Letters

Temperature of Earth Satellites

In the issue of 11 April [*Science* **127**, 811 (1958)], Raymond H. Wilson, Jr., used a short-cut method for computing the temperature of an earth satellite. He concluded that the thermal radiation from the earth is not important, because earth and satellite are at nearly the same temperature. I question this conclusion.

It is true that the *net* exchange between the two will be small. But the calculation requires equating the *total* radiation absorbed by the satellite with that radiated by it *in all directions.* The solar radiation intercepted by the earth is practically equal to the sum of the solar radiation reflected and the thermal radiation from the earth. The average figure for the sum of the intensities of the two latter radiations, at a height of 10 percent of the earth's radius, will be $1/(4 \times 1.1^2) = 0.206$ of the intensity of radiation received directly from the sun.

A satellite in an equatorial orbit would probably average somewhat more than this proportion, and one in a polar orbit somewhat less. On the basis of this figure, a gray satellite, never in the earth's shadow, would reach a temperature 5 percent greater than that calculated on the basis of solar radiation alone, and one in the earth's shadow 20 percent of the time would reach the same temperature as that calculated for exposure to the sun's radiation alone 100 percent of the time.

WILLIAM D. ROSS
Wilmington, Delaware

William D. Ross's extension of my "short-cut" treatment of solar radiation to a discussion of satellite heating due to the earth seems to be a fruitful contribution. By treating the sum of the mean terrestrial radiation and reflection as constant (since the earth's mean temperature is constant), he has not only indicated the correct effect of heat radiated by the earth but has also furnished an independent check on my result for the added temperature due to its reflection of sunlight. Of the total of 15°C which he finds to be added by the earth, I had already included 4°C for reflection alone, corresponding to the 30 percent albedo assumed for the earth. The new estimate of temperature for a continuously sunlit satellite having equal absorptivity and emissivity would thus be 311°K.

However, for such low-temperature infrared radiation as the terrestrial, the absorptivity/emissivity ratio would be almost exactly unity for all types of satellite surfaces, and its flux would be practically independent of the fraction of time the satellite is sunlit. These characteristics of its effectiveness are thus fundamentally different from those of direct and reflected sunlight. The temperature 311°K is the highest mean to be expected for satellites at the particular 400-mile mean height assumed by Ross. For heights above this, the terrestrial contribution falls off rapidly, as his treatment makes clear.

Another possible variation which should be borne in mind is that a satellite temperature decrease of 20°C would result from assuming the 400° lower effective solar temperature 5760°K which is implied by direct measurements of the solar "constant." Also, it is quite certain that the 2-percent eccentricity of the earth's orbit would cause annual variations up to 1 percent, or 3° above and below the mean. An approximate general formula, incorporating all these considerations, would be:

$$T = T_s(D_s/4)^{1/2} \times [1 + (1 + 2\varepsilon/\alpha F)/48(1 + h/3960)^2] \times (\alpha F/\varepsilon)^{1/4}$$

In this, T_s and D_s are, respectively, the effective absolute temperature and radian diameter of the sun, α/ε is the absorptivity/emissivity ratio of the satellite, F its sunlit time fraction, and h the mean height of its orbit in miles.

RAYMOND H. WILSON, JR.
Project Vanguard, U.S. Naval Research Laboratory, Washington, D.C.

Absorption Spectra of Hill Reaction Oxidants

In considering the correlation of absorption spectra with oxidant potential and with antioxidant ability, as in the report of R. J. Marcus, J. L. Hatchett, and K. M. Sancier [*Science* **127**, 647 (1958)], it is of interest to note that F. J. Stubbs and C. N. Hinshelwood [*J. Chem. Soc. Suppl. Issue* **1**, 571 (1949)] showed that with arylamines the activation energy of acylation was partially contributed by the ring substituents. These contributions were additive. Stubbs and Hinshelwood also showed that other properties, such as basicity and absorption spectra, correlated similarly with these contributions.

It is reasonable to assume that, for the phenols and phenoxy radicals related to the quinones of the report of Marcus, Hatchett, and Sancier, the ring substituents control the energy of dissociation of the weakest hydrogen. Perhaps both the redox potential and the absorption spectra of these quinones and their reaction intermediates can then be considered as functions of this dissociation energy.

G. R. WARD
Los Angeles Soap Company, Los Angeles, California