

letters

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 potentialities of fusion energy and the future needs of new energy sources are important enough to justify intensified 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 interna-

tional 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.

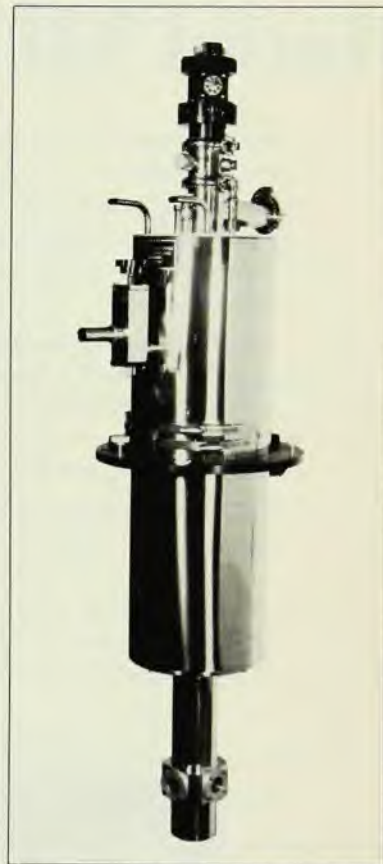
The magnetic-field windings introduce complications in the replacement and repair of construction details.

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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