letters

in an impoverished Indian school might actually organize. As for teaching style, the Indian staff of Hafner's Summer Institute gave prepared lectures and the student-teachers listened, in the good old stiff Indian way. That Institute, far from being a force for change, just reinforced the status quo. On the other hand, the Indian staff members of the Institutes I visited not only practiced, they even preached teaching by discussion and problem solving.

No doubt the quality of the Summer Institutes varies. One expects it is easier to find enlightened staff members in Bombay than in the interior. Furthermore, it's hard to say how much of the new attitude the student-teachers retain. What is important is that the Institutes process some 25 000 school teachers every summer. NSF and its Indian colleagues are now running a program that may have a detectable effect on the whole vast phenomenon of science teaching in India.

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Electrons and x rays

In the November 1969 issue of *physics today*, (page 25) André Guinier described some recent developments in x-ray small-angle scattering (SAS) techniques for the study of defects in metals. Subsequently, in June 1970, Gareth Thomas published a letter (page 19) in praise of the advantages of electron microscopy over x-ray methods. Having recently worked in both of these fields I should like to contribute some observations to this argument that are based on my own experience.

In the first place, I have studied the growth kinetics of Guinier-Preston (GP) zones in Al-Zn alloys[1] using x-ray SAS techniques. The equipment allowed the specimens to be kept at low temperatures during the experiment, so that undesirable aging was avoided. The growth kinetics could therefore be followed and some of the structural parameters of zones formed during aging could be quantitatively determined. More recently[2] the same process was followed from the early stages of zone formation at lower temperatures to compare the results with the predictions of a model previously proposed to explain the atomic mechanisms involved in the growth process. It is important to stress that although the x-ray SAS results are not accurate during the first stages of GP-zone formation, this method has nevertheless provided the most direct means of obtaining the radius versus aging-time law for the growth of GP zones. This was urgently needed for verification of the model. These measurements could not have been done by any electron-microscope technique.

Turning to electron microscopy, I recently had the opportunity, during a stay at the Cavendish Laboratory, to study neutron radiation damage in copper by means of transmission electron microscopy. To determine the nature of this damage ("black dots" in the electron micrograph) it was necessary first to obtain high-quality stereo micrographs and second to make careful depth measurements because, as predicted by the dynamical theory of diffraction, the contrast for a given kind of defect varies periodically with depth in the foil. The measurements of contrast versus depth showed that the majority of defects were interstitial dislocation loops about 100 Å in diameter. Smaller clusters, less than 60 Å in diameter, were identified by the same technique as vacancy loops.[3] These results most certainly could not have been obtained by any techniques other than electron microscopy. In fact a recent x-ray SAS experiment[4] failed to detect in neutron-irradiated nickel small vacancy-type defects that could be seen as tetrahedra in transmission electron micrographs.

These experimental methods both have their specific fields of application and their own different qualities, and there surely can not be a place in the scientific literature for discussions about whose pet technique is the "better."

References

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2. M. Ipohorski, A. F. Bonfiglioli, Acta Met. 18, 281 (1970).
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4. A. Bourret, A. M. Levelut, Phys. Stat. Sol. 37, K101 (1970).

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Corrections

January 1971, page 68—Title of the book reviewed at the bottom of the page should read: "Introduction to University Physics, 2nd edition." The author's name is Morgan, not Magan.

Page 97, center column, line 25—The word "no" is extraneous; sentence should read: "The average duration of observation for the UNKNOWNS was longer than for the KNOWNS..."

February 1971, page 56, right-hand column—Number of pages in the third edition of the *McGraw-Hill Encyclopedia of Science and Technology* is 11 000, not 1100. □