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

HTR design was invented by Interatom in 1979. . . .

The ABB group as well as the Siemens group have already spent in the last 20 years on the order of 500 million deutschemarks of their own funds for HTR development. This development has been supported by additional public funds from the federal government and the state of North Rhine-Westphalia.

The strategic goal is to develop the HTR-500 and the HTR-Module to such a status by 1992-93, that a construction project could be initiated. In case of the HTR-Module, its development has already reached a status where a site-independent licensing procedure on the safety concept has been conducted. The final statement of the German Reactor Safety Committee on the license-worthiness was published in February 1990.

As for the further development costs (first-of-a-kind costs), approximately DM300 million have to be spent for both HTR-500 and HTR-Module. Approximately 50% of this sum has to be paid by the private sector. . . .

Q: We are looking at the HTR as ideal for the East bloc, because of its higher temperatures for cogeneration that can be used for industrial applications and district heating. Are you looking at this market?

What about the Soviet Union itself? You mentioned that you have been assessing their need to repair and replace many of their nuclear reactors. Is the HTGR an option for them?

Weisbrodt: We share your opinion about the applicability of the HTR as an ideal power and heat source for the East bloc and especially for the U.S.S.R. We are already working on this market! In the U.S.S.R. there is a need especially for the upgrading of coal in Siberia, that is, gasification and transport of the upgraded coal as gas in pipelines, for the tertiary oil recovery or recovery of heavy oil by steam injection, for the cogeneration of steam and electricity in the chemical industry, or for electricity generation, district heating, etc. As for the nuclear process heat application or the cogeneration, only the HTR with its high temperature can be applied as a nuclear source.

Besides these applications, however, the HTR can be used for electricity production, too. In the U.S.S.R. the distances are far, and small-sized power plants are needed for distant towns, industries, etc.

In the other East bloc countries, the grids are rather with an uncomplicated periphery need and insensitive to operator errors due to its inherent design and safety characteristics. Therefore, it is the ideal machine for sites close to cities or in industrial complexes.

Q: How fast could you supply modular units?

Weisbrodt: The construction time of a HTR power plant that consists of four module units (each 320 MWe) is on the order of 48 months, counted from the receipt of the construction permit.

Q: How many do you think you could produce in a year? Professor Schulten, one of the West German pioneers in high-temperature reactors, has suggested that West Germany could produce dozens per year.

Weisbrodt: The number of HTR-Modules which can be supplied in a year is largely unlimited. That is, Framatome in France could manufacture in their vessel facility 36 vessels per year—sufficient vessels for 18 HTR-Modules. However, there are other manufacturing capacities in Germany, Spain, Japan, etc. Other limitations cannot be seen.

Q: What is your view of economy of scale versus the savings from mass production? What size plants are you looking to produce?

Weisbrodt: We have been working intensely on these economics. The criteria for judging the economic considerations are very complex. I would like to give you the following information:

In case of series production (10 modules per year), a cost reduction of the overall power plant of about 22-25% can be reached as against the production of a "second power plant." The specific investment costs or electricity production costs of light water reactors with a power for 1,300 MWe cannot be reached by the HTR-Module. If, however, a light water 1,300 MWe reactor can only be loaded with 50% for a period of three to four years, an HTR-Module power plant with 640 MWe would be more economical.

Besides these considerations for electricity production, the HTR has no competition from the light water reactor in the case of the need for cogeneration or process heat plants. In such cases the competition is coal, gas, and oil. For German conditions, the HTR-Module is competitive with these energy carriers. Moreover, there is no environmental pollution. From our point of view, a carbon dioxide penalty and pollution penalty for fossil fuel-powered plants should be taken into account in the future. The main obstacles for the HTR-Module introduction are: the ongoing public hostility against nuclear energy; the financing of the non-commercial, first-of-a-kind costs; and the willingness of customers to take the first power plant and to have the commercial risks for such a plant. . . .

Q: What would you like to see the United States contribute to commercializing HTR technology?

Weisbrodt: In order to overcome the described financial and commercial difficulties, it is worthwhile to consider a joining of forces by developing, planning, constructing, and operating a joint Federal Republic of Germany-U.S.-Japan-U.S.S.R. HTR demonstration plant. The site might be in the East bloc (Poland or the U.S.S.R.), or Bangladesh—as a prototype of a Third World country which urgently needs electricity without having any noteworthy fossil resources of its own—or Peru, or the United States.