Chapter Three

The Uranium Trail Leads to Idaho

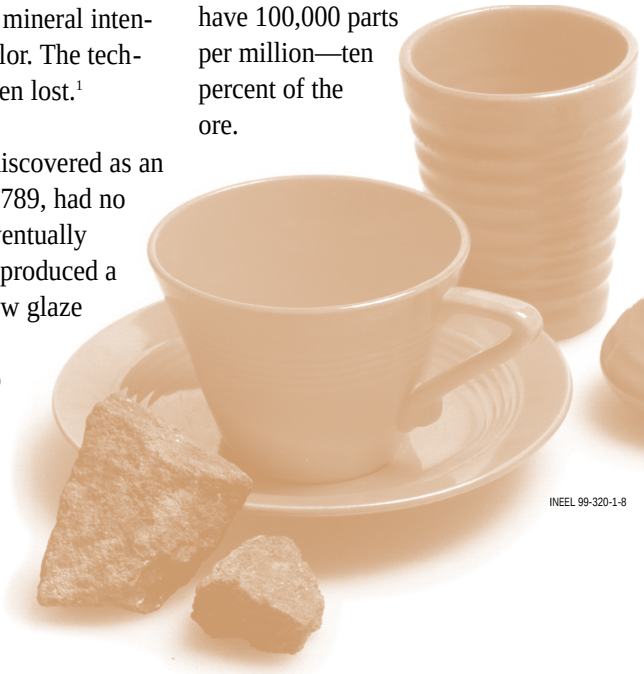
Uranium: a heavy, slightly radioactive metallic element...

–Encyclopedia Britannica–

Archaeologists excavated the Imperial Roman Villa near Naples in 1910. In a first-century A.D. mosaic mural, they found pale yellow-green glass containing one percent uranium. Roman artisans probably used a uranium-bearing mineral intentionally to obtain the color. The technique may then have been lost.[1]

Uranium, when it was discovered as an element and named in 1789, had no known use. Someone eventually learned—again—that it produced a pleasant orange or yellow glaze on ceramic goods. Photographers used it to tint photographs. For such aesthetic uses, the world required only a few hundred tons of ore a year. Mines in Bohemia, Portugal, and Colorado supplied the modest demand. Then Henri Becquerel discovered its property of radioactivity. In 1898 Marie Curie, investigating further, discovered radium in uranium ore and began to elucidate its decay products. Everything changed.

Uranium is dispersed widely over the earth; the soil in the average backyard has 2.7 parts per million. It is more common than tin. But backyard concentrations are hardly worth mining. A good uranium mine might have 30,000 parts of uranium per million, but a bonanza-class uranium mine would have 100,000 parts per million—ten percent of the ore.



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The Homer Laughlin Company, maker of Fiesta Ware, used uranium to obtain the bright orange glaze known as "Fiesta Red." In 1943, the company obtained a license from the Manhattan District and used depleted uranium until 1972.

Such a mine was discovered in Zaire (formerly, the Belgian Congo) about the time that the world was learning that radium might have wonderful curative properties. Because of its richly concentrated ore, the Shinkolobwe mine produced uranium far more cheaply than anywhere else. Other uranium mines closed, and the Shinkolobwe satisfied most world demand until well after World War II.[2]

The discovery of radioactivity was a prelude to other discoveries that led to a new twentieth century market for uranium. First, the world learned that atoms definitely are not the smallest particles of matter—rather, atoms are built of electrons, protons, and neutrons, with most of the weight in the protons and neutrons.

Next, uranium, like most elements, has more than one isotope. Some atoms contain more neutrons than others and weigh slightly more. Uranium-235 weighs less than uranium-238, for example, and more than uranium-233. Although different isotopes act and react the same way when combining

The Trinity fireball, fifteen seconds after detonation on July 16, 1945, rises above the New Mexico desert. The bomb was an implosion device using plutonium made by the reactors at the Hanford Engineering Works.

U.S. Department of Energy

chemically with other elements, the protons and neutrons in their nuclei can behave very differently upon being provoked in certain ways.

Scientists soon found that they could strip the electrons or neutrons from certain atoms and bombard other elements with them. In the 1930s they built great machines—atom smashers—to find out what would happen when they fired streams of neutrons into various elements at high speeds.

Upon bombarding uranium with neutrons moving at a certain speed, they found that some of the uranium atoms break apart (fission). The debris arranges itself into pairs of elements with roughly half the mass of uranium, such as (but not always) barium and krypton. Energy is released in the form of two—sometimes three—neutrons, heat, and other leftover particles. Many of the fission products are themselves radioactive. Of all the uranium isotopes, it appeared that only uranium-235 fissioned.

The ancient quest for some sorcery that would transmute one kind of matter into another was over. Traditionally the quest had been to make gold. Perhaps ironically, however, it turned out that the nuclear sorcerers could turn gold into mercury, but couldn't turn mercury (or lead) into gold.

Playing Marbles with Atomic Particles

After physicists had sorted out the kinds of particles that made up an atom, they learned that they could separate electrons or neutrons or protons from certain atoms. Then they invented ways to shoot the particles at samples of other elements.

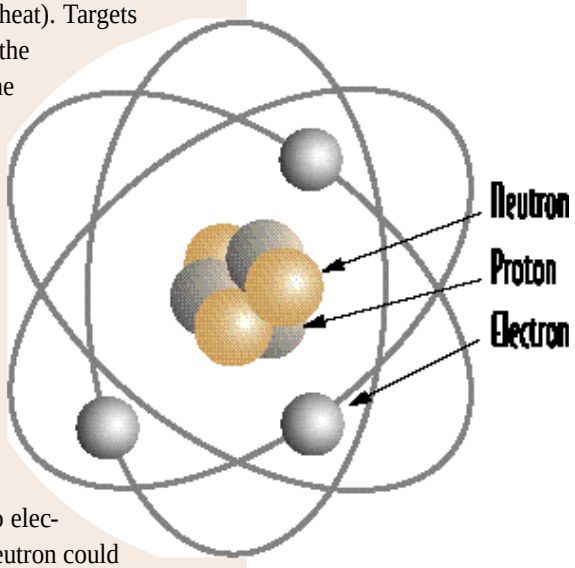
The faster a beam could travel, the more energy it had when it struck the target, and the more interesting the results. Most of what we have learned about energy and matter in the twentieth century, we have learned by bombarding samples of matter with atomic particles.

Particle accelerators, also called "atom smashers," shoot streams of electrons, protons, deuterons, alpha particles, or heavy ions at their targets. The machines that create these fast-moving streams rely on the application of an electric field, which either attracts or repels particles of like charge.

Van de Graaff generators, cyclotrons, synchrotrons, and betatrons are types of particle accelerators.

Nuclear reactors split atoms apart, producing streams of neutrons (and large amounts of heat). Targets are placed inside the reactor close to the flow of neutrons.

The neutron was discovered in the 1930s, the last of the trio of electrons, protons, and neutrons to be found out. Because it had no electric charge, the neutron could penetrate the nucleus of atoms, something other particle accelerators had not been able to do. The big surprise in the 1930s was to learn that shooting a neutron at uranium-235 atoms caused them to split apart.



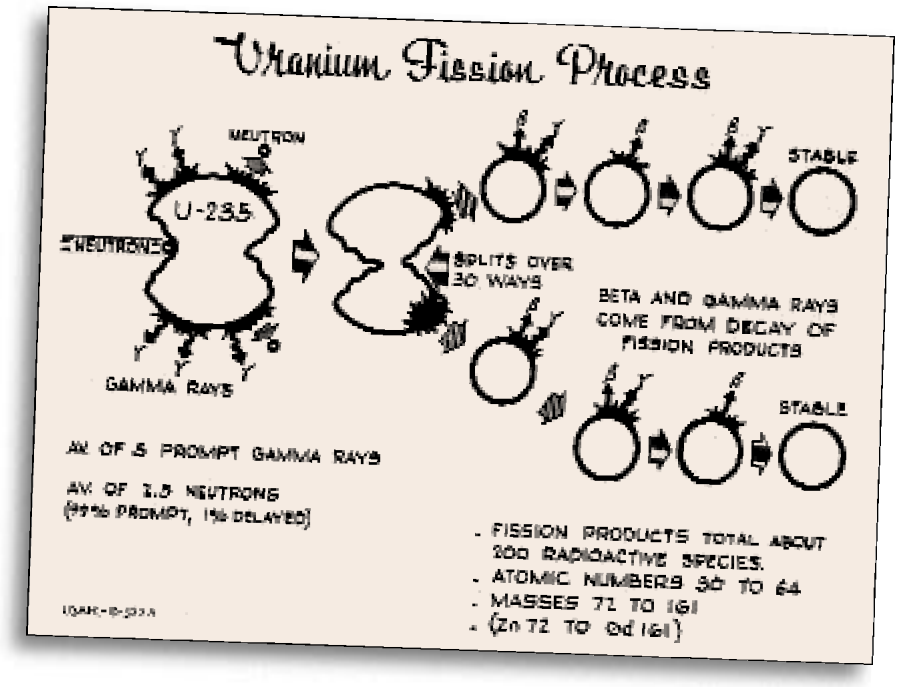
The central portion of the atom depicts the nucleus, consisting of protons and neutrons, which give the atom most of its weight. Electrons orbit the nucleus and are considered weightless.

With the discovery that a neutron could split uranium and generate more neutrons, a new demand for uranium was inevitable. Provided that enough uranium-235 is packaged in just the right way, the liberated neutrons are likely to hit one or two other atoms and cause them to fission also. This was the phenomenon of the chain reaction. Fission released an amount of energy far larger than the energy obtained from chemical reactions of the same mass. Scientists learned that it is possible to create an environment in which to start such a reaction, whereupon nature—and skilled operators—keep the reaction going.

In the late 1930s, events in Europe were pointing to a German war of conquest. It required no great leap of imagination to realize that a chain reaction initiated in a well-engineered container could explode as a bomb. If chain reactions could be controlled, on the other hand, they could produce electricity or help build canals and harbors.

Developing any of these ideas would require a great deal of uranium. One of the inconvenient things about natural uranium is that 99.3 percent of it is uranium-238, an isotope that resists splitting apart under neutron bombardment. For every 140 atoms of U-238, there is only one atom of U-235.[3]

Early in 1939, scientists of the United States Naval Research Laboratory in Washington, D.C., met with scientists from Columbia University and Enrico Fermi, Nobel laureate nuclear physicist. They discussed how the heat of fission might produce steam for a turbine and propel a ship or submarine. Navy scien-



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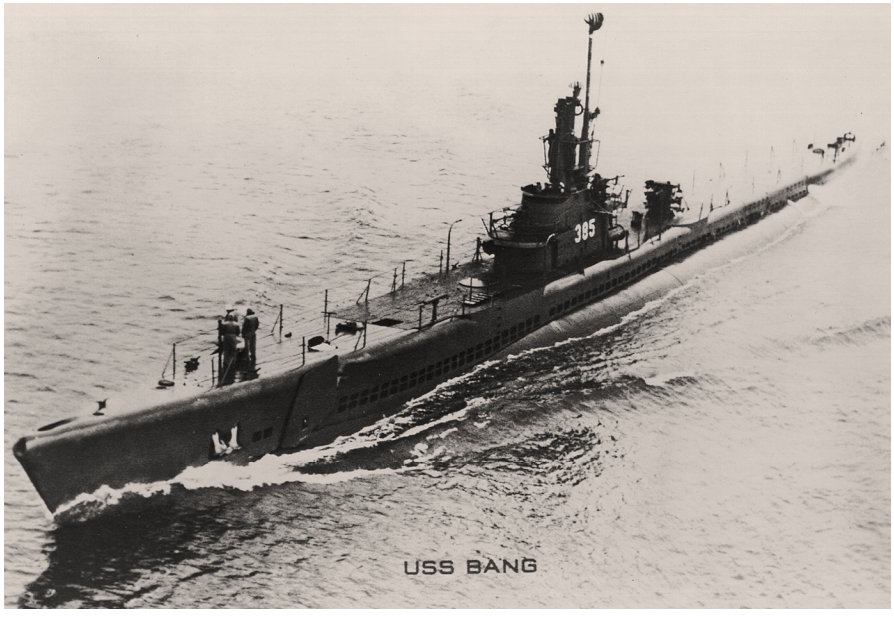

Courtesy of Department of the Navy, Submarine Force Museum

Above. In the 1950s, the AEC published films and booklets to help American citizens understand nuclear energy. Left. The USS Bang, a pre-nuclear U.S. Navy submarine built in 1943, used diesel fuel to generate electricity. When submerged, it ran on battery power and had to surface every 48 hours.

tists Ross Gunn and Philip Abelson concluded that the Navy should pursue the idea. The fission reaction needed no oxygen, which all other fuels need to burn. The benefit of such a fuel in a submarine was obvious. The two realized that the lighter fissionable isotope of uranium would have to be separated from the heavier one in order to create a mass that would fit in a submarine—or a bomb—and begin a chain reaction. They considered how this might be done.[4]

As Adolph Hitler's war grew more menacing in 1939, the scientists in America who had fled Europe grew more fearful that German scientists might produce an atomic bomb. Albert Einstein wrote a letter to President Franklin Roosevelt urging upon him the importance of securing a supply of uranium. "The United States has only poor ores of uranium in moderate quantities," he wrote.

The government should secure a supply of the ore for the United States. He continued:

I understand that Germany has actually stopped the sale of uranium from the Czechoslovakian mines which she has taken over. That she should have taken such early action might perhaps be understood on the ground that the son of the German undersecretary of state, Von Weizsacker, is attached to the Kaiser-Wilhelm-Institut in Berlin, where some of the American work on uranium is now being repeated.[5]

Roosevelt understood the threat and authorized secret research work to begin. By 1942, production seemed feasible, and the job went to the U.S. Army, which created the Manhattan District of its Corps of Engineers. General Leslie Groves took charge of the project and monopolized most of the uranium then in the United States. The Manhattan District bought 1,250 tons of uranium ore from the Belgian owner of the Shinkolobwe mine for $1.60 a pound. As the war progressed, Groves bought more, placing annual orders amounting to $200 million. Scientists Gunn and Abelson had no further access to uranium, so Navy studies of ship propulsion had to pause for the duration of the war.[6]

The Manhattan Project was a success. Enrico Fermi and others built the world's first nuclear reactor in Chicago

No one took photographs when Enrico Fermi and the Met Lab brought Chicago Pile Number One (CP-1) to criticality on December 2, 1942. Artist Gary Sheehan shows the cramped quarters in the squash court underneath the stadium at the University of Chicago. Fermi and the others concentrate on instruments indicating the increasing rate of neutron fission. Three young physicists stationed on the right were the "suicide squad," prepared to pour jugs of cadmium-sulfate, a neutron absorber, onto the pile and kill the chain reaction if the control rods didn't work for some reason. The person below the balcony is prepared to operate a control rod by hand, another precaution. Some employees who participated in the creation of CP-1, not necessarily in the painting, eventually moved to Idaho to become pioneers at the National Reactor Testing Station.

in December 1942. After that, an unprecedented collaboration of military, scientific, and corporate resources managed to build a weapon. A version of the Navy scientists'idea for separating the light from the heavy isotope of uranium was built at Oak Ridge, Tennessee. The technique produced the few pounds of "enriched" uranium needed for one bomb.

Chicago Historical Society P&S-1964.0521

Uranium had another useful quality. In a chain reaction, it could manufacture another fissionable element. Some of the liberated neutrons entered the nuclei of uranium-238, not splitting it but eventually changing it into plutonium, a new element not found, it was thought at the time, in nature. This plutonium activation product, upon being bombarded with neutrons, proved to be fissionable. Therefore, a bomb might also be made with plutonium.

The government built huge "atomic piles" (later called reactors) of uranium and graphite at Hanford, Washington, to manufacture plutonium. The procedure was extremely costly. Despite the massive size of the Hanford reactors, their daily output of plutonium was rarely enough to fill a shot glass. Once plutonium atoms had been created, they had to be separated from the uranium matrix in which they had originated—and from the fission and other activation products. Chemists devised ways to do this. The Manhattan District built two bomb designs, each using one of the two fuels. On July 16, 1945, the team at Los Alamos, New Mexico, tested a plutonium device. On August 6 and 9, 1945, respectively, the United States dropped Little Boy, a uranium-charged bomb on Hiroshima and Fat Man, containing plutonium, on Nagasaki. Hiroshima received the destructive power equivalent to 12,500 tons of TNT; Nagasaki, 22,000 tons.[7]

During the war and immediately afterward, the assumption that uranium was scarce continued to influence the way governments and scientists regarded it. The scarcity was felt to be so serious that General Groves, who continued to administer the Manhattan District after the war, approved a proposal in 1946 to build a reactor that would help solve the uranium shortage.[8]

The proposal came from Walter Zinn, one of the physicists who had been with Enrico Fermi in Chicago. The Manhattan District had organized a "Metallurgical Laboratory" there, a name intended to disguise its true purpose. After the war, the government assigned weapons work to other laboratories, and the Met Lab ceased to exist. Its assets were reorganized as the Argonne National Laboratory with a mission to develop reactors, supported by research in chemistry, physics, metallurgy, and other fields. Zinn became its first director.[9]

Zinn could see that the nation's first priority for uranium would continue to be for weapons. Any use of it for other purposes would have to promote defense goals or make extremely efficient use of uranium. He proposed therefore to design and build at Argonne an experiment to prove that a reactor could generate electricity and manufacture plutonium at the same time.

It was an astonishing idea. The reactor would be built so that the non-fissioning U-238 would be tucked in close to fissioning U-235 fuel rods and also surround them like a blanket. During the chain reaction, one liberated neutron would keep the chain reaction going and another one or two would hit the U-238 and create new atoms of plutonium fuel. It would solve the scarcity of

Making Enriched Uranium

Throughout the Cold War, gaseous diffusion was a reliable way to make enriched uranium. The first step was to change the solid uranium oxide into a gas called uranium hexafluoride. The gas was then circulated thousands of times through fine filters with tiny openings. The lighter U-235 atoms passed through the filters slightly more easily than U-238.

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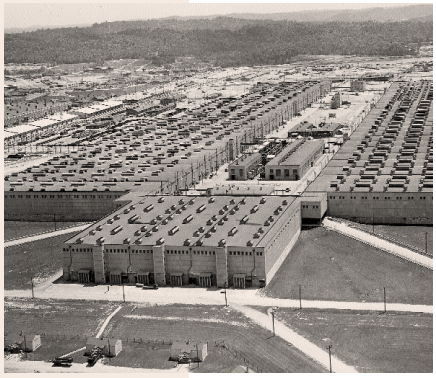
Gradually the percentage of U-235 in the gas increased, and it was said to be "enriched." The gas was then converted back to a solid form and shaped into rods or pellets. These were placed in tubes made of aluminum, zirconium, or stainless steel. These cladding metals do not interfere with the passage of neutrons, but they do protect the uranium from air and water corrosion and provide a path for the heat to leave the fuel.



Oak Ridge National Laboratory

Depending on its intended use, uranium can be enriched to any percentage desired. The uranium in bombs is one hundred percent enriched. Test reactors, which require a rich flow of neutrons, need uranium enriched up to ninety-five percent. Uranium in commercial power reactors is typically two percent to four percent enriched.

Above. Worker holding simulated nuclear fuel pellets. Below. Exterior of the Gaseous Diffusion Plant in Oak Ridge, Tennessee.

uranium, because now the abundant non-fissioning isotope could become fuel. More profoundly, it would provide a revolutionary abundance of energy in a world constantly craving more. That a fuel could replace itself in the very process of consuming itself, perhaps "breed" even more than the original amount, was a fabulous possibility.

General Groves approved Zinn's proposal, observing that independent reviewers would have to agree the reactor could safely operate near Chicago. As it turned out, the decision would not be Groves' to make, and Zinn's idea—along with many others—had to wait a few years while Congress rearranged the nuclear enterprise as a peace-time institution. Those years brought a more pessimistic outlook for world peace and many other changes, but none of them challenged Zinn's logic. Uranium remained costly, and the breeder project remained high on any list of proposed experiments.[10]

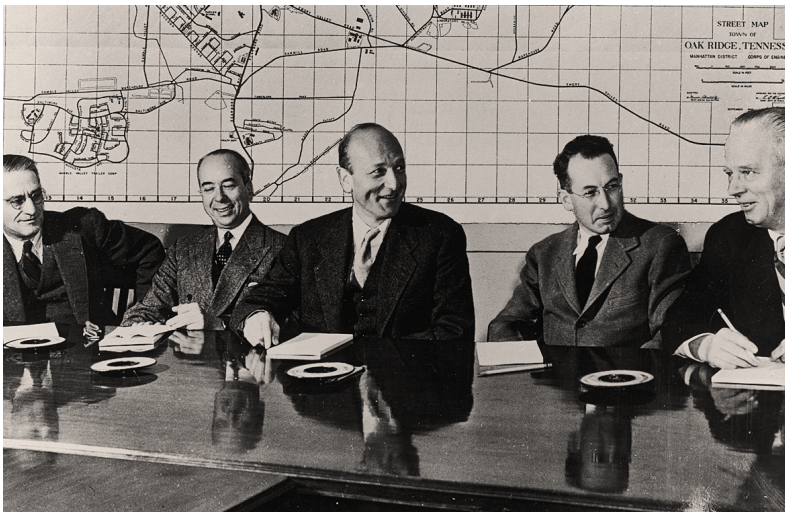
Congress passed the Atomic Energy Act in August 1946. The government continued to monopolize uranium and plutonium. The military handed control of atomic weapons factories and laboratories to a new civilian agency, the Atomic Energy Commission (AEC), headed by five commissioners. Advisory committees assured that the military would influence the distribution of uranium for defense purposes—and help decide on the allocation of resources for defense research.

The Act created a special committee in Congress called the Joint Committee on Atomic Energy (JCAE) to prepare budgets and approve AEC policy directions. The committee was unique. House and Senate members typically created committees as convenient ways to divide their work; this one was mandated by law. Nine members from each chamber sat on the JCAE, concentrating a great deal of authority among very few legislators.[11]

In due course, the new commissioners took their seats, hired their staff, and decided on a plan of action. Everyone—President Harry S. Truman, the scientists who had developed the bombs, and the corporations that had helped build them—desired to develop peaceful uses of nuclear energy. Congress hoped that research and development would eventually show that a civilian nuclear power industry could generate electrical power economically enough to compete with coal and gas fuels.[12]

But such peaceable sentiments were not to dominate the early years of the AEC. Instead, the United States and the Union of Soviet Socialist Republics (USSR), allies in World War II, became antagonists in a tense ideological and geo-political conflict that came to be called the Cold War. One of its major battlegrounds was nuclear weapons technology. The two nations raced to be first to possess and command the most destructive possible power against the other.[13]

When David Lilienthal became the first AEC chairman, he learned how little destructive atomic power the United States actually possessed. The world, including President Truman, assumed that the nation had a sizeable stockpile of atomic bombs. But on April 3, 1947, it was Lilienthal's duty to tell the president that the United States had exactly zero atomic bombs ready for use and that it would be several months before that number could improve. Not surprisingly, the production of bombs became the AEC's most urgent priority.[14]



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President Harry S. Truman appointed the first five AEC commissioners. From left to right, William W. Waymack, Lewis Strauss, Chairman David E. Lilienthal, Robert F. Bacher, and Sumner T. Pike.

The U.S. Air Force became interested in uranium. Colonel Donald J. Keirn, a visionary in the field of jet aircraft propulsion, realized that if nuclear power could be linked with jet engine technology, the country would have an unparalleled offensive weapon. Uranium fuel would occupy less space in an airplane than a baseball. A pound of enriched uranium could replace the energy in 1.7 million pounds of standard chemical fuel. A nuclear-powered airplane could stay aloft for days at a time, ending flight-distance limits. In 1945 J. Carlton Ward, Jr., president of Fairchild Engine and Airplane Corporation, told a senate committee that the range of an atomic plane would be limited only by its ability to carry enough "sandwiches and coffee for the crew." It could deliver bombs anywhere in the world, approach a target from any direction, and never have to rely on a refueling base outside the United States. A bomber combining jet speed with long range would be a useful weapon indeed.[15]

The U.S. Army was similarly tantalized by the idea that a handful of fuel could end the logistical headache of transporting fuel to remote locations. Perhaps nuclear power plants could be mobile, able to travel with a field hospital or command center. If so, a power plant could be mounted on a barge and towed from one port to another,

supplying emergency electrical power to on-shore operations after earthquakes or other disasters. Reactors could be small, medium, or large, depending on the need. Perhaps they could be loaded into trucks or airplanes and then reassembled in the Arctic or in a desert.[16]

The Navy and the Air Force were first to mobilize their interests. They asserted themselves as the AEC struggled to get organized. The growing fear of communism contributed to their causes. But before the AEC could apply nuclear energy to the goals of either service, it had to accomplish a huge backlog of preliminary research.

Leaders to Conduct Arco Desert Tests

"You treat us fine,' 'atomic energy commission officials Thursday told Idahoans an dU. S. Rep. John Sanborn, standing, as they opened four-day eastern Idaho tour. From left, Roger Warner, A E C engineer; Leonard E. Johnston, to manage A E C's $500,000,000 atomic reactor station in Arco desert, and Bion Phillipson, program director. Officials seek employes' homes in present towns.

Courtesy of the Thomas Sutton Family

Once the announcement was made that the atomic reactor station would be in Idaho, the AEC had to decide where to locate its headquarters.

The central fact was that the scientists had produced only a bomb, a sudden explosion finished in seconds. Making electricity had little in common with making bombs. Could a reactor be reliably controlled for long periods of time? What metals and materials could withstand the corrosive forces of heat and radiation for long periods of time? What form should uranium fuel take? What was the best way to carry heat away from the reactor? Could power plants be safe enough to operate near populated areas? Could uranium produce electricity cheaper than coal or natural gas? In sum, the science of nuclear reactors had to be developed nearly from scratch.

The new AEC began to set priorities for experimental reactors and assign projects to its laboratories. These tasks confounded the commissioners for more than two years. They seemed unable to settle on a program. Finally, the AEC's Reactor Safeguards Committee advised that, for safety reasons, the AEC should build proposed reactor experiments at a remote location, not at any existing laboratory. Nuclear research would bring with it nuclear waste and chemical processing, neither of which were suitable by-products for heavily populated areas. Most importantly, if an accident were to occur, it should not endanger large numbers of people. Walter Zinn himself agreed with this:

I am inclined to the opinion that for a nation with the land space of ours and with the financial resources of ours, adopting a very conservative attitude on safety is not an unnecessary luxury.[17]

Or, as AEC Commissioner Sumner Pike put it, "We didn't want to put work like this next to a high school." The decision to build a "testing station" for reactors seemed to liberate the AEC, unsticking it from a two-year habit of talk and no firm decisions. In January 1949 the commissioners created a

Division of Reactor Development and hired Lawrence R. Hafstad to be its director. Lilienthal gave him his first assignment: recommend a site for the testing station.[18]

The site had to meet safety criteria. Fewer than 10,000 people should reside in the nearby area. No other national defense sites should be in the vicinity. The AEC must have complete control of the property. Fuel, water, and electrical power should be plentiful. Weather and geological conditions should prevent contamination of lakes and waterways. Earthquake-prone sites were out.[19]

By the time Hafstad was on board, a list of some twenty sites had shrunk to two candidates: Ft. Peck, Montana, and the Naval Proving Ground in southeast Idaho. Sentiment seemed to favor Ft. Peck. By this time, frustration over inaction was palpable. Still, the AEC paused and asked an engineering firm from Detroit to compare the virtues of the two sites.[20]

The Detroit firm quickly rounded up an impressive array of facts on climate, geology, labor, land, and construction materials. They evaluated rail and highway connections and assessed the socio-economic characteristics of nearby towns. The analysts even took the trouble to ask the commanding officer at the Naval Proving Ground if there was much fog at the site during the winter.

With all the data gathered, the bottom line was that the Montana site would cost the AEC $50 million more than if it built in Idaho. After that, annual operating expenditures in Montana would cost a significant premium. Furthermore, the Idaho location had a far superior socio-economic profile; nearby towns could provide a better base to absorb new population.[21]

The AEC decided on the Idaho site on February 18, 1949, and called it the National Reactor Testing Station (NRTS). The local press called it the "atom plant." Lewis Strauss, one of the commissioners, had old friends at the Navy's Bureau of Ordnance and felt that the Navy would surrender its investment peacefully. He was mistaken; the Navy resisted. It demanded that the AEC support a congressional authorization for funds the Navy could use elsewhere.[22]

Despite the secrecy of AEC deliberations, Montana and Idaho interests both knew that their territory was in the running for something big. The Idaho Falls and Pocatello chambers of commerce had retained former senator D. Worth Clark and his law partner Thomas Corcoran to represent them in Washington and find out if any influence could be exerted, and if so, how. The Montana congressional delegation had been aware of the early tilt toward Ft. Peck and thought the deal was set. Suddenly news leaked out that Idaho was the "top favorite."[23]

Upon the uproar that arose when Montana discovered its loss, Chairman Lilienthal tried to quiet the ruckus by explaining the decision to Montana Governor John Bonner and making the announcement public, which he did on March 22. Montana kicked for another two months, appealing fruitlessly to President Truman and to the JCAE at hearings in April and May.[24]

On April 4, the AEC named Leonard E. Johnston as the man to open and manage an AEC field office near the testing station. His mission was to adapt the Naval Proving Ground for scientific experiments involving nuclear reactors and using uranium.[25]