

is that nobody is keeping Soviet Jews in the country by force. (Digest of the Soviet Press, "Sputnik," October 1982).

Directly responsible for many of Yashchin's troubles, I believe, is Yuri Ossipyan. Being a director of Institute of Solid State Physics, a member of The Academy of Sciences of the USSR and occupying a prominent position in the party hierarchy, Ossipyan has enough influence to be able to help Yashchin leave the Soviet Union. It was Ossipyan's order to fire Yashchin from the institute. It is he who ordered the telephone to be cut off.

Here in the West, there is a tendency to underestimate a personal responsibility in the Soviet Union. There is no doubt that the regime is responsible for what is happening in the USSR. But the regime cannot perform its job without such people as Ossipyan, who are themselves part of the regime. And the regime is awarding such people as Ossipyan. The important part of this award is the possibility of unlimited contacts with foreign colleagues. Unlike the majority of Soviet scientists, Ossipyan is spending an essential part of his time on trips abroad. We welcome these people. We are listening to them and get their versions of what is happening with our persecuted colleagues. Thus, in his letter to the physics department at Iowa State University, Ossipyan claims: "During the past few years more than a dozen people from the staff of the Solid State Physics Institute have emigrated. None of them has ever been dismissed from his scientific position until immediately prior to his departure from the USSR."

Yashchin is not the only one who was dismissed from the institute as a result of his *expressed intention* to go to Israel. In 1976, I was fired under similar circumstances.

We may help the oppressed scientists in the USSR if our reception of such scientists as Ossipyan (and Alexander Prokhorov, Anatoly Dorodnitsyn, Gyorgy Skryabin and Andrey Tikhonov who wrote in "Izvestia" an article vilifying Andrey Sakharov) is predicated on their just behavior towards our colleagues in Russia.

BENJAMIN FAIN
Tel Aviv University
Tel Aviv, Israel

7/84

SDI: no pot of gold

With respect to your reports in June (page 53) on the Strategic Defense Initiative ("Star Wars"), it sounds to me that those who suggest we can build a space-based ballistic missile defense

to render nuclear weapons impotent have much in common with the ancient alchemists. For centuries, the alchemists were certain that they were close to being able to convert lead or other base metals into gold. They did not succeed, although we now know that such a conversion does not violate any of the laws of nature. In fact, our large accelerators frequently convert infinitesimal amounts of various elements into gold. The cost is vastly higher than the cost of mining gold, and you end up with a highly radioactive product that no self-respecting king would want to put into the royal coffers—but it is gold.

Similarly, there is no doubt that both the Soviets and we are capable of shooting down an airplane, a cruise missile, or even an ICBM. However, it recently was considered a disaster when the Syrians, using sophisticated Soviet air defense missiles, were able to down one or two of the many US and Israeli planes that were involved in the Lebanese conflict. Our airplanes, of course, are not sitting ducks, but carry many devices and use tactics to confuse the air defense missiles. Without doubt, Star Wars offensive and defensive systems would evolve in the same way.

In my opinion, starting a whole new arms race for Star Wars defenses in the hope of making nuclear weapons impotent would be a more disastrous mistake than was our decision about ten years ago to start the MIRV race because, at that time, we had a technological lead. Proposals for a space-based ballistic missile defense should be filed in the same place with proposals to turn all the governments' lead into gold.

RICHARD L. KAUFMANN
University of New Hampshire
Durham, New Hampshire

7/84

A bachelor's point of view

I read with interest S. I. Salem's "Worth of a BS" (June, page 92), but from a different point of view. I found his quotation of Berry Yolkin, a manager of TRW Ground System Development, about the physicist being his "best engineer," typical. My degree, a bachelor's in physics, has also made me an engineer, not a physicist. No employer, especially a non-technical degreed or a non-degreed manager, can think of a BS physicist as anything but an engineer, anyway in my 35 years of experience and 21 years as a degreed physics graduate.

It is not at all bad because, in my rationalization, and engineer is but an applied physicist. No sweeping generalities intended.

A physicist, even in our enlightened

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time, suggests some recluse surrounded by piles of books, blackboards covered with equations, mostly partial differentials, and incapable of conversation with the uneducated. Of course, to be a "real" physicist you must hold a doctorate.

It is sad to say that at least I could find neither money nor time to solidify that image by obtaining my doctorate. Nor do I really know if I had what it takes had I not needed to support a loving wife and four children.

My degree has, however, permitted me a range of occupational freedom I had dreamed of but never hoped to achieve.

Yet when you read "Information Exchange," at the back of *PHYSICS TODAY*, as I have for 21 years, you seldom see BS physicists in demand for positions other than lab supervisors or repairmen. Management becomes the last hurrah in some engineering groups and this is most probably due to the "engineering" achievements you may have had.

Yes indeed, Salem, a bachelor in physics is a person of worth, if only to himself.

MARTIN T. SMITH
Lincoln, Nebraska

7/84

Ballistic missile defense

There has been a considerable amount of recent discussion about a proposed ballistic-missile defense, particularly directed energy (particle beam and laser) systems. Much of the discussion ignores or obscures the most elementary criterion for the viability of a defense system, which is that it must be less costly to shoot down an incoming missile than it is to launch another missile.

The justification can be simply shown. Suppose side A has \$a per year to spend on missile defense at an average cost of \$d per missile killed, that is, on a defense system with the capability to defend against n missiles and having a total cost of $nd = a$; side B has N_0 missiles to start with and \$b per year to spend on missiles at a cost of \$m per missile. At the end of Y years, the total number of missiles T which can penetrate the defense, is just the number of missiles owned by B minus the number of missiles which can be killed by A,

$$T = N_0 + bY/m - aY/d.$$

A defense strategy can only succeed if side A can outspend side B by a factor d/m .

In general, we do not expect that one side will be able or willing to outspend the other, year by year by a very large

margin. If we thus assume $b = a$, then the criterion for the feasibility of a defense system is simply $d/m < 1$. A defense system will not work unless it is cheaper to shoot down a missile than it is to build another one.

For more sophisticated models, including allowance for imperfect defense, the analysis is more involved. The general conclusion, that the average cost to shoot down a missile must be less than the cost to the offense of building an additional missile, remains valid. Any system which fails this criterion is not viable regardless of any other technical points, since it can always be saturated by the offensive side.

How do proposed ballistic-missile defense systems rate according to this criterion? Estimates¹ of the cost of a defense against the present Soviet missile force range from \$200 billion to \$500 billion. Because the Soviet missile force comprises² about 2500 missiles, this comes to a cost per kill of \$100 million to \$200 million. In contrast, a currently proposed missile system, "midgetman," is estimated³ to cost between \$10 million and \$70 million per missile. A typical Soviet missile may well be less expensive. Even using the most optimistic numbers, then, the ratio d/m for the proposed ballistic missile defense is 1.4.

Using the more pessimistic (that is, lowest) estimate of missile cost, a ballistic-missile defense would not work unless it could be made to cost less than \$25 billion—an order of magnitude less than currently quoted cost figures.

References

1. J. B. Tucker, *Technology Review*, April 1984, p. 46.
2. B. G. Levi, *PHYSICS TODAY*, March 1983, p. 43.
3. R. Garwin, *Bulletin Atomic Scientists*, August–September 1983, p. 62.

GEOFFREY A. LANDIS

Brown University

7/84

Providence, Rhode Island

Elephants and mahouts

Frank Herman's description of his work on semiconductor band structure (June, page 56) brought back many memories. I knew Herman when I, too, worked at RCA, from 1950 to 1952. I remember his tales of struggle with the orthogonalized-plane-wave method. In fact, one evening over dinner at Renwick's I sought to dissuade him from his labors. I pointed out that not everyone could win a Nobel Prize! Of course, when he published his work, it came as a revelation to those of us who had learned about semiconductors from William Shockley's well written but somewhat simplistic book¹.