Energy: Washington Gets a New Proposal for Using H-Bombs

On 19 March, the Energy Research and Development Administration heard a proposal for intensive study of a system for producing reactor fuel and electricity from repeated underground detonations of thermonuclear explosions. Scientists from the Los Alamos national laboratory and a research and development company in California who made the presentation say that it was "very well received."

If the plan were implemented, the explosions would quickly dwarf the total megatonnage detonated by the United States, or any other country, for avowedly peaceful purposes. In a mile-deep cavity, probably mined in the type of salt formation found along the Gulf Coast, at least two thermonuclear devices would be detonated each day, producing superheated steam to power a regular generating plant on the site and breeding reactor fuel that could be shipped to other parts of the country. A single plant would probably require 700 detonations per year, and the scientists who are planning this project talk of producing 100,000 thermonuclear devices per year, a number which exceeds by orders of magnitude the number of nuclear warheads in the arms stockpile.

No one assumes that the safety or economy of such a system could be assured without extensive study and testing, which is the purpose of the pending request for approximately $13 million per year for the next 3 years. "We can give a definite answer to these questions in a finite time," says Harold M. Agnew, director of Los Alamos, "and I don't know of any other fusion program that can make that promise for any price."

While it is billed as the only system that could accomplish fusion within the next decade, the plan would also be a stark realization of the great fear, that has so far been groundless, that nuclear power would somehow involve nuclear bombs. Named "Pacer," from an approved list that curiously favors race horse names, the project seems to be the ultimate in "can do" thinking. Weapons designers note that it utilizes the only fusion concept where the technology has been proved for over 20 years. Indeed, the idea was suggested in 1957, quite unsuccessfully, by William M. Brobeck, who was the chief engineer for the man who was perhaps the most unrestrained technological optimist of the atomic era, Ernest O. Lawrence.

The Pacer plan "sounds like a weapon builder's monstrosity, and should be squashed at birth," says Richard Wilson, a high energy physicist at Harvard. He, along with others, feels that the Pacer plan, if taken seriously, would inevitably be tied up with the arguments over the safety of current nuclear power plants. The strongest critics of the plan think it could trigger public rejection of both fission and fusion. The plan could also complicate the negotiation of an effective threshold nuclear test ban, since the Pacer devices will have yields in the same range needed for new weapon development, 10 to 100 kilotons.

The proponents of the Pacer concept realize quite well that they cannot go very far with the plan unless they can convince the public to accept it. They have sent out a number of press releases, and they frankly admit that they are looking for better ways to persuade the public about an idea that they firmly believe will be proved safe.

Many ideas for peaceful uses of nuclear explosives have arisen from the Plowshare program, which was responsible for more than 20 detonations, the last being the Rio Blanco test in Colorado in 1973 that unsuccessfully attempted to stimulate natural gas production. Plowshare officials at the Livermore national laboratory say that they have discussed producing commercial power from time to time, but that their ideas never reached the stage of a formal proposal.

Underground Detonation in Salt Domes

The latest revival of the Pacer idea apparently came from a Santa Monica, California, firm that has done extensive study of underground nuclear explosions. Albert Latter, president of R & D Associates (RDA), had suggested experiments which showed that the seismic effect of an underground nuclear blast is reduced 100-fold if the blast is conducted in a large cavity. The firm also was familiar with the feasibility of the construction of such cavities, and proposed to the Atomic Energy Commission in October 1972 that the Pacer concept should be reconsidered, using a salt cavity for containment. The Los Alamos laboratory was named to manage the project, which would so effectively "decouple" the nuclear blast from the surroundings that people a few miles away would barely notice the "thump" beneath their feet. Slightly under $1 million has been spent so far, the effort being about evenly split between Los Alamos and RDA.

Salt formations are particularly attractive for an underground cavity because they are structurally very stable, and because small cracks in the walls of a salt cavity tend to heal themselves when exposed to water and heat. The most favorable formations for large cavities are salt domes, which are massive intrusions of almost pure rock salt that have pushed upward 4 or 5 miles through overlying layers of sedimentary rocks. These domes are roughly circular in cross section, and cavities can be cheaply excavated in them by drilling a well to the desired depth and circulating hot water to dissolve the salt. The largest cavity excavated by this technique, called solution mining, is in the Bryan Mound salt dome, about 50 miles from Freeport, Texas. The Bryan Mound cavity is about 250 meters across and 300 meters high. A cavity for the Pacer project would have to be 200 to 400 meters in size, depending on the yield of the thermonuclear device.

About 300 salt domes have been discovered in a belt stretching from Texas to Mississippi. The Rio Grande basin in southern Texas has at least 6 domes, the northeast Texas basin has more than 20 domes, and the interior basin of northern Louisiana and southern Mississippi has about 75 domes. Many domes have also been found underwater in the Gulf of Mexico since the first one was verified in 1968 by drilling from the ship *Glomar Challenger*. Pacer scientists have talked of putting systems offshore in the Gulf of Mexico.

In the minds of the scientists at Los Alamos and RDA, the foremost technical question about Pacer is whether salt cavities will stand up to the frequent blasts. Each explosion would

create a shock wave that would momentarily double the pressure at the cavity wall, springing the walls briefly outward about 2 cm. The Pacer scientists intend to study how the shock will affect the cavity wall, and how the steam will affect other minerals, particularly anhydrite seams that occur in salt domes.

The Pacer cavity would be filled with 1 million tons of water which the thermonuclear explosions would vaporize into high-temperature steam at about 200 times atmospheric pressure. The steam would continually circulate through surface facilities, which would draw out heat to power turbine generators and filter out the fine particles of newly bred fissionable material carried up by the steam. New detonations would maintain the cavity temperature at about 500°C. At this high temperature, the tendency of the salt cavity walls to deform, or "creep," must be seriously considered to determine whether the cavity would slowly collapse. The Los Alamos scientists hope to be able to certify, with rigorous computer codes, that the cavity will remain stable for periods exceeding 20 years. They will also check calculations that show that the hot cavity only rises, like a bubble, extremely slowly through the salt formation.

Emphasis on Breeding

The power that can be produced with a Pacer system depends on the number of thermonuclear devices that are fired each year. About 700 devices with a 50-kiloton yield would be sufficient to produce 2000 megawatts of electricity for a year. But five times that power could ultimately be produced from breeding in the same system. After looking at the potentialities for 2 years, "We're placing our emphasis on the system as a breeder," says Robert G. Shreffler at Los Alamos, "and in that mode the heat is a secondary consideration."

The thermonuclear device for Pacer will use pure deuterium fuel which produces plentiful fast neutrons that are ideal for breeding. Uranium-233 and plutonium-239 could be bred equally easily. But the scientists working on Pacer are concentrating on uranium-233 because they believe that shipping it to "burner" reactors around the country would be much less risky than shipping plutonium because uranium-233 could be diluted with natural uranium, and potential saboteurs would hardly have the sophisticated isotope separation equipment needed to enrich it again. Uranium-233 would be bred from thorium, which would be either placed on the outside of the thermonuclear device or incorporated into it, because the neutrons would only travel a few meters before they were slowed down by the dense steam. Uranium-233 bred by rapid neutron bursts would be free of the gamma ray contamination, from uranium-232, that would occur if it were slowly bred in a reactor.

Besides the material intentionally bred in the Pacer cavity, there would be radioactive fission fragments and tritium from the thermonuclear reaction. Considerable effort is being made in the design of the Pacer device to make it as clean as possible, but tritium is an inevitable product of the fusion reaction. Approximately 7 kilograms of tritium would be produced each year, most of which would go into the steam in the form of tritiated water (HTO).

The economic feasibility of the project is quite sensitive to the cost of the thermonuclear devices, and the program's critics think that cost will prove to be the plan's downfall, even if it proves technically feasible. The most authoritative estimate of the expense of thermonuclear devices, published by the AEC during the heyday of Plowshare, puts the cost of a 50-kiloton device at $420,000. The goal of the Pacer program is to reduce this figure, through careful engineering, exhaustive testing, and mass production, by a factor of 10. According to a Livermore scientist familiar with the Plowshare program, "the lower end of this range seems terribly optimistic."

A further impediment to great cost savings would be the need to use devices with a lower yield than 50 kilotons, either to employ smaller cavities or to reduce the effect on the environment. To a first approximation, large and small thermonuclear devices apparently cost about the same. But Shreffler thinks that a cost reduction by a factor of 10 is well within the range of feasibility and that a cost of several hundred thousand dollars would "still be in the ballpark" for a breeder system. Several tests of the Pacer device are planned during the 1976–1978 study period at the Nevada proving site.

Provided that the 3-year study of the Pacer concept does not prove it unfeasible, scientists at Los Alamos and RDA plan to field test the idea in a small salt cavity with approximately 200 explosions of low-yield (0.1-kiloton) devices. The cavity for these tests could be in a less ideal salt formation, perhaps in a salt mine where the ease of access to the room would expedite experiments. No test site has been selected yet, nor have Pacer officials even completed criteria by which it would be chosen.

The administrators at ERDA are now considering the pros and cons of Pacer. According to one scientist involved in the Pacer program, "We think this is a program for a peaceful nuclear explosion with universal applications and the only one that makes sense. What we are asking is to give the idea a chance."

—WILLIAM D. METZ

Hepatitis B: A New Vaccine Ready for Human Testing

The search for hepatitis viruses has accelerated rapidly in the last few years, and several different groups of investigators have observed two viruses that are thought, but have not been proved, to cause the two forms of hepatitis. Unfortunately, no one has been able to grow either of the viruses in culture, which is normally one of the most important steps in the production of a vaccine. Last month, however, two investigators told a National Academy of Sciences symposium on hepatitis that they had independently employed a novel, but not unprecedented, approach that sidesteps that requirement. They have isolated viral antigens from human carriers of hepatitis and used them to prepare a vaccine that has proved successful in chimpanzees and that should be tested in humans in the near future.

One group that prepared the vaccine was headed by Robert H. Purcell of