much can be learned about the school, the house, and the local environment that will increase general awareness and appreciation. Schools need not all do the same things; things suitable for urban Los Angeles might not be appropriate for rural Maine. But a constructive and interested attitude toward science should be the same.

ELROY O. LACASCE
Bowdoin College
6/81 *Brunswick, Maine*

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The Oregon Section of AAPT devoted most of its spring meeting to the problem of secondary physics education and covered much of the same ground that was covered by Feshbach and Fuller in April. In neither the meeting nor the letter was the root cause of the problem considered.

Any person capable of learning the physics necessary to do a good job of teaching is also capable of qualifying for any number of interesting and well-paying positions. Remuneration for teaching has always been less than for other jobs requiring comparable training, but the gap is widening at an alarming rate. Without other income or a working spouse, a person cannot support a family on a beginning high-school teacher's salary.

What is true in the high schools today could very well be true in college physics departments in a few years, and is already happening in the engineering colleges. Bachelor of science graduates are in many cases receiving salary offers which compare with their professors' salaries. There is little financial incentive to go on to graduate school, much less consider a teaching career. The information exchange section of PHYSICS TODAY regularly has listings where the salary offered for a position requiring a PhD (with an average of seven years of graduate school) is less than the starting wages of many two-year technical school graduates.

While university-school cooperation may be of some help, what is really needed to improve and maintain the quality of physics teaching are ways to help educational institutions at all levels compete successfully for technical manpower in the marketplace.

EARL KURTZ
Oregon Institute of Technology
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THE AUTHOR COMMENTS: I agree with Earl Kurtz that one cause of our problem which has become much worse in the past year, is the low salary level for many of the physics positions at educational institutions. I see no evidence of any national, state, or local resolve to address this extremely serious aspect of the problem. Perhaps the AIP Corporate Associates can show us some ways that the private sector of our economy can help solve this problem.

I also agree with Harry Manos. Teaching physics is rewarded less highly than doing physics research. Further, in our society, the younger the child you teach the lower is your professional prestige and salary (probably an interesting inverse relationship to how much real influence you have on your students). Accepting those professional and cultural givens, then our call for closer cooperation between universities and high schools is a way to transfer a little prestige. Will it work? Ten years from now we will know if anything has happened. Meanwhile it looks as if the scientific leadership so long enjoyed by the US is in jeopardy.

ROBERT J. FULLER
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Preemptive strikes

I feel obligated to respond to the letter by Robert Yaes in May (page 107). Yaes attempts to shed "considerable light" on the vulnerability of our deterrent systems using a "very simple problem in high school mathematics." He then goes on to calculate the joint probability of kill for a Soviet attack and reaches the conclusion that the probability of all our nuclear weapons being destroyed is extremely small. He then makes remarks about the paranoia of military analysts for being so worried about such a small number. "Remember," he says, "(with) . . . a single nuclear warhead . . . we can still wipe out Moscow."

Yaes' logic is flawless, but grossly incomplete. I am reminded of the parable of the blind men and the elephant. One blind man, upon feeling the elephant's trunk, concluded that the elephant was much like a snake. Another, at the tail, concluded that the elephant was like a rope. The one at the leg knew that an elephant was like a tree, the one at the ear knew it was like a leaf, and the one at the side knew it was as a wall. But those of us that can see know that an elephant is none of these things. So, Mr. Yaes, let me open your eyes and show you some more of the elephant.

Consider the scenario; for whatever reason, the Soviets launch a nuclear first strike. We will assume that this strike is counterforce, that is, targeted against strategic military sites and not population centers. We will further assume that this preemptive strike destroys 80% of our ICBMs, 70% of our bombers, and 30% of our missile subs. I make no claims about the accuracy of these numbers, I simply made them up.

In the aftermath of this hypothetical strike, what is the strategic situation? The US nuclear capability is badly

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crippled. The Soviet capability is unimpaired as yet. We can presume that the Soviets will be reloading their silos—we know that they have that capability (we do not have that capability)—and that their bombers are dispersed and their missile subs are all at sea in launch positions. We will not consider conventional forces, although their situation would be similar.

So what are US options at this point? (1) We could launch a retaliatory strike against Soviet military sites. (2) We could strike their population centers. (3) We could surrender.

Let us consider these options.

▶ If we counterstrike against military targets, the effectiveness would be limited. As has been mentioned, their vulnerable hardware, bombers and subs are dispersed. Their hard sites, missile silos, are simply too hard to hit and too numerous for us to destroy many of them with our relatively few remaining warheads. Furthermore, after we launch this strike, we have shot our bolt. We will have no nuclear capability left. In short, given this scenario, we cannot severely cripple their military.

▶ Yes, as Yaes has pointed out, we could destroy their cities. But keep this in mind; at this point most American cities and most Americans are still alive. If we wipe out their cities, their completely unimpaired military will proceed to reduce the entire North American continent to radioactive rubble. Not a very appealing option. MAD, as a matter of fact.

▶ Of course, no further discussion of option 3 is required.

So tell me, Mr. Yaes, faced with this situation, what would you do?

Myself, I prefer to try to make my weapons survivable so that I can reduce the probability of this scenario occurring. I don't want to have to make that choice. I do not think that is paranoid, merely prudent. That, Mr Yaes, is what we in the defense industry are working for—the ability to survive in an increasingly dangerous world.

JAMES R. LOCKER
Wright-Patterson Air Force Base
5/81 *Dayton, Ohio*

THE AUTHOR COMMENTS: I am grateful to James Locker for reminding me of the fable of the blind men and the elephant, with which I have been familiar since junior high school. In the case of the MX missile system, however, the question is whether those of us who cannot use blindness as an excuse for bad judgment are able to recognize a *white* elephant when we see one.

Military analysts are so absorbed in the scenarios, their neat little calculations and their game-theory mentality that they completely lose sight of what

nuclear war means in the real world. They see a nuclear exchange as a game of chess where the "winner" is the one who has lost the fewest pieces. The player who retains his king, two rooks and a knight is in a better postion than the player with just his king and a bishop. However, in a nuclear war, the pawns that are knocked off the board are real people, my friends, your neighbors, perhaps my girlfriend or perhaps people close to Locker. The pieces cannot be set up again later to start a new game. In the face of such losses it is possible that we and our military and political leaders might lose our emotional detachment and be tempted to make irrational decisions.

It has been estimated that even in the type of surgical first strike described by Locker, 10 to 20 million Americans would be killed by blast, by fallout and perhaps, here and there, by an errant missile that was aimed at a silo in Nevada, but landed on Toledo, Ohio, instead. It goes without saying that Locker is much less concerned with this than the fact that we might subsequently be tempted to "surrender." He dismisses too quickly the possibility that we might also be tempted to use some of our remaining warheads on soft civilian targets. The fact is that even after a first strike we will still have more than enough warheads left to completely destroy the Soviet Union as a viable society. The mere *possibility* that we might do so (even though it would seem an irrational choice to Locker) should be enough to deter the Soviet Union from launching a first strike in the first place.

Our only experience with nuclear war comes from a situation where one side had a handful of small nuclear devices (of which it used two) and the other side had none at all. The destruction, nevertheless, was considerable. At present the US and the USSR each have in excess of 10 000 warheads. We probably have enough warheads to destroy the USSR 50 times over. After a first strike we may be left with merely enough warheads to destroy the USSR only 5 times over.

Anyone who considers an all-out nuclear confrontation between the US and the USSR as a "game" that can be "won" rather than an exercise in mutual mass suicide, and feels that the safeguard ABM system or the MX missile system (whether deployed on racetracks in Utah, submarines off the coast of California, or railroad cars on the BMT subway) would make a difference, is just plain crazy.

Finally let me add parenthetically that military analysts always ignore the "Murphy Factor." Murphy's sixth law, which applies particularly to high technology systems, states that the more complicated a contraption is, the less likely it is to work or, in other words, "The reliability of any device is inversely proportional to the number of its working parts." In high technology military procurement, delay, cost overruns and equipment that *never* lives up to design specifications are the rule rather than the exception. Playing three-card monte with twenty-ton ballistic missiles can be a very complicated business. If, in a situation critical to the foreign policy of the United States, the US military was unable to master a fleet of eight helicopters in good working order for the attack on the US embassy to free the hostages in Iran, do we really think that they will be able to make the MX missile system work as planned under combat conditions? More than likely we will find many of our missiles neither hidden in the launch sites nor protected by silos, but sitting ducks in the middle of the racetracks because the transporters have developed overheated engines, broken axles or flat tires.

ROBERT JOEL YAES
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Effects of undulators

Ednor Rowe's article in May (page 28), which summarizes the synchrotron radiation facilities now available in the US, provides valuable information to those planning experiments utilizing synchrotron radiation. On one point, however, his statements do not conform to our experience at Stanford, and we feel that this point should be discussed further to avoid errors in the planning for experiments and facilities.

Undulators, which emit synchrotron radiation that is sharply peaked at certain wavelengths, have been installed at several machines. In discussing their use, Rowe states: "... the effects of the undulator on the beam dynamics of the storage ring are such as to seriously degrade the brightness of the radiation from the normal bending-magnet points." As mentioned in our article in the same issue, an undulator has been installed in the SPEAR storage ring at the Stanford Linear Accelerator Center. The storage ring operates for synchrotron radiation work in the energy range 3 to 3.5 GeV. The undulator is a 30 period, permanent magnet device with a field variable (by varying the gap) from 500 gauss to 2.3 kG.

The effects of this device on the stored beam have been studied. As expected there is a negligibly small increase in the vertical focusing in the lattice, caused by the edge focusing in the undulator. The fields of the undulator do also stimulate a sum resonance where the horizontal and vertical beta-