thermore, he showed how ammonia metabolism, and with it the metabolism of glutamic acid and glutamine, is closely linked to the operation and rate of the citric acid cycle and of CO_2 fixation in the central nervous system. The role of CO_2 fixation as a possible link between function and metabolism of the nervous system was pointed out.

Among the institutes and laboratories both in Moscow and Leningrad visited by the participants during the week and the days following the conference was the Sechenov Institute of Physiology. The present director, P. K. Anokhin, holds the position which corresponds to the chair of physiology at the University held by Sechenov. Anokhin acquainted the participants with many of the original apparatus, manuscripts, and memorabilia of Sechenov's scientific life.

Much contact was established with the younger generation of Soviet scientists in the medical sciences and throughout all the discussions a strong desire for closer collaboration on the international and interdisciplinary level was apparent. The great general interest in brain sciences may be seen in the fact that on Friday, 28 November, Asratyan and Anokhin (U.S.S.R.), Dell (France), and Waelsch (U.S.) were invited to discuss international and interdisciplinary research in brain sciences on Soviet television.

The conference was sponsored jointly by the U.S.S.R. Academy of Science and the International Brain Research Organization.

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Reference

1. H. Waelsch, *Nature* **198**, 344 (1963).

Magnetism

The fundamental and applied aspects of magnetism were discussed at the 9th Annual Conference on Magnetism and Magnetic Materials, Atlantic City, N.J., 12–15 November 1963. Approximately 20 percent of the 167 papers were delivered by representatives from foreign countries.

Most of our present knowledge of how magnetic substances behave is based on a model involving interactions between pairs of local magnetic moments attached to some fraction of the constituent atoms. This model, with which the names of W. Heisenberg, P. A. M. Dirac, and J. H. Van Vleck are associated, is literally applicable only to magnetic compounds, and to rare earth metals, and it is, at best, only the basis for a phenomenology of the "classic" ferromagnets, iron, nickel, and cobalt. Because of their nonintegral spins and large electronic-specific heat, and because of other evidence, notably high field galvanomagnetic measurements on nickel reported by W. A. Reed (Bell Telephone Laboratories), the itinerant-electron concept is expected to be applicable to these metals. Making use of existing calculations of the band structure of nickel in its nonferromagnetic state, H. Ehrenreich (Harvard) and H. R. Philipp (General Electric) constructed a model of the band structure of ferromagnetic nickel which is consistent with the available data.

For the metals of the first transition series, the band theory has yielded the same phenomenology as the Heisenberg-Dirac-Van Vleck model. T. Izuyama (M.I.T.) and R. Kubo (University of Chicago) showed that an itinerant-electron model can account for the existence of spin waves as well as the existing neutron-diffraction data in the neighborhood of the Curie temperature if the electron-correlation effect is taken into account. D. C. Mattis (I.B.M.) also found spin waves in a band picture with the dominant interaction among *d*-band electrons or holes, taken to be the Hund's rule mechanism of intra-atomic exchange.

The long-range indirect exchange by means of conduction electrons is generally invoked in discussions of the behavior of rare metals. F. Holtzberg *et al.* (I.B.M.) discussed the striking properties of rare-earth group compounds with the Th_3P_4 structure, relating the Curie temperature to electrical conductivity in the Gd_4Sb_3-Gd_4Bi_3 system in terms of this model. Similarly, the ferromagnetic conductor $Gd_{2.1}Se_{2.9}$ becomes semiconducting and paramagnetic when it is doped with $Eu_{0.5}$; it remains conducting and ferromagnetic when doped with $Y_{0.5}$. S. H. Liu (I.B.M.) found that the indirect exchange model leads to a term in the equation for electrical resistivity proportional to the deviation of the magnetization from its ground state value, but unfortunately, no appropriate experimental data are available. This model was also applied to the case of dilute magnetic impurities in a nonmagnetic conductor. M. W. Klein (Sperry Rand) was able to explain simultaneously the very different dependences of the excess low-temperature specific heat on small concentrations c of iron, cobalt, and manganese in copper. In terms of the indirect exchange model, the different effective spins on these ions in copper, and the limited experimental temperature range, he showed that the result is proportional to c^0, c, and c^2 for manganese, iron, and cobalt, respectively.

In compounds, we have recently seen the development of materials having, from the theoretical point of view, very nearly ideal Heisenberg-Dirac-Van Vleck properties. Joining the very simple antiferromagnet $RbMnF_3$ are the europium chalcogenides on which T. R. McGuire and M. W. Shafer (I.B.M.) reported. For the cubic ferromagnet EuS, S. H. Charap (I.B.M.) used spin-wave theory to determine the exchange interactions between the nearest and next-to-nearest neighbor europium atoms from low-temperature magnetization and specific heat data. An independent test was provided by P. J. Wojtowicz (R.C.A.). He derived an expression for the magnetic specific heat of EuS above its Curie point and showed that the low-temperature constants obtained by Charap, when used in his expression, reproduce the measured high-temperature specific heat within experimental uncertainty. A. Narath (Sandia) discussed the antiferromagnet $CrCl_3$ as ferromagnetic sheets (two-dimensional ferromagnets) antiferromagnetically ordered. He successfully analyzed the sublattice magnetization measured by nuclear magnetic resonance of Cr^{53} nuclei in terms of the spin-wave theory and determined the exchange constants.

The study of the interaction of the magnetic lattice with its surroundings is interesting in its own right and valuable as a tool for studying the nature of magnetism itself. Because of their simple crystalline and spin structure, garnets doped with rare earths provide an excellent opportunity for both the theoretician and experimentalist to study the loss mechanisms in conducting ferromagnetic materials. The losses are experimentally investigated by measuring the ferromagnetic resonance line width. J. H. Van Vleck (Harvard) reviewed the state of the theoretical interpretation of the resonance data on the basis of both a longitudinal (slow) and a transverse (fast) relaxation process. F. Hartmann-Boutron (University of Paris) extended and generalized the theoretical calculations of both processes. P. E. Seiden (I.B.M.) presented experimental results showing that over most of the observable temperature range the loss mechanism is of the "slow" relaxation type. However, he pointed out that, for very low temperatures, the "slow" relaxation model is not complete.

The interest in memory applications and fundamental properties of thin magnegtic films is continuing to grow (33 papers were presented on the subject). J. I. Raffel (Lincoln Laboratory) discussed the problems of large-capacity magnetic film memories. He pointed out that the prime requirements of the magnetic element are capability of sharing common drive and sense circuity, small size and low power consumption, and ability to be batch-fabricated. He then described an approach to a 36-million bit, thin-film memory with an access time of less than 1 microsecond at a cost of about 3 mils per bit. Along the same lines, T. J. Matcovich, W. Flannery, W. Luciw, and A. A. Adomines (Univac) discussed a low-power, 64- by 24-bit film memory plane. Output signals of 50 microvolts were obtained with drive currents of less than 35 milliamperes.

Recently, magnetic film elements exhibiting biaxial anisotropy (possessing four stable states of remanent magnetization) have received attention because of their possible storage and logic applications in the computer industry. Three types of biaxial films were treated. H. Chang (I.B.M.) calculated the static and dynamic properties of a biaxial structure formed by magnetostatically coupling two uniaxial thin films. R. J. Prosen, Y. Gondo, and B. E. Gran (Honeywell Research Center) investigated the properties of biaxial films simulated by a collection of small rectangularly shaped isotropic films. W. D. Doyle (Franklin Institute) described a series of torque and rotational hysteresis measurements of single-crystal cobalt films possessing biaxial crystalline anisotropy.

The conference was jointly sponsored by the American Institute of Physics and the Institute of Electrical and Electronics Engineers. A complete record of the meeting is scheduled to appear in the spring as a supplement to the *Journal of Applied Physics.*

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