mic activity in the respective regions. Some new instruments for measuring these deformations were described and the need for an instrument to measure precisely long-term changes in water levels in off-shore areas was emphasized; many shocks occur near coastlines and important data could be collected in this manner.

In discussions on seismicity, Suyehiro and Asada made an interesting point based on data on microearthquakes. In the one case for which data are available, foreshocks could be identified by studying their frequency of occurrence as a function of magnitude. This factor could be an important point for earthquake prediction if borne out in subsequent studies. K. Mogi described his laboratory experiments on microfractures associated with rock failure in specimens with various degrees of heterogeneity and attempted to relate his results to data on microearthquakes. This work shows considerable promise.

The statistics of seismicity, harmonic analyses of the time series, relation between seismicity and gravity anomalies, seismicity and heat flow were all covered. Most of the data originated with researchers from Japan. A quantitative statistical prediction of earthquakes in Japan was presented in terms of the probability of an earthquake occurring in the near future. This probability increases regularly with time until a shock occurs.

A number of Japanese scientists discussed geomagnetic effects associated with earthquakes; some found promise for earthquake prediction in this work, which is on a subject rarely pursued in the United States. Benioff's negative results, based on limited and restricted observations from California, comprised the only United States report. There is a need for observations near the epicenter, and such data are difficult to obtain.

The relation between earthquakes and geological observations in various parts of Japan was reported in some detail. In some areas geologic data agree reasonably well with results on crustal movements deduced from earthquake activity; in others the relation, if any, is not clear. In Japan the major active faults strike perpendicular to the trend of Honshu Island and the motion is left-lateral. This is in contrast to the case in California where the major faults parallel the trend and motion is right-lateral.

Field trips during the conference included visits to the Tsukuba and Nokogiriyama seismic stations in the Tokyo area, the Matsushiro station near Nagano, and the Abuyama and Osakayama stations near Kyoto. Much of the Japanese instrumentation at these stations is, of course, directed toward the study of local earthquakes. There are many strainmeters and water tube tiltmeters, in addition to more conventional seismographs. All of the vaults for the stations listed, with the exception of Abuyama, are in tunnels or rooms cut into the hard rock of a hill or mountain. The American participants were, of course, well aware, prior to the meeting, of the Japanese proficiency in geophysics, particularly in the field of seismology. However, all left Japan with an even higher regard for the work of their colleagues in that country and with a feeling of gratitude for their most kind hospitality as hosts for this conference.

The Japanese delegation included C. Tsuboi, K. Wadati, T. Hagiwara, K. Tajime, Y. Kato, S. Miyamura, I. Ysubokawa, K. Iida, E. Nishimura, T. Hirono, and H. Kawasumi. The United States delegation consisted of H. Benioff, R. Hanson, L. Knopoff, J. Oliver, J. Steinhart, G. Sutton, and D. Tocher. In addition two other Americans, C. H. Dix and R. Oetjen, and about 40 Japanese participated in the program. Unfortunately, one delegate, E. Nishimura (Kyoto University), who had participated enthusiastically in the program planning, became seriously ill just prior to the conference and died the day before it ended.

The participation of the United States was supported by the National Science Foundation. This conference was one of the approximately ten annual bilateral scientific seminars convened under the U.S.–Japan Cooperative Science Program for which the National Science Foundation's Office of International Activities bears administrative responsibility in the United States. A complete summary of the conference will be published in Japan in about 6 months. Copies will be available on request from T. Hagiwara, Earthquake Research Institute, Tokyo University, Tokyo, Japan, and Jack Oliver, Lamont Geological Observatory, Palisades, New York 10964.

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Solid-State Physics

The first of what may become an annual series of conferences on solid-state physics was sponsored by the Institute of Physics and the Physical Society at Bristol, England, 1–4 January. Four hundred scientists from Great Britain and from nearly 20 other nations attended.

The papers represented most of the currently active areas in solid-state physics, including metals, semiconductors, defects, and magnetism. A. B. Pippard (Cambridge University) opened the conference with an invited paper in which he suggested that the recent preoccupation with structure by metals physicists is giving way to a concern with function. He noted that the intensive study during the past few years of the band structure and Fermi surfaces of metals was made possible by the discovery of new phenomena, such as the Azbel'-Kaner cyclotron resonance, and by the proper understanding and wide application of more venerable phenomena, such as magnetoresistance, but that such study is now being supplemented by an increasing interest in the phenomena themselves. He illustrated his point by discussing longitudinal magnetoresistance in metals, such as copper, with multiply connected Fermi surfaces. This effect does not give direct structural information about the Fermi surface but is an example of an effect for which the usual theory, based on the Boltzmann equation with the relaxation time assumption, is qualitatively incorrect. He showed how the observed behavior might be understood and how it might be used to study the details of the scattering process in metals.

These two aspects of current work in the physics of metals, which might be called Fermiography and phenomenology, were further exemplified in two papers. D. Shoenberg (Cambridge University) described a new technique for studying the de Haas-van Alphen effect and its application to the alkali metals. With this technique, fractional deviations from sphericity of the nearly spherical Fermi surfaces of these metals as small as 10^{-3} could be measured. The accuracy of the results permitted a very precise comparison with the theoretically computed Fermi surfaces; there was disagreement between surfaces computed experimentally and theoretically in respect to both the size and shape of the deviation from sphericity. In another paper A. F. Kip (University of California) discussed a new phenomenon observed in experiments on the Azbel'-Kaner cyclotron resonance in aluminum. Qualitative changes in the resonance were observed when the applied magnetic field was inclined with respect to the sample surface at angles as small as a few minutes. Kip explained how such changes might be caused by the existence of current sheets in the interior of the sample. Although the argument in this case depended on a special feature of the Fermi surface geometry of aluminum, it appears that similar effects observed in other metals may have similar origins and that these effects, once understood, may increase the utility of these experiments as sources of information on the Fermi surfaces of metals.

M. H. Cohen (University of Chicago) reviewed recent progress in the theoretical understanding of metals, and briefly discussed the use of pseudopotentials in the calculation of metallic parameters and the attempts to study many body effects in real metals by interpolating into the existing theory the Landau theory of Fermi liquids. He also discussed a general framework for theoretical calculations in metals. This framework is based on a decomposition of the desired property into parts of decreasing magnitude. The first depends only on electron density, the second on electron density and composition, and the third on electron density, composition, and structure. It can be shown that such decomposition is possible and is in accord with such simple general features of metals as the similarity of properties of different alloys that have similar average compositions and the insensitivity of properties, such as electrical resistivity, to changes in structure that occur in melting.

Experimental and theoretical aspects of transition metals were discussed in several very interesting papers on chromium. J. A. Marcus (Northwestern University) described measurements of the anisotropy of the magnetic susceptibility. His results indicate that chromium is not magnetically cubic if cooled through the antiferromagnetic Nèel temperature (312°K) in a magnetic field. Striking changes in the anisotropy also occurred at a spin flip temperature of 120°K, a transition temperature that had previously been detected only by neutron diffraction and in measurements of elastic constants. Further indications that chromium is not magnetically cubic in the ordered state were among the results of experiments on critical scattering of neutrons near the Nèel temperature (A. R. Mackintosh, A.E.K. Research Establishment, Denmark). B. R. Watts (Cambridge University) described measurements of the de Haas-van Alphen effect in chromium in pulsed magnetic fields above 100 kilooersteds on samples which had been cooled through the Nèel temperature in fields of about 80 kilooersteds. The pulsed measuring field did not eliminate the effects of the cooling field and the de Haas-van Alphen periods showed tetragonal rather than cubic symmetry, indicating significant changes in the Fermi surface geometry due to the magnetic ordering.

W. Marshall (United Kingdom Atomic Energy Research Establishment, Harwell) suggested that the Mössbauer effect has reached the end of its "gee-whiz" phase and is now taking a place as a routine tool of the solid-state physicist. After reviewing some past successful applications, he discussed some current and future applications which included the measurement of the temperature dependence of the magnetization in ferromagnets near the Curie temperature and the study of localized magnetic moments in alloys.

Dealing with some current problems with defects in solids, E. W. J. Mitchell (University of Reading) quickly reviewed the historical background of intrinsic defects in the alkali halides and then elaborated on the problem of the mechanism of the production of such defects by electron irradiation and the use of this means to produce them in controlled numbers. The structure of optical absorption spectra in zinc sulfide, cadmium sulfide, and diamond was also covered. C. D. Clark (University of Reading) effectively supplemented this discussion in his paper on the absorption bands of color centers in natural diamonds after electron irradiation and heating. It was shown that these bands, which are analogous to those of Mössbauer γ-ray spectra in solids, are closely associated with the four phonon frequencies that correspond to the maximum density of lattice modes for the various vibrational branches.

Interest was focused on another current problem of defect physics—the mechanism of self diffusion in body-centered cubic metals. J. N. Mundy (United Kingdom Atomic Energy Research Establishment, Harwell) presented data on the relative diffusion rates of the radioisotopes Na^{22} and Na^{24} in sodium. In principle the mechanism of diffusion could be determined by such measurements, but unfortunately the nature of the results makes it impossible to distinguish between a relaxed vacancy and a two-atom interstitial as the dominant mechanism of diffusion in sodium.

One of the most interesting papers on research in semiconductors was presented by K. F. Hulme (Royal Aircraft Establishment, Malvern) who discussed the changes in tunnel current in germanium tunnel diodes at 300°C. From observations of changes in current due to arsenic impurities that move a few angstroms by diffusion and drift at the *p-n* junction, the diffusion characteristics of arsenic in germanium were calculated. The results were consistent with data obtained by other techniques and extrapolated for high temperatures.

In another area of semiconductor study, D. L. Greenaway (R.C.A., Zurich) showed the effectiveness of optical reflectivity studies in the evaluation of the band structure of semiconductors and semimetals. Measurements on materials with rocksalt structure (PbS, PbSe, and PbTe) and the semimetals (As, Sb, and Bi) reveal a consistent picture of deep-lying band structure when they are correlated with other experimental and theoretical results.

One of the few papers with an immediate practical application was given by M. J. Aitkin (Oxford University) who described the usefulness of thermoluminescent studies for dating ancient ceramics. Measurements on many pottery fragments, varying in date from 5500 B.C. to A.D. 1500, show that the glow emitted when a pulverized sample is heated in the temperature range of 350° to 500°C is proportional to the age of the sample if the glow curve is taken in an atmosphere of nitrogen and the sample is not exposed to light after grinding.

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University of Pennsylvania, Philadelphia

R. F. Peart
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Forthcoming Events

June

15–19. **Molecular Spectroscopy,** symp., Columbus, Ohio. (H. H. Nielsen, Dept. of Physics, Ohio State Univ., 174 W. 18 Ave., Columbus 43210)