

The "LITTLE GENEVA" Conference



Shown at right is a session in progress at the International Conference on the Electronic Properties of Metals at Low Temperatures, which was held last year in Geneva, N. Y. The following account was written by R. W. Schmitt of the General Electric Research Laboratory in Schenectady and P. M. Marcus of the Carnegie Institute of Technology in Pittsburgh.

A report by Roland W. Schmitt and Paul M. Marcus

ALMOST simultaneously with the Second Atoms for Peace Conference in Geneva, Switzerland, a much smaller international group of physicists gathered in Geneva, New York, August 25 to 29, 1958. This group of about 125 scientists met to discuss the "Electronic Properties of Metals at Low Temperatures", a topic narrow enough to hold the number of participants to manageable size, but broad enough to evoke lively interest.

The conference was held in the congenial surroundings of a small liberal arts college (Hobart) and had the modest tempo that many summer conferences have been adopting—morning and evening sessions with the afternoon free for tennis, sightseeing, informal sessions, or naps. The number of formal contributors at each session was limited so that each presentation could be adequate, yet enough time was left so that anyone with something to say had the chance to say it.

The many recent advances in our understanding of metals and alloys have been of international origin. Efforts were made to get representatives from all of the countries with a significant amount of work in the field. These efforts were successful, except that none of the five Russians invited attended. Other countries, besides the US, represented by one or more scientists were Australia, Canada, England, France, Holland, Japan, Switzerland, and West Germany.

A departure from the usual roles of such conferences was to allow the presence of even very young children—the youngest turned out to be a few months old. One might think they would distract from the air of relaxed concentration on physics, but this turned out not to be true. Whether it was the spacious lawns of Hobart, available for dissipating energy, self-sacrificing mothers, or just exceptionally good children, the effect was to emphasize the pleasant informality of the conference.

The title of the conference is not completely descriptive of its content since there is hardly any property of metals not critically influenced by electrons. In general, emphasis was on electronic structure and transport properties, but such topics as lattice vibrations and magnetism entered to the extent they bore directly on the primary interests. The six principal topic areas and the people who organized the sessions devoted to them were (1) Electronic Structure (J. E. Goldman, Ford Scientific Laboratories), (2) Superconductivity (J. Bardeen, University of Illinois), (3) Transport Phenomena (D. K. C. MacDonald, National Research Council, Canada), (4) Electric and Magnetic Properties of Alloys (R. W. Schmitt, GE Research Laboratory), (5) Ultrasonic Attenuation in Metals (H. Brooks, Harvard University), (6) Resonance Measurements on Metals (A. F. Kip, University of California).

The conference originated from the initiative of M.

D. Fiske (GE Research Laboratory), who was chairman of the planning and steering committee which consisted of the session organizers, named above, and J. G. Daunt (Ohio State University), J. K. Hulm (Westinghouse Research Laboratory), C. Kittel (University of California), and R. T. Webber (Naval Research Laboratory). Generous support was received from several sponsors: the Office of Naval Research, National Science Foundation, Air Force Office of Scientific Research, International Union of Pure and Applied Physics, and the General Electric Research Laboratory.

The whole conference demonstrated once again the fact that an individual scientist recognizing the need for a conference in an active area of science can obtain the enthusiastic support of other scientists and supporting agencies, and a profitable, stimulating conference can be the result. The only disconcerting event of the week was a mild virus infection that invaded Hobart's otherwise friendly campus. This, however, was beyond reach of the best planning and must be regarded an occupational hazard for conferees.

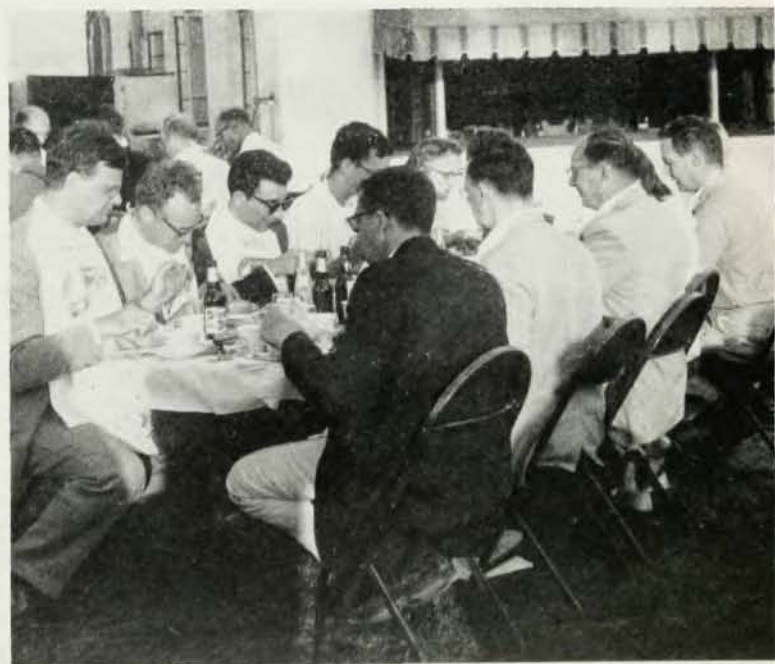
The 62 papers presented cannot possibly be mentioned in the present article. Paul M. Marcus has written a summary article of the conference, which will appear in the *Reviews of Modern Physics*. A conference report to the sponsors has also been prepared and a limited number of copies are available from the Conference Chairman (M. D. Fiske). In the present summary we can mention only the main themes that ran through the conference.

THE subject of electronic structure is fundamental to the whole field of metals and alloys. The primary questions in this area are two: (1) is a one-electron approach—leading to the band theory—adequate for treating most metallic properties? and (2) if so, how can the shape of the Fermi surface ("F. S." the energy surface in k space bounding the occupied electronic states) be determined? A key to the first question would be found in discovering that several independent ways of determining the F.S. all give the same result. This ideal had not been achieved, but some significant new progress was reported.

The techniques that were reported included high-frequency surface resistivity (in the anomalous skin effect region), the de Haas-van Alphen effect, cyclotron resonance, the magnetoacoustic effect, and magneto-resistance measurements. Each of these techniques had been successful on one or more metals, but there was no metal for which a Fermi surface determination had been achieved by several techniques. Most of the laboratories had their hands full with developing a particular technique and reported applications of it to whatever metal happened to be most suitable for that technique. The need was for several techniques to be successful on a single metal, preferably a simple monovalent one. Previously, only the high-frequency surface resistivity measurements had been able to yield a F.S. for such a simple metal (copper), but since the conference Shoenberg (Cambridge) has achieved notable success with



C. A. Swenson of Iowa State College, J. S. Dugdale of the Canadian National Research Council, Ottawa, and two small conferees.



Identified among clambake crowd: H. Brooks (Harvard University), P. H. E. Meijer (Catholic University), L. N. Cooper (Ohio State University), R. W. Morse (Brown University), A. B. Pippard (Cambridge University), J. Bardeen (University of Illinois), and A. F. Kip (University of California at Berkeley).

the de Haas-van Alphen effect in copper and Morse (Brown) has published magnetoacoustic data for copper single crystals.

Lacking an adequate fundamental theory of electronic structure, physicists have resorted to simplified models to cope with metallic behavior and the results of alloying. New work of this type was also presented. For example, much of the experimental information—Knight shift data, electronic specific heats, magnetic susceptibility—about the alkali metals and the noble metals and their dilute alloys can be correlated with simple models. New attempts were also being made to treat the magnetic properties of binary ferromagnetic alloys with simplified models. Work of this sort has always proven fruitful as a guide to new experimental work and a stimulus to further correlations of data.

The session on ultrasonic effects grew out of papers originally scheduled for the electronic structure session. Experimental and theoretical work on the magnetoacoustic effect (varying attenuation of sound waves in metals in the presence of a magnetic field) is burgeoning and the field is being rapidly developed. As mentioned earlier, the magnetoacoustic effect is probably a new way of getting information about the Fermi surface. Thus lively discussion marked this session, but not all conferees felt the phenomena were well understood yet.

The sessions on superconductivity were dominated by the Bardeen, Cooper, Schrieffer (BCS) theory. In 1957, at the Madison Low-Temperature Conference, the BCS theory was just beginning to be disseminated among low-temperature physicists, and much of the work reported there was still in the "classical" tradition of superconductivity. However, at Geneva, in 1958, a preponderance of work reported, both experimental and theoretical, was guided by the outstanding success of the BCS theory. Experimentalists are now concerned with secondary deviations from the BCS theory and theoreticians are concerned with relaxing some of the simplifying assumptions and with generalizing the theory.

A variety of topics was discussed in the sessions on transport phenomena. Two important processes that have not been adequately understood—electronic umklapp collisions and deviations from equilibrium of the phonon distribution—received new attention and the Bloch theory was reviewed with the aim of extracting those results that are independent of detailed assumptions. Theoretical and experimental work on electrical conductivity in very high magnetic fields was presented in addition to new experimental work on both the electrical and thermal conductivity of a variety of metals.

The session on electrical and magnetic properties of alloys was an outgrowth of interest in particular transport properties—the resistance and magnetoresistance of dilute alloys. The low-temperature resistance minimum and maximum had been known for a number of years, but only recently had the experimental situation begun to be clarified enough to know the theoretical problems involved. Magnetic behavior formed a part of the discussions because of the close relation between it and some of the resistance anomalies.

Resonance measurements, like ultrasonic measurements, received attention in a separate session because they are important new techniques for studying metals. Nuclear magnetic resonance and nuclear quadrupole resonance were shown to be useful and complementary techniques for studying metals in the solid and liquid states, and the usefulness of nuclear quadrupole resonance for superconductivity studies was shown. Most of the resonance session was devoted to cyclotron resonances at both microwave frequencies and infrared. The emphasis in these studies has been on semi-metals, such as Bi and Sb, where the extraction of useful information had proven a little simpler than in good metals.

This summary of the topics covered by the conference and of certain main themes developed during the week does not do justice to the many superb individual contributions. Thus anyone with more than a casual interest in the field should refer to Marcus' more complete report to be published in *Reviews of Modern Physics*.



Sober discussion of transport problems by R. Kubo (University of Tokyo), H. Kawamura (Osaka University), Y. Kanai (Nippon Telegraph & Telephone Public Co., Tokyo), and W. Sasaki (Electrical Engineering Laboratory, Nagoya University).

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