

letters

mass, V_{2e} and V_{Pe} are the rocket exhaust velocities for the second stage and the PBV ("bus"), respectively, and P is the mass of the PBV including warheads and fuel. The stage-2 velocity gain from offload of a small mass ε from the bus would be

$$\Delta V_o = \varepsilon \times V_{2e} / (fM_2 + P),$$

but PBV velocity gain from retaining and burning that fuel would be

$$\Delta V_P = \varepsilon \times V_{Pe} / P$$

More than payload-offload calculations is involved in designing a hardened missile. What is required for a uniform coat to withstand 20 kJ/cm^2 of laser heat? For a coat that can absorb the heat of vaporization of carbon, only 0.4 g/cm^2 is needed—1200 kg to cover the entire missile surface. An asymmetrically hardened missile could fly with the greater hardness toward the closest laser, and with much less hardening below, where there is no laser threat.

In preparing this response I reviewed my original chart (available upon request) presented on 29 May 1984 at the AAAS panel, which I prepared in response to Jastrow's statement at the AAAS conference that the weight of hardening anywhere on the missile must be subtracted from the payload. Because the analysis is not rigorous, I used a numerical calculation in my March letter. The model used for the chart deals not with an SS-18, but a generic ICBM, with three stages of equal velocity gain 2.3 km/sec . But perhaps because "3" is both the number of stages and the exhaust velocity in km/sec , I derived a stage-mass ratio r of 10, as befits a velocity gain in one stage of 7 km/sec . I took a tapered rocket like the Soviet SS-X-25, and determined the stage-area ratio to be 5. I apportioned the total shielding (Jastrow's assumed "4 tons") according to the stage areas, and maintained constant total speed by offloading a payload mass equal to the shielding mass on a stage divided by the appropriate power of r : r^2 for the first stage and r for the second stage (r assumed large). My blunder in stage-mass ratio invalidates the result of May 1984; the error is my own. The approach is invalid unless r is large, and so can't be used with the true r . I must also confess that I sometimes call 1000 kg a "ton" instead of a "tonne."

In response to Albert Petschek, I would say that only under very artificial assumptions—an infinite and uniform distribution of boosters, a flat Earth, laser battle stations deployed at ground level (or not higher than the height of booster burnout) and zero laser-retarget time—would the re-

quired number of laser battle stations grow as the square root of the missile threat. (The latter two restrictions were not explicitly mentioned² in the derivation.) But see how this is distorted by Worden in his letter: "He [Garwin] has also verified that the number of standard lasers needed scales as the square root of the number of offensive missiles added to the current Soviet offensive force." I did no such thing!

My *Nature* paper shows⁴ clearly that "square-root scaling" can enter only at low satellite density or low booster density." In its analysis of distributed boosters, it relaxes only the requirement of zero retarget time, and that is why I say that my derivation (and, *a fortiori*, Canavan's) is faulty for finite deployments and "holds in no relevant parameter regime." For the real distribution of Soviet boosters, square-root scaling assumes that satellites outside the deployment area are not permitted to shoot in. Furthermore, a nation would be responding no more logically to a large deployment of laser battle stations by deploying additional MIRVed, long-burn boosters distributed over its territory than it would by hardening only the first stage.

Like Petschek, I would like to avoid adjectives or who said what and when, but the reader must judge the illumination cast by this exchange.

References

1. *Strategic Defense and Anti-satellite Weapons*, hearing report, Committee on Foreign Relations, US Senate (25 April 1984). The background paper is printed on pp. 259-338. The "DOD comments..." are pp. 350-353. An OTA response is found on pp. 353-355.
2. G. Canavan, H. Flicker, O. Judd, K. Taggart, *Comments on the OTA Paper on Directed Energy Missile Defense in Space*, P/AC:84-43, Los Alamos National Laboratory, Los Alamos, N.M. (8 May 1984).
3. S. P. Worden, debate with R. L. Garwin held 22 November 1985, Colorado Springs, Colorado, proceedings to be published by US Space Foundation.
4. R. L. Garwin, *Nature* **315**, 286 (1985).

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Apartheid

The propriety of publishing advertisements for faculty positions in South African universities has recently been questioned by several correspondents (October, page 148). Attention is drawn to the small-print condition regarding equal opportunity at the beginning of each advertisement section in *PHYSICS TODAY*.

It is not so long ago that apartheid existed in certain parts of the United States, but the propriety of publishing

advertisements from universities in the deep South was never questioned. Also, most editions of *PHYSICS TODAY* include advertisements from employers (including the US government) who claim to be offering equal opportunity but who require candidates to be American citizens! Different degrees of equality are implied, perhaps?

I do not support apartheid but I do not support double standards either. I believe that all forms of discrimination are to be deplored everywhere, not just in South Africa.

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11/85

Third atomic bomb?

Erich Hutzler suggests in his letter (December, page 13) that in a television interview Senator Barry Goldwater may have inadvertently revealed a third combat use of nuclear weapons, in Southeast Asia.

I feel a more plausible explanation is that the senator was referring to the 15 000-pound bomb, the largest convention munition in the Vietnam-era inventory. This bomb was too large to be carried by existing bombers and was dropped from C-130 transports. Its principal use was the demolition of trees to clear landing spaces in the jungle.

In the conversation the senator did not explicitly state that the weapon used in Vietnam was nuclear; however, he did state that it was used for jungle clearing. It would appear reasonable to assume that he was discussing the 15 000-pound bomb and nuclear weapons as being the largest munitions used by US forces.

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Kondo problem

I am writing to correct an important omission from the subsection entitled "Solution of the Kondo problem (at last)" that appeared in the condensed-matter-physics section of *Physics News* in 1985 in the January issue of *PHYSICS TODAY* (page S-22). In referring to earlier work on exact solutions of aspects of the Kondo problem, I omitted a reference to important work by Soviet colleagues. An appropriate addition to reference 1 would be the review article of A. M. Tsvelick and P. B. Wiegmann, *Advances in Physics* **32**, 453 (1983). I regret any distortion of the description of the progress made on the Kondo problem that resulted from its omission.

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