letters

plete and correct definition of a planetary nebula, and ended up by saying that a planetary nebula is an object listed in a catalogue of planetary nebulae, but most definitions of them stress their morphology and origin. In any case, the Crab Nebula is not included in any modern catalogue of planetary nebulae, and so far as I know no serious astronomer or astrophysicist has considered it a planetary nebula since the work of Mayall, Baade and Oort in the years around 1940. Surely Steven Weinberg can't have written that caption for figure 1 of his article in the June issue (page 33).

DONALD E. OSTERBROCK Lick Observatory Santa Cruz, California

EDITOR'S COMMENT: Reader Osterbrock is certainly right when he says that Weinberg could not have written the erroneous caption. It was written by a member of the PHYSICS TODAY staff on the basis of information given in the Catalogue of Photographs and Slides of Hale Observatories, which supplied the photo.

Measuring loudness

Although Edgar Shaw has given an overview (January, page 46) of the problem of quantitatively evaluating noise pollution, this reader wishes to dispel any impression that the problem is solved by any of the completely empirical numerical measures discussed in the article. Even the fundamentals are debatable. For example, according to current orthodoxy, a 10-dB reduction in sound-pressure level corresponds to halving the loudness. This result was derived from subjective loudness judgment, or psychoacoustic, tests.1 However, the most recent, extensive (1320 subjects) and unbiased psychoacoustic tests indicate that a 6-dB (not 10) reduction corresponds to half loudness.2 This result receives strong support from mathematical analysis of neurophysiological data.3

Shaw has used A-weighted, sound-pressure level (dBA) as his basic subjective measure of noise. Of the available measures of loudness, this one is probably the best.⁴ Noisiness and other subjective quantities are too complex to be evaluated at present.⁵ In any event, for a subject in a given emotional state, loudness may serve as a satisfactory indicator of relative noisiness. Unfortunately dBA is not a very good measure of loudness. For example, the loudness level of a steady sound at constant dBA may vary up to 15 phons (decibels) depending on the bandwidth of the sound.

The broader the bandwidth, the louder the sound. This is certainly a significant effect. A new measure of loudness is called for.

Basic studies of human response to sound as related to noise pollution seem to have been dominated by psychologists. However, an understanding of the connection between sound and loudness requires knowledge of intermediate operations of the auditory system, that is, of human physiology, especially neurophysiology. Ultimately the data collected by psychologists and physiologists can best be correlated into mathematical theories of the sensations by physicists, since the system must obey physical principles. For this reason the still unsolved problem of quantitative evaluation of noise pollution offers a fertile field for the physicist.

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THE AUTHOR COMMENTS: To cover the entire field of noise pollution in a single article was no easy task. The point mainly at issue was touched on in the single clause "a 10-dB increase in sound level (more properly, loudness level) is perceived as a doubling of 'loudness' " (page 46 of my article). This, I am assured, correctly reflects a well-established scientific consensus in an area of psychophysics fraught with difficulty. The subject of loudness is of course, like all scientific questions, open to further enquiry. I am indebted to Howes for drawing attention to noise pollution as a fertile field for the physicist. It is a point I intended to make.

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The 20-micron window

In my review on "The Past and Future of American Astronomy" (December, page 23) I refer to the work of H. Rubens and E. Aschkinass, in the course of which I stated that "in essence they also found the 10- and 20-micron windows in the Earth's atmosphere." The phrase "in essence" is—at least for the 20-micron window—too strong. Ru-

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