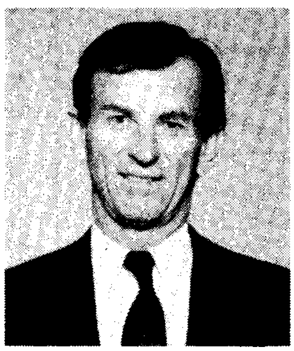
Nuclear power to help the developing world

Linden S. Blue, vice chairman of General Atomics, talks to Marjorie Mazel Hecht about the relatively cheap, very safe, and versatile modular helium nuclear reactor.



Linden S. Blue, vice chairman, General Atomics

General Atomics, in San Diego, California, is ready to start building its modular helium nuclear reactor (MHR) worldwide. This second-generation nuclear reactor (which is also called high-temperature gas-cooled nuclear reactor—MHTGR—or HTR in Germany) is relatively inexpensive and extremely versatile, providing electricity as well as process heat for cogeneration and industrial processing. It also features unique safety features, in that the reactor can shut down and cool down by itself, even if all its cooling systems fail. Marjorie Mazel Hecht, the managing editor of 21st Century Science & Technology, *talked with General Atomics vice chairman Linden Blue on March 9, 1990. Blue was formerly CEO of Beech Aircraft and general manager of Lear Jet, both in Wichita, Kansas.*

Q: What led you from the aerospace industry to your involvement with General Atomics and nuclear energy?

Blue: As a student of world economics and energy resources, I cannot but conclude that nuclear has a place in the energy equation of the future. This has been my conclusion going back, I suppose, as far as the introduction of nuclear power itself during Eisenhower's Atoms for Peace program.

My brother and I got involved with General Atomics essentially four years ago, because of our belief that nuclear is both inevitable and very desirable for the energy equation. The General Atomics opportunity came up when Chevron decided they wanted to raise some money to offset the debt they accumulated when they bought Gulf. GA had been a subsidiary of Gulf and became a part of Chevron when Chevron acquired Gulf.

So here was a company that had the technical ingredients in an area that had always been interesting to my brother and me. (My brother's interest has been just as great or greater than mine in these technical areas, for a comparable amount of time.) Here was a company that had enormous technical resources. They had worked on nuclear technology for 30 years and had pumped a billion dollars of their cash into this technology. The company had been founded on, and was dedicated to, the peaceful uses of nuclear energy, and over that 30-year period it had also managed to accumulate some of the best brains in the world in these areas.

Although I'm not a physicist, and neither is my brother, we believe that the thrust for bringing back the nuclear option has to be much greater levels of safety, both perceived and actual, than had been possible in the early generations of nuclear. GA appeared to have a totally different level of safety—safety that essentially precludes the possibility of a meltdown, of a "China Syndrome." We believed that the safety ingredient was there, and that because the MHR emphasizes standardization, the ability to build these reactors in factories and control the quality, the cost, and the schedules through proven factory production capabilities, that these were all the right ingredients.

Also, we thought that GA started with the right technical parts of the nuclear equation. For example, there are three key elements to a reactor: the fuel, the moderator, and the coolant—and maybe I'll add a fourth, the size, because the size relates to complexity and therefore safety.

Let's talk about the fuel first. If you have a ceramic fuel that can take extremely high temperatures, you no longer are tied to the requirement of always having coolant present, no matter what. The conventional solution to the problem of having to keep coolant present has worked well in water-cooled reactors with two major exceptions, TMI [Three Mile Island] and Chernobyl. So it would be very nice if you could have a fuel that was so resilient to high temperature that the absence of coolant was not a problem.

The size factor comes in here too. Size limits the temperature to which a reactor can go under any circumstance that's reasonably foreseeable. The fuel in the MHR can go to 2,000°C, compared to less than a 1,000°C for typical light water reactor fuel. Given its size limit, our reactor can only get to about 1,600°C even under severe accident conditions. So this gives us the right characteristics of fuel and size to ensure safety and preclude—virtually, preclude—a meltdown.

Next, you need a moderator that cannot change state. In other words, a moderator that is not a liquid under one set of temperatures and pressures and a gas under another set of temperatures and pressures. Water can change state, and if you happen to be relying on water for your moderation and cooling and it suddenly becomes steam, you've "bought the farm," so to speak. Graphite is a great moderator; it's a solid block. The graphite we use is very highly refined, not ordinary graphite, but "nuclear grade" graphite. It's extremely pure and has excellent high-temperature characteristics; it gets stronger as it gets hotter.

You also want to pick a coolant that will not change state, for the same reasons. Water, for example, will take away a great deal more heat than steam will. Also, you want a coolant that won't be corrosive. My guess is that probably 50% of the problems in terms of reliability and operability of light water reactors are due to the corrosion caused by water in steam generators and other primary system compounds. Well, if you could have a coolant that was inert, that would be non-corrosive, that's the ideal. Helium is just that: It doesn't change state, it is always a gas.

So, you have to start with the right basics, and if you start with the right basics in the moderator, coolant, fuel, and size, then everything becomes simple and relatively inexpensive because of its simplicity. This is the key to safety as well. When we're talking safety, we mean the kind of safety that precludes a "China Syndrome" meltdown accident under any reasonably foreseeable circumstance. . . . Jane Fonda couldn't touch this one. . . . The MHR is understandable and totally predictable. Other reactor designs are extremely complicated systems that must have their coolant present at all times. If they lose that coolant present is danger of a meltdown. It's as simple as that. In light water reactors, if the water goes away, you've had it! The light water nuclear industry has done a very good job in providing reactors with tremendous redundant systems to back up a coolant loss, but these are complicated and expensive. Even so, I believe those reactors are safe. They have had a tremendous record with the two exceptions of TMI and Chernobyl. But there is no way they can get to the ultimate inherent safety characteristics that MHR has, because they don't start from the same basics. That's why we think the MHR is so great.

Because we believed fundamentally in the need for nuclear energy in the world energy equation, when we saw a company that seemed to have the technological characteristics we thought that the world needs for its next generation of nuclear reactors, namely, inherent safety, we thought that company would be a darn good thing to acquire. . . .

Q: General Atomics has shown some welcome boldness in promoting the MHR as an ideal next-generation reactor for developing nations, as well as the advanced sector. What would it take to begin to build reactors in those countries that are desperately in need of reliable energy?

Blue: Well, whatever is true about its applicability to the United States is multiplied several times over in the developing countries and in the newly liberated countries like Poland. Let's talk about Poland for a second. Poland has a terrible sort of "Catch 22." They need more energy consumption if they are going to make their economy work; it's an absolute shambles now. The problem is that their present energy consumption has them in a desperate situation environmentally, with almost instant health problems. They really don't have any solution but to seek a different source of energy other than the ghastly low-grade coal that they burn not only for electricity, but also for industrial process heat and for district heating of homes, offices, and factories.

The MHR just happens to be not only a better source of electricity but, unlike the conventional nuclear technologies, it can also provide process heat, which is at least as big an energy need as electricity. In the U.S. the amount of energy consumed for electricity is about the same as the amount of energy consumed for process heat. Because of the MHR's high temperature, we're uniquely able to provide process heat, and we are the only technology that can provide district heating for homes, offices, and factories. Currently in Poland there are siting restrictions for a big light water reactor to keep the reactor 100 kilometers from a population center. An MHR could be sited right up close. Also, for district heating, you cannot transport heat over great distances; either you're close by or you can't use the heat.

In the event of even the worst case accident with an MHR, you could stand at the boundary of the site, which would be only about 400 meters from the center where the accident was occurring. Even if you stood there for a month, the dose of radiation you would receive would be similar to what I receive every time I fly from San Diego to Washington, which is frequently. In other words, an MHR accident is just a non-event, a non-problem.

Unlike the other reactors that can produce only electricity, the MHR can provide all three: electricity, process heat, and district heat. This advantage is more urgent in countries like Poland, because they don't have any alternatives. Here in the U.S., for example, we use natural gas for heating, almost entirely.

Although we truly should be making more use of nuclear for industrial process heat, the real problem in expanding uses of energy isn't in the developed countries as much as it is in the newly liberated countries and the Third World. The point is that the MHR fits the rest of the world even better than it fits the United States.

Q: What would it take to build an MHR in Poland?
Blue: Well, really, you have to build your lead plant here in the U.S., because we have all the infrastructure. You could build it elsewhere, but inevitably foreign goverments, before they buy anything, want to see one that is working in the U.S., one that has passed muster with the Nuclear Regulatory Commission. That isn't to say that it would be impossible to put the lead plant someplace else, but it would be a lot easier if we have already built one here.

Q: So, we really need a prototype here.
Blue: I hate to call it a prototype, because we have really already built our experimental prototype plants. We need a *lead* plant. There's nothing new in the technology of the MHR; it takes the best parts of all the prototypes that have been built before. Peach Bottom in Pennsylvania operated with an 86% availability, which is outstanding. Fort St. Vrain, in Colorado, had a very low availability because of one system (circulator bearing lubrication). The physics worked very well.

Because of these two and other prototypes, all the technical questions are really behind us: It's a matter of building a plant and showing it is economical. There are two ways we can do that; one is to have a commercial demonstration project. We belive there are several potential commercial sites for this. Also, the new defense production reactor, an MHR, will show the efficiency of the modular helium reactor, which should satisfy people that this is really the right combination of size and everything else.

I've used here the term modular helium reactor (MHR), but it's synonymous with modular HTGR. I like MHR a little better, because it has fewer letters, is more descriptive, and is more friendly. Helium is a very wonderful gas. There are other gas-cooled reactors using carbon dioxide. We like to differentiate ourselves from those, because helium is inert and carbon dioxide is not.

Q: What are the major obstacles to a crash program for mass production?
Blue: Demand for the product. The need is there and the need is becoming aggravated, but the utilities must see one working. That why the New Production Reactor is such an important project. We expect to have that one operating in 1998.

Q: But does that mean that any large-scale development program elsewhere would not go until after 1998?
Blue: It shouldn't, because every month that we refine and get closer to completion of our design, people should become more comfortable with it. We'll be testing all the components and we'll be building our case for why this thing is going to run better than anything that has ever run before. We are willing, along with the other suppliers, to make certain guarantees of operation. Then there is the question of regulations; it is terribly important that the NRC work quickly though the licensing process.

The need is already there, but is anybody ready to step up and pay money for it? I believe they would in Poland, if they had the money, because their need is so desperate.

It does take time to finish the design; that's roughly a four-year proposition. And then it takes about five years to build one.

Q: Would it take five years to build the first one? I thought that once you had a factory going that could mass produce them it would take less time.
Blue: Sure, then it would take only two to three years. If you can pull components off the shelf, your actual site time could be a lot less than that.

Q: The French company Framatome has said that right now it could produce 18 MHR vessels per year. How long would it take the United States to gear up to do this?
Blue: Framatome could do it because they have great capacity. We could do it in this country as well. If there was a will to do it, it could be done as rapidly as you could finish the design. What you are talking about is steel fabrication capacity, and the capacity is there, for example, in Chattanooga, Tennessee, where Combustion Engineering produced 70% of the reactor vessels that are currently in operation in the United States. They could easily produce MHR reactor vessels. The vessels themselves are very similar to water reactor vessels.

Q: Do they still have that capacity up and running?
Blue: It's not up and running because there isn't any demand. It's still there and it would take some modernization, but it could be done. I believe that Babcock and Wilcox has some capability and there is Chicago Bridge and Iron, which has some capability. I'm most familiar with Combustion Engineering. . . . The French have good capacity but there's capacity here also. But don't let me confuse you, it's not up and running now. I can assure you that the people in Tennessee would be delighted to have it regenerated.

Q: The MHR with its high-temperature cogeneration advantages seems especially suited to East bloc countries that now

depend on coal. Do you have any specific plans for involvement there?
Blue: We could convert their low-grade coal to gas and solve the environmental problems and still unlock the wealth of that natural resource. If Poland made the decision to go with MHR, that would not mean they were consigning their coal to the ground forever; rather it would mean that we could pull that coal out, gasify it, and avoid the environmental problems. We hope to get a full-blown study under way that will prove the feasibility of the MHR in Poland, and we would like to move ahead. We think it is the right technology for that part of the world. Where the money will come from is another question.

Q: That was going to be my next question. How would the financing work? What would it take actually to get something going there, at least one set of modules?
Blue: This is a very rough estimate, but the first four modules will take $2 billion. Each set of four modules after that will take $1 billon. And that is roughly $2,000 per kilowatt, which is a very feasible price for a new plant, a very good price. One billion dollars is about what we in the U.S. spend each week on imported oil.

Q: That's really not a lot of money when you consider that you are talking about developing the potential for an entire country, including turning its skilled labor into a resource, instead of unemployed.
Blue: That's an important point. One of the other advantages is that because our steam condition is the same as that for fossil—same pressure, same temperature—we can use a lot of the componentry that the Poles are already building, and know how to build. Other nuclear plants use a less efficient steam condition that is incompatible with what they have been doing before. So MHR's steam condition should be a big advantage to the Poles. Inevitably, because money is a problem, the more you can use of an indigenous industrial capability the better off you are and the better off they are.

Q: So they could actually make the steam generation parts of the plant?
Blue: They could make the turbine generator and a lot of the componentry. One of the things that our detailed study would do is a survey of their industrial capacity, just what parts they could produce themselves and what we would have to supply. In terms of cost, we're competitive with coal and the best projections for the big water-cooled nuclear plants. And I emphasize projections, because we both know that projections haven't been realized recently; they've been three and four and five times what they projected.

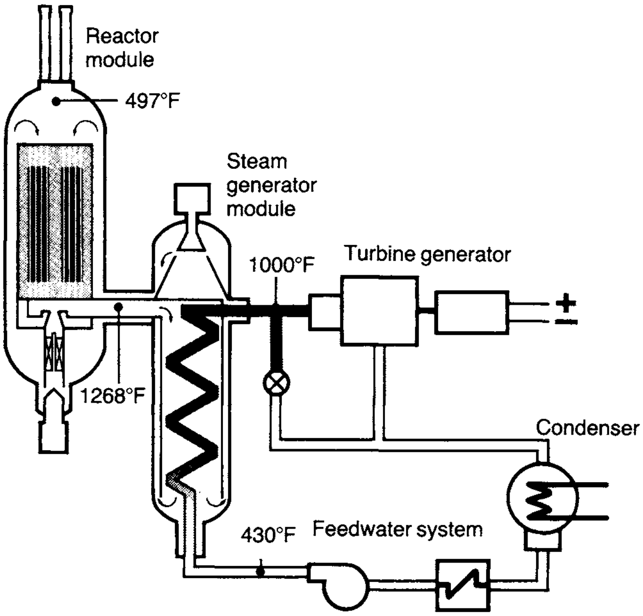
Q: Right now, the West Germans, French, and Japanese seem to have a much better understanding of the importance of infrastructure development for creating world stability than does most of the U.S. administration. What do you think it will take to change this situation here?
Blue: Well, I go crazy when I go to a big conference and the subject is, "What should the U.S. energy policy be?" because that implies that we are only looking at the United States. Usually my statement starts out that we are asking the wrong question, and we may get the wrong answer because of it. The real question should be, "What should U.S. policy be in the context of the world energy environment?" because that is exactly what it is. You can't separate the price of oil or the demand for fossil fuels in the United States from world markets. You can't separate U.S. air from world air, environment, atmosphere. You can't separate the problem that the Chinese have, who would very much like to build their prosperity. When they hear the highly developed countries, who became productive and prosperous largely by burning coal, pontificating about the need for the Chinese *not* burning coal, that's not very convincing to the people who must have electricity for their industry, heat for their apartments, and fuel for cooking.

Q: That's basic middle-class, U.S. environmentalism. It's nice to think about clean air in your warm house, but it doesn't do much for the people who are starving, or struggling just to stay alive in the real world.
Blue: And truly, you know, that is a U.S. problem. We, as a nation, are very parochial. The Japanese are not; they can't afford to be. They were decimated in a war. The same is true of the Germans. They're living in close proximity to the Eastern sector. They know those problems. Everybody in Europe is affected by the environment created in the East bloc. The French, of course, are into nuclear, and are well aware of these problems, because like other European powers they recognize the importance of world commerce, the world market, and they don't have any other energy alternative but nuclear. As you know, they're 70% nuclear now. The French also have figured out that if they don't ensure that the cost of energy is low, then they can't expect to have high wage costs. Said in another way, you can have high wage costs only when you have low energy costs—or, wages can be high only when energy costs are low. The U.S. needs to come to that realization as well. I think this attitude is gradually being felt in the United States, although it seems that it takes gasoline lines to get people to understand the problem.

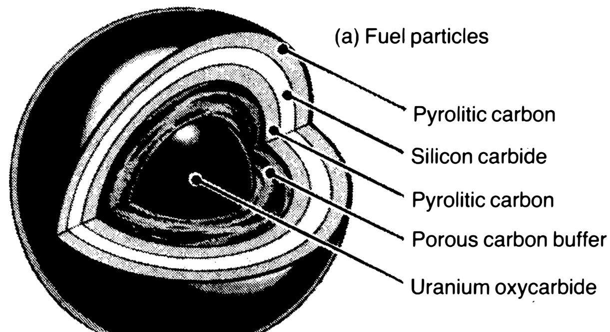
I was looking at a survey of opinions in Europe just the other day, and 55% are anti-nuclear, but 71% say that the priority overall is the environment. So they haven't made the connection yet that nuclear is the cleanest fuel, other than solar. The world population is increasingly sophisticated, and they will come to those realizations, but they haven't yet.

Q: If you look at what people are fed for information on television, and what our President, "the environmentalist,"

The modular high-temperature gas-cooled reactor



(a) Fuel particles



The most visible difference between conventional nuclear reactors and the MHTGR is its fuel and containment design. The fission power of the MHTGR comes from tiny fuel particles, the size of grains of sand. Each tiny sphere, about 0.03 inch in diameter, consists of a particle of enriched uranium coated with a graphite buffer and then encapsulated by three successive layers of pyrolytic carbon, silicon carbide, and pyrolytic carbon (below). These ceramic layers are the "containment" buildings for the nuclear reaction.

The design of the MHTGR is such that if something goes wrong, even in the highly unlikely worst case where all the coolant and control systems fail, the MHTGR fuel pellets can withstand the maximum temperatures that could be generated. Because of this inherent safety feature, the MHTGR will not have to have an additional containment building.

The schematic flow diagram shows the reactor module and the steam generator module. Helium coolant moves downward through the reactor core and is heated by the nuclear reactions. The hot helium then flows through the connecting duct to the steam generator, where its heat is transferred to the water to make steam. Cooled helium then is recompressed by the circulator and reenters the reactor. Inside the reactor core are graphite fuel blocks, hexagonal in cross-section. Fuel elements (composed of fuel pellets mixed with graphite and formed into rods) are stacked in columns in the hexagonal blocks.

The proposed power plant design of General Atomics groups four reactor modules, each at 135 MWe, for a total power output of about 540 MW. Each reactor module is housed in a below-ground concrete silo and is completely separate from the electric power generating system.

Source: General Atomics

is saying, you see that there is a great deal of unreality. I think that the situation really changed in Europe as a result of the wall coming down. It opened up the question of development not just Europe but also Asia and Africa. Poor, starving people don't make a good environment.

Blue: . . . You've got to be sure that you do things that are responsible, environmentally, but you shouldn't wreck economies in the process. The truth is that you can do both—you can have energy and you can have a good environment.

If you want energy you've got to understand you're going to have waste, and that includes the energy that comes from the human body. You've got to decide whether you want to use the atmosphere, which happens to be the only atmosphere we have, as a sewer, or whether you want to put very small amounts of waste in the ground where it is secure. You can do that with nuclear.

Q: What do you think it will take to change the situation here?

Blue: Articles like yours, and other media attention. We as an industry have to tell the story better. I think one of the reasons that the industry hasn't told it better is because the utilities don't want to close down their generating capacities. Most all of them have both coal and nuclear plants. They have to somehow explain the fact that there is a new, much safer type of technology, like the MHR, doesn't mean that their old reactors are dangerous. . . .

Q: The problem is really we haven't built anything new.

Blue: Precisely. What will change the situation here? Well, if we had gasoline lines, that would change it, but I hope we don't have to go to that extreme. If you had massive brownouts and blackouts that would change the situation. Mean-while, what we'll do is build a lot of our new capacity, almost in desperation, based on gas turbines, and that's using one of our best sources of energy, natural gas, for stationary power when it should be preserved for transportation. Unless we change our attitudes, we'll keep ourselves away from blackouts by burning valuable natural gas, while it lasts.

Q: Virginia has just contracted with the Japanese to build a gas turbine, because there is such an electricity shortfall, and that seems like lunacy to me.
Blue: That's right, and I'm sorry to say it's very widespread—to make gas turbines the source of added power. Everybody's doing it.

Q: What is the goal of the Department of Energy civilian fission R&D program on the MHR, and how does it mesh with the plan to make the military New Production Reactor an MHR?
Blue: It is very important that they both proceed. If we only did the defense part, we would just be delayed that much more in doing the civilian. The civilian looks the same from the outside, uses the same kinds of pipes and valves and all that, but the core itself is totally different. The civilian reactor uses a low-enriched fuel and the defense core uses a high-enriched fuel. That is a huge difference. Basically, if you have high-enriched uranium you can make weapons. It's important that we keep on with the effort of designing the low-enriched core so we will be ready to go with commercial version quickly behind the defense version. No one will be able to make weapons materials from the commercial version.

Q: What is the timetable for the MHR under the civilian R&D program of DOE, and what is the budget?
Blue: There have been several budgets. Without getting into them in detail, if the civilian program will proceed at a rate of about $25 million this year, then slightly increase each year for the next eight years, and then have private sector involvement added, I think we could get a project going that would mean a civilian reactor could come on stream perhaps a year or two after the New Production Reactor came on stream. . . . It's too bad it can't be sooner, but the NRC is very deliberate. And rightfully so, because people want the safest possible technology they can get. The NRC is used to taking a long time because the light water reactor is very complicated; it takes a long time to review. I think they could do the helium reactor in a shorter time, but at least the first time around they will want to be very deliberate. What we hope and trust is that they will come up with a certification process where once the reactor is certified it can essentially be built exactly the same in other locations.

Now, to get back to how do the civilian and military programs mesh? They mesh extremely well. There's virtually no overlap in terms of duplicated effort; the discrete parts and componentry are virtually all interchangeable. But I hasten to add that doesn't mean that you can get weapons material from a civilian reactor. In fact, the opposite is true.

Q: The point is that doing the one—MHR—will help give you the necessary experience with the other.
Blue: It's a way that we as a nation can spend the money once and get two benefits. It's analogous to the way we developed the KC-135 for the Air Force. It became the prototype for the Boeing 707, which put Boeing and the United States in the leadership of jet transport for the next 40 years. Thank God for that. That's been a lot of positive foreign exchange for the U.S.

Q: In general, we have promoted this idea of science as the "driver" for the economy. We need a space or a Strategic Defense Initiative program to give a mission sense to the economy and move it forward. And then we use the spinoffs from those technologies, whether for defense or for space exploration, to upgrade productivity in the rest of the economy. That works. That's the only thing that's given our country prosperity.
Blue: Defense budgets have done that, and this can be every bit as important to the U.S. balance of payments as the KC-135 was.

Q: Next, I have a question that has come up from several people in the nuclear industry about economy of scale—the bigger the reactor, the less expensive. From what I see of General Atomics' studies, the economics for your smaller-size reactor is very competitive with larger reactors because of mass production.
Blue: That's right. Factory quality control and factory production. You could almost say that everything we have that is good, efficient, and low cost in our world, is because it is mass produced. Anything that is hand built one at a time is very expensive. The economy of scale sort of grew. People said, "Well, if we could just up the megawatts, it won't cost that much more to operate and won't cost that much more to build, but we'll be amortizing our cost over a much larger base," and that's what economy of scale is all about. Well, it works in theory, but in fact, for the nuclear plants above about 600 MWe, the opposite may have been true. The bigger plants got, the more complicated and more expensive they became, because that's the nature of the beast from a design standpoint. To a large extent the increased expense came, because the larger the plants became, the more resistance they met in the communities where they were to be placed, and so the longer it took to get one done.

I'm not saying that economy of scale isn't a valid approach and can't work in the future. It has, in fact, worked in the past, but it hasn't worked in many nuclear projects. In too many the reverse has been true.

Well, another way to get the cost down is to build things efficiently using modern industrial processes, automation, and all those good things. To a great extent we sort of borrow the kind of technology that has made it economical for us to build airplanes, the learning curve. That's just as good, and in fact maybe even a better proven way of reducing costs than "economy of scale," because the learning curve is well known in industry.

When I was in the aerospace business, we either conformed to the learning curve of about 80%, or we would be looking for somebody who could. Industrial production using the learning curve is well understood, and it is something that it's time the nuclear industry took advantage of.

By contrast, think of building a [Boeing] 747 the way we build nuclear plants. That would involve calling up Seattle and saying, "All right, you guys send me the parts for a 747, and we'll sort of do the finished engineering on them here in San Diego. Then we'll hire a bunch of mechanics to put it all together." Guess what? It would cost probably 20 times as much as buying a finished product from Seattle, and it would be a pretty dangerous thing to get into, as far as I'm concerned, because you would have people building it who weren't experienced, hadn't had the advantages of tools and factory setup, and all that implies. This is the direction in which the nuclear industry must evolve if we are to be competitive, and the modular helium reactor is perfectly suited to that kind of a building process. That's why I said at the start that the small size and the modularity are also the key to economy.

Q: Is the question on economy of scale one of what has happened in the United States over the past 20 years to the nuclear industry? Is it the environmentalist movement's objections to nuclear that have made it uneconomical to do a large-scale reactor? Is that what is factored in your economics?
Blue: Those are among the problems. I'll give you an example. In an average light water reactor there are something like 40,000 valves. When you look at the nuclear-grade piping and valving, which is very expensive, the MHR has, we believe, 100 times less nuclear-grade piping and valving per reactor. That is a heck of a lot of leverage to get cost down. I'm mixing a little bit apples and oranges here, because the 40,000 includes non-nuclear-grade stuff, so I'm giving you two numbers. I don't have an exact valve count for a whole plant, but the best estimate on nuclear-grade piping and valving, by weight, which is important, is that the MHR has 100 times less.

Things generally cost by weight and by number. The fewer parts you have, the less something is going to cost. The less it weighs, the less something is going to cost, generally speaking. That gives us a huge amount of leverage. The MHR may take eight modules to make 1,000 megawatts, but we still have fewer parts, perhaps by a factor of 10. And it's that simplicity, again, that is the key to the cost and the safety.

The thing that we say, as far as the economics go, is that we are competitive with coal, and we're about the same as the large, "economy-of-scale" nuclear plants are supposed to be, but don't normally achieve. I think we will be economical, because we are able to operate much more reliably and efficiently, and have much greater capacity factors.

Q: Your plan is for four 135 MW modules at one site?
Blue: Yes, but the pressure vessel itself is a large piece of steel. It's small in the sense of its output, but it is large physically because it has a low power density. That's one of the things that leads to its safety characteristics.

Q: What do you think it will take to get nuclear energy moving worldwide as it was envisioned in the Atoms for Peace days?
Blue: Need, which we have; and understanding, which we're lacking. I think we must develop a great degree of cooperation worldwide where the United States understands that one of the responsibilities of the developed world is to help the developing world. We can't expect them not to utilize energy. If we don't want them to wreck the environment, then we have to help with our technology. We have to help them solve their problems in an environmentally sound way, namely, with technology.

Interview: Isidor A. Weisbrodt

Let's build a joint East-West HTR plant

Isidor A. Weisbrodt is the general manager of the West German joint venture company to develop and market the high-temperature gas-cooled reactor, Gesellschaft für Hochtemperaturreaktoren (HTR-GmbH). The joint venture was formed in May 1988 by ABB-Germany/Hochtemperaturreaktorbau GmbH—formerly 51% Brown Boveri Company and 49% General Atomics, and now 100% Asea Brown Boveri—and Siemens-KWU/Interatom, a wholly owned subsidiary of Siemens, for the future HTR development marketing, planning, and construction of HTR power plants, namely, the HTR-500 and HTR-Module.

The German design differs from that of General Atomics in the way the fuel is configured. The HTR uses a pebble-bed design, with 6-centimeter balls of fuel instead of a ring-shaped core. Mr. Weisbrodt was interviewed by Marjorie Mazel Hecht on March 9.

Q: What is Interatom's plan to develop the HTR and what kind of investment is necessary from the private sector?
Weisbrodt: Siemens-KWU/Interatom (a 100% subsidiary of Siemens) entered the HTR field in 1972. The modular