## *The Properties of Liquid Metals*

An international conference on the properties of liquid metals was held at Brookhaven National Laboratory, 19–23 September, 1966. The meeting was sponsored by the US Atomic Energy Commission with the blessing of the International Union of Pure and Applied Physics. About 175 people from seven countries attended and heard about sixty papers. As these statistics suggest, and as anyone who attended can confirm, the conference could be characterized by education, enthusiasm, exhaustion and entertaining exhibitions of English erudition.

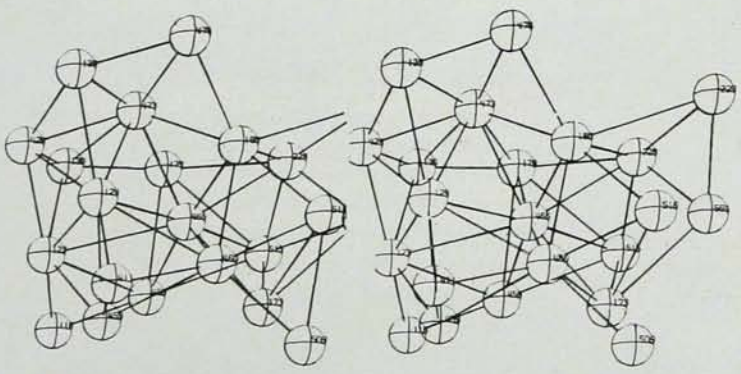
In a way the most timely aspect of the conference was the critical, quantitative evaluation of the Ziman pseudopotential approach to liquid metals. About five years have elapsed since J. M. Ziman published his paper entitled "Theory of the Electrical Properties of Liquid Metals." In this paper the foundation was laid for our qualitative and quantitative understanding of the electrical properties of liquid metals. A key feature of this approach is that most of the important properties can be expressed in terms of the product of a pseudopotential and a structure factor. In the intervening years, a great deal of work has been done to get accurate structure data and valid pseudopotentials. Without going into the details of any of the papers, I shall briefly try to highlight the answers given to some important questions about the properties of liquid metals.

In a review of neutron inelastic-scattering data, P. A. Egelstaff presented evidence indicating that some of the time-dependent properties are similar in both the liquid and solid state. However, the time-dependent molecular-dynamic calculations of liquid properties surveyed by A. Paskin give little evidence of solid-like behavior. Some light on this dilemma is presumably contained in the three-dimensional motion picture of atomic motion in liquid sodium produced by A. M. Noll, Paskin and A. Rahman. Unfortunately the projector used in the demonstration was found (afterwards) to have been at fault. This coupled with the inability of some to see stereoscopic photographs in three-dimensional perspective leaves still unresolved the question of solid-like versus the Bernal random arrangement of hard spheres as the key structural mechanism in liquid metals.

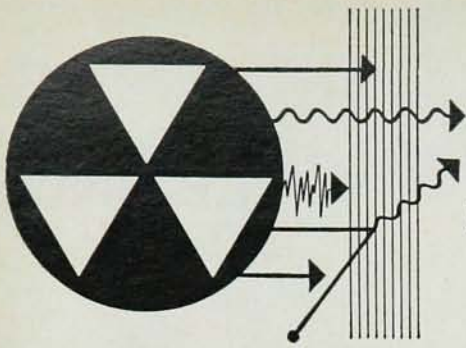
In the use of structure in transport theory, fittingly reviewed by Ziman, it would seem that either the data or recent calculations of N. W. Ashcroft and J. Lekner using the hard-sphere approximation and the Percus-Yevick theory are adequate. The uncertainty in quantitative comparison at present seems to rest mainly with an uncertainty of as much as a factor of four arising from differences between various pseudopotential calculations. This was a fact that emerged mainly as a byproduct of the many discussions in the corridors outside the lecture hall. Another question was raised at the meeting: Is the Born approximation used in the Ziman formulation sufficient for accurate quantitative comparison? The question was not answered at the meeting, although it did raise the temperature of some of the attendees to near their boiling point.

Some stimulating issues, reviewed by J. E. Enderby, were introduced by metal theorists who tried to relate directly the structure and the pair potential derived from pseudopotential considerations. The "aficionados" of statistical mechanics could not understand why the approach of the physics-of-metals practitioners should work, while the latter used arguments based on the success of the theory in understanding the vibrational modes and compressibility of solids as justification of its extension to liquids.

In addition to the controversial elements there were a number of interesting survey papers that indicated how much progress we have made recently in liquid metals. In particular, the T. E. Faber summary of our understanding liquid metal alloys might be pointed out as an especial area of success for the pseudopotential approach. The Faber-Ziman theory of electrical resistivity of alloys has been qualitatively substantiated in a number of ways. There were many other properties of liquid metals discussed in the lengthy and extensive program. N. H. Nachtrieb's discussion of self-diffusion in liquid metals yielded a



**STEREOSCOPIC REPRESENTATION of a local configuration of atoms in liquid sodium. To see the structure in the vicinity of atom 465, place a sheet of paper perpendicular to the photograph in such a way that your right eye can only see the right picture and your left eye the left picture—with your eyes approximately 12 in. from photograph. Three-dimensional representation should be visible. Note that the local arrangement in the liquid is not body centered cubic in the liquid as in the solid.**



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simplified approach to self-diffusion that would seem to be a useful tool for the nonspecialist. S. F. Edwards masterfully and entertainingly reviewed the problems of electronic states in liquid metals. M. H. Cohen introduced the exciting question of the possibility of the conduction electrons in some alkali metals having "liquid-like characteristics" that strongly effect their ability to alloy.

Last but not least, J. S. L. Leach raised the question: "What do we know of the thermodynamic properties of liquid metals and what do we want to know?" It is to be hoped that the answer to this and other questions raised at the conference might receive more attention in a subsequent report on the *sequel* to this conference. It was proposed that a next meeting be held in three years. Ziman amended this by suggesting that the next meeting be held *not sooner* than three years hence. This suggestion was heartily supported by the attendees weary from five days "education, enthusiasm, exhaustion . . ." and etc.

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## *Cairo Solid State*

In the Middle East the three important American educational endeavors at the college level are Robert College in Istanbul, the American University in Beirut, and the American University in Cairo. The Cairo institution was not founded until 1919, and so is probably not as well known as the other two, both of which are about a hundred years old. However, it has developed greatly in recent years. When I was in Cairo in 1957, it had no graduate or research program in physics. Under the able leadership of Adli Bishay, chairman of its department of physical science, all this is changed. The graduate enrollment in solid-state science has grown from 5 in 1962 to 50 in 1966. The construction of the new six-story science building, with fifty-thousand square feet of floor space, can be regarded as symbolic of this expansion. It is situated on the edge of Liberation Square, and its architecture somehow manages to harmonize both with the older Moslem buildings and newer edifices such as the Nile Hilton, which are located around this square.

The resources of the American University in Cairo are not sufficient to carry graduate instruction in all aspects of physical science, and so the graduate program, in contrast to the more diversified undergraduate curricula, is wisely focused almost entirely on the solid state. (The other areas in which there are graduate programs are English, economic-political science, sociology-anthropology, and Arabic studies.) Nuclear physics, for instance, is left to the Atomic Energy Establishment, the National Research Center and universiites of the United Arab Republic.

It is thus appropriate that the dedication of the new building should be accompanied by a conference on solid-state science, which was held 3-8 September, 1966. This conference was sponsored not alone by the American University, but "in cooperation with the Supreme Council for Scientific Research in the United Arab Republic." Particularly gratifying was the interest that leading figures in the educational scientific life of the UAR took in the conference, and the hospitality that they showed. The four speeches at the dedication ceremony that opened the conference included not only brief addresses by Thomas A. Bartlett, president and Adli Bishay, of the American University, but also ones by A. Riad Torkey, head of the Supreme Council for Scientific Research of the UAR and Hussein Said, minister of higher education, who conveyed personal greetings from President Nasser.

In connection with the dedication, Theodore Edison presented to the American University an incandescent lamp with a carbonized bamboo filament made by his father, Thomas Edison, in 1884, and also one of Edison's electromotographs, which were precursors of the chalk telephone. In accepting these gifts, Bishay said: "Their presence in Cairo . . . represents the very sort of intellectual and cultural exchange that is at the core of the objectives of this university. As an Egyptian, I take this gesture as a dec-