Chapter Thirteen

The Triumph of Political Gravity Over Nuclear Flight

If everything had worked out perfectly, it still would have been a bum airplane.

—Charles Wilson, Secretary of Defense—

When IDO HPs understood that the NRTS was going to be home base for a nuclear-powered airplane, they researched the hazards this might bring to the desert. Test aircraft, they found, crashed most typically on takeoff or landing. What would happen to the nuclear fuel in a crash involving fire, and what kind of emergency response would be needed? In 1957 Dr. Victor Beard, IDO director of Health and Safety at the time, organized a pair of Fuel Element Burn Tests, soon dubbed by the participants as Operation Wiener Roast. John Horan, Beard's successor, was then working at the NRF and observed the tests. He recalled how Beard obtained a well-aged MTR fuel element for an experiment.

The key idea was to burn it. For the first test, a pool of [jet fuel] was used (500 gallons, I think) and part of an aluminum fuselage...The element was suspended directly over the center of the fuel and then [the fuel was] ignited. This was done at Test Grid No. III out on Lincoln Boulevard...The Y axis was a few miles east of NRF...and highly instrumented.

Movie cameras were operating [when] they set the thing on fire. Basically, there was no release. That was Wiener Roast No. 1...[The fuel reached a temperature of 2,250 degrees F., but after the fire burned two hours, the element was essentially intact.]

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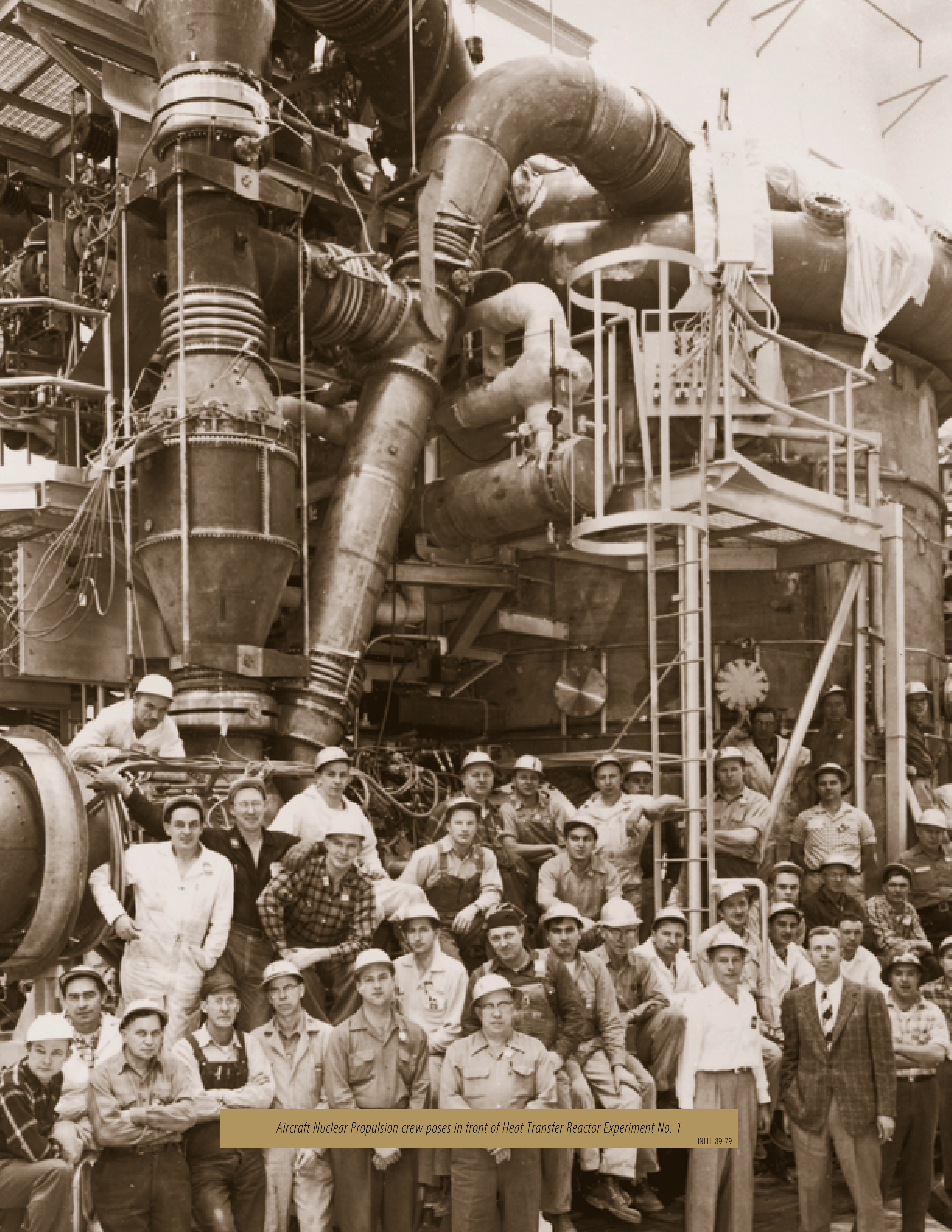
Operation Wiener Roast

The second time, they used an induction furnace to supply higher heat to the fuel element. This time, success. A release [was attained. The fuel melted within ninety seconds.] When I returned to NRF, the security guard told me we had an alarm on the portal monitor. I associated it with the Wiener Roast release. I took a sample from our continuous air monitor. It turned out to be cesium-137. At eight p.m. I called Beard at home and told him the cloud came over the NRF. He said, "Impossible."

The cloud had gone out on the grid. The weather changed, a shear had come in and it went back over NRF. It was barely detectable over background, so there were no health concerns.[1]

Elsewhere at the NRTS, preparations for the project were somewhat more prosaic. Bill Johnston had informed



Aircraft Nuclear Propulsion crew poses in front of Heat Transfer Reactor Experiment No. 1

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Allan C. Johnson

southeast Idaho in July 1952 that a nuclear airplane station was coming. Soon he and his staff, particularly Allan C. Johnson, his director of Engineering and Construction, were calling for bids on new roads, wells, power lines, a substation, and finally for construction of a huge assembly complex and a test pad. The project was called the Aircraft Nuclear Propulsion (ANP) Program.[2]

The program brought a substantial burst of growth to the NRTS, occurring just as construction payrolls for the first three reactors and the CPP had diminished. The airplane station would employ a thousand laborers. When Bill Johnston left the NRTS in the spring of 1954, the AEC appointed Allan Johnson, who was well into the swing of things, as the new manager.

Allan Johnson had been an NRTS pioneer, in charge of construction since July 1949. An architect by training, he had earned a year of post-graduate work at Princeton University by winning a national design competition in 1937. With the Corps of Engineers during the war, he had run the Washington office of the Manhattan District. After that he joined a New York company primarily concerned with the design of hospitals.[3]

Johnson had been recruited to Idaho, done well, and now it was his turn to cope with a see-saw situation in Washington. Fortunately, he could be just as smooth with Congressional representatives as was his predecessor Bill Johnston. This time, the waffling about policy wasn't confined within the AEC family but involved a huge array of conflicting interests at the center of national power.[4]

The main issue was the timing and structure of the project. The Air Force even in 1947 insisted that it would take only five years to transform paper plans into an actual demonstration of nuclear flight. "Fly early!" was its theme. The physicists who knew what there was to know about reactor development at the time, including J. Robert Oppenheimer, felt that such a schedule—and perhaps the idea of nuclear flight itself—bordered on lunacy. They proposed that an orderly technical program be integrated into the rest of the AEC's reactor research, where high-temperature materials would evolve in due course. The state of reactor physics and materials science was then far too primitive. Applied research should come before any flight plans.[5]

To help settle the matter, a group of experts convened at MIT in 1948 to evaluate the feasibility of the airplane project. Known as the Lexington Project, the group predicted that the project would consume at least a billion dollars and fifteen years before all of the theoretical problems were solved and an airplane flew. It also noted that in fifteen years guided missiles might make an atom-powered bomber obsolete.

Instead of drawing together, the antagonists each emphasized different parts of the Lexington Report. The Air Force liked the sentence saying there was "a strong probability that some version of nuclear-powered flight can be achieved." The scientists and budget managers pointed out the report's warning: "It is to be expected that crashes may occur, and the site of a crash will be uninhabitable."[6]

The Air Force forged the political alliances needed to overrule the scientists. It was a poor start for a complicated project, because the scientists also had their allies, and the two sides remained in a state of tension throughout the 1950s. The Air Force team included the airplane manufacturers and the members of the JCAE. The scientists' allies were the Bureau of the Budget and Eisenhower's Secretary of Defense, each of which, for its own reasons, tried to keep military budgets under control.

Throughout the 1950s, one or the other side in this conflict was ascendant in Washington, and neither side remained in the saddle for long. Therefore, the specific objectives of the ANP mission changed frequently. In the field, scientists complained that this was no way to run a technical program. Money either flowed copiously from Washington or it dribbled out, choked and stinted. Idaho supporters of the NRTS observed this and learned a valuable lesson.

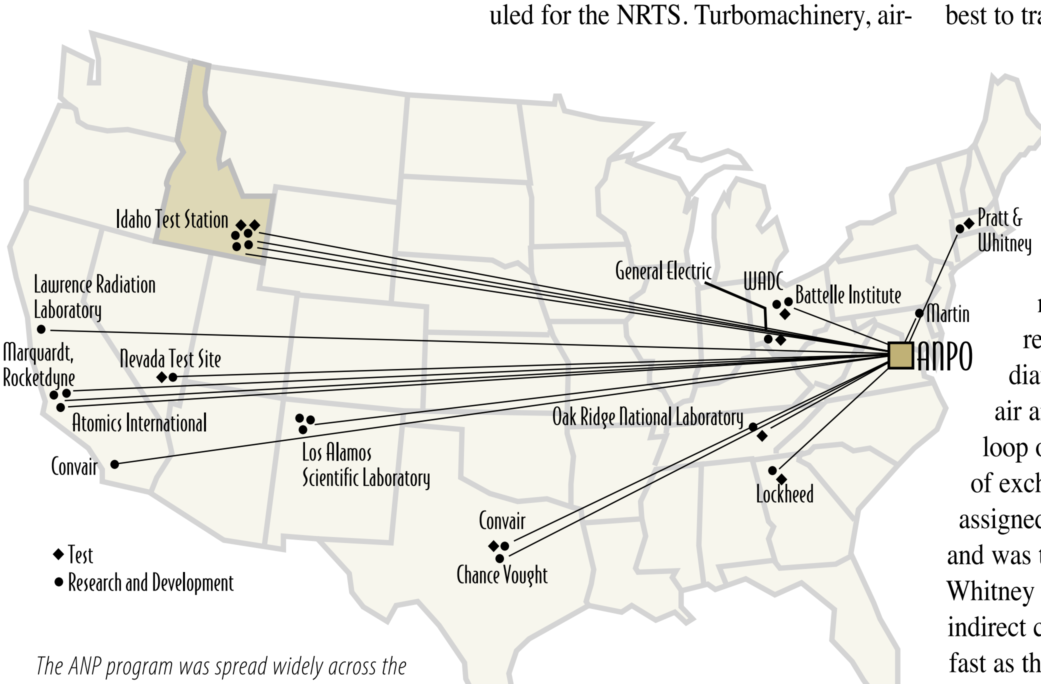
One of the policy shuffles occurred in 1953. Rumors reached Idaho Falls in May that the AEC was preparing to suspend the program and reduce its budget in Idaho. The AEC was now spending millions of dollars a year in Idaho and was fast becoming the largest employer in the state. Fat construction payrolls were extra fodder for the growth machine. Retrenchment was unthinkable.

The program survived, but in the face of the airplane's shiftable fortunes, the political and economic leaders in southeast Idaho now realized that the NRTS could shrink as well as grow. Old 1949 views that AEC decisions were based purely on technical grounds were thoroughly discredited. To defend and nurture its federal growth machine, the region needed an insider. Idaho needed representation on the JCAE itself. Idaho senator Henry Dworshak looked for his chance and wrote, with some understatement, to a senate colleague in 1956 that "there is sentiment in my state for me to sit on the Joint Committee on Atomic Energy." Upon his appointment, southeast Idaho was well pleased.[7]

Not all the Washington money for the ANP program was spent in Idaho. Pieces of the project were flung all over the nation. Engineers had conceived two approaches for the airplane's propulsion system, and only the ground tests for one approach were scheduled for the NRTS. Turbomachinery, airframe, shielding, and other studies took place in many other states.

In a conventional airplane, the combustion of chemical fuel produces heat. Hot compressed air passes through a turbine and is exhausted through an opening (nozzle) at the rear of the aircraft, providing thrust in the opposite direction. The function of a nuclear reactor was to produce heat, replacing the combustion chamber. It would have to fit within an airframe and generate extremely high temperatures. Shielding to protect the crew had to weigh as little as possible, or the plane couldn't get off the ground. The reactor and turbomachinery materials had to perform reliably amidst extreme heat, compression, and stress.

A key engineering problem was how best to transfer the heat to the air. In the "direct cycle" approach, compressed air would flow through the reactor and absorb heat directly from the fuel elements. It would then pass through the turbine and be expelled through the nozzle. By contrast, the "indirect cycle" provided an intermediate heat exchanger between the air and the reactor, using a closed loop of liquid metal as the medium of exchange. The direct cycle was assigned to General Electric in 1951 and was to be tested in Idaho. (Pratt & Whitney of Massachusetts undertook the indirect cycle, which didn't progress as fast as the direct cycle testing.)[8]



The ANP program was spread widely across the nation, with the ANP office in Washington, D.C.

GE built a huge laboratory for the project in Evendale, Ohio, where it designed the reactor and the experiments that would run in the remoteness of Idaho. A new set of home-lab scientists began traveling to Idaho Falls, sometimes on a C-54 aircraft officially called "Site Flight" and unofficially, "Slite Fright."[9]

Courtesy of Wright-Patterson Air Force Base

Major General Donald Keirn

Donald Keirn, the earliest promoter of the project, was now a major general and the director of the program. He sent Air Force liaison officers to each field laboratory, including Idaho, to monitor progress. The Air Force desired to be as independent of its NRTS landlord as possible and declined to use most of the IDO's central services. Autonomy was important. Secrecy was important. Planners wanted plenty of room to expand. They would need to build a runway, for example. Although the purpose of the project was known to the public, the goal was to produce a weapons delivery system. Technical work was classified. GE wanted to be as distant from everyone else at the NRTS as possible. GE manned its own fire station, provided its own food service, supplied its own security force, and built its own fabrication shops and health physics labs.[10]

So the IDO opened up Test Area North (TAN), thirty miles northeast of Central. Lincoln Boulevard cut a new ribbon of asphalt across the desert, and State Highway 33 connecting Arco, TAN, Mud Lake, Terreton, and Rexburg took on new importance. The first phase of the project was called Initial Engine Test (IET), and the mission was simple: prove that nuclear heat could run a turbojet engine. The tests involved a modified J-47 engine, but no airplane and no flight.

The big difference between this reactor and all the other reactors then at the NRTS was that it was mobile. Contaminated air could not be allowed to blow out the nozzle indoors—or near work areas. Rather, the reactor-*cum*-engine traveled back and forth between an assembly area and the test pad, a distance of a mile and a half. A man driving a shielded locomotive hauled a dolly carrying the eighty-ton assembly on four-rail tracks. At the test pad, the engine connected to a "coupling station" where the exhaust was filtered, went up a 150-foot stack, and was released to the open air.

After the first test, the test engine assembly would become a mobile radioactive hazard. This situation called for a new safety philosophy: place the shielding around people rather than around the reactor. Thus, the IET control-room building and its entrance were well shielded. Near the test pad,

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The IET in 1957. The reactor-jet engine assembly was sheltered in the mobile aluminum building. Exhaust went through the horizontal pipe to the stack. The control building is buried under earth shielding.

the control room was an elaborate bunker, its walls and ceilings made of thick reinforced concrete and covered with earth. Remote-control techniques connected dials and switches to leads for fuel, air, water, electricity, and monitoring devices.[11]

The first Heat Transfer Reactor Experiment (HTRE-1), "Heater One" in informal parlance, proved it could go critical on November 4, 1955, not yet attached to an engine. The enriched uranium fuel was clad with nickel-chromium. Water was the moderator and coolant. The engineers made no attempt to restrict the size or weight of the assembly or to approximate a flight version. The assembly was deliberately large so that crews could easily install monitoring devices and instrumentation.[12]

On December 30, 1955, HTRE-1 sat on its dolly at the test pad. The locomotive driver had taken cover. Inside the bunker, the scientists had checked and double-checked all systems. The engine began operating on chemical fuel. Operators gradually withdrew the control rods, taking the reactor critical. As the temperature rose, an automatic sensor closed the chemical fuel valve. The contraption worked. For the first time in the world, the heat of fissioning uranium alone powered an airplane engine. The GE test team had proven the principle. They cheered each other, buttoned up, and went off to celebrate at the nearest bar, which was ten miles away at Mud Lake.[13]

The test results went out to the rest of the ANP network. The reactor had produced more gamma radiation than expected. Oak Ridge, the scene of the major shielding research, considered the implications: additional shield weight would have to burden the aircraft unless ways could be found to reduce it. Experimentation with the HTRE-1 reactor, its fuel, and the engines continued. With this initial success, it was reasonable to plan the next phase of the Idaho program: an airplane hangar, a runway, and most obviously, an airplane.[14]

GE and the Air Force were imagining war-time scenarios: Suppose the bomber penetrates enemy territory and drops its payload of atomic bombs. Perhaps it takes a hit. Crippled, trailing contaminated exhaust, it nears the United States. What was the best route to Idaho? GE's chief HP, Carl Gamertsfelder, considered the implications.

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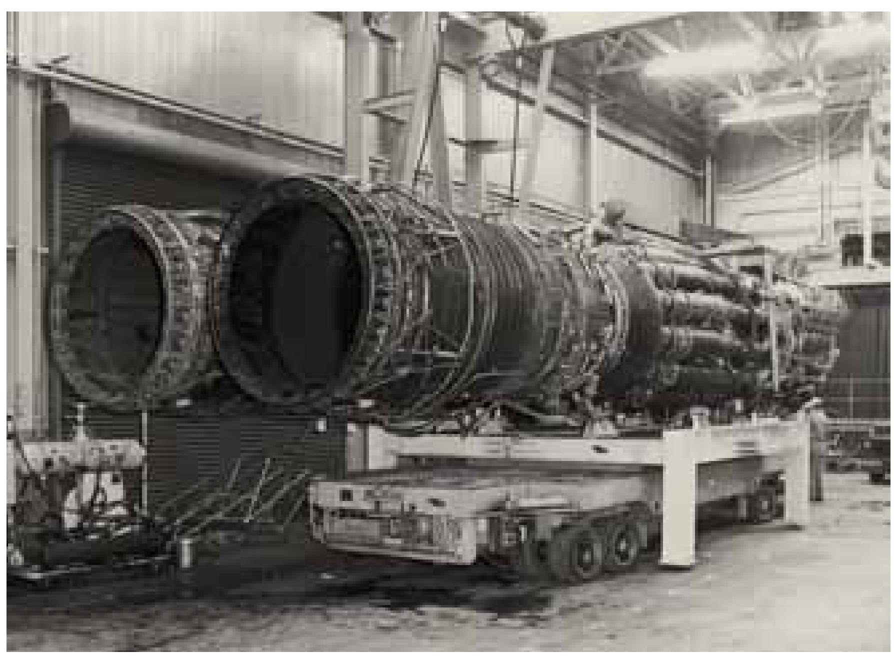
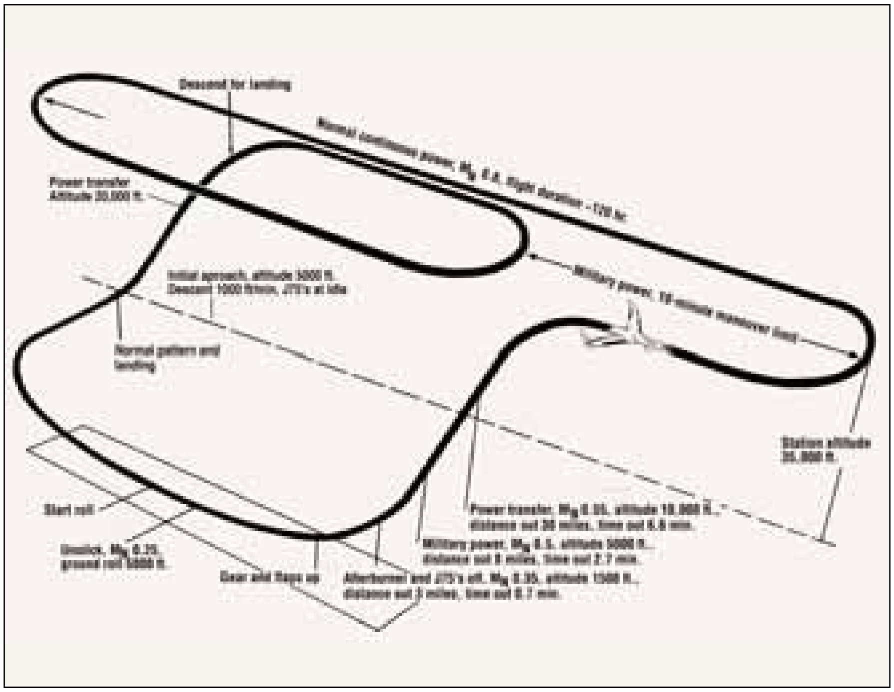
Right. TAN Hot Shop just after completion in 1955 and before operation began. Below. Jet engine before assembly with reactor.



Courtesy of General Electric Aircraft Engines Division



APEX-901

Above. Typical mission profile envisaged by U.S. Air Force for a nuclear-powered aircraft flight. Below. HTRE-3 components: reactor shield, single chemical combustor mounted behind the reactor-shield assembly, two modified J-47 turbojet engines, and interconnecting ducting.

Courtesy of General Electric Aircraft Engines Division

The mission was...to fly [reconnaissance] around Russia... If necessary, they would come in, dive down low, deliver a few bombs in strategic spots and leave. And then come back [to the American coast], turn off the reactors [to] let them cool off some, and fly through a corridor [on chemical fuel] back to our site.

We looked at population densities along the [possible corridor routes]. The airplane would have been escorted in [and] escorted out. [If it crashed] we would have been able to dump tons and tons of foam, things of that kind... This was during the Cold War. People were serious.[15]

During 1955 and 1956, the Air Force was ascendant once more in Washington, so "Fly early" was the order of the day. If for no other reason than to invent and rehearse the procedures on the ground when an airplane returned from its mission, GE needed a special hangar—a Flight Engine Test (FET) facility. The power plant inside the airplane, crippled or not, would somehow have to be removed from the airframe and taken to GE's huge Hot Shop, disassembled and studied, repaired or replaced. Hangar crews would have to handle the ordinary maintenance of a hot airplane, not only its nuclear features. Such problems as extracting crew members from their shielded cockpit without exposing them to a gamma field had to be solved. Nothing about nuclear flight could be taken for granted. Money flowed, and NRTS construction payrolls bulged again.[16]

Meanwhile, HTRE experiments continued, but reactor fuel and materials had a long way to go. GE wanted to irradiate fuel elements in the MTR, but they were too large to fit in the MTR's test holes and the ETR was not yet ready. So GE retooled the HTRE as a materials test reactor. Machinists drilled a hexagonal space in the center of the reactor. GE called it HTRE-2. The hole was a generous eleven inches wide across the sides of the hexagon. Physicists inserted various metals and fuel elements, subjecting them to neutron flux and temperatures up to 2,800 degrees F. for sustained periods of time. Their work moved high-heat reactor materials into the realm of ceramics.

Moving closer to its flight objective, GE built a completely new experiment. HTRE-3 operated between September 1959 and December 1960. The engines and the reactor were arranged horizontally, more typical of an aircraft, and had a flight-type shield. The reactor vessel was double-walled, with a gap of about seven inches between the two walls. When the reactor was running, operators filled the space between the two walls (the annulus) with water, which acted as a moderator and a shield. Richard Meservey, an instrumentation engineer, recalled how the operators managed to conduct numerous tests in fairly rapid order.

As soon as a test was finished, they drained the water from the annulus and pumped the space full of mercury. Mercury is a high-density material, and it made a great shield. It allowed the workers to climb back up on the assembly sooner to change out the instrumentation or make other adjustments. The mercury reduced their exposure. They didn't have to wait for the short-lived isotopes to decay away. As soon as they were finished changing the instruments, they would drain out the mercury and pump water back in. Then they'd haul the reactor back down the track to the coupling station and run another test.

We had three-quarters of the free world's supply of mercury here at the Site at one time. We had so much, that when the program was over, we had to release it slowly back on the market so that it wouldn't cause an economic upheaval. It wasn't radioactive because the mercury wasn't in the annulus when the reactor was running, so it wasn't irradiated.[17]

The HTRE-3 experiments eventually ran two turbojet engines at a time at 2,000 degrees F. In December 1960, the experiments hit another milestone when the reactor started the engines without the help of any chemical fuel at all.[18]

All GE tests involved IDO's Health and Safety personnel because the exhaust releases affected territory beyond the GE fence. Each time the jets operated, argon and other constituents of the air passing through the reactor became radioactive. Fuel elements occasionally ruptured or melted, discharging fission products. Some tests imitated accidents by deliberately blocking the flow of air to fuel elements, which also caused releases. The HPs collaborated with the U.S. Weather Bureau and defined the meteorological conditions under which each test could run. The Air Force chafed under this regimen and regarded John Horan, Dr. Beard's successor, as far too conservative. Horan recalled:

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Above right. Shielded locomotive with turntable in background. Snow plow in front. Right. Looking east past the railroad turntable toward doors of ANP Assembly and Maintenance Building.

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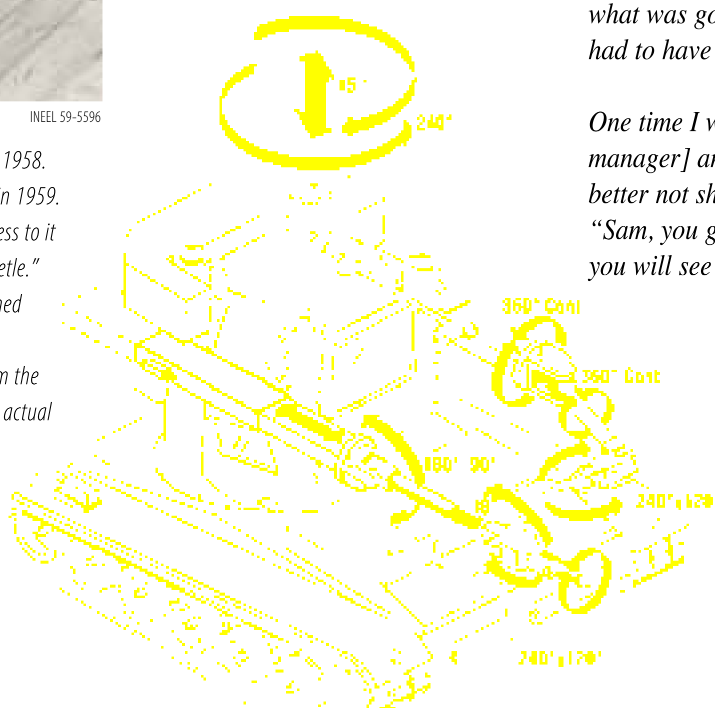
Above. The hangar under construction in 1958. Middle. The hangar as it was completed in 1959. Control building is shielded by earth. Access to it was via a shielded tunnel. Right. The "Beetle." This manned, shielded vehicle was designed for use in the hangar. Its purpose was to remove the reactor and power plants from the aircraft mockup, and eventually, from an actual aircraft. It was never used in Idaho, but moved to the nuclear rocket program.



We had a captain from the Air Force out there [at TAN] in charge, and periodically he would call me in town when we would not allow them to start up [because] the meteorology wasn't right for them to be running. He would...say, "I'm sitting here in my office looking out and the flag is in the right direction and it is standing straight out and exactly meeting your conditions."

I'd reply, "I'm sorry, but that is not the situation at 150 feet, where the effluent will be released."

The Air Force appealed unsuccessfully to the AEC operations office at Cincinnati for relief. Horan continued:

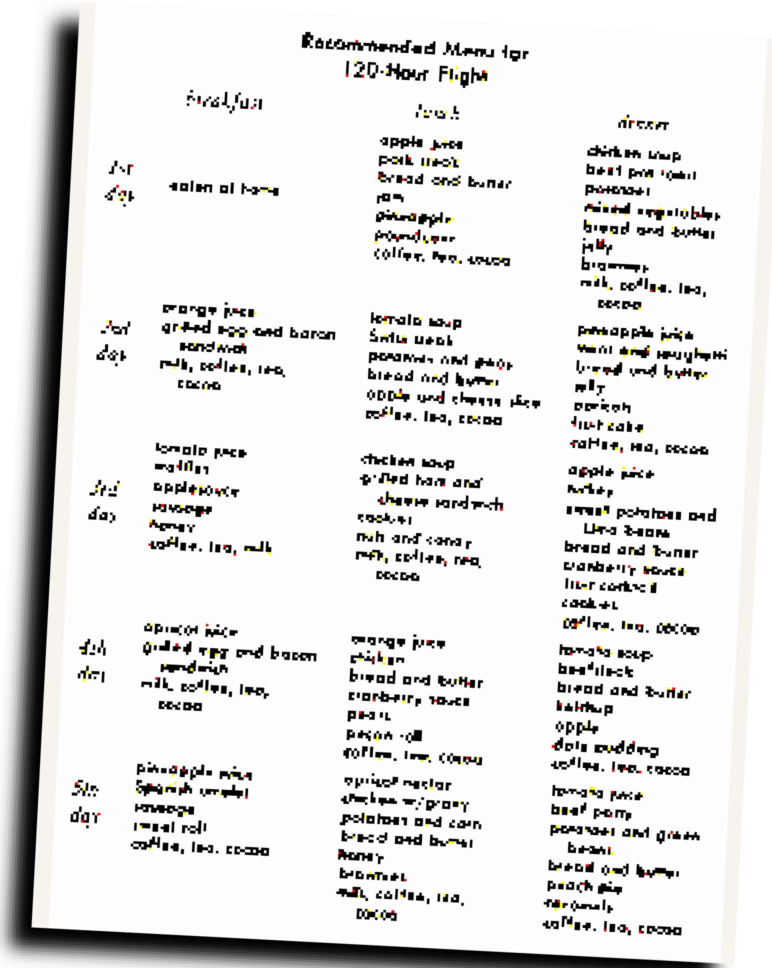
We told GE that they couldn't plan on using their full 500 mR exposure off-site. We said, "You're allowed ten percent [of that]." To the public, the NRTS was one site, and we interfaced with the public, not Cincinnati. We had to know what was going up the stacks, and we had to have shutdown authority.

One time I was in the office [of the GE manager] and he said, "By God, you better not shut us down." And I said, "Sam, you give us a reason to do it, and you will see it'll be done."[19]

The $8 million hangar was finished in July 1959. The graceful barrel-vaulted building had a clear space of 320 feet by 234 feet. The designers figured the plane would weigh at least 600,000 pounds. It would reach 135 feet from wing tip to wing tip, be 205 feet long and 53 feet high or higher at the tail.[20]

Plans for the runway showed a strip 23,000-feet long—over four miles. Perhaps survey stakes went into the ground, but GE never built it. The AEC decided in December 1958 that neither the NRTS nor any other AEC installation would be used for an ANP flight test site. Despite the millions invested in the hangar building and its shielded control room, the wasted money was "more than outweighed by the potential risks involved." The AEC told the Air Force that nuclear test flights would have to originate from an island or coastal station and fly only over the ocean.[21]

Still, in 1960 the Air Force was confident that the hangar would be used for a prototype aircraft. It could be ground-tested in Idaho before it was hauled overland to a coastal base for flight tests. In Evendale, GE mocked up a compartment for a five-person bomber crew: commander, nuclear engineer, bombardier-navigator, defense director, and co-pilot. Located far forward in the airplane as distant as possible from the reactor, the shielded cabin contained a kitchen, work room, and sleeping quarters so detailed that they included a ventilated drawer for stuffing dirty underwear. Dietitians planned a nutritious five-day menu down to the peach pie for the fifth-day dessert.[22]

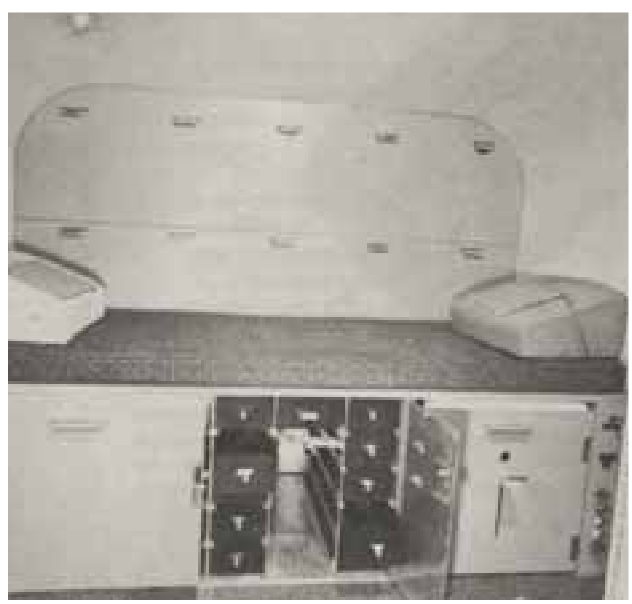


Recommended Menu for 120-Hour Flight

	Breakfast	Lunch	Dinner
1st day	eaten at home	apple juice pork steak bread and butter jam pineapple [illegible] coffee, tea, cocoa	chicken soup beef pot roast potatoes mixed vegetables bread and butter jelly brownies milk, coffee, tea, cocoa
2nd day	orange juice grilled egg and bacon sandwich milk, coffee, tea, cocoa	tomato soup Swiss steak potatoes and peas bread and butter apple and cheese slice coffee, tea, cocoa	pineapple juice meat and spaghetti bread and butter jelly apricots fruit cake coffee, tea, cocoa
3rd day	tomato juice waffles applesauce sausage honey coffee, tea, milk	chicken soup grilled ham and cheese sandwich cookies fruit and candy milk, coffee, tea, cocoa	apple juice turkey sweet potatoes and lima beans bread and butter cranberry sauce [illegible] cookies coffee, tea, cocoa
4th day	apricot juice grilled egg and bacon sandwich milk, coffee, tea, cocoa	orange juice chicken bread and butter cranberry sauce pears pecan roll coffee, tea, cocoa	tomato soup beefsteak bread and butter ketchup apple date pudding coffee, tea, cocoa
5th day	pineapple juice Spanish omelet sausage sweet roll coffee, tea, cocoa	apricot nectar chicken w/gravy potatoes and corn bread and butter honey brownies milk, coffee, tea, cocoa	tomato juice beef patty potatoes and green beans bread and butter peach pie [illegible] coffee, tea, cocoa

From *Nuclear Flight* edited by Lt. Colonel Kenneth F. Gantz

Above. Design of crew compartment for airplane took place in Evendale. Sleeping, storage, and relief facilities are integrated in a 36-sq.-ft. space. Two full-size beds permit simultaneous sleeping of two crewmen. Clothing and personal articles are stored in individual lockers above the bed. Right are containers for soiled clothing. The pull-out electric incinerator toilet is at the lower right and the second bed, a pull-out berth, is at the lower left.



From *Nuclear Flight* edited by Lt. Colonel Kenneth F. Gantz

The Idaho hangar reflected equal attention to detail. The shielded locomotive would tow the airplane inside on the four-rail track. Using remote controls from a bunker next door, operators would draw the plane abreast of a coupling station similar to the one at the test pad. The crew would slip from the cockpit through a hatch shielded with lead bricks and descend to the basement below. They would make their way through a maze of tunnels to a changing room, shed their contaminated clothing, shower, and submit to medical examinations and mission debriefings. Eventually, they would emerge in the control room. Back on the hangar floor, remote manipulations would lower the entire power plant to the floor of a platform elevator and it too would go below, its first stop before remote transport to the Hot Shop. A shielded window gave visual access into the hangar, and a side door leading to the control room was protected against accidental explosions or criticalities by a "shadow shield," a concrete barrier four feet thick intended to block gamma radiation from passing into the control room hallway.[23]

In January 1961 John F. Kennedy became president. Eisenhower already had suggested that either the direct or indirect approach to the airplane be canceled, greatly alarming the ANP corner of the "military-industrial complex." He never said which approach, and everyone expected Kennedy to make the choice.[24]

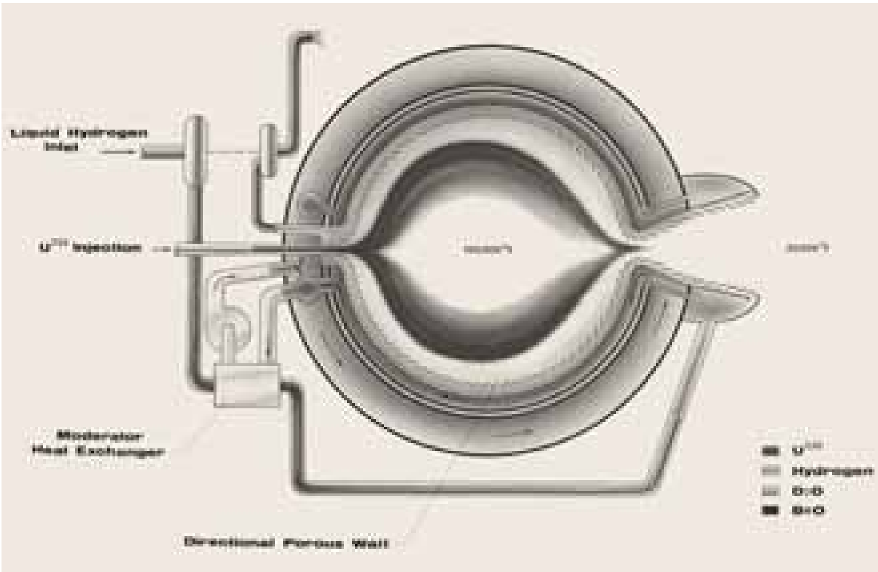
It had been fifteen years since the end of World War II, and as the Lexington Report had predicted, $1 billion had been spent on the project. But the airplane had not materialized. Supporters said reactor experiments were "on the threshold" of significant new progress; all the program needed was "less than one-fifth of one billion dollars" and a plane could fly in 1963. At the same time, the range and accuracy of guided missiles had greatly improved.[25]

The JCAE still felt the sting of Sputnik, the Soviet Union's successful September 1957 launch of the first satellite to circle the globe. Putting an atomic plane into the air before the Soviets could do so offered great psychological appeal. The JCAE was under no illusion that the promised 1963 airplane would be combat worthy. It would be a slow-flying subsonic showpiece with no function but to be the first.[26]

But the old coalition of doubters had heard such promises before, and they had the ear of the new president. Besides, Kennedy had ideas of his own. Eisenhower's years of budget cutting had eroded conventional defense capability to the point that the Army had only eleven combat-ready divisions, a shortage of ammunition, and low airlift capacity. In order to provide tactical air support for the Army, the Air Force admitted it would have to borrow ordnance from the Navy. Kennedy wanted more flexibility to take the initiative, realizing that a Third World existed, where the struggle against communism required political and economic initiatives. The nation needed a capacity to make limited responses—more missile-firing Polaris submarines, more Minuteman rockets, more guerrilla-warfare capability—not just a massive atomic arsenal.[27]

On March 28, 1961, Kennedy canceled the entire airplane project, saying, "the possibility of a militarily useful aircraft in the foreseeable future is still very remote..." He also canceled the Army's Nike-Zeus anti-missile missile and the Air Force's B-70 bomber, both unproven technologies.[28]

Kennedy made the cancellation effective instantly. Stunned, southeast Idaho flooded Senator Henry Dworshak with telegrams. Idaho Governor Robert Smylie wrote directly to President Kennedy, warning him that the loss of ANP's 500 jobs would be a blow to Idaho of "disastrous proportions" and



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Above. Gas-core nuclear rocket concept. Uranium-235 gas is in the center like a bubble. Hydrogen flows around the uranium, heats up, and exits the core through a small opening, providing thrust.

asked for some replacement research that would keep the jobs in Idaho.[29]

At TAN, the Idaho Falls *Post-Register* reported, employees were "thunderstruck." One of them was Jay Kunze, an ANP physicist and engineer.[30]

There were employee meetings, and the word got out immediately. I was shocked. I had started with GE in 1959 and had a new baby and a new house. Now I was out of a job! I was scared stiff. But GE had a history of never laying off an engineer. The company kept about a hundred of us in Idaho...and sent others to San Jose or GE facilities elsewhere.

Eventually, we got into space electric power and worked on a thermionic reactor, in which the fuel elements were thermionic cells. The fuel gave off electrons to supply heat. Then Phillips experimented with the "710," a high-temperature reactor for rocket propulsion. The concept never went into operation.

Later, we investigated another concept for NASA rocket propulsion. This was for a manned mission to Mars. NASA hoped that a one-year mission to Mars using chemical fuel could be reduced to three months on nuclear fuel. It was a cavity reactor, a sphere about twelve inches in diameter. In the center was the fuel, uranium hexafluoride, which above room temperature, is a gas. Hydrogen would flow around the chain reaction in the fuel, heat up to temperatures up to 20,000 degrees F. and exit through a small nozzle, providing thrust.[31]

Thus, some replacement research came to Idaho. The new work made some use of TAN's empire of buildings. The hangar had never been used. The government had poured over $41 million into the Idaho ANP buildings and facilities through 1961. NASA put on hold its plans for a manned mission to Mars, so the Cavity Reactor and the other space-related reactors were shut down in the early 1970s. The vacant TAN facilities went up for rent, a testimonial that the NRTS, no matter how brilliant its scientists and engineers, could not control its destiny when the political winds of Washington blew across the desert.[32]