gram available and for assistance in using it.

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Developing countries ignored

It is regrettable though not surprising that, in your 1300-word report on Dixie Lee Ray and her assignment to formulate international science policy in the State Department, not one of those words pertained to the three-quarters of the world's population living in less developed countries, or to the international assistance to and scientific cooperation with these countries. Indeed, the phrase "international science policy" means, to most people, UN treaties on ocean beds, cumbersome exchange agreements with Roumania, or scientific attaches in Bonn or Tokyo, so that "we" form an increasingly more tightly knit scientific community, whereas "they" continue to be ignored and isolated.

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Critical comments on fusion

The fusion reactor should not only provide a very large and probably cheap energy source with new possibilities of application, but should also possess favorable properties in respect to safety and environmental problems. It is recognized that, with the present limited resources of fusion research, the fission breeder is likely to come into practical operation before the fusion reactor has been realized on full scale. Nevertheless the potentialties of fusion energy and the future needs of new energy sources are important enough to justify itensified fusion research along broad lines, regardless of the existence of the fission breeder and other possible alternatives of energy production.

Important general progress has so far been made in fusion research and technology. With special devices such as Tokamaks, Stellarators, theta pinches, magnetic mirrors, laser fusion schemes, and some other systems, considerable further steps have been taken on the way to high plasma temperatures and large products of plasma density and confinement time. However, the general development of fusion physics is at this stage as important as maximum experimental-parameter data obtained by means of individual devices, because *none* of the present specific confinement schemes has, for certain, provided a final solution of the fusion-reactor problems.

A considerable part of the international fusion-research program is now devoted to large experiments with magnetic bottles having a main toroidal field component, as well as to a number of large laser-fusion devices. In particular, for these bottles that now are widely considered to represent one of the most promising lines, attention should be drawn to the following full-scale reactor problems:

So far only small total beta values have been reached in Tokamaks and Stellarators, leading to large required magnetic field strengths and associated cyclotron radiation losses, considerable mechanical coil stresses, and a slightly screw-shaped field line structure having long magnetic connection lengths between "bad" and "good" regions and being sensitive to disturbances that affect the field and plasma symmetry.

The complicated transport processes prevailing under normal experimental operation are not yet fully understood, but appear to be consistent with anomalous phenomena due to weakly pronounced instabilities.

Violent and so far unexplained "disruptive" instabilities arise when certain parameter values are exceeded. In particular, there is a density limit that has not yet been exceeded in hot Tokamak plasmas. This limit is possibly associated with the critical ion density dividing "permeable" plasmas from those being "impermeable" to neutral gas. Thus, high-temperature experiments have so far been conducted under conditions not necessarily representing those of full-scale Tokamak reactors, which have to operate far inside the "impermeable" ion density range.

Tokamak operation by means of a "boot-strap" mechanism has not yet been demonstrated. If the impurity problem cannot be solved, pulsed operation should in any case become necessary, but this reduces the chances of achieving a practically useful reactor.

The magnetic-field windings introduce complications in the replacement and repair of construction details.

The present concentration of the main activities and resources of fusion research to rather narrow lines and to a few large projects at the expense of basic investigations is *not reconcilable* with a corresponding necessary knowledge in fusion physics and technology. In the case that none of these projects is able to keep the promise of being a solution of the reactor problem, fusion research as a whole may end up in a difficult dilemma. The situation is partly a result of attempts to accelerate this research towards its final goal under the contemporary constraints of limited resources.

Needless to say, a substantial increase in available funds is strongly needed for the fusion reactor to come in

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due time. At the present economical level the efficiency of future research programs could be improved by reducing the number of intermediate-size experiments with devices of a more "conventional" Tokamak, Stellarator, pinch, and mirror type and by avoiding unnecessary duplication. Only a few large devices for studies of the not completely understood scaling laws should be further developed. Further, a certain fraction of the total budget should be reserved for investigations on modified toroidal devices and other schemes, as well as for basic research conducted on broad lines and by means of moderate-size experiments. Finally a systematic research for more alternatives to the present lines of approach should be continued. *New* ideas, as well as *reconsiderations* of earlier ideas from new angles, may even become necessary for a future success.

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Public understanding

Your editorial in the June issue (page 88) described some of the ways in which individual physicists were contributing to an improved public understanding of science. I would like to describe several other approaches used at the National Bureau of Standards. These include:

Open House. In October of 1973 some 30 000 persons traveled to Gaithersburg, Maryland for a tour of our facilities. Approximately 60% of them were students. Many of the students who visited with us on Friday returned with their parents on Saturday; some even had to cross state lines to do it. People really are eager to walk into the lab and find out what you're doing. The National Institutes of Health and other federal laboratories in the Washington area indicate a similar degree of public interest.

Tour Program. Aside from establishing good will, a vigorous tour program can establish a veritable army of contacts reaching out into all areas of the community. Public tours of NBS are available at specific hours each week. Special tours are arranged for any group that makes a request. These have included Congressional staff, diplomatic training classes, professional societies (APS included), school groups, etc. About 3500 come to the Gaithersburg site each year.

Speaker's Bureau. NBS professional staff members speak before a wide range of audiences. Demonstrations are often included (properties of air, cryogenics, chemistry, fire, etc.). It's quite a thrill to watch a pack of Cub Scouts swarming over a beaker of liquid nitrogen, asking "What would happen if . . ." That's when you know you've sparked the creative process in at least one young mind.

Film Loan. We have a collection of about 35 16mm movies available for free loan to school systems. A catalog and order forms are available. There are about 2000–4000 bookings each year.

Exhibits. A considerable amount of space has been set aside in various buildings at both the Gaithersburg and Boulder sites for exhibits of current work. These areas are often used for small informal meetings where visitors can find a quick overview of the full spectrum of our activities. Current publications and handouts are also found here. (Westinghouse Research Lab in Pittsburgh provides some special chairs equipped with videotape playback units and a selection of eight short films describing recent work. Visitors can fruitfully use some free time while waiting for an appointment.)

Special exhibits, designed for use at professional meetings, are staffed by technical personnel. These exhibits provide an exceptional opportunity to establish an interaction with new groups. For example the NBS Micrometrology Section recently had a booth at the International Machine Tool Show. Other persons concerned with radiation measurements had a booth at the National Conference of Radiation Control Program Directors.

Several exhibits for the general public have also been assembled and travel a circuit of about 50 science museums in this country. These exhibits have potential exposure to *20 million people* in a single year. Two are concerned with metrication, while another traces the history of time measurement. The American Chemical Society is currently sponsoring an exhibit on "Taking Things Apart and Putting Things Together," which is traveling the same circuit. It is interesting to note that one of these science museums was a winner in the recent store-front physics contest.

Science Fairs. Hundreds of school children and parents attend a science fair at the NBS sites each year.

Assistance to schools. We are currently meeting with the head of science education in one of the local secondary-school systems to explore ways in which we may help to supplement their curriculum. One of the possible approaches is to provide special tours, lectures and demonstrations for select groups of students, some of whom could be offered summer jobs in the various NBS laboratories.

Despite the limited resources available to NBS, we consider it essential to communicate with the general public so