellant both in the tank and pump inlet line can directly affect the conditioning of the fluid entering the pump.

The program planned for the B-3 stand will study the effects of liquid hydrogen inlet temperatures on turbopump cavitation. The Aerojet Mark III, Mod 4 turbopump which was used for the start-up studies will be used in the new experiments.

PREVIOUS INVESTIGATION has shown that the radiation from a nuclear engine causes an undesirable and perhaps unavoidable increase in temperatures of the liquid hydrogen in the propellant tank.

Actual nuclear heating in a liquid hydrogen tank was investigated under a contract with General Dynamics, Fort Worth, Texas.

Planned tests at Plum Brook will include studies of turbopump performance throughout the entire anticipated range of operations, flow rates, and pressure changes, not only under design conditions, but at low speed conditions as well.

THE B-3 FACILITY includes a vertical tower 200 feet high. The turbopump was installed at the 94 foot level directly above the KIWI reactor. The reactor nozzle was exhausted into an altitude simulation system which also served the B-1 propellant start-up system test stand.

A 46,000 gallon liquid hydrogen tank was installed in the B-3 stand above the 115 foot level. Operation of B-3 stand experiments were conducted remotely at the B control building.

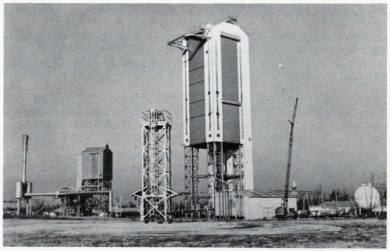
The B-3 test facility is equipped with a digital instrumentation system. Four hundred separate channels provided information on flow rates, pressures, material and fluid temperatures, acceleration, pump rpm., and other data.

THE B-3 COMPLEX, completed in mid-1965, includes a 200,000 gallon storage vessel and a control building. Cost of the entire B-3 complex was $3 million, a half- million dollars under the estimated construction cost.

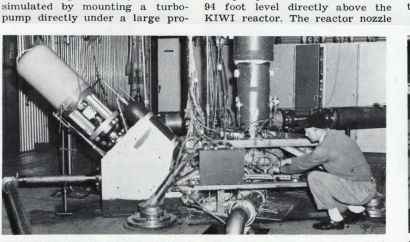
Another savings was confirmed when the recent test program was completed. The reheat system developed by Plum Brook engineers and built into the B-3 facility shortened the program completion date by approximately three months and saved more than $50,000 worth of propellants. The reheat system allowed engineers to perform six series of two back-to back tests.

THE RESEARCH GROUP which has directed experimental investigations to date also will be in charge of the new program. Albert G. Powers is head of the Systems Dynamics Section and Robert C. Phillips is B-3 test cell manager.

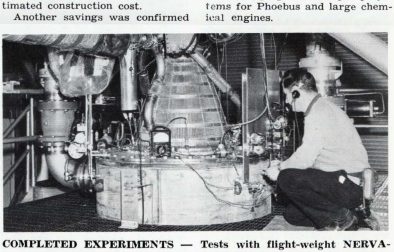
Powers pointed out last week that information obtained in the new program is expected to be valuable also to researchers who are developing the turbopump systems for Phoebus and large chemical engines.



STANDING READY for new projects, the year-and-a-half-old B-3 facility at Plum Brook already has been the site of two dozen valuable experiments for NERVA. Non-nuclear tests of various components for large nuclear engines are conducted at B-3 — Lewis' Nuclear Rocket Dynamics and Control Complex. Facilities, left to right above are: Second stage ejector for simulation of altitude conditions, B-1 Stand, B-3 burnoff used for low speed tests, B-3 Stand, and 200,000 gallon liquid hydrogen storage vessel.



EXPERIMENTAL TURBOPUMP installed last year for start-up tests in the B-3 facility received liquid hydrogen at low pressure and boosted the pressure to feed other components of the system. The large piece of equipment angled at 45 degrees at left is the turbine power control valve used for four low speed tests. A flight-weight turbine control valve was installed for 19 other start-up tests. The Plum Brook workman above is installing transducers which monitor pressures, temperatures, and vibrations of the pump.



COMPLETED EXPERIMENTS — Tests with flight-weight NERVA-type nuclear reactor engines and a rocketdyne regeneratively cooled nozzles were conducted at the B-3 facility. Radioactive fuel elements were not used in the engine during tests. Here, an electrician checks wiring connections for one of the many remotely operated valves prior to a test run. In space operation, this valve would feed liquid hydrogen to the reactor where it would be converted to gas and provide the rocket thrust.