

LETTERS

picture. The intent of my article was primarily to give a technical description of photovoltaics and to consider a number of important applications; I did not say that if the technology had to supplant present sources it could do it. At this point the issue is not whether technical feasibility has been demonstrated but rather whether photovoltaics can be economically viable. Although there are a large variety of storage approaches, relatively little attention has been given to exploring ways to reduce their cost. Several examples of backup systems for when the sun does not shine exist: There has been a recent rebirth of interest in the concept of the solar-powered satellite, which would beam microwave power generated by solar cells in space back to Earth. The satellite would always be in sunlight, except during predictable eclipses. The production of hydrogen using solar power also is being seriously considered. The improvements in performance in high-temperature superconductors make superconducting magnetic energy storage and superconducting flywheels practical possibilities. Rather than debate the merits of each of the above, I prefer to stay with the natural evolution of the technology. As costs decline with the introduction of new, larger, cost-effective production facilities, new applications will emerge. At the appropriate time, electric utilities will introduce photovoltaics in larger quantity, first in high-value applications and eventually in central-station ones.

With respect to John Gilman's criticisms, I pointed out in my article that the availability of the solar resource is not the problem: "A photovoltaic generating station 140 × 140 km in area at an average US location could generate all the electricity needed in the US," assuming certain reasonable efficiencies and other factors. An area of that size is not prohibitive, though of course one would need to factor the requirements for storage into the economics to determine whether the approach would be viable. Gilman's second point is correct. However, I know of no one advocating zero-efficiency modules. Obviously if the cost of money is high, high efficiency becomes a premium. Gilman's third point is a misinterpretation of figure 6. That figure is one way to plot the module efficiency and cost needed to produce the cost of electricity shown on the abscissa. What figure 6 actually shows is that with a module efficiency of 8% the modules would have to be free in order to produce electricity costing 6¢ per

kilowatt-hour, due to other balance-of-systems costs. My response to Gilman's last comment is that there are now many economically viable applications. Recent calculations have shown that if electricity is needed at a location more than about a third of a mile off the utility grid, at today's price photovoltaics with battery storage is more economical than the cost of line extension to serve the application. There are numerous other examples of distributed electrical requirements. I urge Gilman to keep his eyes open as he travels around: He may be surprised by how much photovoltaics has been deployed.

Peter Reppert makes a very important point about the necessity of placing a monetary value on the environmentally benign aspects of renewable energy systems. Although care must be exercised not to harm the environment during the production of photovoltaic modules, the operation of the installed systems is essentially pollution free. The several attempts to determine the value of this characteristic have yielded results of a few cents per kilowatt-hour. I purposely did not spend much time on this matter in my article, feeling that if photovoltaics can compete without this "subsidy," its benefits will be recognized and appropriately valued. I disagree with Reppert's assertion that the technology is aimed at "an infinitely receding future." The number of economically viable applications is large and is growing rapidly as the costs decline. Certainly if Reppert's points could be addressed, deployment of the systems would be accelerated.

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A Tale of Two Mesons

In his review of the late Robert Marshak's *Conceptual Foundations of Modern Particle Physics* (April, page 63), Sidney Bludman writes: "Independently of Shoichi Sakata and Takeshi Inoue (1946), Marshak and Hans Bethe (1947) were responsible for the two-meson hypothesis, correctly distinguishing the weakly interacting μ lepton from the strongly interacting π meson. Marshak (1951) went on to propose the detailed balance experiment by which Bethe and Marshak's prediction of zero spin for the π^+ was confirmed." Like many brief historical remarks, this needs some qualification: The Sakata-

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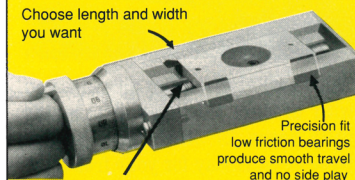
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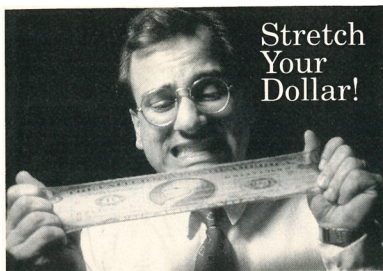
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Inoue date should be 1942, and Marshak and Bethe did not in 1947 predict zero spin for "the strongly interacting π meson."

Based upon documentary evidence (such as Hideki Yukawa's unpublished diary), Satio Hayakawa has noted that the two-meson idea was proposed in a colloquium at Kyoto University given by Sakata on 13 May 1942. Papers on the subject were read on 11 July 1942 at a meeting of the Physico-Mathematical Society of Japan. (Marshak and Hayakawa each discuss the two-meson theory in reference 1. There is no essential disagreement.) The Sakata-Inoue paper was published in 1942; its English-language version appeared in 1946.² In this paper the heavy (Yukawa) meson was a boson (spin 1), and the light meson (muon) was a fermion (spin $\frac{1}{2}$). Another version, presented by Yasutaka Tanikawa and Seitaru Nakamura, had these assignments reversed. (Nakamura gives an account of the two-meson history with full documentation in reference 3.)

Marshak made his suggestion at a conference at Shelter Island, New York, on 2-4 June 1947. He then asked Hans Bethe to join him on the details "because of his extensive knowledge of the cosmic-ray data" (according to Marshak's account in reference 1). They thus made use of the published results on muon capture of the Rome group (Marcello Conversi, Ettore Pancini and Oreste Piccioni) and on π - μ decay of the Bristol group (Cesare Lattes, H. Muirhead, Giuseppe Occhialini and Cecil Powell). The latter work, published on 24 May 1947, had not reached America at the time of the Shelter Island conference, but Marshak saw the paper in mid-June. Although the possibility of a pseudoscalar meson was stated in the Bethe-Marshak paper, the case actually selected for rough quantitative treatment was that of a heavier, strongly interacting spin- $\frac{1}{2}$ meson (obviously not a Yukawa meson!) decaying into a lighter, weakly interacting spin-0 meson. The reason for this preference was probably Marshak's pair theory of strong nuclear interaction.⁴

References

1. L. M. Brown, L. Hod-

deson, eds., *The Birth of Particle Physics*, Cambridge U. P., Cambridge, England (1982), pp. 82 (Hayakawa), 376 (Marshak).

2. S. Sakata, K. Inoue, J. Phys.-Math. Soc. Jpn. **16**, 232 (1942); Prog. Theor. Phys. **1**, 143 (1946).
3. S. Nakamura, Prog. Theor. Phys. Suppl. **105**, 46 (1991).
4. R. E. Marshak, Phys. Rev. **57**, 1101 (1940).

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4/94

APS Bosnia Statement Betrays Inconsistency

I read in your July 1993 issue (page 70) the report "APS Council Adopts Statement on Behalf of Bosnians."

This kind of political correctness is a pain (without elaborating). The US has in recent times (with no letup of the activity in sight) attacked the mighty nations Panama, Granada and Iraq, among others, to the accompaniment of the slaughter of (depending on the particular "freedom action" involved) thousands to hundreds of thousands. I don't recall any "statements on behalf" from the APS.

In the interests of brevity I leave to another time the discussion of the slaughter, at US instigation, of hundreds of thousands in Central and South America.

It is this kind of correctness that convinces many of a symbiotic relationship between physicists and the military. Cease, desist, mend your ways.

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