New thinking?

The October/November issue (pp. 12–14) sported three letters in raucous opposition to the August/September article "Barriers to thinking new about energy," by Laura Nader (p. 24). In a paranoid frame of mind, I might suspect that Dr. Nader made up the three letters to buttress her original case. In a more charitable view, the letters show the value of free and open speech. In my reading, Dr. Nader's detractors unintentionally provide strong support for the points made in her original article.

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Relativity and clocks

I enjoyed the article on the Global Positioning System in the October/November issue (pp. 24–27). I think it would be of interest to your readers to note that adjustments are made to the readings of the clocks to compensate for the general relativity effects on the signals passing through the Earth's gravitational field. I believe there also may be compensations based on special relativity consequences of the relative velocity of the satellites in relation to the receivers on the surface of the Earth.

Dick Medvick
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In his article "Global Positioning System: A High-Tech Success" (October/November 2002), Neil Ashby states that "Louis Essen and John V. L. Parry built the first atomic clock in 1955 at the National Physical Laboratory in Teddington, England." That is incorrect. The first practical working cesium clock was built by Jesse Sherwood at the National Bureau of Standards (NBS) shortly before 1952. Jesse came to Oak Ridge National Laboratory in 1952 after building the clock and putting it into operation at NBS. He left NBS after his supervisor, Ernest Lyons, who had little first-hand connection with the project, took credit for the clock and presented a paper on the subject. That whole scenario was covered in an article in *Physics Today* about 20–30 years ago.

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[*Author replies*: Dick Medvick has called attention to some important effects arising from both special and general relativity that have to be accounted for if the Global Positioning System (GPS) is to work properly. These effects include gravitational frequency shifts of satellite clocks relative to clocks on Earth's geoid, and Doppler shifts, including second-order Doppler shifts (time dilation). First-order Doppler shifts are removed by receiver circuitry. These effects are discussed in a recent article published in *Physics Today* (*1*). The Shapiro effect—the time delay of electromagnetic signals passing through Earth's gravitational field—is only a few hundredths of a nanosecond and ordinarily is negligible in the GPS except in the most demanding applications.

Historians generally credit Essen and Parry with the first successful cesium clock

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(2–4). It is true that research on the cesium clock was carried out at NBS in Gaithersburg, Maryland, before Essen and Parry began their work, but a cesium clock was not successfully operated at NBS until the late 1950s, and the early research apparently existed only in internal reports and was not published in the open literature. Essen visited NBS on several occasions and referenced the early NBS work in the first published paper on cesium clocks (5).

Neil Ashby]

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New bachelor?

The article "Introducing a Bachelor of Industrial Physics" (August/September, pp. 28–29), was appropriate and interesting, but not as new in concept as the author assumes.

In 1949, I graduated from Virginia Polytechnic Institute (now Virginia Polytechnic Institute and State University) with a B.S. in industrial physics. At the time, the physics department was small, and, in developing the curricula, it relied on many of the larger engineering department courses to supplement the available ones in physics. I omit the usual English course requirements in the discussion below.

I cannot find the list of my courses, which, considering their time frame, certainly paralleled those in your article, and their intent was the same. I still have some of my textbooks and, with their help, have reconstructed parts of the curriculum. I took engineering drawing, machine shop (which is still useful), engineering statistics, and statics and dynamics. I took courses in ac/dc circuits and electronics in the electrical engineering department, which were about vacuum tubes at the time, but circuit design principles are still valid. Inorganic and physical chemistry in the chemistry department also were required. I remember taking a course in metallurgy that has been forever helpful. The curriculum included the usual math courses, along with physics courses such as optics, thermodynamics, and applied nuclear physics. Quantum mechanics was not taught at the undergraduate level, although the introduction to nuclear physics course presented some of the concepts.

Advanced laboratory courses were designed to use industrial instruments (digital computers, scanning electron microscopes, secondary ion mass spectroscopy, and Auger spectroscopy had not been invented at that time). We had lab courses in X-ray diffraction and spectroscopy, both of which were extensively used in industrial labs for analysis. Looking back, I believe I received good preparation for my life's work.

It is worth following my career path after this training.

I was hired as an electronic engineer in 1950, partly because of my being a ham radio operator. I received an M.S. in physics in 1959 at the University of Maryland while working, and I published 11 papers in *The Physical Review* and the *Journal of Applied Physics*. However, I eventually migrated back to my industrial physics background and am now involved in electronics packaging and interconnections, writing books on wire-bond interconnections (an ultrasonic welding method used to interconnect chips to the outside circuit), and publishing mostly in transactions and conferences of the Institute of Electrical and Electronic Engineers (IEEE). I am a Life Fellow of the IEEE and still maintain membership in the American Physical Society.

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[*Author replies*: I thank George Harman for his comments and support. His alma mater has an interesting history of the physics department on its Web page (http://www.phys.vt.edu/department/history.html) and lists the years for which a B.S. in industrial physics was offered as 1937–1953. A master's degree in applied and industrial physics was introduced in 1996.

Another parallel to the industrial physics curriculum is the idea of a core curriculum in engineering. This is the idea that you are an engineer first, and then you have a specialty. Perhaps with the pendulum swinging widely to the side of specialization, the need for generalists is emerging. If this is true, then physics is in a good position to benefit from the trend. We should try to convince business and students that more-fundamental training will serve both industry and students better in the long run than a highly specialized technology-dependent education. The dividing line between the sciences and engineering is getting increasingly blurry. Personally, I welcome the change.

We at East Stroudsburg University have a lot of work to do. Your encouragement is much appreciated.

David A. Larrabee]

Nuclear insecurity

Physicists should be encouraged to look at, and then beyond, the post-9/11 challenges that have befallen the Nuclear Regulatory Commission (NRC) as summarized by Richard A. Meserve's article ("Nuclear security in a new world," October/ November, pp. 20–23). Probably no other profession is more connected to nuclear security by its craft or by its history than physics. Physicists can make themselves knowledgeable about the problems that face the NRC and about other related issues of nuclear terrorism by accessing the available information (see some examples in the references). This playing field is broad, with many competitors in the arena, but with a bit of effort one can ascertain the primary issues concerning our nuclear "insecurity" problem. They include the following:

1. Nuclear watchdog organizations such as


Lasse Skarbøvik

the Nuclear Control Institute (NCI) contend that the NRC acts like a regulatory agency "captured" by the industry it regulates. This, they say, jeopardizes nuclear security because of the apparent contradiction in the function of the NRC (*1*).

2. The NRC has been accused of running mock terrorist drills that do not sufficiently mimic the present threat (the so-called design basis threat or DBT). The DBT response by nuclear-plant security forces has a controversial history. The NCI reported a failure rate (marked by the inability to repel the mock force) of about 50%, although the results have been debated (*2*). According to Dr. Meserve, the DBT is to be revised. Hopefully, success rates using a more rigorous DBT will be higher and not as disputable.

3. In an analogous situation, the U.S. Department of Energy (DOE) faces security threats at some of its installations that hold inventories of weapons-grade plutonium and highly enriched uranium. The Project on Government Oversight critiqued the failure of DOE security forces to repel mock terrorist attacks (*3*). Again, an inability to repel many attacks was seen. Recently, DOE moved plutonium from its Los Alamos valley site to the more-secure Nevada Test Site because the valley enhanced the ability of terrorists to steal nuclear materials.

4. Although nuclear containment buildings are sturdy structures that may be able to withstand the worst of the destructive effects of an impact by a fully fueled jetliner, ancillary structures like spent-uranium fuel-holding facilities are not as rugged. To respond to this problem, reactor operators can strengthen spent-fuel facilities against fire and impact or, if given the opportunity, transfer the spent fuel off-site to a national high-level nuclear waste repository such as the Yucca Mountain, Nevada, site run by DOE. Its ecological considerations are still debated (*4*). The controversial shipments of spent nuclear-reactor fuel that may also require security measures are not expected to begin until 2010.

5. The international nature of nuclear security and how it impacts home is demonstrated by the demilitarization of nuclear weapons. By agreement, the U.S. and Russia have both put 34 metric tons of plutonium derived from weapons into surplus. The plan to burn plutonium as mixed oxide fuel at privately owned U.S. plants is controversial (*5*). The security of this material and highly enriched uranium in Russia is also worrisome (*6*).

These few points illustrate that the nuclear terrorism problem goes beyond one agency and one kind of threat. Consider also the "dirty-bomb" issue that the Health Physics Society and the Federation of American Scientists are attempting to address (go to www.hps.org or www.fas.org for more information).

It has recently been said that Americans are becoming complacent about homeland terrorism. If so, this would be a good time for practitioners of physics, a profession with a legacy of nuclear concerns and debate, to examine the issues and weigh in with rational solutions to this most terrible of threats.

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[*Author replies*: I strongly endorse Dr. Maiello's recommendation that physicists become actively engaged in helping to address the security issues confronting our nation. We have an adversary that is quite unlike any we have confronted before, and, as in the past, I am confident that our best scientific minds can contribute significantly in developing the policies and the means to protect our society.

Let me comment on a few of the issues raised by Dr. Maiello.

Nuclear security has certainly not escaped the controversy that generally surrounds nuclear issues. Although there has been criticism of the NRC by some, significant progress has in fact been made. The defenses at nuclear facilities are far more substantial than those available at other critical infrastructure, and that security has been significantly enhanced over the past year.

In the aftermath of the September 11 attacks, the NRC commenced a comprehensive review of its policies and procedures relating to security. As noted by Dr. Maiello, this review will include a revision of the design basis threat against which our licensees must prepare. Moreover, the inspection program is being revised so as to provide force-on-force drills on a three-year cycle at every plant rather than on the eight-year cycle that existed in the past. These efforts have already commenced with the conduct of table-top drills that, for the first time, have included extensive involvement of state, local, and federal law enforcement officials.

Dr. Maiello notes that concerns have been expressed about the fact that vulnerabilities have been found in past force-on-force drills. Although the results are subject to different interpretations from those he cites—the licensee success ratio on a drill-by-drill basis is far better than he indicates—the fact is that the drills are hard and the NRC has been a hard grader. This should be reassuring to the public and obviously undermines any claims that the NRC is a "captive" of its licensees. Perhaps more important, the NRC has required the correction of any defects in security strategy that are revealed through these drills.

Dr. Maiello appropriately raises issues concerning a radiological dispersal device (RDD). Although the health consequences of such a device are not likely to be substantial, the use of an RDD could have severe economic consequences and might cause great public concern. As a result, the NRC has issued advisories to its materials licensees and is conducting an evaluation of the controls governing those materials that constitute the greatest hazard to public health and safety. We are also working with the Office of Homeland Security and other agencies to ensure that the federal government is prepared for an event involving the use of an RDD.

I certainly agree with Dr. Maiello's observation that the terrorism issue extends beyond one agency and one type of threat. Let me also note, however, that the issues extend far beyond the nuclear sector. Although there no doubt are improvements in security for the nuclear plants that should be pursued, many threats are directed at other sectors for which comparatively little has been done. The defenses that exist to protect nuclear plants, for example, are far more robust and comprehensive than those surrounding other parts of our civilian infrastructure. Although I value thoughtful input to address our nuclear vulnerabilities, I hope that your readers will also consider and help address the many other terrorism challenges that our nation faces.

Richard A. Meserve] Ω

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