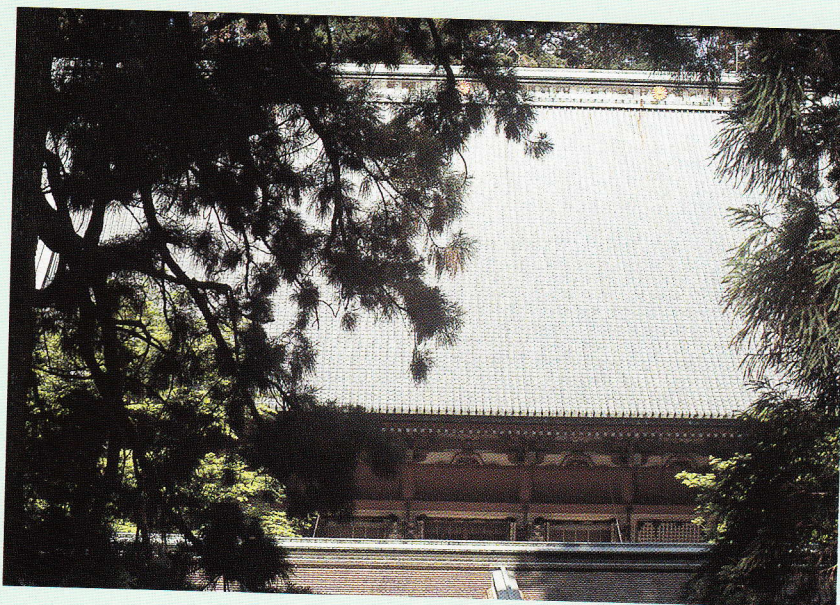


# Plutonium

*Summer 1996 No.14*



*Opinion*

**Dismantled N-Weapons Will Best Be  
Used in Reactors**

*Pu-Series 14*

**Energy Security and FBR's Role in  
Future**

*Pluto*

**A Short Trip**

*Council for Nuclear Fuel Cycle*



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Summer 1996 No.14

## Council for Nuclear Fuel Cycle

Juzen Bldg., Room 801,  
2-9-6, Nagata-cho, Chiyoda-ku,  
Tokyo 100, Japan  
TEL : 81-3-3591-2081  
FAX : 81-3-3591-2088

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**Executive Editor & Publisher**  
Masao Hori

**Editorial Office**  
Council for Nuclear Fuel Cycle

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Cover : Tiled Roof of the Konpon Chudo Hall of the Temple  
Hieizan Enryakuji

Konpon Chudo, an all 'keyaki' wood building standing as the central hall of Hieizan Enryakuji, has a flame kept burning for 1,200 years as the light of Buddhism. It was not totally put out even when the temple was set on fire by Oda Nobunaga in 1517, for a part of the flame was moved to Risshakuji, a temple in Yamagata Prefecture, to keep the light of Buddhism burning there. Sixty years after the temple was burned down, Iemitsu, the third 'shogun' of the Tokugawa line, spent eight years getting it rebuilt in 1642 and the light returned there from Risshakuji. Not a day has been without a supply of rapeseed oil to keep the light burning to date.



## Dismantled N-Weapons Will Best Be Used in Reactors

The warheads of a 3-megaton hydrogen bomb is equal to the power of all gunpowder used during World War II. Atomic and hydrogen bombs in the world, all taken together, will have the blast equivalent of 40 billion tons TNT. This amounts to 6 tons per head of mankind. The question is what is in store for them.

The U.S. and Russia are obligated by the Second Strategic Arms Reduction Treaty (START II) to reduce their strategic nuclear weapons to 3,500 each by 2003. It is not a success in international politics, but national financial stringency or insolvency, that brought the two countries to conclude the treaty. However, ironically enough, reports from Russia say financial problems stand in the way of dismantling nuclear weapons in that country.

The International Court of Justice (ICJ) on July 8 offered an advisory opinion on the illegality of the use or the threat of use of nuclear weapons. The advisory opinion came after the court, while regarding the use of nuclear weapons as generally violating the rule of law concerning humanity, found it impossible to conclude definitely whether it is lawful or unlawful for a country to use nuclear weapons for purposes of self-defense. There was a discrepancy in the interpretation of "self-defense," in particular, as the 14 ICJ judges, reflecting their respective positions, split 7 to 7 into the pros and

cons of the situation. In this connection, *Newsweek* magazine (Japanese edition) on July 24, in an article on "the significance and insignificance of the nuclear arms trial," likened the division of opinion among the judges to "Rashomon," a well-known film directed by Akira Kurosawa, indicating that anything can be interpreted quite differently depending on the way it is looked at.

The use or the threat of use of nuclear weapons, as admitted by the ICJ, naturally violates the rule of law concerning humanity. For nuclear weapons are more than chemical and biological weapons as weapons of indiscriminate mass destruction. As Barton J. Bernstein, Professor of History at Stanford University, U.S.A., puts it, quote—The earlier moral insistence on noncombatant immunity crumbled during the savage war. . . . It was that redefinition of morality that made Hiroshima and Nagasaki possible and ushered in the atomic age in a frightening way -unquote. ("The Atomic Bombings Reconsidered," *FOREIGN AFFAIRS*, January/February 1995)

The existence of nuclear weapons can only be justified by hypocrites no matter how moral views of the weapons may be redefined. As long as international politics allows the Nuclear Non-Proliferation Treaty (NPT) to be extended indefinitely, the five nuclear-weapons states are authorized to continue having nuclear weapons. If in the name of "self-defense," they could threaten to use, and

then use, nuclear weapons without letting no one decide whether it would be unlawful or lawful for a country to use them to kill noncombatants indiscriminately.

Nonetheless, there are moves in some way or other toward nuclear disarmament now. The task before the U.S. and Russia is how to dispose of the nuclear materials, especially the plutonium, that come through the dismantling of nuclear weapons. Studies are being made in the U.S. on vitrifying the material for deposition deep in the ground or burning it in reactors. Perhaps the most realistic way will be for the material to be burned in reactors if no source of concern is to be left for the future and if society is to derive some benefits from the vast investments made in the development of nuclear weapons.

The study of problems involved in the burning of plutonium in reactors should not be left to nuclear-weapons states alone. Other nuclear-energy states and private companies having the experience of burning plutonium in reactors should also be asked to cooperate in order to provide a good opportunity for the promotion of nuclear disarmament and nuclear non-proliferation. This will contribute largely toward building a reassuring, stable international society in the post-Cold War period.

*Executive Editor*



# Energy Security and FBR's Role in Future

**Kazuhisa Mori**Executive Vice Chairman  
Japan Atomic Industrial Forum, Inc.

The sodium leakage accident of the prototype fast breeder reactor (FBR) "Monju" has opened up arguments over the significance of the peaceful uses of plutonium and the development of FBRs. Use of plutonium is important in that it promotes efficiency in the use of resources. Developing the FBRs that burn plutonium efficiently is also important in that it will achieve the stability of energy supply in the future. Now, Mr. Kazuhisa Mori, Executive Vice Chairman of the Japan Atomic Industrial Forum, is available for comments on the peaceful uses of plutonium and the FBR's role through the perspective of energy problems in the future.

*(Editor)*

## Real Tasks Need to Be Explored

Several months have passed since sodium leaked in an accident at "Monju" FBR in early December last year. Investigators say they have at last found the cause of the accident. They say nothing more than what one can find at first sight. Technically, it is an accident Japan should be ashamed of.

Besides, the sodium leak occurred in the secondary system that contained no radioactivity and that had no adverse effect to produce on human bodies inside the facility and out. Investigation shows that nearly 140 sodium leaks have so far been reported in the world outside of the U.S.. None of them had occurred in Japan until "Monju" leaked sodium. I would like to see what it is that caused this accident to have great repercussions. The repercussions are so resounding that some nuclear interests seem to be still unable to regain their presence of mind. I have been trying to contact some of them for comments on what they have to say. As was

the case with the nuclear ship "Mutsu," there are problems that could be settled for the time being, giving the interests involved something that they could "get off with." It would come to the same thing if they fail to straighten out the real problems they have to settle, because they do not have the next proposals to make for themselves to let there be no such problems again.

## Oil Prices Are Stable: Thanks to Nuclear Power

It is common knowledge that nuclear power now accounts for one-sixth, or about 17%, of all electricity generated in the world. This is equal to energy produced by 500 million tons of oil annually. World oil production now is some 3 billion tons a year. When compared to the trade volume of oil, after its requirements for self-consumption are subtracted from the production, the energy equivalent of 500 million tons of oil is equal to about one-third of the trade volume. So it can be said now that oil prices are sta-



Kazuhisa Mori

ble primarily because of nuclear power.

However, most nuclear energy now is being produced by light water reactors which use, in most cases, uranium 235, a fissionable material accounting for 0.7% of natural uranium. They use uranium 235 after enriching it until its content increases to about 3%.

The remaining 99.3% is uranium 238. In other words, most of natural uranium is a material which is not fissionable. If allowed to absorb



surplus neutrons as they come through the fission and chain reaction of uranium, the material will turn into plutonium, which can be used as fuel. If this process can be repeated over and over again, it will be possible to make energy out of half, if not all, of the uranium.

The fact is that in addition to energy coming through the fission of uranium 235, the existing light water reactors have some uranium 238 burning in the core as they change it into plutonium there. Plutonium accounts for some one-third of electricity generated by light water reactors. Nuclear power represents 30% of all electricity supplied in Japan now, and, therefore, it can be said that 10% of the total supply is energy produced by plutonium.

### First Nuclear Power Generated by Fast Reactor

This is the first source of energy ever available to mankind in that it is a fuel which, when burned, will produce a new fuel. That has been the focus of attention since man found out about nuclear fission and chain reaction. Forty-five years ago, in December 1951, when the U.S. successfully operated a nuclear power plant to generate electricity, it was by a fast reactor. Sodium was used then as coolant for the reactor. So, in this context, sodium has long been a familiar material. The trouble is that it is not well known because few have been closely concerned with it.

It is for a variety of reasons. One

reason has been competition from Russia-the Soviet Union. It was all of a sudden that the Soviet Union launched the Sputnik in an attempt to outstrip the U.S. in space exploration. In 1954, some three years after the U.S. used a fast reactor for power generation, the Soviet Union began operating the world first 5 MW (full-scale) nuclear power plant. Since the U.S. was about to embark on the peaceful uses of nuclear energy, the Soviet lead in this respect hurried it into building a nuclear power plant. That was a 60 MW plant operating on a small reactor originally designed for nuclear submarines and converted to work with a generator. Americans thought this could put them on a level with Russian nuclear power.

A man who was then a U.S. Atomic Energy Commission director for development called on me at my office some 10 years ago and said, "In the matter of nuclear power, Japan is doing better than the U.S.. For all its experience with atomic bombs, Japan is doing well. I came here to congratulate you on what you are doing." His name was Hafstad. I said to him, "I understand that you served as the first director for nuclear development. But I have not heard much about you since then. What have you been doing in the past 40 years?" "When the Soviet Union got ahead of us in the matter of nuclear power," he said in reply, "we were told to build whatever reactor we can have to generate electricity." When arguments were prevailing

that the fastest and simplest way was to use a light water reactor for power generation, the nuclear development chief opposed it. "Nuclear energy is something very elaborate and it refuses to be produced in such a fast and simple way as water is boiled by the use of oil or coal," he said. He called for a comparative study of sodium, direct generation and other methods from which to choose something better than the fast and simple method. But most others went in for the light water reactor on the ground that they could not allow the Soviet Union to take the lead. Since he was discouraged from going along with them, according to what he said to me, he returned to his university post. I thought he was right, for it was a sodium-cooled fast reactor that the U.S. used in its first efforts toward nuclear power.

### Should Fast Reactors Be Developed Slowly?

If an oil crisis should happen, raising oil prices, say, 20 times as high as they are, the light water reactors would be good enough to overcome the difficulty, and the more they were built the lower the cost of power supply could be involved. This idea led most nuclear power companies to set their course for light water reactors. They thought that fast reactors, which were a little expensive, could be developed slowly. As the production of nuclear weapons was somewhat declining, they thought they would be supplied with enough ura-



nium to operate their nuclear power plants. So the era of light water reactors began. Since then, they have been thinking that the development of fast breeder reactors could wait until the time comes when they eventually run short of uranium.

## U.S. and British N-Energy Projects Started with Plutonium

Uranium reserves now are believed to be several million tons. If only uranium 235 is to be used for energy — in other words, if light water reactor operators follow the present U.S. policy of throwing it away after once using it as fuel in their reactors — then the uranium reserves, even when taking further possible discoveries into account, will not last any longer than oil or natural gas reserves are expected to continue serving purposes of energy. But if spent fuel is recycled for the use of plutonium, uranium will be used several times longer than coal. In other words, it will keep mankind supplied with energy for 1,000 years, or rather for several thousand years. Success or failure in nuclear fuel recycling is the point that decides whether uranium ends up serving as a resource no more abundant than oil or comes into use several times longer than coal and oil combined. Uranium happens to be cheap now, and light water reactors could go on burning it with no thought for recycling, because the fuel would pay if thrown away after it was used once. But this is no way to go at a time

Table Number of Sodium Leakages in Foreign Countries

United Kingdom	
DFR(Experimental Reactor)	7*
PFR(Prototype Reactor)	20
France	
Rapsodie(Experimental Reactor)	2*
Phénix(Prototype Reactor)	23
Super-Phénix(Demonstration Reactor)	3
Germany	
KNK-II(Experimental Reactor)	21
SNR-300(Prototype Reactor)	1
Former Soviet Union	
BR-10(Experimental Reactor)	19
BN-350(Prototype Reactor)	15
BN-600(Prototype Reactor)	27 *
Total	
	138

Note: Nak was used for DFR.

No confirmed information is available about American cases.

The asterisks show the cases where a leak was found in the primary system.

when the social trend is toward recycling.

The U.S., Britain, and even the Soviet Union were thinking about using plutonium when they took their first steps toward the peaceful uses of nuclear energy. Until the beginning of the 1970's, the U.S. was telling other nuclear-energy states to "consider using plutonium, instead of asking easily for the supply of enriched uranium." Since Americans were taken up with what they have to do with their uranium enrichment facilities, they were not ready to give enriched uranium to other countries unless they were seriously considering using plutonium. So Japanese electric utility companies pledged to the U.S. that they would "use plutonium as soon as Japanese efforts toward the utilization of plutonium

materialize." For more than 10 years, any company had to make the pledge in writing if it wanted to be assured of an additional supply of enriched uranium.

In 1974, India carried out an underground nuclear explosion test for what it described as the purpose of making peaceful use of nuclear energy. The test was made with plutonium produced in a reactor which India imported from Canada. Immediately after this event, the U.S. made an about-face on the policy of promoting uses of plutonium. The U.S. told Japan not to start up the reprocessing plant that had just been completed at Tokai-mura. Japanese operators were told that they could not operate their plant without the U.S.'s consent because it was to reprocess the enriched uranium that they received from the U.S.. The Japanese were so agitated that Carter (then U.S. President) could be likened to the commander of the American "black ship" fleet who took it to Japan, demanding it open up to trade with the West. Excited newspapers and political parties were squaring off for the possibly the first confrontation to arise between Japan and the U.S. in the postwar era. Japan was making a common cause with Germany. After all, the Tokai reprocessing plant was somehow permitted to operate with conditions attached.

In this respect, the situation is just about the same as it was 20 years ago. However, some news media, though having agitated against the U.S. 20 years ago, have



now reversed their attitudes. I cannot see why they oppose proponents of the use of plutonium, describing them as something like traitors and describing plutonium as a devil's product. Plutonium is not a devil. If there is a devil, it is the man who uses plutonium. People will feel sorry for plutonium if it is not used properly. I wonder if the fashion of the day is not what I thought it to be. Or rather, I might say there are people who would not see others, especially the Japanese, gaining access to what could produce scores of times as much energy as may be expected from oil and coal combined.

In all senses, it is desirable that nuclear energy should be used to a certain extent. For this will prevent prices for oil, gas and coal from being set at any level wanted by those who supply them. The odd thing about Japan, which is buying oil around the world, is that since the oil crisis, nothing has been

secured, except Arabian oil, as a resource that can be placed at the disposal of this country. In this respect, people could not be faulted for denouncing Japanese businessmen for lacking the decision needed for them to save Japan from staying in the buyers' market forever. Wild fancies come to my mind when I speculate why plutonium suddenly fell out of favor with the Japanese.

#### Poor Welding Responsible for All Sodium Leaks in Foreign Countries

A total of 138 sodium leaks have been reported in the world outside of the U.S. (Table). The asterisk indicates the case of a radioactive sodium leak occurring in the primary cooling system, near the reactor.

According to a close study by the Power Reactor and Nuclear Fuel Development Corporation (PNC) of these leaks in other countries, poor welding is responsible for all of them. Whether direct or indirect,

all causes are due to welding. So the first idea that came to the minds of PNC officials when they faced the "Monju" accident, I believe, was that there might be "something wrong somewhere in the weld." A sodium leak in the weld would usually not come through a wide-open crack. Assuming it to be an oozing leakage, reactor operators checked out the sodium tank to see if there was a decline in quantity. There was not a tangible decline. A tangible decline in the quantity of sodium there would have led the operators to effect an emergency shutdown. Assuming it to be a leak in the weld, they were probably thinking about an unhurried shutdown.

What happened first was a high-temperature reading of the temperature sensor in question. First it showed a "high outlet temperature." Being a very important apparatus in the way of safety, the temperature sensor is designed to err on the safe side when it is broken. So it will show the more alarming of its readings. A broken clinical thermometer would give a lower temperature reading. If a sensor gives a "high-temperature" reading while others, provided before and after it, are normal, the indications are that the sensor in question is "broken."

The temperature sensor, one of the few components inserted into the thick 90-cm-diameter pipe that allows the flow of sodium, is a sheath 1 cm in diameter and 3 mm in thickness, with a 4-mm cavity inside. Operators should have

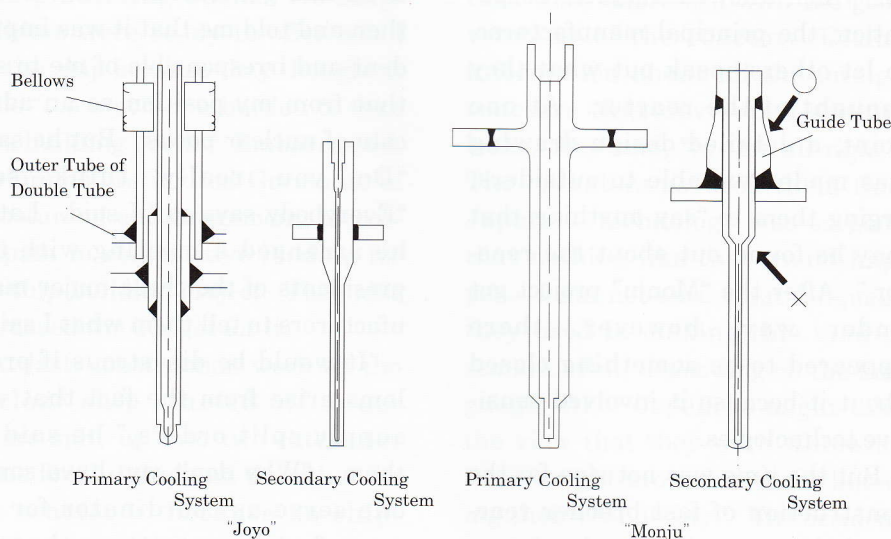


Figure Comparison of Temperature Sensors in the Shape of Piping



gained the idea of a possible oozing leakage through the 4-mm cavity. Foreign studies may have been too long for them to think their own thoughts. They were obviously pre-occupied with what happened in other countries. As a result, they took time to stop the reactor and give the notice.

What happened after they took time to stop the reactor? A reactor, when stopped, will stop like a pump. It has sodium pushed out with a force equal to some two atmospheres. Still there is enough pressure applied to circulate the coolant. If there had not been the pressure, so much of the amount of sodium leaked would have been reduced. If the reactor had been stopped sooner, the temperature would have dropped sooner. It would have dropped to the level of 300°C, instead of 480°C. These two things can be thought of as what happened after the unhurried shutdown. Another thing to be regretted is that a careful and unhurried shutdown gave cause to the impression that something "disastrous" had happened.

### Why Did the Shape of "Monju" Temperature Sensor Not Attract Attention?

After comparing "Joyo" and "Monju" in the shape of temperature sensor tubing (Figure), I marked off one from the other by circles and crosses. I suppose the sections marked with crosses would make people who see them wonder if they are "all right." Besides, I believe no



one has ever placed one temperature sensor by the side of another in an attempt to compare all four of them.

By contrast, the sections marked with circles are strong tube holders. They are welded very well. Close care had been taken to get them so solidly welded that "nothing of the kind seen in other countries will happen to them." But the trouble is that due attention had not been paid to the sections marked with crosses as they were likely to break off.

"Joyo" was an experimental reactor which allowed Toshiba Corporation, the principal manufacturer, to let others speak out what they thought of the reactor. At one point, a detailed design drawing was made available to outsiders, urging them to "say anything that may be found out about the reactor." After the "Monju" project got under way, however, there appeared to be something closed about it because it involved sensitive technologies.

But the time was not ripe for the construction of fast breeder reactors in large numbers, and so it was not advisable if the three manufac-

turers were left competing with one another. FBR technologies had to be brought together so that they could be handed down through a coordinated effort. FBR Engineering Co., Ltd. was established before "Monju" was built. But soon after the company was set up, electric utilities were awakened to their responsibility for the construction of fast breeder reactors. Since the utilities were active, it was decided that reactor manufacturers should be left competing with one another. So the company, set up to bring together FBR technologies for preservation, could not play the role originally expected from it.

I recall an episode I had when the prototype advanced thermal reactor "Fugen" was built prior to "Monju." I was young then and had the effrontery to say, "Fulfilling split orders as they are placed separately with them, the manufacturers will not be able to get the reactor going." Mr. Toshio Doko, now dead and gone, heard what I said then and told me that it was imprudent and irresponsible of me to say that from my position as an advocate of nuclear power. But he said, "Do you really think so?" "Everybody says so," I said. Later, he arranged a meeting with the presidents of the three major manufacturers to tell them what I said.

"It would be disastrous if problems arise from the fact that you supply split orders," he said to them. "Why don't you have someone serve as coordinator for all manufacturers, getting them to show their detailed designs for joint



study?" Mr. Tsutomu Watamori, then managing director at Hitachi Ltd., took the trouble of organizing the comparative study of design drawings that resulted in correcting a total of 200 sections in the final conception of the reactor. That was the major factor for success in the "Fugen" construction project.

"Fugen" has already consumed 100 tons of uranium-plutonium mixed oxide (MOX) fuel. Although the governor of the prefecture in which the reactor is located says nothing about it, plutonium is certainly consumed there.

Another case is the nuclear ship "Mutsu." It was in the midst of a ship-building recession when designs and cost estimates were made for its construction. Since any ship-builders would be glad to receive an order for the ship, it was to be built on a modest budget. When orders for the ship were to be placed at last, it was in the midst of a ship-building boom. No ship-builders were ready to offer a bid for the ship because they thought it to be "too much of a burden to take up a building berth." Embarrassed, the promoters invited Germans, in a gesture of encouragement, to participate in competitive bidding for the ship-building project. They also increased the budget for it.

At last, construction work on the nuclear ship started off under orders split up into two categories — one for the ship and the other for the reactor — because no ship-builders wanted the project to take up a building berth for a long time.

The reactor was to be built by Mitsubishi Heavy Industries Ltd. and the ship by Ishikawajima-Harima Heavy Industries Ltd. The project went to thoughtless lengths in that a reactor, the first of its kind, would be put in motion for the first time with a ship on demonstration voyage. For any reactor for power generation, it is a common practice to undergo a number of trial runs after going through a critical test, so that sufficient time can be given for adjustment. It is not a common practice to let a reactor have its first test run in the presence of news reporters. The uproar over the nuclear ship was due to the radiation leak that occurred during its first voyage.

Similar things preceded what happened to "Monju." Unfortunately, the accident happened a week after reactor operators met with a team of local newspapermen and another team of media people visiting the reactor installation. The visitors then were impressed with the good working of the reactor. Citing information about all the foreign reactors that developed sodium leaks, they said, "Is this all right?" The operators assured them that Japanese technology was so good that nothing like that would happen. I am not sure what language they used in making this kind of remark. But, depending on the language, other Japanese might take the view that they were "throwing their weight around without knowing their real ability." The accident happened when they were thought to be "puffed up with the success

that they believe has been achieved among their circle." The "Monju" uproar arose as long-standing opponents of the peaceful uses of plutonium joined forces with those who had a bad feeling toward the reactor operators as they appeared to be "self-conceited."

### Videos Are Taken to Be Edited

While I am speaking about "Monju," I might say something about the videotape that was said to have been concealed to keep back information about the accident. The other day, when I met with media people, they asked me questions about the videotape. I told them that from my experience as a TV program director in my youth, I know that videotapes are taken to be edited later. It would be impolite toward video viewers, I said to them, if they were shown everything that was recorded on videotapes. Since it is a common practice to let news reporters see videotapes after they are taken and edited in order to show what was summed up in sections where they proved successful, I told the journalists that it would be wrong to charge the reactor operators with failing to show an un-edited version of the video record. They acknowledged that I was right to say so. The trouble is that a version of the video record was found kept back after the operators said they had shown "everything on record." That is the question.

One lesson from the uproar over "Monju" is that the reactor opera-



tors must be prepared for the news media. When the accident happened, they had no idea how many newsmen would come up. They were so unprepared that their office building was temporarily occupied by the newsmen. If, for example, the president of the PNC was to come to the aid of the operators, a schedule would be put up indicating the arrival of the president some three days before. Then the newsmen would be interested to know "what he is coming for and what he will say." In the presence of the newsmen, the president could not possibly say, "You are doing a fine job. Let's stick it out no matter what others say about us." Instead, he would have to say something stereotyped. Then some members of the field staff might have the impression that people from the headquarters in Tokyo had no sympathy for them. "They are going to force everything on us," they might say. The circumstances were such that field staff could hardly have an intimate talk, especially with people visiting them from their headquarters.

So it might be advisable to ensure that an important installation, such as the "Monju" project, has a building or two reserved for visiting newsmen, with video equipment provided for them to see what they want to see at any time. Since people involved in an accident are likely to be too disturbed to answer questions about it, it is necessary to set up a separate organization and provide it with sufficient experience and knowledge to give convincing

information to newsmen.

## Fault Obviously Lies with Manufacturers

There is no doubt that the manufacturers were at fault for causing the sodium leak at "Monju." If any man of decision responsible for the manufacturers had said that it was their fault and that it would never be repeated again, then the uproar over the accident might have been held to one-third or half of what actually took place. But that could hardly be the case. An investigation committee was set up and experiments were carried out only to let debate last for months over questions, such as about the direction in which the flow was swirling, before it could be established that the accident was due to a bad design. It was not until then that the manufacturers began to acknowledge that it was their fault. There is every indication of the system under which nuclear interests are compelled to become time-servers — a system which outsiders can hardly understand.

Certainly it would not be impossible to consider something other than sodium for use as the coolant for fast breeder reactors. One difficulty in the use of sodium is that it has to be heated to some 100°C. before it turns liquid. The boiling point of sodium is 882°C. and its specific gravity is a little smaller than that of water. Being a metal, it has much better characteristics than water has for heat transfer. It also has a good propensity for coex-

istence with other metals. It will not reduce the speed of neutrons, nor will it absorb them. The only difficulty with sodium is that it is so chemically active as to burn on contact with air or water. When in a liquid state, it assures a relatively wide range of temperature and permits heat exchange at high temperature. That is why the choice has fallen on sodium.

Some Russians suggest that lead might be used for the coolant for FBRs. But that is not an easy task because lead can hardly be used unless it is heated to 300°C or higher before it turns liquid. Another possible coolant is helium.

The trouble with sodium is that its specific heat being about 0.3, it will not gain the same quantity of heat as water does unless it is circulated three times as often as water is done. That is why the secondary system has a pipe that is large enough for it to be circulated in larger quantities than for water. But it is so light and smooth that it will involve much less of the power needed for pumping, or of the energy required for circulation.

The experimental fast reactor "Joyo" has been in good operation for 19 years. Of course, it has a designed temperature that is somewhat different. But its performance in operation should have been given study with more intellectual humility before it was taken for granted. It would be wrong to argue against the use of sodium just because it has leaked for the first time in 19 years. But I do not think things will go so well.