letters

batten, the former UK Chief of Defence Staff Lord Carver, and the former US Secretary of Defense Harold Brown.

A second example illustrates that passive, apparently purely defensive, technology also can lead to serious destablization. The doctrine of deterrence by Mutual Assured Destruction rests finally on the invulnerability of submarine-based intercontinental missiles. But now enormous effort is being put into technologies that might be capable of submarine detection and tracking, with, of course, concomitant vast expenditures on yet quieter and less detectable submarines. At best we will end up by paying a lot more for nuclear submarines. (At a time of serious economic recession the UK government is to spend £6000 million—say $11 billion—on its "independent" force of four Trident submarines. The independent circumstances in which they would be used are vague beyond definition, but the expenditure is real enough, and will come from a weakening of conventional forces, thus encouraging NATO's tendency to plan to resort to nuclear weapons at an early stage of any conflict.). At worst we will lose whatever protection we had from MAD.

Rosen's superficial generalization, that better weapons will make for a safer world, is one that is accepted all too uncritically by scientists and engineers working in defense industries. The aerospace and electronics companies hold to a similar belief, but one that in their case is perhaps not devoid of self interest.

We live in a world that is close to catastrophe; it is essential that we acquire the foresight to see which developments will make it more perilous, and which less so. To then control those developments is a difficult but not impossible task; it has been done before with the Anti-Ballistic Missile Agreement, for example.

As a foreigner, it seems to me that in this direction the US has a particular responsibility, because of its role as a superpower and its immense technological strength, and a particular capability, because of the open nature of its political processes. Therefore, the work of groups such as POPA has a supranational relevance. The necessary information is far more freely available in the US than it is in most West European countries; you have had (at least until recently) a well-funded and well-staffed Arms Control and Disarmament Agency, numerous Congressional hearings, and also the 'Impact' statements from the Department of Defense to Congress on the likely repercussions of proposed weapons and systems.

A substantial fraction of the readers of PHYSICS TODAY are employed directly by defense industries, a further large number in universities and research institutes receive funding in one way or another from defense agencies (I am aware that a great deal of the funding for university research by certain US defense agencies is genuinely non-military in intent, and that this circumstance arises from the history of federal funding of research). A regular review by POPA, published in PHYSICS TODAY, on the directions being taken by research that has military implications, would help to give physicists the information whereby they can make responsible decisions about the work that they do. In the other direction, POPA should be well placed to put soundly based technical representations to government, perhaps through the Arms Control and Disarmament Agency. Both tasks will require a great deal of hard work, but both are responsibilities owed by the physics community to a world that is generally threatened, albeit unwittingly, by the results of physicists' curiosity and insight.

A. David Caplin
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9/81

THE AUTHOR COMMENTS: I have strongly emphasized the high priority I give to arms control, if we are to avoid an eventual catastrophe. However, we must also avoid catastrophe in the near term, and I believe that an adequate defense posture is essential to do that. It is therefore not quite cricket for David Caplin to interpret my remarks as a generalization that "better weapons will make a safer world." What realistic choice have we, aside from deterrence, to buy the world the time it needs to achieve the conditions which will permit arms control? Every care must, of course, be taken to ensure that deterrence doesn't fuel an arms race. It has been my experience that almost all research can have military implications. It is the technology that derives from research which may be specifically targeted and such targeting is almost always transparent.

I can, therefore, see no purpose to be served by POPA attempting to characterize research in terms of its potential military importance. This would seem to me to be a hopeless, as well as useless, expenditure of high-level expertise.

LOUIS ROSEN
Panel on Public Affairs
American Physical Society
New York, NY
10/81

Optical ebullience

Much as I enjoyed Peter Franken's ebullient article on optics (November,

page 160), I must take issue with two of his points regarding large optical telescopes. The first of these is his rejection of borosilicate (Pyrex) glass as modern mirror material, because of its finite thermal expansion. It is true that massive solid blanks which are slow to come into thermal equilibrium are best made from 'zero' expansion materials. However, lightweight blanks with internal honeycomb, the optimum structure for very large mirrors, actually have rather rapid thermal response. My group at the University of Arizona is investigating methods to cast large blanks of 7–8 m diameter of honeycombed borosilicate glass. Properly ventilated, these would have thermal time constants of a few minutes as compared to many hours for solid blanks. Our experience now in figuring test sections of 60-cm diameter shows rapid optical testing is indeed possible. We anticipate that thermal distortion of these mirrors, operating in ground-based telescopes, will never be significant compared to the distortion of 'seeing,' even under the best atmospheric conditions. In fact, because they follow the ambient air temperature, these mirrors reduce the convection at the mirror surface that contributes significantly to image degradation in current large telescopes which have solid zero-expansion mirrors. The mirrors also have potential application in space for longer wavelength telescopes. As a practical matter, fabrication and material costs for borosilicate honeycomb are low. On the basis of costs of our current 2-m furnace located in the Optical Sciences Center we project that mirror blanks of 8-m diameter should cost and weigh no more than the present generation of 4-m solid blanks.

My second concern is with Franken's doubts about the value of a large ground-based telescope in the era of the space telescope. Given no financial restriction, astronomers would prefer, of course, to place all their telescopes in space to avoid the limiting effects imposed by the Earth's atmosphere. It is not sensible, however, to waste time with space telescopes doing those observations that can be done at far less cost on the ground. The proposed National 15-m Telescope will be much less expensive than the Space Telescope, and have 40 times the collecting area. It will not see ultraviolet light or have tenth-arc-second resolution in visible light, but it can perform with many vital complementary observatories for which light grasp is essential. Interferometric methods will allow the reconstruction of images with an angular resolution ten times that of the space telescope in visible light. The potential exists, in the infrared, to correct actively for the atmosphere and reach the diffraction limit of the full telescope aperture for direct imaging or spectroscopy.

It is well-known that telescopes in space or in new wavelength domains result in ever-larger demands for follow-up optical and infrared observations. Far from making the largest possible ground-based telescopes obsolete, the space telescope will surely redouble demand for their use.

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THE AUTHOR COMMENTS: Roger Angel's collegial vesuviation about my deprecation, en passant, of pyrex as a telescope material is absolutely appropriate. In fact, I even think he's right! However, I would like to clarify my remark about pyrex and place it into the simple context I had intended but not accomplished. To wit, it would indeed be idiocy to cast a largely solid mirror blank out of pyrex these days because we have better, albeit far more expensive, materials with which to work. Angel, however, has been pushing (and in our basement!) an exciting technology for fabricating very thin "shells," utilizing new casting and fabrication techniques, that show substantial promise as viable candidates for large and exquisitely figured primaries of the future. And, indeed, pyrex could well be the most plausible material for such mirrors. I was remiss in not massaging this point in my article, and I am grateful to Angel for flagging my dereliction.

With respect to Angel's comments about ". . . Franken's doubts about the value of a large ground-based telescope . . . ." I have reread that part of my article, and I do not agree with his assessment of what is actually said. Rather than debate the matter in this column, however, let me refer possibly interested readers to the original text. I might just add, however, that what I think—or what anyone thinks I think—is going to have very little significance compared to what the Director of the National Science Foundation or other potentially interested agencies in Washington might think!

PETER FRANKEN
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Nuclear physics complaint

The scene is a corridor in the basement of a physics laboratory. Lighting is dim, in the background the noise of mechanical vacuum pumps. Two physicists, slightly round-shouldered, leaning on opposite walls.

First physicist—Did you see the No-