Letters

Environment Planning: The Role of Engineers

It is a function of engineers to apply science to human problems involving human situations. The Report of the Environmental Pollution Panel of the President's Science Advisory Committee [see News and Comment, 19 Nov., p. 1006] impels me to call attention to the recent contributions made by the engineering profession to an attack on the environmental-pollution problem.

In 1962, a report of the Committee on Engineering Research Needs stressed the importance of considering the total physical environment in relation to human well-being.

In a report in 1964 on Urban Planning Definitions, a committee of the American Society of Civil Engineers stipulated as one of the principal groups of operations in urban planning the consideration of the effect on health of physical-environmental factors as a whole. It defined these factors as including both natural and man-made conditions affecting physical and mental health, as well as safety. In this report and in an explanatory note by the chairman of the committee, a number of means of dealing with environmental conditions are indicated. In general, they comprise public education, special measures, physical improvements, and regulations. The very essence of environmental planning as part of urban planning is in evolving a balanced use of all these means to deal with the combined effects of various environmental conditions upon health.

It is understandable that, without a rational engineering planning system, and without enough competent engineers in environment planning, these means have not been effectively utilized. The way is now open to correcting these deficiencies. The recently established National Academy of Engineering is closely related to the National Academy of Sciences. Both are serviced by the National Research Council. This arrangement encourages collaboration between scientists and engineers while recognizing the differences in their functions. It is hoped that it will enable the nation and its leadership to see more clearly the role of engineers in bringing about practical, scientific solutions to our environmental problems.

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Attribution of Error

Ti Li Loo (Letters, 15 Oct., p. 292) writes that a statement I made in my article "Cell division and cancer" (2 July, p. 34) is "unfortunately erroneous." My statement referred to findings of Freedlander and French [*Cancer Res.* **18**, 1286 (1958)]. On rechecking I find that I quoted them correctly. What Ti Li Loo probably meant is that his findings differed from those of Freedlander and French.

I think that open letters should be worded carefully so as not to cast unwarranted doubt on the reliability of other researchers.

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Frequency Scale for Spectra

Wald's plea (Letters, 3 Dec., p. 1239) for plotting spectra as a function of frequency rather than wavelength deserves support on pragmatic grounds, and because when radiation traverses media of different kinds it is indeed frequency rather than wavelength which is invariant and may therefore properly be considered the more fundamental quantity. However, it must be remembered that in the optical region wavelength is as yet the only measurable quantity and that frequency must be computed. This is not "a curious historical mischance" but an experimental reality.

Wald speaks of ways of plotting spectra as being "rational" or "irrational." There seems also to be a need to distinguish between a "normal" spectrum and a "rational" one. The diffraction grating provides a rational but not a normal spectrum; the latter must be computed. The problem of what constitutes a "true" representation of a spectral distribution is a very old one—Rayleigh treated it in 1883 (*Nature* **27**, 559)—and to say that "things that are the same look the same on a frequency scale" seems to me to involve prejudgment. For instance, is the ultraviolet region more or less extensive than the infrared region?

In arguing the merits of the "Fresnel unit" for a frequency scale, Wald says that "a wavelength scale from 400 to 750 mμ becomes a scale of 750 to 400 Fresnel units." This is a bit misleading, for it would seem to imply that 575 mμ equals 575 Fresnel units, which is not the case. The Fresnel unit, by the way, is the same as the terahertz, established in 1960 as a part of the *Système International d'Unités.*

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. . . With the main burden of Wald's argument I agree, but I think that expressing frequency in Fresnel units would represent an unnecessary departure from conventional terminology. The established unit of frequency is the cycle-per-second; the alternative name "hertz" was adopted for this unit by the General Conference on Weights and Measures, which also adopted a set of metric prefixes that includes "tera-" to indicate multiplication by 10^{12}. Accordingly, "teracycle per second" and "terahertz" are already well established in the literature (on lasers, for example), and there is no need for a third name for the same unit.

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. . . In addition to the advantages Wald outlines, the use of frequencies rather than wavelengths provides yet another important advantage. Because frequencies are directly proportional to energies, significant relations between fundamental, overtone, and combination vibrational bands are immediately apparent from spectra linear in frequency units but are obscured by wavelength presentation.

Wald's letter makes the valid point that this reform will best be brought about when editors of journals require or strongly recommend the reporting of spectral data in frequency units. In certain fields of science, such a policy could be instituted now without any major difficulty, for the changeover to frequency units is already in progress. A rapid survey of recent literature provides some indications of the extent to which this change has taken place in chemistry. Issues of the American Chemical Society journal *Inorganic Chemistry* for February and December 1965 (chosen arbitrarily) contain 24 articles in which vibrational spectra or data appear; in all but one the data are presented and tabulated in frequency units (cm^{-1}). In the same issues 19 articles contain electronic spectral information; the data appear in frequency units in 12 and in wavelength units in 7. In the recent literature of organic chemistry usage in articles presenting infrared data appears to be about evenly divided between frequency units and wavelengths. In both fields, the use of frequency units has increased markedly during the last five years. However, nearly all data on visible and ultraviolet spectra in organic chemistry journals are still published in wavelength units. That the change to frequency units for electronic spectra is lagging behind that for vibrational spectra reflects the fact that frequency-recording infrared spectrometers are now routinely available, whereas most ultraviolet-visible spectrometers can be obtained only with wavelength recording.

In chemical articles reporting vibrational data in frequency units, wave numbers (cm^{-1}) are universally used, and the same frequency units are also most commonly employed for electronic spectra. Because the change to wave numbers is already well under way for vibrational spectra, and because it would be desirable to have compatible units in all the main spectral regions, wave-number units (possibly in mm^{-1}) seem preferable to Fresnel units for the visible and ultraviolet regions also.

Wald recommends an ascending scale of frequencies from left to right. Nearly all of the tens of thousands of infrared spectra already in the literature appear with frequency decreasing from left to right, and the same direction is usual for electronic spectra when frequency units are employed. It would probably be wise not to try to alter the present convention. An arbitrary change would certainly lead to much confusion and might seriously impede the change to frequency units which is now taking place.

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. . . In the study of optical properties of insulating solids, the practice of plotting spectra on a frequency scale has been widespread for a number of years. It dates back at least to the early 1930's and the work of Pohl's group on the alkali halides. The frequency unit most often used is the energy unit, electron volt. The numbers are convenient; an *F* center absorbs at 2 to 3 eV, a pure alkali halide at about 5 eV or more. Furthermore, since the fundamental theoretical quantity is the energy (as Wald points out), no further conversion, however trivial, is necessary.

The advantages of using energy (or frequency) rather than wavelength are all that Wald claims. And to the experimentalist who is interested in having his work noticed, there is another point: given two papers containing the same data, in the first case plotted linearly as a function of energy, in the second plotted linearly as a function of wavelength, theorists will study, try to interpret, and refer to the first much sooner than they will the second.

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. . . In developing and using spectrophotometers over a period of 25 years, I have found that the ultimate problem is one of accommodating the many different spectral ranges and different magnifications of range that a modern spectrophotometer affords. The ideal answer is a logarithm-of-frequency scale (which, happily, is the same, except for right-left inversion, as a logarithm-of-wavelength scale). Using such a scale an investigator can deal equally well with the range from 2000 to 4000 Å, 3000 to 6000 Å, 4000 to 8000 Å, 8000 to 16,000 Å, and so on. The point is that on a logarithmic scale each of these ranges covers the same width of graph paper and indeed can be drawn on the identical grid (identical format). Or, if desired, a five or ten times greater magnification of abscissa can be employed, in any subportion of the spectrum, again with the same format of graph paper. In acoustics, electronics, chemistry, and other fields, logarithmic scales have proved to be invaluable—the decibel scale, for example, or *p*H. Some years ago I presented many unanswerable arguments for using a logarithmic scale [*J. Opt. Soc. Am.* **32**, 229 (1942)]. With the equipment described in that paper, many millions of spectral curves have been plotted —with logarithm-of-frequency used as abscissa—and have had a variety of applications.

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Toward Innovation

In his editorial "Barriers to innovation" (15 Oct., p. 295), Wolfle points out that "In new and undeveloped areas such as space exploration, only cost, ingenuity, and technological feasibility place limits on innovation. But innovation in civilian industry encounters a number of other barriers." There is no question that innovation is primarily controlled by political considerations—economic, social, managerial, fiscal, regulatory. Technological knowledge is an impotent force unless political consensus creates a climate conducive to its application. Such consensus requires fresh attitudes by those who control the resources for innovation—government, industry, labor, and the professions. The problem is how best to gain such new attitudes.

I suggest that we would do well to experiment with new institutional relations between these power groups in order to make them aware of the mutuality of enlightened self-interest in innovation. Such awareness can lead to progressive attitudes and to actions that are complementary instead of antagonistic. The School Construction Systems Development project in California (set up by Educational Facilities Laboratories, 477 Madison Avenue, New York 10022) is one example of a successful experiment where new institutional relations helped create an improved climate for innovation—in this case, in building technology. Plans are now being considered by other groups to conduct similar experiments in other parts of the country on other functional needs of society, for example, transportation and education. . . .

My recent experiences in government and in industry make me as hopeful as Wolfle that increasing attention is being paid to the nontechnical barriers to innovation. As yet, however, we are for the most part still talking singly. Let us experiment together.

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How the Spider Got into the Psalm

In 40 years of Old Testament study I have never come across a spider in the Psalms. Frank Allen (Letters, 29 Oct., p. 554) claims he sees one in Psalm 90:9—

> *Ki kal yomenu panu b'ebrascha,*
> *Kilinu shanenu k'mo hegeh,*

the second line of which he translates, "We spend our years like a spider," adding "—spinning our webs of life."

Beautiful poetic imagery, but not a translation of the Hebrew text.

Psalm 90 was written about 550 to 450 B.C. It was incorporated into the final edition of the Psalter circa 100 B.C. The whole of the Hebrew Bible (Law, Prophets, and Hagiographa) was canonized at Jamnia, Palestine, in 93 Christian Era. Then came the translations: Western Aramaic (Targum), Greek (Septuagint), Latin (Vulgate), Arabic (Saadya Gaon), German (Luther), and English (Coverdale, 1535; King James, 1611; Protestant American Standard Version, 1901; Jewish Publication Society, 1917; New American Catholic Edition, 1952; Protestant Revised Standard, 1952). Not one hints of a spider in Psalm 90.

In the University of Chicago's *An American Translation* (1931), J. M. Powis Smith renders Psalm 90:9—

> For all our years vanish in Thy wrath,
> We come to an end; our years are
> like a cobweb wiped away.

I find no more textual basis for Smith's cobweb than for Allen's spider. The literal translation, the English for every Hebrew word, is:

> For all our days we have faced Thy
> wrath,
> We end our years as in a sigh.

The Psalms are Hebrew poems. Biblical Hebrew poetry is characterized by parallelism; the words or clauses of the alpha half of a verse parallel those of the beta half. Thus *yomenu* ("our days")