today, until by early in the 21st century Americans will "pretty much be on a breeder economy."

Chief among ERDA's breeder projects are the Clinch River demonstration reactor and a 400-MW thermal breeder, the Fast Flux Test Facility, which will be used to test materials as fuels rather than to generate electricity. Roberts estimates that work on the LMFBR and its associated base technology, together with other R&D efforts connected with breeders, costs on the order of $500 million per year.

Both the FFTF and the CRBR have been beset by delays and cost overruns, but Roberts thinks the projects are proceeding well. In the case of the Fast Flux effort, he said, "the reactor underwent considerable rethinking as it was being constructed," and such changes slowed progress; changing regulations constituted another factor. Complications that have held up the Clinch River reactor's schedule, according to Roberts, go beyond the straightforward problems in science and engineering. The CRBR is a participative project, with contributions of approximately $260 million from the electric utilities; so "it's a reactor in the utility network—the electrons produced are going out onto the TVA grid." Moreover, the CRBR must go through the full regulatory licensing process. Asked if the private sector should pay a greater share in the development of the breeder, Roberts told us, "In any new technology as complicated and involved as this one, with so many risks built into it, it really is the government's role to assume most of the responsibility."

Other approaches, progress abroad. A gas-cooled reactor located near Denver, Colorado, may be the only such facility of significant size operating in the US, according to Roberts. Recent cancellation of other orders for the device puts its commercialization in doubt, he told us, but ERDA is embarking on a study, joined by private-sector researchers, to see if there is a future for this approach. Roberts said the agency is also looking at the concept of a fast gas breeder reactor, which would operate using pressurized helium as a coolant; it remains largely in the early study phase so far.

ERDA is pursuing the development of a thorium breeder reactor as well. The reactor's core is to be installed in the Shippingport reactor outside Pittsburgh by ERDA's Bettis Laboratory. Roberts described the device's U^{233}–Th cycle as intriguing, but he cautioned that that particular system, the thorium breeder, if successful, would produce only enough fuel for itself. In contrast, the LMFBR is expected to produce more nuclear fuel than it consumes. This difference, he said, "has been the main driving force in the development of the fast breeder rather than the thermal breeder."

The USSR and some European nations have moved quickly to take advantage of the breeder's promise, according to Roberts. "In terms of installed megawatts," he said, "the Soviets have only 10% of our nuclear-power capability." But they also have an operating 350-MW breeder reactor, with a 600-MW device under construction. The French have moved rapidly to build a demonstration plant, with the result that a 250-MW breeder named Phenix has been operating for almost two years now. Roberts said France is very aggressively pursuing the development and marketing of a 1200-MW super-Phenix. Are they ahead of us? "Our program has been a more measured one: We seek to develop a total technological and industrial base for the system, so the breeder industry in the US will be competitive." Roberts suggested that France and some other countries may be pushing their breeder programs harder than we are because of their relative shortages of both fossil resources and uranium.

Are reactors safe? Nuclear safety has been a prominent issue of late, and Roberts sees the public debate as a healthy thing. "I think everyone in the nuclear industry, worldwide, has been very conscious of the safety aspect from the very beginning," he said. As to a breeder-dominated energy system, he denies any inherently insurmountable danger: "To handle the flow of plutonium in a civilian economy, you can have the cores from light-water or breeder reactors sent to one main location. On that site you could reprocess the fuel, separate out high-level waste products, convert recovered plutonium to oxides and store wastes permanently." Such a system would be designed to prevent diversion of potential bomb material by antisocial elements.

Roberts told us that in his opinion the main benefit of the present nuclear-power debate is that it causes people to focus on a technology that provides an ever greater fraction of their needs. "My impression has been," he said, "that the more people learn about nuclear energy, the more they support it."

Mars and the physicists. "We have some plutonium sitting on the surface of Mars right now," Roberts told us. Several Space Nuclear Auxiliary Power generators, small isotopic sources, have been operating on the Moon these past seven years, and two 70-watt generators on the Viking lander are expected to power all its systems for years. The decay heat in the nuclear sources is used to produce a thermal emf, which in turn keeps the space probes running.

Back on Earth, according to Roberts, nuclear-energy R&D continues to offer opportunities for physicists. "There still remain many questions that require a basic-level understanding," we were told. He stressed problems in solid-state and materials sciences ("What causes metals to swell under high fluxes of neutrons?") and the need for better models for the prediction of systems' behavior in radiation fields. More generally, Roberts added, the training physicists receive provides a foundation not only for basic research, but also for the logical development of complicated systems at a more applied level. —FCB

Washington Bulletins

★ **NASA, NSF get FY 1977 appropriations.** A House–Senate compromise measure allots $3.693 billion to NASA, in close accord with the Administration's $3.697-billion request. Of this amount, about $2.7 billion is for research and development. The NSF received $773.6 million for the coming fiscal year, $28.4 million less than had been sought but still an increase beyond expected inflation. Basic research accounts for $582.6 million of the total, while science-education programs will get $59 million plus funds carried over from FY 1976. President Gerald Ford had signed the bill into law.

★ **New NSF acting director** is Richard T. Atkinson, former deputy director under H. Guyford Stever. Atkinson, a psychologist, is the first social scientist to wield top authority at the Foundation.

NSF considers institute for theoretical physics

Alternative mechanisms are being weighed by the National Science Foundation to bring together theorists from diverse subfields of physics; participants would unite to tackle problems that cut across traditional lines of research. In its budget request for FY 1977, NSF has indicated an intent to seek additional funds for inter-subfield effort in theoretical physics, and suggestions on basic approaches are being sought.

One possibility being considered by the Foundation is to establish a single large institute of about 30 physicists, mainly one-year visitors; a core of several longer-term researchers would provide continuity and leadership. While encouraging the general exchange of ideas, the institute would focus on inter-subfield problems and would announce in advance the areas of physics to be pursued in any given year. It would be located near a center of experimental activity, such as a major university or national laboratory,

and the group would maintain contact with experimentalists through seminars and other activities. The institute would aim at bringing in theorists from different subfields, home institutions and age groups; according to present estimates, about three-quarters of the staff would be supported by the institute—others would employ sabbatical funds or other outside aid.

Another idea suggested to the Foundation calls for several smaller endeavors, each of which would work on one particular inter-subfield area. Three to five groups composed of perhaps ten physicists apiece would carry on their research at existing universities and labs. Most group members would participate while on long-term leaves from their home institutions. Both the single-institute and the multi-group approaches include limited lifetimes of several years.

The following represent the sort of physics problems to which the institute or groups might contribute:

- the study of fundamental forces, such as the weak interaction, by means of experiments involving nuclei;
- the physics of atoms with nuclear charges on the order of 200, formed momentarily in heavy-ion collisions, and
- the study of neutron stars.

The NSF is soliciting ideas from the physics community as to what form the new institute for theoretical physics should take; suggestions need not conform to any predetermined guidelines at this stage, nor are full-scale proposals being sought prior to FY1977. Letters should be sent to Boris Kayser, Program Director for Theoretical Physics, Division of Physics, NSF, 1800 G St, N.W., Washington, D.C. 20550.

in brief

ERDA has signed a $1.6-million contract with the Rand Corp to conduct a program of broad, long-range energy policy studies.

Copies of LCD-74-122, *Further Opportunities to Improve Radio Spectrum Management in the Federal Sector*, are available from the US General Accounting Office, Washington, D.C. 20548.

the physics community

AAPM chooses Wootton as president-elect

Peter Wootton has been chosen the new president-elect of the American Association of Physicists in Medicine. Wootton, professor of radiology and director of medical radiation physics at the University of Washington, Seattle, succeeds William R. Hendee, who has become president of AAPM.

A native of England, Wootton studied at the University of Birmingham and

WOOTTON

worked as a radiation physicist at the Royal Infirmary in Glasgow, 1948–51. He then moved to the US and held positions at the University of Texas M.D. Anderson Hospital and the Swedish Hospital, Seattle, before accepting a post in the radiology department of the University of Washington in 1964. His research interests, in the area of applications of radiation physics in medicine, include dosimetry of all types of ionizing radiations and fast-neutron therapy.

New graduate students being redistributed

A geographic redistribution of first-year graduate enrollments at physics PhD-granting institutions is predicted for the fall in a recent survey conducted by the Manpower Statistics Division of the American Institute of Physics. The eastern and north-central regions anticipate a decline while the southwestern, mountain and Pacific regions anticipate a corresponding increase in first-year graduate students. No overall decline was indicated—those first-year graduate enrollments that started to level-off at 2200 students in 1972 will continue to do so, it is expected.

Copies of this survey are available from Susanne Ellis, AIP Manpower Statistics Division, 335 East 45th St, New York, N.Y. 10017.

Bernstein wins science-writing award again

Jeremy Bernstein, professor of physics at the Stevens Institute of Technology, has been named the 1976 winner of the American Institute of Physics–United States Steel Foundation Science-Writing Award in Physics and Astronomy. This is the second time Bernstein has received the award—in 1970 he was honored for his booklet *The Elusive Neutrino*, which was published by the Atomic Energy Commission and distributed to high-school students.

This year's prize was given to Bernstein

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for his two-part article "Physicist: I.I. Rabi," which appeared in *The New Yorker* on 13 and 20 October 1975. His other published works include "The Analytical Engine: Computers, Past, Present and Future," "A Comprehensible World" and "Einstein."

He received his doctorate in physics from Harvard University in 1955 and then worked for the Harvard Cyclotron Laboratory (1955–57), the Institute for Advanced Study at Princeton (1957–59) and Brookhaven National Laboratory (1960–62). Bernstein was a faculty member at New York University for five years before accepting his current position at Stevens Institute of Technology in 1967.

The award, along with $1500 and a moebius-strip trophy, will be presented to Bernstein in November at the annual meeting of the American Institute of Physics Corporate Associates. □