physics background would be most useful, and even though I plan eventually on a career in medical research.

I agree that a physics education is both enlightening and ennobling (and like Nedder, I maintain my APS membership), but one must still buy the groceries and pay the rent. While it is acknowledged that all PhD physicists will not be able to obtain employment in their field, it is assumed that most of them will be able to obtain engineering jobs in fields related to their area of training where they will be able to use their expertise. This is a good assumption for solving one's conscience, but there is no hard evidence that it is actually the case. We simply do not know what happens to those physicists who are forced to leave physics, but it is likely that many are forced to take rather menial positions for a person of their educational level. I would suspect that a physics education might prove even less useful to a taxi driver than to a physician.

ROBERT J. YAES
11/83 *Brooklyn, New York*

Scientists versus philosphers

The difference between scientists and philosophers, emphasized by Helier J. Robinson in "A theorist's philosophy of science" (March, page 24), can be accounted for by Darwin's theory of survival of the fittest.

Science survives better when airies and earthies cooperate, whereas philosophy survives better when they compete. Historically, at least, that would appear to be the empirical conclusion. Theoretically, it might be explained by noting that philosophy is largely thought, and it may actually progress better when philosophers jolt each other, as depicted on page 25. Scientists, on the other hand, are lured on by the mystery of the unknown, and need less prodding to stay on the right track.

From what is going on in the world, one would think that the leaders of nations are philosophers rather than scientists, and that there would be much more cooperation if scientists took over. Such a population inversion in Russia would place the refuseniks on top, and they would then undoubtedly cooperate completely in allowing the Kremlin to leave the country.

All roads lead to the March editorial (page 168), in a sense, when real thought is given to exactly why the refuseniks are not allowed to leave. Soviet strategists obviously fear that some of them may become Einsteins and Fermis, contributing to the defeat of the Soviet Union in war. This in turn implies that the Soviets contemplate war during the active lifetimes of the refuseniks, so there is great danger that World War III could start around 1990, fifty years after the start of World War II, consistent with the well-known theory that worldwide political and economic cycles tend to run in fifty-year periods.

Robinson may not have pointed out a weakness in philosophy (disagreement among earthies and airies may be its mainstay), but he may have pinpointed why world orders cannot be based on philosophical differences, and why scientists must cooperate (as on page 32) to achieve global harmony despite individual differences.

KENNETH J. EPSTEIN
3/84 *Chicago, Illinois*

Military strategy

As an ordinary citizen with only a very modest knowledge of foreign affairs, psychology of nations and military technology and strategy, I am finding it difficult to understand what the optimum policy for the US should be to avoid nuclear war and yet preserve our liberties. Many distinguished authors have written on the subject. All give highly convincing arguments for their theses, but disagreement among them is common. Each implies disaster if his recommendations are not followed. Consequently, it would be very helpful toward resolving confusion if authors would include, and editors would require, discussion of the following three subjects in any analyses:

Historical comparison. This is a form of experimental test of the proposed theory—imperfect, but the best realistic test we have short of implementation or catastrophe. Would a similar policy as advocated by the author have worked in an earlier era? (Of course adjusted for the era.) For example, would a weapons freeze have worked in the 1930s to contain the Nazis? Or, how often has disarmament helped the democracies? How often hurt them? Has excess armament by itself provoked war in the past?

Effect of proposals on adversary. Suppose the author's thesis is in fact adopted by the US. As a consequence, will our adversaries be more or less likely to cooperate toward reduction of tension and aggression? In particular, of course, will the Russians see disarmament, freeze proposals and so on as weakness and then be more likely to make new Afghanistans, Angolas, Ethiopias, Polands, Hungarys, Czechoslovakias, East Germanys, Estonias, Latvias, Lithuanias, Finlands and so on? Or, in contrast, will the Russians find our arming as provoking and dangerous to them and risk yet more

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aggression and the enslavement of more states? If we weaken ourselves, will the Russians follow suit? Have they ever? What do the Russians themselves say about their purposes for arming? Is it just for defense of the homeland? For socialist imperialism? Does Russian Marxism–Leninism in fact hold that conflict, including war, with capitalistic countries is inevitable?

Delta-factor. With great erudition and arithmetic detail, authors have calculated what might happen in various military or confrontational scenarios. However, they all seem to omit an important factor, a factor so incredibly small and preposterous that it would deserve instant disbelief were it not so repeatedly found in military conflict. This factor is the probability, call it δ, that people or events in a war, a battle or even a skirmish will actually go as planned. Allowance for this factor is therefore of the utmost importance in deciding how much munitions or how many troops are enough. Extreme danger occurs when planners unconsciously assume the factor to be of the order of 1.

Examples, incredible examples, of small delta abound. We need only mention two. For those sentient in the 1940s, the Pearl Harbor debacle jumps to mind as a classic case with $\delta \ll 1$. In brief (and vastly oversimplified), Washington, having knowledge, did not clearly and effectively inform the Hawaii commanders that war was imminent. (In fact, an army message was sent by Western Union! It arrived a few hours after the attack was over.) The military was, in any case, not prepared. In fact, it was unbelievably, inconceivably unprepared and complacent. Finally, what local warning military leaders did have, to wit radar and sub contacts, were ignored.

More appropriate as an analogy (not an identity) to present missile reliability was the Navy experience with torpedoes in the Pacific in early World War II. In short, they didn't work. And submarine commanders who reported that fact or who altered the torpedoes so they would work were summarily relieved of command. Great loss of life in the submarines and in the torpedo bombers (and consequently to Americans generally) ensued. Again $\delta \ll 1$.

In ballistic missiles and multiply targeted re-entry vehicles together with their launching and control devices, we have an enormously more complicated munition, (I hope forever) untested in combat. This weapon system is properly under very tight control. But tight control also inevitably decreases δ. (There is an apocryphal story of an ammunition sergeant at Hickam Air Field in Hawaii, 7 December 1941, under actual Japanese air attack, who refused to release anti-aircraft ammunition without proper authorization.) The strategic nuclear stakes are the highest possible—civilization itself—again leading properly to caution, but also perhaps to indecision, consequently to a yet smaller δ. What then is δ for this entire weapon system? For example, if δ is even as large as 0.05 then a ten times "overkill" in vehicles calculated on target is not sufficient. Calculation-on-target is itself a smaller number than the vehicles available before conflict in the US, and a much smaller number after a first strike against us. What if $\delta < 0.01$? What if $\delta \ll 0.01$? Unfortunately the delta factor includes such imponderables as errors, stupidity, ignorance, unexpected contingencies, military rigidity, peacetime attitudes, battle confusion, inaction in novel stressful situations, and hesitancy, not to mention poor, ambiguous or absent communication.

So estimates of δ are both difficult and unreliable—extremely so. But for truly realistic planning for peace it appears essential, absolutely essential, to estimate and conservatively allow for δ.

JOSEPH J. DAVANEY
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3/84

PT as recruiting device

I thought that some of your readers at academic institutions might be interested in a use we at George Mason University have found for old issues of PHYSICS TODAY. We have placed a large display poster, using PHYSICS TODAY covers to illustrate numerous reasons students might want to major in physics, in the front lobby of the physics building. Students can often be found reading the poster, which is probably an effective and inexpensive recruiting device.

ROBERT EHRLICH
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2/84

Early days in heavy elements

Commenting on C. P. Snow's *The Physicists*, Ruth Sime (December, page 84) remarks that nobody "saw through" (Snow's phrase) the problem of interpreting Fermi's experiments on uranium bombarded with neutrons. There is danger of forgetting that Ida Noddack did "see through" it, but was ignored.

Fermi[1] reported that the bombardment produced several β-active nuclear species, including one with a halflife of 13 minutes. Chemical procedures that resulted in precipitation of this species did not have a similar result when applied to known elements near the end of the periodic table. Fermi concluded that the investigation "suggests the possibility that the atomic number" of the 13-minute β-rayer "may be greater than 92." That interpretation was widely accepted.

Noddack,[2] however, having repeated Fermi's chemical manipulations and having found that many elements could by that process be carried down in the precipitate, asserted that Fermi's line of reasoning was not convincing. Instead (my translation),

> One can just as well suppose that, in these new kinds of nucleus-smashing by neutrons, "nuclear reactions" take place that are significantly different from those observed up to now in the action of