

letters

modulation at a microwave or infrared frequency. The lower frequency is transferred thereby into the optical domain as a known frequency difference. Simultaneous interferometric determination of the ratio of the sideband frequencies yields the carrier frequency. Started and pursued by Z. Bay and coworkers, this technique was used to measure the 473 THz of the 633-nm red laser line in a recent prototype experiment, connecting the 10-GHz microwave frequency to the optical in one step (Z. Bay et al, *Phys. Rev. Lett.* **29**, 189, 1972). Extension of the modulation frequency into the infrared, notably up to 88 THz in one experiment, has been demonstrated by K. M. Baird et al (*Opt. Com.* **7**, 107, 1973). The method is applicable to any laser light with predictable improvements in accuracy to the limit of frequency standards. It uses relatively simple equipment. Thus the practical requirements for the introduction of the unified system are fulfilled.

The idea of using fundamental constants of nature for the definition of the units of measurements in general was suggested by M. Planck as early as

1906. Owing to the large uncertainties in the constants at that time, the idea remained dormant. After the advent of lasers, C. H. Townes in 1961 directed attention to the future possibility of measuring optical frequencies and then connecting the units of time and length through the speed of light. An explicit proposal to measure optical frequencies and to introduce a time-length measurement system unified by a defined value of c , was made in the National Bureau of Standards by Z. Bay in 1965. Detailed studies of the problems involved¹⁻³ and the successful experiments mentioned above fully justify in our opinion a decision in favor of the unified system.

References

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Disagreement with Wigner

Recently Eugene Wigner addressed a large group of physicists and physics students at the Southeastern Sectional meeting of the American Physical Society in Winston-Salem, North Carolina, on the subject "On Some of Physics Problem." In view of the fact that he is perhaps one of the greatest minds of the twentieth century (Nobel prize in 1963 for application of symmetry principles to quantum mechanics, inventing parity and isospin, among other things) what he says can not be taken lightly. He says first of all that physics has perhaps grown too fast and become too complicated, so that even he can not follow all of the review articles in the latest "Annual Reviews of Nuclear Science." Second he says that because of the enormous success of physics it is physically possible for everyone to have a materially carefree life, at least in countries where it is fully operative. Hence new developments in physics and technology are less needed; society problems become of a social and human nature. He said that he knew many people in the audience would disagree with him and would not like what he said.

I would like to take up the cudgel for those who disagree. Let me begin by saying that at that same meeting I had lunch with three black students who

were physics majors, and they were saying more or less the same thing, with the additional point that they resented the fact that the West was so much trying to say that its civilization was better than the African civilization and trying to impose its way of life on the Africans. Their point was, if the Africans have a happy, carefree life why not let them stay that way unencumbered by physics and technology? But then I reminded them of the millions who are going to starve to death next year because the Sahara desert is gradually moving south.

Let me now turn to the happy carefree life in the US, the most technologically advanced country in the world. Do we have enough physics and technology? Now that the oil from the Arab world has actually stopped flowing into our country we are confronted with a major disruption of our society. Millions of people may be thrown out of work, food and heat shortages may develop and a state of near chaos may prevail. Is this the carefree life? I think it has never been more clear that we need more technology and even more physics. Of course that is not all that we need. Also and terribly important we must learn to live with the fact that each new development in science and technology can be turned into a wonderful means of enriching our lives or a monster that may kill us

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all. We must find ways to profit from the former effect and eliminate the latter.

I don't disagree with Wigner about the importance of other disciplines, such as economics, the arts, languages, music and so on. I just think this is not the time to slow down on the production of physicists or the development of physics.

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Bootleg bombs

Richard Wilson's review of *Nuclear Energy: Its Physics and Social Challenge* (by D. R. Inglis) in the November issue (page 47) contains an important error. Specifically, Wilson contends that Inglis has overstated the problem of diversion of nuclear fuels by failing to point out that "Plutonium has to be a pure isotope (Pu^{239}) to make a bomb and that plutonium produced in most power reactors will be diluted with other isotopes and must be isotopically separated to make a bomb."

Unfortunately, this is not the case. It is true that plutonium produced in today's light-water reactors contains as much as 20-30% Pu^{240} , but this "reactor-grade" plutonium can nevertheless be fashioned into formidable bombs without isotopic separation. The presence of the prolific neutron emitter Pu^{240} renders the bomb maker's task more difficult and the explosive yield less predictable than is the case with pure Pu^{239} , but the resulting weapon is likely to be more than adequate for the purposes of terrorists, blackmailers, and even for some military applications. This conclusion has been stated emphatically in the unclassified literature by authorities in the weapons field.^{1,2} One need not even transform the plutonium oxide found in most reactor fuels to plutonium metal—the oxide will do as it is.¹

Many people may also be unaware of how large the quantity of material to be safeguarded will be in an expanded nuclear-power program, even if breeder reactors are not deployed at all. A large (1000 MWe) contemporary burner reactor of the light-water variety has an output of 220 to 285 kg of plutonium per year, versus 250 to 500 kg per year for a liquid-metal-cooled fast breeder reactor of the same capacity.³ The breeder's plutonium is "better" bomb material than that from the LWR—it contains less Pu^{240} —but the difference is only one of degree, as noted above.

Wilson suggests, rightly, that an attempt be made to compare the hazards

of energy alternatives—to weigh the potential consequences of dam failures, LNG explosions, and so on against the potential consequences of missteps with nuclear fission. Although large numbers of immediate deaths could indeed result from accidents with a variety of energy technologists, a liability that may be unique to fission is the potential for a legacy of environmental contamination and genetic damage far outliving the generation that makes the mistakes.

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2. T. B. Taylor, "Diversion by Non-Governmental Organizations" in *International Safeguards and Nuclear Industry*, (M. Willrich, ed), Johns Hopkins Press, Baltimore (1973); page 181.
3. US Atomic Energy Commission, *Potential Nuclear Power Growth Patterns*, WASH 1098, US Government Printing Office, Washington, D.C. (1970).

CORRECTION: The sense of Wilson's review was altered by omission of the adjective "efficient" applied to "bomb." Thus the next-to-last sentence of the third paragraph should read: "Nor is it clear that plutonium has to be a pure isotope (Pu^{239}) to make an *efficient* bomb and that plutonium produced in most power reactors will be diluted with other isotopes and must be isotopically separated to make an *efficient* bomb."

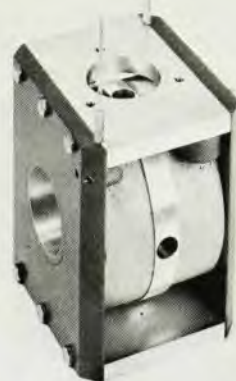
EDITOR

New math critic

As an answer to J. S. Huebner's observation that the decline in physics enrollment has occurred at a time that suggests it might be related to the introduction of the "new math" into the public schools, I wish to suggest the following:

The introduction of set theory as a frame of reference for the teaching of all math courses, from kindergarten on, means that a student learns set theory every semester—with applications to the various subjects such as addition, multiplication, algebra, geometry, and so on. The students are therefore burdened with carrying along throughout their entire school career a subject easily mastered in one semester at the college level and of interest mainly to the theoretical mathematician and not to the physicist or engineer. This burden

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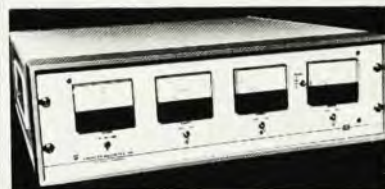
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