utes, an indication of rising water level led the operators, who were conditioned to maintain a certain level, to turn off the high-pressure injection. Despite earlier conjectures that the water-level indicator was reading erroneously, the level indication was probably correct. However, the falling pressure, coupled with a constant reactor coolant temperature after the high-pressure injection system came on, should have clearly alerted the operators that TMI-2 had suffered a loss of coolant accident, and safety required they maintain high-pressure injection. But the operators did not realize their mistake for over four hours.

Isolation. The Kemeny Commission also discovered why the containment building did not isolate itself for nearly four hours after the start of the accident. Isolation is intended to help prevent radioactive material released by an accident from escaping to the environment. In 1975, the NRC instituted new criteria for isolation that listed three conditions—increased pressure, rising radiation levels, and emergency core cooling system activation—and required that containment buildings isolate on any two of the three. However, the plan was not applied to nuclear plants that had already received their construction permits, like TMI-2. In the TMI-2 design, isolation occurred only when pressure in the containment building reached 4 psi above the ambient pressure. Radiation releases alone, no matter how intense, would not initiate isolation. Even after isolation was in effect, pipes carrying coolant between the containment and auxiliary buildings could be opened manually by the operators. They were at TMI, and radioactive water flowed through these pipes, some of which leaked radioactive material into the auxiliary building. The radioactivity escaped from there into the atmosphere outside.

The Kemeny Commission also provided a numerical estimate of how much of the core was uncovered at the worst point. "... evidence indicates as much as two-thirds of the 12-foot high core stood uncovered" three hours after the start of the accident.

Among the other areas covered by the Kemeny group were public and worker health and safety and the handling of the emergency. "Based on our investigation of the health effects of the accident, we conclude that in spite of serious damage to the plant, most of the radiation was contained and the actual release will have a negligible effect on the physical health of individuals. The major health effect of the accident was found to be mental stress... It is entirely possible that not a single extra cancer death will result. And for all our estimates, it is practically certain that the additional number of cancer deaths will be less than 10." The Commission called for further research on the consequences of radiation exposure as the basis for new safety guidelines and stronger efforts by both the states and the utilities to keep workers and the public informed about health issues and preventive measures.

"We are disturbed both by the highly uneven quality of emergency plans and by the problems created by multiple jurisdictions in the case of radiation emergency. Most emergency plans rely on prompt action at the local level to initiate a needed evacuation or to take other protective action. We found an almost total lack of detailed plans in the local communities around Three Mile Island ... The response to the emergency was dominated by an atmosphere of almost total confusion ... Those who managed the accident were slow to realize the significance and implications of the events that had taken place."

Copies of the Kemeny Commission's report are available for $5.50 (order number 052-003-00718-51) from the Government Printing Office, Washington, D.C. 20401. —MEJ

Action on Kemeny recommendations

President Jimmy Carter announced in December his plans to ensure the safe operation of nuclear power plants in the US, based on the recommendations of the Kemeny Commission.

Carter introduced his plans by reiterating his position on nuclear power, saying that, although we can minimize our reliance on nuclear power, "we cannot shut the door on nuclear energy" completely. Nor do we have the "luxury" of imposing a lengthy moratorium on its further use, he said.

The President said that he agrees "fully with the spirit and intent of the Kemeny Commission's recommendations." To fund the increased safety measures the President is calling for, he is asking Congress for a supplemental appropriation for fiscal year 1980 totalling $65 million. The NRC would receive $49 million of this.

NRC. The Kemeny Commission's most controversial recommendation was to abolish the NRC as it now exists and replace the five-member commission with a new independent agency under the President, to be headed by a single administrator appointed by the President.

The Kemeny Commission found fault with both the normal operation of the NRC and its performance during the March accident. "We found serious managerial problems within the organization. These problems start at the very top."

The Kemeny Commission summed up its evaluation of the NRC's response to the Three Mile Island Accident in this way: "There was a serious lack of communication among the commisssioners, those who were attempting to make the decisions about the accident in Bethesda,

Decontaminating Three Mile Island

The process of decontaminating TMI is now in progress. While the reactor itself has been brought to a "cold shutdown," there are vast amounts of radioactive material trapped within the containment and auxiliary buildings. The cleanup process carries its own potential dangers to public health. For this reason, the NRC is now preparing an environmental impact statement on the decontamination and disposal of radioactive wastes from TMI. So far, about 75 000 gallons of water from the auxiliary building's tanks have been put through the three-stage demineralization being used to process the contaminated water. NRC estimated the total volume of water in the auxiliary building alone to be about 400 000 gallons. Although radiation in the processed water has been reduced to levels that meet EPA drinking water standards except for tritium, which is not removable by the process being used, no disposal of that water will be permitted until the environmental impact statement is completed, probably in December. The water in the tanks in the auxiliary building is radiating between 1 and 30 microcuries per ml, attributed mainly to radioactive cesium in the water.

The cleanup process is expected to take another three years at the minimum, according to the NRC. Metropolitan Edison prepared a cost estimate of the cleanup process, including the costs of replacing the core and putting the plant back into operation. The figure they came up with was $400 million.

Nothing has been done to the containment building yet. The first step there will be the removal of radioactive krypton gas. The cleanup of the reactor building will be much more complicated than that of the auxiliary building because the water there is much more radioactive than the water in the auxiliary building, and there is more of it—between 500 000 and 600 000 gallons. There are still many uncertainties concerning the precise conditions inside the containment building.

Although a video scan of the building's interior did not show any obvious problems, the condition of the reactor core is not known and won't be until the containment building has been entered and the reactor vessel opened.

the field offices, and those actually on site. This lack of communication contributed to the confusion of the accident. We are also skeptical whether the collegial mode of the five commissioners makes them a suitable body for the management of an emergency, and of the agency itself."

In response to this, Carter is reorganizing the NRC to strengthen the role of the chairman and clarify the roles of the chairman, commissioners and executive director for operations. Several groups disagreed with the Kemeny Commission's criticism of the five-commissioner format. The President is offering a compromise by keeping the old structure, but giving the chairman more power, including the authority to act on behalf of the Commission during an emergency. Carter has also announced that Joseph Hendrie, who had served as chairman of the Commission since 1977, will be replaced by someone from outside the NRC. Until a replacement is found, commissioner John Ahearne is serving as chairman.

Last May the NRC decided to issue no new nuclear power plant licenses or construction permits until it reviewed the safety issues raised by TMI and established new licensing requirements and safety procedures. The President, in his proposals, called upon the NRC to "complete work as quickly as possible, and in any event, no later than six months" from December, when he made the announcement, so that plant licensing and construction can be resumed.

Carter is also asking the NRC to accelerate its program to place a resident Federal inspector at every reactor site.

METROPOLITAN EDISON

"We note a preoccupation with regulations [in the NRC] . . . we are convinced that regulations alone cannot assure safety. Indeed, once regulations become as voluminous and complex as those regulations now in place, they can serve as a negative factor in nuclear safety," the Kemeny Commission found. One basic flaw in the safety regulations in effect at the time of the accident, they said, was their concentration on "large-break," or very serious, accidents, and their preoccupation with the safety of equipment, ignoring the human element. "Large-break accidents require extremely fast reaction, which therefore must be automatically performed by the equipment. Lesser accidents may develop more slowly and their control may be dependent on the appropriate actions of human beings. This was the tragedy of Three Mile Island, where the equipment failures in the accident were significantly less dramatic than those that had been thoroughly analyzed, but where the results confused those who managed the accident."

The Kemeny Commission also noted that the lessons learned from previous accidents and safety studies did not result in new, clear instructions being passed on to the operators. In 1977, for example, the Davis-Bessie nuclear plant in Ohio, also of Babcock & Wilcox manufacture, experienced a loss of cooling water accident when a pressure relief valve stuck open. This was the same valve that precipitated the trouble at TMI (see accompanying story). The Kemeny Commission recommended a rigorous screening and investigation of every abnormal event to assess the implications for design, operation, training, management and regulation.

The Commissioners of the NRC did not have to wait for the Kemeny Commission report to realize that they were at fault both in their handling of the accident and in establishing a regulatory structure under which an accident like TMI could occur. Soon after the accident, they therefore took several steps toward self-examination and improved safety. Almost immediately after the accident, a special NRC "Lessons Learned" task force was set up to analyze the accident and identify necessary changes in licensing requirements. That study has resulted in 48 specific recommendations for changes in hardware and procedures, several of which have already been implemented. The Office of Inspection and Enforcement conducted an extensive investigation into the facts concerning the events of the accident. The NRC also commissioned an independent special inquiry into the circumstances leading up to the accident, the accident itself, and the industry and Commission response. Its director, Mitchell Rogovin, and deputy director were from outside the NRC and the investigatory staff numbered about 60. That report was due last month. A safety data evaluation office has been set up to learn from small mistakes before they become big ones. New control room instruments are being required. Direct telephone lines linking each reactor to NRC headquarters have been set up to speed communications and as a signal that NRC intends to have a role in any emergency.

The Utilities. "Met Ed did not have sufficient knowledge, expertise and personnel to operate the plant or maintain it adequately," said the Kemeny Commission. "As a result of these deficiencies the safe operation of the TMI-2 plant was impaired."

Bruce Babbitt, Governor of Arizona and a member of the Kemeny Commission, stated in a supplemental view to the main Commission report, "It is now time . . . to determine which companies are qualified to handle such a technology and which companies are not." Victor Gilinsky, one of the NRC commissioners, agreed with Babbitt in a speech he made in November at Brown University: "Governor Babbitt rightly complained . . . that the proprietors of Three Mile Island were obviously not the only electric utility that did not measure up even to minimal standards. (Our staff, by the way, puts them about in the middle of the scale.)"

Floyd W. Lewis, chairman of the Three Mile Island Ad Hoc Nuclear Oversight Committee set up by the utility industry after the accident to oversee improvements, said that "during the past six months we have been working diligently to put in place programs that will assure that this higher level of safety consciousness will be maintained." Among those measures already taken by the nuclear power industry was the establishment of the Institute of Nuclear Power Operations, which will attempt to improve the utility's performance by concentrating on operator training, and the creation of the Nuclear Safety Analysis Center, an arm of the Electric Power Research Institute, which undertook a detailed technical study of the TMI accident.

"We haven't been idle since the accident," Carl Walske, president of the Atomic Industrial Forum, said. "Nuclear power operations are significantly better as a result of the lessons we have learned."

Specifically, the Kemeny Commission recommended, and the President supported, that the industry specify safety standards and establish within each nuclear utility a separate safety group.

With regard to operator training, the Kemeny Commission and the President urged the establishment of accredited training institutions, training by individual utilities in the specifics of particular plants, emphasis on understanding abnormal operational conditions and on the fundamentals of reactor safety and

regular training with simulators. Insufficient attention has been paid in the past to training for emergency situations, the Commissioners said, and "the role that the NRC plays in monitoring operator training contributes little and may actualy aggravate the problem."

Another problem area singled out by the Kemeny Commission is the design of nuclear power plant control rooms. "The control room [at TMI] . . . is lacking in many ways. The control panel is huge, with hundreds of alarms, and there are some key indicators placed in locations where the operators cannot see them . . . During the first few minutes of the accident, more than 100 alarms went off, and there was no system for suppressing the unimportant signals so that operators could concentrate on the significant alarms." Carter has urged NRC and the industry to simplify control rooms, and standardize their format.

A warning. The Kemeny Commissioners cautioned policy-makers against trying to answer their charges by merely plugging the holes in the present system. "Fundamental changes must occur in organizations, procedures, and above all, in the attitudes of people. No amount of technical 'fixes' will cure this underlying problem. There have been many previous recommendations for greater safety for nuclear power plants, which have had limited impact. What we consider crucial is whether the proposed improvements are carried out by the same organizations (unchanged), with the same kinds of practices and the same attitudes that were prevalent prior to the accident. As long as proposed improvements are carried out in a 'business as usual' atmosphere, the fundamental changes necessitated by the accident at Three Mile Island cannot be realized." —MEJ

the physics community

AAPM chooses Orton as president-elect

The American Association of Physicists in Medicine has a new president-elect for 1980—Colin G. Orton, director of medical physics at Rhode Island Hospital, Providence. He takes over from Robert G. Waggener of the University of Texas

ORTON

Health Science Center, who assumed the AAPM presidency on 1 January.

Orton has done research in radiobiology, radiation onocology and dosimetry and on the use of computers in medicine. He earned a BSc from Bristol University (1959), an MSc and a PhD in radiation physics from the University of London (1961 and 1965). Orton lectured in physics at St. Bartholomew's Hospital, University of London from 1961 to 1966. He then joined the Medical Center at New York University where he eventually rose to the position of associate professor of physics. In 1976, the same year he came to Rhode Island Hospital, Orton was appointed associate professor of radiation medicine at Brown University. Orton has served as editor of the AAPM's *Quarterly Bulletin* for three years.

Other AAPM officers recently installed are the secretary, Arnold Feldman (radiological physicist at the Methodist Medical Center of Illinois in Peoria), and the treasurer, Ann Forsaith (manager of the medical-physics section at William Beaumont Hospital, Royal Oak, Michigan).

DOE group studies high-energy accelerators

The Department of Energy has appointed a subpanel of its High Energy Physics Advisory Panel to review the overall quality and scope of the high-energy accelerator R&D effort in the US. The review, headed by Maury Tigner (Cornell), will, in addition to examining existing accelerator R&D projects, compare US efforts with efforts abroad and make recommendations to the DOE with regard to the balance among short, mid, and long-term R&D, priorities within the field and appropriate funding levels.

The review is expected to be completed by June. Those with relevant opinions are invited to write to the secretary of the subpanel, David Sutter, Division of High Energy Physics, Office of Energy Research, Department of Energy, Washington, D.C. 20545.

SPS elects Shwe to second term

Hla Shwe has been re-elected to a second two-year term as President of the National Council of the Society of Physics Students. Shwe is dean of the School of Arts and Sciences and professor of physics at East Stroudsburg State College in Pennsylvania.

In addition, four physics faculty members were elected to three-year terms as councillors. Councillors represent the SPS chapters at academic institutions in their region. They are: Raymond F. Askew (Auburn University), Richard C. Waring (University of Missouri-Kansas City), Gordon C. Whitten (Olivet Nazarene College, Illinois) and Paul Stephas (Eastern Orgeon State College).

in brief

The Gravity Research Foundation is offering five awards for essays of 1500 words or less on the subject of gravitation, its theory, applications or effects. First prize is $1500. Essays must be received before 1 April. Additional information is available from the Gravity Research Foundation, 58 Middle Street, Gloucester, Mass. 01930.

The *1978 Census of High-Energy Physicists & Graduate Students*, a listing of physicists and students associated with high-energy physics in the US, is now available from the National Technical Information Service, US Department of Commerce, 5285 Port Royal Road, Springfield, Va. 22161. For each person the entry indicates his affiliation, specialties, sources of Federal support and other information. Printed copies are $13 each, and microfiche copies are $3.

The American Physical Society is now offering subscriptions to *Reviews of Modern Physics* to members of the Italian, Japanese, British and French physical societies for $25 (including air freight postage), a savings of $32 over the regular foreign rate. □

APS meeting date changed

The American Physical Society has rescheduled its next Washington meeting to begin on 28 April. The four-day gathering originally was to start on 21 April.