the number of male graduate students, we should at least try. There are few mechanisms whereby recruiting more women will scare away men. Consideration should be given to alternative teaching modes that do not sacrifice intellectual rigor. Some students apparently benefit from single-sex rather than mixed classroom situations, perhaps because faculty can confuse aggressiveness with intellectual ability. Under present legal constraints, this may mean encouraging physics at the surviving women's colleges. Some students (perhaps not equally men and women) are algebraically rather than geometrically inclined. We should accept that drawing pictures and constructing free-body diagrams can be hindrances, not aids, to understanding for some students.

The largest loss of potential physics students occurs, however, in high school, not college. Students who opt out of high-school mathematics sequences without completing the algebra–plane geometry–trigonometry sequence are essentially certain not to become physicists, regardless of their other talents. The removable difficulty is that American parents erroneously (superstitiously?) believe that success in mathematics in due entirely to innate talent. In contrast, parents in many foreign nations tell their children (apparently correctly, to judge from standardized mathematics testing) that hard work is the key to success in mathematics.

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Industry's Case of Mistaken Identity

Harry Levinson (September 1987, page 114) expresses an extremely myopic viewpoint when he berates research and (if I understand the implications of his letter correctly) reduces the role of experimental physics to a teaching tool.

Although in many respects the duties of scientists and engineers overlap, the two are not the same. In the same way that engineers can and often must carry out research into fundamental phenomena, physicists can perform the duties of engineers. But to view the two as equivalent, as Levinson evidently does, is to misunderstand the role of the physical scientist. Basic research has as its primary goal the understanding of nature and not necessarily the solution of specific engineering problems, as Levinson and apparently Venkatesh Narayanamurti (in his reply to Levinson) and others believe.

The lure of a steady job and comfortable income may make engineers out of many of us who would rather be involved in the interesting and exciting work that constitutes true basic research. Despite our desire to do so, despite the more immediate benefits to be gained and despite my own belief that benefit to society is the eventual product of scientific enquiry, I frankly do not feel that physicists in general should be expected to contribute to a solution to America's current industrial problems. This is, after all, what management is paid to do.

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Reflecting on Liquid Mercury Mirrors

Per Andersen's news item (June 1987, page 23) about Ermanno Borra's exploring the potential use of liquid mercury mirrors in astronomical telescopes is interesting, but raises many questions about hazards to the health of those working around the mirrors.

The mercury pollution scares of the early 1970s led to clear documentation of very substantial, severe and cumulative health hazards stemming from exposure to mercury vapor (which is present to a dangerous degree around any open vessel of mercury).

Gallium would be a much safer choice and also has the engineering advantage of being much less dense, thereby facilitating design of a smoothly acting and more economical precision rotation system.

Not surprisingly, there are also disadvantages to gallium. First, it melts at about 30 °C, so a modest heating system would be needed to keep it molten. Second, gallium costs about 30 times as much as mercury. I calculate that a 1.5-m-diameter mirror consisting of 1 cm of gallium riding on a parabolic form would have a mass of about 104 kg. Standard 4N-purity gallium would cost about $300 000 for such a mirror. Perhaps, however, such a mirror could use slightly chemically contaminated gallium, which is commonly recycled from the GaAs and GaP industry, reducing the cost to about $200 000.

The higher materials cost and heating system cost would be partially offset by a lower cost for the precision rotation system. Additional savings would result from reduced costs of health and environmental protection

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measures.

Although Borra has apparently rejected the use of gallium (I suggested it to him in December 1986), I hope other astronomers interested in liquid mirrors will take very seriously the health hazards of mercury and the safer alternative of gallium.

EDWARD M. DICKSON
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ANDERSEN REPLIES: To respond to Edward Dickson's concerns about safety, I am quoting a section from one of the two papers referenced[1] in my news story:

"The toxicity of mercury vapors is probably the single concern most often voiced to us.... Most of the mercury poisoning incidents (such as the one occurring in Minamata [Japan]) are actually due to mercury salts.... Metallic mercury is far less toxic and, unlike some salts, can be eliminated by the human body.... Mercury evaporates exceedingly slowly at ambient temperature so that any aeration will get rid of what little vapor is in the air.... The vapor concentration in our laboratory was measured by a professional chemist on two separate days.... The vapor concentration was ... above industrial safety levels only directly above the mirror and only after operating for several hours in a closed and warm room.... The gradient with height in mercury concentration (due to the high mass of Hg)... suggests that controlling the vapor concentration should be easy to achieve inside a silo-like housing, with weak suction pumps near floor level.... There is no need for a human in the mirror room during observations. Mercury vapor poisoning and environmental pollution should therefore not be major problems, provided industrial standards are followed as well as simple common sense."

Reference

1. E. F. Borra, M. Beauchemin, R. Arsenault, R. Lalande, Pub. Astron. Soc. Pacific **97**, 454 (1985).

'Tis a Gift to Be Simple

Alexander Firestone, in his review (August 1987, page 72) of *The Story of the W and Z* by Peter Watkins, misses the central focus of the book. Firestone is looking at the book only from a physicist's point of view rather than as Watkins intended. In the introduction Watkins states that the "prime aim of this book is to communicate to a wider audience some of the excitement of the most recent results from the study of particle physics." Firestone says that he thought that since Watkins is a member of the UA1 group at CERN, the book would be a serious technical discussion of the UA1 experiment.

I am not a physicist, nor do I have a physics background. However, as a physics administrator I enjoy reading, and most of all learning, about physics. Unfortunately, there are not enough good physics books aimed at a general audience.

Watkins shares his knowledge of physics, and the excitement of working on a major experiment, with nonphysicists. Firestone feels that the book would annoy some physicists, and no doubt it would, but for nonphysicists Watkins gives information in layman-like terms to establish a broader understanding of what was going on at UA1. This opens up physics to the rest of us. The ability to simplify complicated ideas is a gift that should be encouraged.

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Corporate Job Security and the Bottom Line

I was dismayed by the approbatory tone of William Sweet's news story "Despite Cuts, Basic Research Survives and Revives at Exxon" (July 1987, page 59). I suspect you also outraged the 100 PhDs who were let go. Industrial researchers have in the past expected job security nearly comparable to that of their brethren in universities and government. It was understood by management that a research lab is built up and produces results only over the long term, and will not survive much tampering. In the present climate of mergermania, with next quarter's bottom line the major concern of management, the future of corporate labs is in jeopardy. It can't help to have a professional magazine blessing the halving of an important lab.

Reading between the lines of the article's excess of quotes from Exxon scientists in management, it is hardly surprising that "one-third of the physicists at the corporate lab are currently working on complex fluids," management's pet project. This may not be entirely due to the intrinsic interest of this "pioneering" field. Perhaps in the future we will see similar articles about the salutary effects of letting half the physicists go at Bell Labs, NBS or MIT. Whatever