

the writers' comments that there has not been a serious investigation and development of the many systems required for a practical power plant. They repeatedly refer to "conceptions" of plant configurations, which are hardly a meaningful basis for serious evaluations. The utility industry's comments on the ARIES design (cited in the letter from Farrokh Najmabadi *et al.*) was merely polite approval of the performance goals set for an operational plant. The many formal reviews of the US fusion program have similarly focused on research directions, not ultimate feasibility. The reality is that the engineering development of a fusion power plant has not been undertaken, and that the many issues raised in our three letters have not been faced or resolved.

Our letters did not address the wisdom of the scale of resource allocation appropriate to exploring the science of fusion. That is a matter of priorities for the national scientific community to determine based on the value of understanding plasma physics. The massive investment in fusion research during the past decades has been devoted almost entirely to the physics endeavor to demonstrate that as much energy can be released from a plasma as is required to heat it.

Our point was that even if the science of a controlled fusion process is eventually understood and demonstrated, any usable power application will face engineering barriers that appear much more extreme than those faced by the current quest for "break-even." There is no reasonable possibility of achieving the target of practical feasibility in the foreseeable future, even with an intensive engineering R&D program.

Consider this: During the next hundred years, when we will still have available all the fossil fuels, fission power and renewables, a practical fusion plant will have to achieve and demonstrate sustained performance reliability for several decades, need only a few scheduled outages for maintenance, meet stringent environmental criteria and be economically competitive with other electricity sources. We believe the present fusion concepts will not be able to meet any of these requirements. It is therefore misleading both the general public and the policymakers to include fusion in our national energy strategy for a dependable mix of electricity sources adaptable to uncertain future circumstances.

Our letters mentioned some of the special technical problems that arose in the development of successful fission plants and that would have to be

faced in engineering any nuclear plant. The combined effects of those problems compound the difficulties of designing a practical operating system. Experience with conventional nuclear fission power plants, of which several hundred have been operating internationally for decades, provides useful insights into the unique aspects of nuclear engineering. Analogies with historical nonnuclear large-scale engineering developments such as aircraft and rocket vehicles are only marginally relevant. The hopes of the fusion community cannot rest on such analogies.

But relevant history does provide a powerful message that must not be ignored. After the discovery of fission was announced in 1939, Hans Bethe came forward with the first theory of energy production in the Sun through fusion. In less than five years after the discovery of fission, fission reactor production plants of hundreds of megawatts were operating that could have been converted to power generation. In the case of fusion, however, after a half-century of research effort, the first demonstration of an operating fusion reactor is still far away. And even if such a demonstration should ever occur, it would be only an academic achievement. As has been pointed out, additional insurmountable obstacles

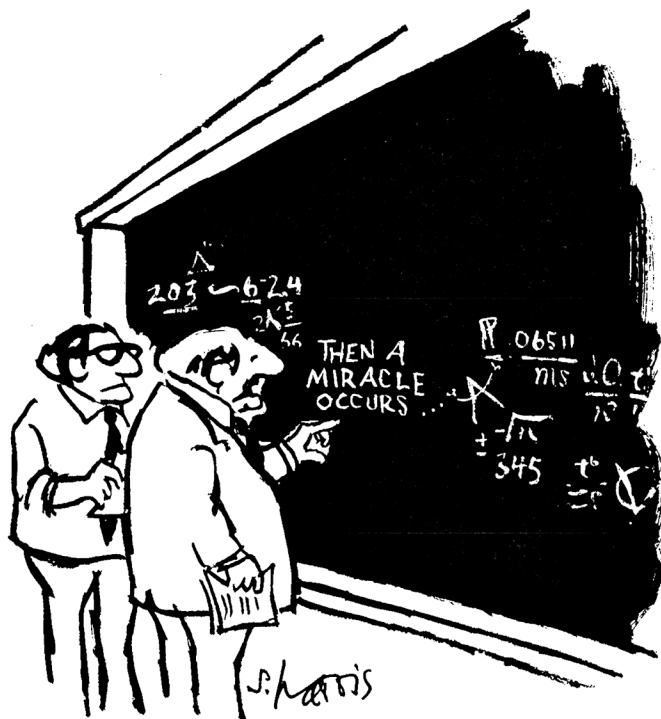
stand in the way of any practical application of fusion power.

Nature (which cannot be fooled, as Dick Feynman reminded us) imposes fundamental constraints that mankind cannot change and must accept. In the case of fission, a remarkably fortuitous set of technical properties made today's nuclear power industry possible. In the case of fusion, a very unfortunate set of constraints appears to obviate any future power industry based on the fusion principle.

WILLIAM E. PARKINS
Woodland Hills, California
JAMES A. KRUMHANS

Cornell University
Ithaca, New York

CHAUNCEY STARR
Electric Power Research Institute
Palo Alto, California



"I THINK YOU SHOULD BE MORE EXPLICIT HERE IN STEP TWO."

Canada Is Chided for Abandoning Its TASCC

Recently, the international nuclear physics community was shocked by the news that the Canadian government had closed the Tandem Accelerator Superconducting Cyclotron (TASCC) in Chalk River, Ontario (see PHYSICS TODAY, February, page 59, and March, page 69). This facility, in

the prime of its existence, was closed not as a result of scientific peer review but by a brutal, budget-reducing bludgeoning.

Aside from the direct threat of unemployment faced by the TASC staff, the most dire consequence of this shortsighted decision is that it tells Canadians—and everyone else—that the government places no value on fundamental research and has no interest in conserving any type of intellectual capacity in Canada whatsoever.

I am a Canadian, educated at McGill University, and now hang my head in shame as a result of this action. As Canadian research positions have become extremely difficult to obtain, I was obliged to leave my country in order to pursue fundamental research. Fortunately for me, I was welcomed into France's national research organization. Though the CNRS faces financial burdens of its own, it continues to do its utmost to support fundamental science with all the pedagogical enrichment that this entails, and it offers opportunities equally to non-French citizens.

Some of TASC's former researchers may eventually be able to remain in Canada, though the only remaining Canadian nuclear physics facility, TRIUMF, will be able to absorb but a small fraction. The rest will be forced to leave the country, and take all of their advanced knowledge—which only research can foster—with them, depriving Canada of a precious commodity and one that Canada itself was able to produce.

Research is first and foremost teaching. You must teach yourself about an unknown problem, which you can then explain to colleagues and eventually students and the public. History has shown that where curiosity has been given free rein, society has always benefited. The Canadian government has now made war on scientific inquiry, but with what consequences for society?

DAVID LUNNEY

(lunney@csnsm.in2p3.fr)

National Center for Scientific

Research (CNRS)

Orsay, France

Corona Program Is Finally Discovered

I read Albert Wheelon's excellent article on the Corona reconnaissance satellite program in the February issue of PHYSICS TODAY with a bit of nostalgia. It is not that I was ever a part of the program or had any ac-

cess to its secrets. On the contrary, when Corona XIII was recovered from the sea in August 1960, I was not quite 15 years old. Nonetheless, I had known about Corona XIII, but under another name: Discoverer XIII.

I was one of those kids who followed everything I could in the aerospace program by means of the popular press and *Aviation Week* (before it was *Aviation Week & Space Technology*). The Discoverer program was acknowledged in the press as a military program, and, if my memory is not faulty, everyone knew that the plans to recover small capsules had something to do with reconnaissance. After all, those satellites were to be the first ones put into polar orbit and why do that?

Satellite after satellite was launched, as related by Wheelon, but each time, something happened to prevent what would be the first successful recovery of an object from orbit. I remember the loss near Spitsbergen—or rather the announcement that searches for the capsule had been made in that area and had failed. Finally, in 1960, Discoverer XIII fell into the sea and was recovered. It was the very first object returned from orbit (Soviets not excluded).

A bit later, Discoverer XIV was snagged in the air by a C-119. That we all knew from the newspapers. Of course, the recovery of Discoverer XIV was somewhat overshadowed by the Soviet recovery of a prototype weighing 5000 pounds or so of the Vostok manned spacecraft that would take Yuri Gagarin into space in April 1961. I suppose that the people working on Corona didn't mind the Soviet feat too much as it probably took the eyes of the press off the really important goings-on. After that, the Discoverer launches did not seem so interesting or important (though we know differently now).

The Corona XIV capsule and its parachute are currently on public display at the US Air Force Museum near Dayton Ohio. Of course, the name on the display is Discoverer XIV.

LEONARD GORDON

Nassau Community College

Garden City, New York

WHEELON REPLIES: Leonard Gordon adds an interesting and important footnote to my article. An initial cover story was devised in 1959 that identified these missions as scientific undertakings and carried the Discoverer label. In fact, some science was done on the early flights, and several nonrecovery missions (numbers 19 and 21) carried radiometric pay-

loads. The results of those experiments were reported promptly in the scientific literature. However, the scientific yield was incommensurate with the vast undertaking that the launches represented. The last Corona mission to carry the Discoverer label (number 37) was launched on 13 January 1962. At that point the CIA judged that the cover story had simply worn out. Later flights were identified as classified Air Force launches from Vandenberg Air Force Base.

In retrospect, the Discoverer cover story was a tiny fig leaf for an immense program. On the other hand, it probably eased the Soviets' acceptance of these flights by providing an apparent purpose that did not challenge their sovereignty directly.

ALBERT D. WHEELON

Montecito, California

Figure Reproduction Simplified With 'Blanket Permission'

The problem of obtaining permission to use figures in review articles raised by David P. Stern ("Letters," February, page 11) is indeed an annoying one for authors, but there is an easier solution than trying to obtain a formal agreement among all scientific publishers (the haggling over precise language could go on forever). Instead, there should be a push for all publishers of scientific literature to adopt, as part of their formal copyright policies, some form of "blanket permission" covering precisely the sort of use Stern describes. The American Meteorological Society has taken this approach, and for many years the following has appeared in the copyright statement on the inside cover of every issue of the journals published by the AMS: "Permission to use figures, tables, and brief excerpts from this journal in scientific and educational works is hereby granted provided that the source is acknowledged."

Other publishers have used somewhat different language to provide similar permission for reuse with acknowledgment, but too few scientific publishers have implemented this approach.

KEITH L. SEITTER

(kseitter@ametsoc.org)

American Meteorological Society

Boston, Massachusetts ■