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Chapter 6

SOME VIGNETTES FROM AN EARLY ROCKETEER'S DIARY: A MEMOIR*

Bernard Smith
as told to Frederick I. Ordway, III†

THE EARLY NINETEEN THIRTIES

When the Great Depression of 1929 appeared, those who had been living in real or imagined affluence suffered a catastrophic change in lifestyle. The rest of us hardly noticed any difference. But, years of staying alive by doing odd jobs wore thin; everything seemed likely to remain at subsistence levels forever. Having much time to spare I used the free New York City libraries and museums for all they were worth to store in my memory as odd a collection of pseudo-scientific smatterings as ever led a naive youth into believing a better world existed.

Where was it? Certainly not on this planet. At this point we come to the psychological counterpart of the continental divide and the watershed effect: an announcement that the American Interplanetary Society would hold one of its meetings in the American Museum of Natural History. There it was: the means for going to a better world wherever it existed. And that is how I came to join the ranks of yesterday's pioneers of the future.

The American Interplanetary Society was pulled together by a number of science fiction writers who believed that interplanetary travel was imminent, needing hardly more than a few mechanics to put things together. They did indeed have a mechanic in the body of H. Franklin Pierce who was assisted by perhaps a dozen members dedicated to the task of determining how Pierce could do the work of thirteen men. When events did not proceed fast enough, the members entertained the notion of changing the organization's name to the American Rocket Society (ARS), since interplanetary travel might take awhile. I came on the scene at about this time, when G. Edward Pendray took over the leadership. He had returned from a tour of European interplanetary societies, had put the American Society on a more rational basis, and had helped to run some furtive static tests of liquid fuel motors patterned after German models.

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I attended one meeting late in 1932 where much of the above was reviewed, thrilled to overflowing with what was going on but too timid to voice all the ideas popping into my head. When it was over, I caught Pendray's eye and suggested a way of salvaging the components of a rocket damaged in earlier static tests. Ed Pendray was never one to overlook any opportunities. One thing led to another and before I knew it the components were in my hands to be reborn Phoenix-like from the old ashes. Ah, the exhilaration of those days! They will never be recaptured. We were just a few optimistic individuals attempting to do on a shoestring what no one today seems able to begin without enormous subsidies and thousands of trained technicians.

And how was I prepared to undertake this grandiose project of building ARS No. 2? In the best possible way. I had a grammar school diploma, I had done some locksmithing, tinsmithing, and iron mongering. I had won a prize for sculpture at Cooper Union in New York City and knew something about using the Pythagorean Theorem as well as solving a quadratic. Not until later was Pendray aware of this splendid background--otherwise he may have had second thoughts about the whole assignment. When he realized what he was into, he wisely decided to become my mentor; and when life became too tough for me, he often created some work around his home in Crestwood where I could live and earn some money.

The best description of the rocket's construction was to say that it was "accumulated." The cowl over the motor was carefully and accurately fashioned from a discarded aluminum coffee pot; the turn-on valves were gas-cocks liberated from an old cooking range; the fins were pieces of balsa wood begged from someone who had some scraps. And so it went, looking more like a rocket from week to week. There is not much purpose is going to more design detail which is covered elsewhere. In the light of today's knowledge much of the design approach was erroneous. Putting the rocket nozzle ahead of the C. G. did nothing to improve stability, nor did placing the fuel orifice near the nozzle throat produce an aspirating effect. Fortunately, these mistakes were not catastrophic.

Finally came the great day at Great Kill, Staten Island. Pendray saw to it that everything was legal so he could invite the press and the newsreel photographers. I believe ARS members John Shesta and Carl Ahrens were responsible for the launcher. They set it up pointing a bit to seaward to ensure some remoteness to the rocket's return. Pendray and I were responsible for mounting and loading the rocket and I was honored with the privilege of turning on the fuel cocks.

The firing procedure was as follows: After the gasoline and liquid oxygen tanks were charged and closed, a stick was slid into a horizontal slot cut into the cock handles. The outer end of the stick was fastened to a lanyard that stretched to the firing pit. I had designed the handle to hold the stick until the lanyard had turned the cocks a quarter turn, whereupon the stick would fall away. With everything in readiness a gasoline-soaked rag placed under the nozzle was ignited and everyone ran to the pit to watch me pull the lanyard. But the angle of pull was not quite right and the stick fell away before the cock was turned. My professional reputation being at stake I knew what I had to do. I ran back to the launcher, replaced the stick, reignited the rag, payed out the lanyard in the right direction and pulled it, thereby becoming on 14 May 1933, a day before my 23rd birthday, the first lad in America to publicly launch a liquid fuel rocket.

Judging by the criteria exercised decades later at Cape Canaveral, wherein any rocket that rose at least six inches off the pad was pronounced a success, this one was a resounding achievement. It rose a couple of hundred feet before it exploded. A man in a rowboat offshore saw it fall and retrieved it for us in triumph. Good thing the fins were of balsa; otherwise it would be at the bottom of Lower New York Bay to this very day.

During the post mortem it was pointed out that I could have gone up instead of the rocket. In helping Pendray with the Lox, both he and I were steeped in the concentrated oxygen vapors which had permeated our clothing and therefore I was in more jeopardy than I knew when I replaced the stick near the burning rag. I explained my action by saying that I dreaded doing a lick more work on that rocket and wanted to see it disappear off into space so I would work on the next one. Ah, yes, the next one. . . .there is always the next one to light up one's eyes.

Next, came three rockets proposed by teams. Pendray and I comprised one of the teams. We had a great time jockeying for position with the others; yet despite the spirit of competition, we helped each other on every occasion. Shesta, who headed another team, often machined experimental parts for me. And Nathan Carver, yet another competitor, made available to me work space in a loft he had rented. However, getting started was difficult for all of us and more than a year passed before we had anything to show for our troubles.

The agonizingly slow progress of ARS Rocket No. 3 set my mind going in another direction, one that I hoped would be less inhibited by the outside world. I began to fiddle around with air breathers requiring less esoteric materials and processes. To the great cause of science I sacrificed a gasoline blow-torch which was useful on many an odd job. Nothing was too sacred to offer up to the advance of knowledge. I redesigned the components and mounted them on a vertical pivot such that the whole business could revolve in a horizontal plane (Figure 1). After some adjustments I was able to make that machine turn at a fair slip, spewing hot flame in all directions.

Pleased with myself, I offered to demonstrate my "blow-torch" motor the next time the Society met at Pendray's home in Crestwood. On the appointed day we gathered in his garage around my machine as I prepared to prime it for firing. This consisted of soaking the nozzle and preheating coils with copious amounts of gasoline and lighting up. During this operation I could detect the quiet exit of certain science fiction writers who will remain unnamed. But Pendray was steadfast, even when the burning gasoline dripped over his garage floor. When the motor settled down to a steady state everyone returned to see the fiery display and to conclude that the device did not have enough thrust to lift its own weight. Ever after Pendray proclaimed this to be the first firing of an "Athodyd" (ramjet). But no question about it: I was a menace to New York from the Bronx to Staten Island!

Shesta's rocket, ARS No. 4, was finished first and was fired in September of 1934 at Great Kills. It had four nozzles up front pulling the tanks between them, one behind the other. It went up, burned out a nozzle and looped back into the bay. Mine, ARS No. 3, was readied for firing in the same place later that month. The firmed-up design now consisted of a blast chamber leading into a long nozzle about which was wrapped, consecutively and concentrically, a gasoline tank, a nitrogen pressure tank, and a Lox tank. I reasoned that a form of regenerative heating and cooling would take place through the conducting walls. The hot nozzle would keep the gasoline from being frozen into mush by the Lox and the cold gasoline would keep the nozzle from melting; something like boiling water in a paper bag over a flame, the flame keeping the bag from becoming water-soaked and the water keeping the flame from burning the paper. A beautiful theory, but we never found out how it worked; all that aluminum acting as a heat sink was our undoing.

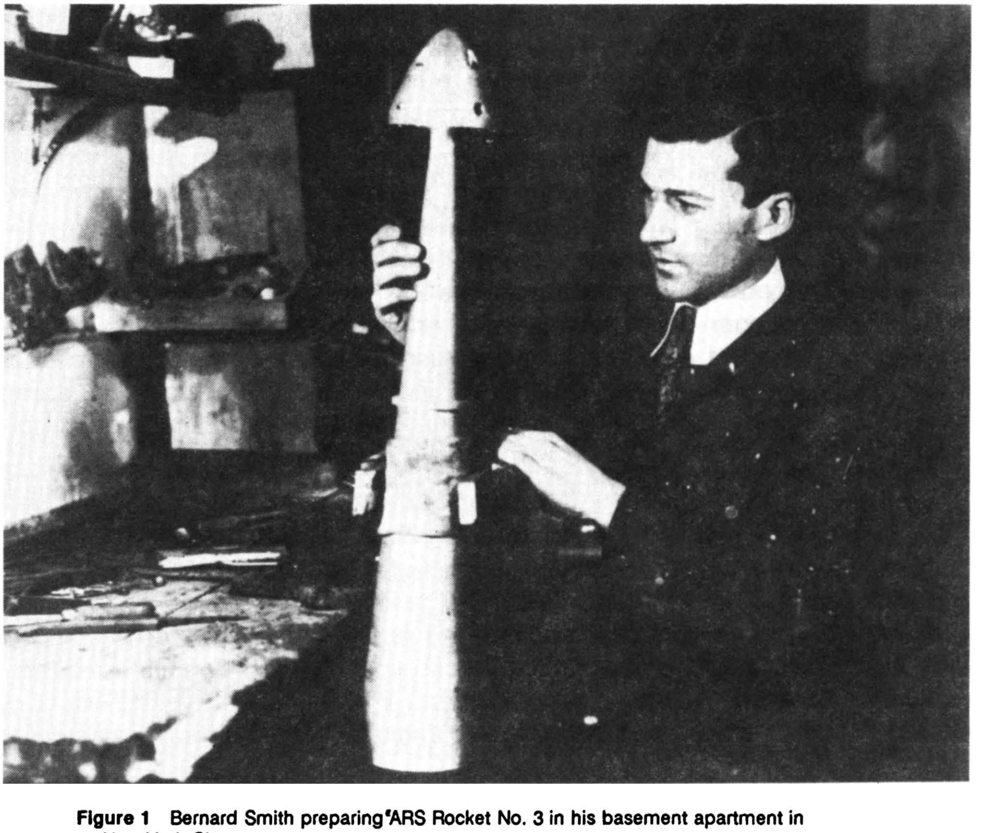

Figure 1 Bernard Smith preparing ARS Rocket No. 3 in his basement apartment in New York City.

No one, least of all I, foresaw the difficultly of filling the oxygen tank on that frustrating day in September 1934. The fill hole was simply too small. As fast as Pendray poured Lox into it the boiled-off gas came out. It was impossible to cool the uninsulated tank fast enough to hold liquid oxygen. The test had to be aborted to everybody's disappointment. I don't know why I didn't go back to the drawing board when in retrospect it would have been logical to cut a larger fill hole and add a bit of blanket around the oxygen tank, to be left behind at firing. The first and only test of that model was destined to be its last. In 1939, when I returned to the scene of the crime, I saw it on display at the New York World's Fair. The rocket and I had made our peace.

The failure of ARS No. 3 also failed to cure my rashness; in fact, it allowed failure to go to my head. My thoughts now centered on a scheme for fastening to the soles of my feet a low-thrust rocket motor connected through flexible hoses to fuel tanks held in my hands. I was convinced that the natural reactions of my feet would keep me erect if I should tilt in any direction, and hovering could be accomplished with the greatest of ease. I abandoned this notion before anyone could ridicule me when I realized that the "hot foot" motor would never become popular; nobody likes to stand on an overheated platform throwing all that dust. Twenty years later, William B. McLean, Technical Director at the Naval Ordnance Test Station, used a "house-broke" reacting platform to show that the correct foot response did indeed occur naturally.

The economic low point in New York occurred for me about six months after the ARS rocket No. 3 test. And so in the Spring of 1935, I seized an invitation by my uncle to come west and seek my fortune. I left to John Shesta in New York a graphite motor machined out of a giant furnace electrode. He tested it after I had gone and notified me that it blew up immediately after ignition. Years later, in California, I learned to make one that didn't blow up. So ended my early attempts to leave the planet from New York City.

Yet, as I moved westward from state to state on my way to California, schemes for accomplishing that end persisted. I dreamed of a track running up the side of an Andes mountain on which a tremendous booster would accelerate a space ship to March 3, at 20,000 feet (6,100 meters). Near the very peak the last two stages would be released and, with the Earth's easting, bring the ship to satellite velocity in the proper orbit. Long afterward, I read a Russian report describing a similar proposal. But I would not be in charge of a real satellite project until almost a quarter century had passed.

VALHALLA OF THE AMATEURS (1935-1948)

Entering the enormous overgrown village of Los Angeles in 1935 by way of Valley Boulevard, I came at last to the heartland of the Southern California Chamber of Commerce. The scenes I saw have been compared to the finest tourist haunts of the Holy Land, Egypt, the Riviera, Greece, Bermuda, and sometimes with California itself. Actually there is no comparison. Only at one point could you believe you were entering a foreign country - the port of entry at the California border where your belongings were searched by customs officials. However, if you came by air your belongings were untouched and thereby you lost even that illusion.

Shortly after arriving at my uncle's home in Los Angeles, I took evening classes in welding to bring my blacksmithing up to modern times, and in mining, to help me discover gold and oil. The first paid off handsomely in providing the means to a modest livelihood for the next twelve years. There was no payoff to the second except for a little gold dust laboriously panned in the San Gabriel Canyon, soon lost in debauchery. The real gold was in the welding and once I gathered enough skill, I was never out of work thereafter. Near the end of the first year in California, my progress in welding opened doors to design experiences and shop practices that served me well for the rest of my life.

Meanwhile rockets were still on my mind. John Shesta had written to request some conductivity tests on various metals if at all possible. He was not sure that conductivity through metals constituted the overriding characteristic; chemically attacked surfaces at high temperatures could change the picture. Obviously he was working with James H. Wyld on a regenerative motor wherein the liquid fuel itself would be used to cool the combustion chamber, although he did not say so. However, Shesta had helped me in the past and I was determined to help him now.

I designed and built a fixture that allowed an oxy-acetylene flame to pass inside a specimen tube while a jacket of flowing water bathed its outside surface. The tubes I collected were thin-walled, of the same diameter and wall thickness, mostly of copper, aluminum, steel and their alloys. The measurements were very simple. With the flame passing through the tube, a fixed quantity of water was run by gravity through the jacket and collected in a container at the outlet. A thermometer in the collecting container told the story. To check on the flow rate, each run was timed and, not surprisingly, was found to be the same. Much more to my surprise I found the heat transfer through the tubes differed by very little, probably attributable to the thinness of the tube walls.

I concluded that under the conditions stainless steel was about as good as any and probably the most practical. I passed the test results along to Shesta but never learned how it was used, if at all. Many years later, when I had occasion to visit Reaction Motors in New Jersey, where the regenerative motor was being manufactured for the Defense Department, he briefed me on its design. It suddenly stuck me that I had conducted the original tests incorrectly: The cooling water should have passed inside the tube and the hot blast outside, against half the wall. But I noted that the tubes lining the inside of his blast chamber looked suspiciously like stainless steel. Perhaps my small contribution was not in vain after all.

Sometime during the year of 1939, Robert Gordon, packing a membership card in the American Rocket Society, showed up at my front door to form a California Rocket Society. He had written to the American Rocket Society about his idea and they quickly assured him only one man was qualified to form it, namely me. Pretty soon even I came to believe it a grevious mistake. Nevertheless, we proceeded onward and upward and with a few announcements in the newspapers collected an increasing membership at monthly meetings, convened in the Los Angeles Museum near Exposition Park.

As president of the new rocket society, I supposed it was my responsibility to come up with rocket designs and to organize tests. And so I put together a number of small projects to keep the members constructively occupied. These were basically schemes for stabilizing and streamlining common black powder rockets and though they did little to advance rocketry, they did wonders for morale insofar as they delivered fire and smoke and other visible tokens of action such as the successful and gentle lowering of payloads by parachute (Figure 2). However, I suspected that this fiddling around would soon wear thin; the burning problem was reaching great heights, payloads had a habit of coming down by themselves anyway.

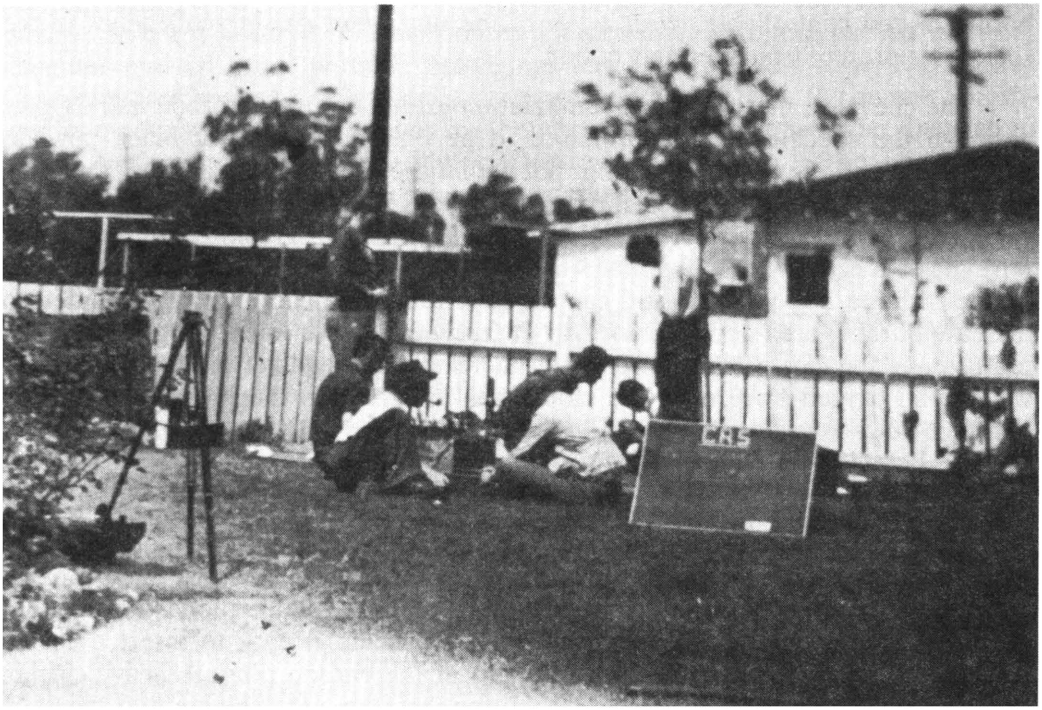

Figure 2 Members of the California Rocket Society preparing to fire a rocket to test a parachute-release device to recover the vehicle without damage, ca 1943.

We conducted our tests in the Arroyo Seco, a parched riverbed near Pasadena. So sure were we of success, we invariably let the press know about it. It was after one of these sessions that I came out with my most profound statement, one that is destined to ensure my undying fame. "Will these things ever be used in warfare?" one reporter asked. "Not at all", I replied knowingly. "Rockets were last used for warfare during the 19th Century, but they have since been superseded by projectiles fired from rifled guns, which are far more accurate. However, the rocket has excellent potential as a scientific instrument, for probing high altitudes and as an aid in meteorology. Only in that sense does it have military value." I think those reporters were pretty ignorant to be taken in by such a bald-faced pacifist statement when only a short distance away Franklin Malina and his crew at the California Institute of Technology were successfully developing military rockets for the U.S. Defense Department. To ease the reader's mind, I must state immediately that this was not the first nor the last time I was dead wrong as a result of ignorance in my own field.

Overstimulated by the conflicts in all the walks of life about me, I came at last to a rocket concept that satisfied the peculiar requirements of an amateur rocket society: the solid-fluid reaction motor, I reasoned, why not pass an oxidizing fluid over a reducing solid? A dense high-temperature solid without any oxidant admixture could only burn at its surface and therefore could never produce a large sudden explosive mixture, nor would there be a problem of pressure balance between fluid co-fuels. A single plumbing line could meter the fluid; thus the system was both safe and controllable. With a few of the more enterprising colleagues in the society we promptly pursued this notion.

The cheapest, most practical combination turned out to be carbon and oxygen, although the specific impulse promised to be only about that of black powder. More esoteric fuels were feasible but not within the society's scope of operations. I picked over a bunch of broken furnace electrodes in the Southern Pacific salvage yards and found exactly what I needed, a solid cylinder of graphite and another of pure massive carbon without voids. The graphite was machined to form a liner and nozzle inside a heavy-walled and capped steel tube. The carbon rod was fluted to increase burning area and machined to fit freely inside the liner. Oxygen would be fed through the cap as a gas; I reasoned there was no need yet to complicate tests with liquid oxygen since once the motor was in operation the liquid would gasify before it flowed over the hot plug.

We made everything ourselves including the test stand for measuring thrust. The remaining problem was ignition. I thought about packing black powder between the plug and the liner and inserting a piece of fuse cord. But this would be betraying my best friend, Gavin Calceron, who graciously allowed us the use of his backyard as a test site on my assurance that nothing would explode. Fortunately, the motor was to be tested upside down, which made it easy to insert a coated electrode through the nozzle against the tip of the carbon plug. A heavy current supplied by a bank of car batteries could bring the plug up to the ignition temperature.

By courtesy of the Fruehauf Trailer Co., I borrowed an oxygen tank, gauges and pressure hoses for the big event. With everything in readiness and a movie camera grinding away I inserted the electrode into the motor, waited a few seconds until I could spy a glow at the tip of the plug and withdrew with a signal to Gordon to turn on the oxygen. It worked with a roar! We could turn it on and off and regulate thrust at will! A great success but not perfect, for we soon found free oxygen in the exhaust which indicated insufficient burning area in the plug. Increasing the burning area then became the next problem, never really solved because the society was overtaken by other events.

At about this time the facts of life caught up with me. I was being bypassed by well-financed rocket activities in which I could not participate without more advanced training. Moreover, the society's members were as poor as I was and too many of them had interests bordering on the occult rather than on realities. The jig was pretty much up for rocket amateurs.

It didn't take much courage to decide that the only logical thing left to do was to get myself a different union card - a college degree. But no college would admit me without a high school diploma except Reed College, Portland, Oregon and then only after I had successfully passed about 18 hours of written examination. So I took the exams and one fateful day received notice that I was entered as a *special student*. In short order, I sold my house, liquidated all holdings, packed my wife, daughter and all other portable belongings into and onto my trusty Studebaker Champion and headed for Portland, in the late summer of 1944, to become a freshman in my 34th year of life. And so for the next four years I came under the wing of Dr. A. A. Knowlton, head of the Physics Department of Reed College; he approved my entry there and realized that it was his responsibility to get me through.

THE MAKING OF A PROFESSIONAL NEOPHYTE (1948-1959)

In my junior year, Knowlton was visited by a Dr. Loeb, a friend who was, I discovered later, a highly qualified scientist as well as a naval officer. He came to recruit scientists for the Naval Ordnance Test Station (NOTS), in California, a rocket and missile research, development and test center just established by the Navy in the middle of the Mojave Desert. Knowlton felt that because of my previous rocket experience Loeb should interview me for employment and arranged a meeting. I think Loeb was taken aback when he saw a gray-headed junior, but with recruitment not going too well he offered me a position as soon as I graduated. I promptly dismissed the whole idea, finding the thought of working for the military not too inviting. I didn't want to develop weapons; I wanted to develop high-altitude scientific probes. But fate had already ordained that I would get to the probes through the weapons. Knowlton bided his time.

Only because I was desperate for work did I apply for it at NOTS in 1948. At that time they were ready to take almost anyone with a diploma. Thus did two desperations join hands to form one contentment. And thus we see that oftentimes good decisions can be made during periods of quiet desperation. Wherever he is, Dr. Knowlton must be smiling over the unobtrusive way he steered me into channels that shaped the rest of my career. He was great, I miss him. I leave to the reader one of A. A. Knowlton's more profound statements. "The practicing physicist tries to reconcile concepts with precepts. He doesn't prattle too much about 'truth'".

I view my quarter century of research and development in the Navy as the most exhilarating time in my life. It began with instructions from a sailor at the landlocked Naval Ordnance Test Station to go "through the bulkhead, up the ladder to the next deck" for formal processing as a U.S. Civil Service rating GS-7 and ended a quarter century later with my retirement as a GS-18 with the creation of the annual Bernard Smith Award, for Navy professionals who have rendered their services in the face of great odds. The path from one to the other is strewn with projects covering the development of squibs, igniters, rockets, warheads, projectiles, torpedoes, guided missiles, sensors, fire control, launchers and guns--some of each for surface ships, for aircraft, for submarines, and many undertaken simultaneously. By the time I faded away hardly a combatant vessel in the Navy escaped being furnished with some equipment I invented, initiated, developed or managed to deployment. To screw up the density of activity yet another turn, throw in a satellite and a deep-space probe smack in the middle of my career and you pack into it enough excitement to last a few lifetimes.

A squib is a small device that converts electric energy into a thermal shock. This sets off a pyrotechnic chain serving purposes as far apart as blasting ore out of a mountain or launching a space rocket. My first job at NOTS was to replace the squib furnished reluctantly by the DuPont Company, which refused to specify what it was selling to the Navy and, moreover, served a notice that it would not fill any more orders after a certain date. I never finished the job. Before I had gone very far I was assigned responsibility for five rocket igniters, each of which was supposed to contain those selfsame squibs. By the second year, assistance on an anti-tank, shaped-charge weapon and an anti-air rod warhead were added to my duties. By the end of the third year, I was developing a ship-launched, nuclear-headed monster nicknamed "Big Stupe," and by virtue of some human kindness I was relieved of my other responsibilities, but only for the six months allotted to the project.

Big Stupe turned out to be a two-stage rocket containing a couple of tons (1,800 kilograms) of propellant. It weighed five tons (4,500 kilograms), making it the largest rocket ever launched to that time at NOTS. To help me as much as possible, I was given one boss and two assistants. Again in the spirit of helpfulness, my boss locked the four of us behind a secret door and never permitted anything to come or go unless it was covered with a black shroud. These measures aroused the curiosity of all 4,000 employees on the base and soon the children in the government schools at China Lake were drawing pictures of the secret weapon "Big Stupe." Nevertheless, the project went along smartly because there were so few involved. Six firings, each with successful second-stage separation, were carried out. Within a week of the last firing, the complete report was delivered in Washington exactly on the final project day. But our hasty little project successfully and unintentionally proved that for those times it was far too cumbersome to be used aboard ship. Today we launch with greater ease much larger missiles from submarines.

My next assignments came in a bunch: the antisubmarine weapon, Weapon A, Weapon A subcaliber and Weapon B; the 5-inch (13 cm) flare rocket; the 2.75 (7 cm) subcaliber SCAR; the tank-launched Line Charge, and a few 5-inch spin-stabilized Barrage Rockets. This was enough to make me a Branch Head and accordingly I was promoted into the ranks of GS-13s (Figure 3).

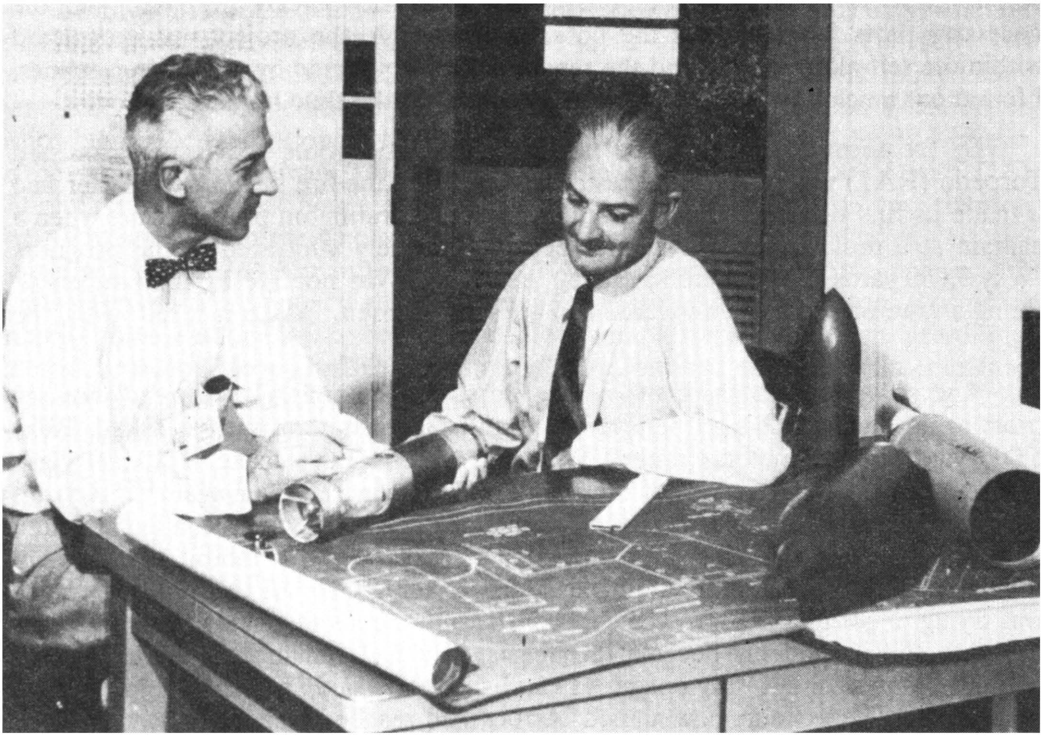

Figure 3 Smith (left) at work at NOTS.

These programs were mostly hand-me-downs started by others but left unfinished, in trouble, or ready to be cashiered. Now came something different from the best combination of a ballistician and a politician to be found in the old Navy's Bureau of Ordnance. Albert Wertheimer, who had responsibility for anti-submarine torpedoes would always arrive where the submarine had left if they had to swim all the way. He proposed hurling the torpedo to the last known submarine position with a rocket boost. The response was not even luke warm. Torpedoes were not designed to take the rocket acceleration or water entry at that speed. Moreover, what was the use of projecting the torpedo beyond the range of the ship's sonar? And the sonar people were asking, "What's the use of extending sonar beyond the range of the torpedo?" So Wertheimer, grimly determined to break this circular reasoning, had to prove his point by circumventing the torpedo people. He sent an assignment to NOTS entitled "Improvement of Ahead-Thrown Weapons," which covered a scheme to project a mobile mine out to 3,000 yards (2,700 meters). A mobile mine is a homing mine with self-contained propulsion, about as close to being a torpedo as one can get. This program kicked around for a while and finally landed in my lap.

I was immediately taken with the concept and decided we would do it in Big Stupe fashion: six firings within six months ending with the final report three days after the last firing. The mine chosen, Mark 24, was most appropriate, being already fitted with a parachute for air release that would reduce water impact. The rocket motor most nearly of the right impulse turned out to be an excess JATO bottle. About these two available components a design was quickly prepared and the necessary parts fabricated on the base. Sure enough, the project was completed within the self-allotted time and the report delivered in hand by me to Wertheimer. I found out much later that he was impressed, but at the time he never let on.

By the second year after the new program's inception, the Rocket Assisted Torpedo (RAT) was ready to be tested at sea. Then the fun began. No sooner had it made its first demonstrations and talk was concentrating on pilot product when a captain at a desk above Wertheimer became intensely interested in the program. "Why 3,000 yards (2,700 meters) range?" he asked, "Why not 5,000 (4,600 meters)?" Being a man of action he answered the question himself. "Make it 5,000 yards," he said.

And so, after a lapse of two more years, the Super RAT was ready for sea trials again and, would you believe it?, a still higher authority then asked, "Why 5,000 yards (4,600 meters) range? Why not 10,000? Let's make it 10,000 yards (9,100 meters)." I had visions of old man Smith starting all over again far into his advanced years on Super Duper RAT. But once again I met the challenge with a new design incorporating a large torpedo, a more powerful motor, a more ambitious launcher, and a more sophisticated everything else. At this point everyone was trying to get into the act. The concept that no one loved when Wertheimer was trying to sell it suddenly became the biggest "me too" bonanza in the world. His comment was most apt. "My enemies I can handle," he said, "but God help me from my friends." The weapon, now named "Asroc," had reached respectability.

Having served apprenticeship at every rung on the ladder from designer of small components to manager of all our organization's programs at one time or another, I eventually became head of the Weapons Development Department. I felt personally attached to every project, even to Sidewinder, the brainchild of William B. McLean, Technical Director of NOTS; that air-to-air rocket had components in it that I had designed. He spent more time with me than with the other department heads simply because headquarters had authorized an improved Sidewinder--a near impossible task--and he wished to keep his hand on it. However, McLean's intense interest in the details of the new Sidewinder design overflowed into all the other design work of the department, which made for a somewhat less than happy situation.

I reasoned that the best way to cope with the problem would be to initiate one or more programs that I could run according to my own preferences, while taking care of administrative problems (disliked by McLean) associated with the programs that occupied his attention. The opportunity arose when a Navy flier with memories of the Korean conflict came to me with the problem of trying to evade the enemy's gun-laying radar while attempting to drop a load of bombs on target. What could we do to blind that radar? It struck us both simultaneously that the radar beam itself was an excellent homing signal.

Forthwith, I put a team together to work on an air-launched, anti-radiation missile (ARM) and received instant support for it in Washington. The shoe was now on the other foot and McLean, to my surprise, didn't like it. He immediately generated competing ideas for achieving the same end and felt that I should be following his design notions, which I resisted. It was the first time I found McLean to be technically in error. To put it simply, he had so much trouble with D.C. (Direct Current) signal biases in Sidewinder circuitry that he felt the best solution for ARM was to spin the whole missile at a high rate and to convert all signals and responses to A.C. (Alternating Current). It was a disarmingly simple notion. But D.C. biases were no longer a severe problem in missile circuitry whereas spinning a homing missile added enormous and needless complexity to its design, presenting control problems never before encountered. I so advised McLean who remained unconvinced and I so advised the headquarters research and development chief, who was promptly convinced. ARM became the Shrike and remains in the arsenal.

The next big shambles in the sky took place a short while after Sputnik so startled the western world. We all watched in chagrin while the U.S. Navy struggled unsuccessfully time after time at Cape Canaveral to match that achievement. Unable to stand it any more, Mclean and Howard Wilcox, my former boss, traveled to Washington, D.C. to meet with Roy Johnson, head of the Department of Defense's Advance Research Projects Agency. They carried with them a proposal for putting into orbit a satellite in only four months at a cost of $300,000. Johnson accepted the proposal.

The idea was excellent. The satellite launcher's first stage was to be an F4 aircraft (a Navy fighter-bomber). At 40,000 feet altitude (12,200 meters) moving in the proper direction, inclination and speed, the F4 would release a 2,100 pound (955 kilogram) five-stage rocket. The ignition of each successive stage would be accomplished by timers and horizon detectors. The flight path in each case would be ballistic. The satellite payload would be an orbiting radio beeper. Analysis indicated the feasibility of the idea. Here was a potential, low-cost system that could serve less affluent nations that might wish to place into orbit small scientific payloads. Practically all the work involved could be accomplished at NOTS (Figures 4-6 and Table 1).

The schedule appeared impossible. Nevertheless, we almost made it. The first two attempts failed, and the third try in 1958 ended in one beep heard at the right time by a receiver stationed for the purpose at Christchurch in New Zealand; it was never heard again. By then, we were out of time and had exhausted our funds, including monies generously added by the Bureau. Wertheimer, who had suggested we put up a satellite years before Sputnik, was wonderfully supportive. And everyone was sorry. Nothing was left but to go back to Roy Johnson in Washington with our report of failure, and ask for additional money.

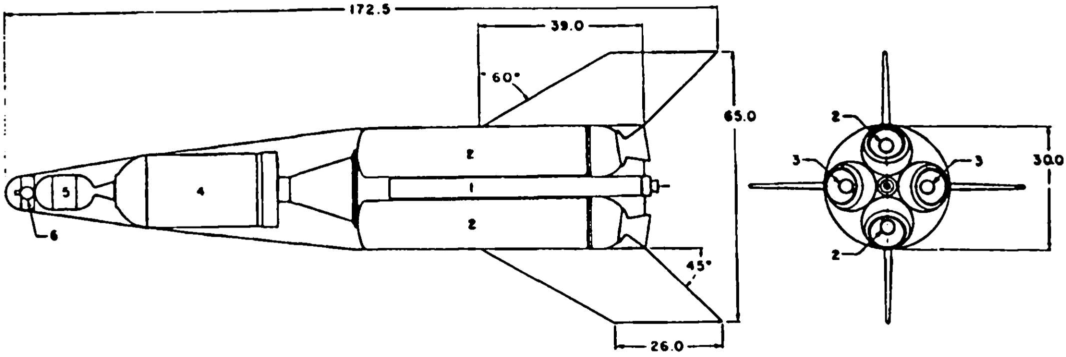

Figure 4 Six-stage, air-launched NOTS satellite configuration.

Table 1
DETAILS OF SIX STAGES OF NOTS SATELLITE

ITEM	WEIGHT LB	INITIAL WEIGHT OF STAGE LB	BURNT WEIGHT OF STAGE LB	TOTAL IMPULSE OF STAGE LB-SEC	BURNING TIME SEC	THRUST LB	NOZZLE EXIT AREA IN^2	SPECIFIC IMPULSE $\frac{LB\text{-}SEC}{LB}$
1ST STAGE (ZUNI) MOTOR METAL PARTS PROPELLANT	 22 33 55	2104	2071	6800	1.0	6800	NO CORRECTIONS	200
2ND STAGE (2 HOTROCS) MOTOR METAL PARTS PROPELLANT	 120 600 720	2049	1449	138,000	4.86	28,396	190	230
3RD STAGE (2 HOTROCS) MOTOR METAL PARTS PROPELLANT FINS, STRUCTURE & FAIRING	 120 600 130 850	1449	849	138,000	4.86	28,396	190	230
4TH STAGE (ABL X-241) MOTOR METAL PARTS PROPELLANT FAIRING & TIMER	 56 376 10 442	479	103	97,930	36	2720	VAC	260.1
5TH STAGE (8-IN. JPN) MOTOR METAL PARTS PROPELLANT FAIRING	 6.0 26.9 0.5 33.4	37.0	10.1	6590	5.7	1155	VAC	245
6TH STAGE (3-IN. X-14) PAYLOAD MOTOR METAL PARTS TIMER PROPELLANT	 2.0 0.55 0.35 0.7 3.6	3.6	2.9	172	1.0	172	VAC	245

It was a hopeless mission to Washington; Johnson was irritated by the addition of our failure to many others that occurred during the early years of the U.S. space program. Support was denied our "NOTSnik" because it did not come out high enough in his dollars-per-pound-of-payload-in-orbit criterion. It was a sad day.

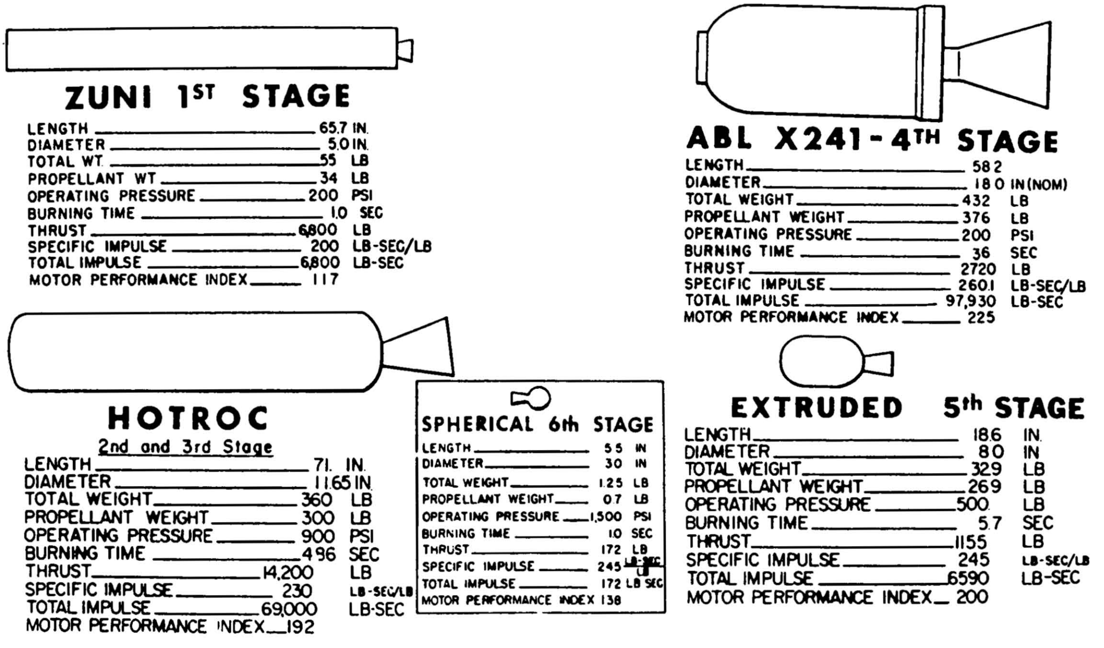

Figure 5 Propulsion units of NOTS satellite.

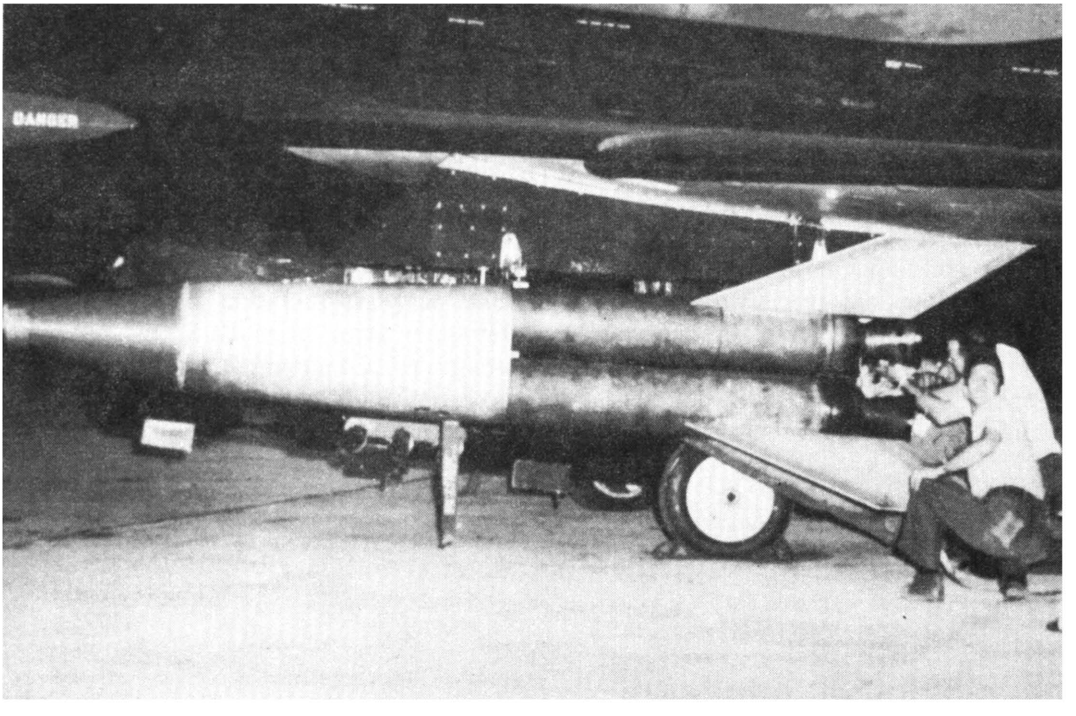

Figure 6 Preparing the NOTS air-launched satellite for test.

Our satellite project was placed in cold storage to await a request from the Naval Research Laboratory for a 1,000-mile (1,600-kilometer) deep space probe required for the "HiHo" program. Our project was revived as Caleb, which employed an aircraft first stage as originally planned, successfully accomplished its task. My assistant, Charles Bernard (now director of land warfare in the Office of Secretary of Defense) mothered the project to its conclusion in 1959. So all was not in vain.

At about this time, after a continuous diet of crash programs for almost 12 years, I was sorely in need of a sabbatical leave; and, accordingly, the Navy created one for me at the Naval War College in Newport, Rhode Island. This assured for the Navy my service for another 14 years.

In leaving NOTS, I could not help but feel that the part of me born in liquid oxygen and gasoline in New York City had died in the Mojave Desert in California a quarter of a century later. The desire to leave Planet Earth had evaporated. Antarctica, the Sahara, and the oceans appeared by far more hospitable than the most attractive sites on other worlds or in interplanetary space. Nonetheless, I am most fortunate to have been among the few to enjoy the last chance to accomplish pioneering work in rocketry and astronautics as an individual experimenter, before all important programs became vast government-corporate enterprises.