A few of the participants at the conference: from left to right, H. Pick (Stuttgart), H. Kawamura (Osaka), J. Rolfe (NRC of Canada), W. Hayes (Oxford), Y. Haven (Philips, Eindhoven), P. Yuster (Argonne), M. Ueta (Tohoku).

A. B. Lidiard (Reading), R. W. Pohl (Göttingen), A. B. Scott (Oregon State), and, lower left, Y. Nakai (Kyoto and Rochester).

E. E. Schneider (Newcastle-upon-Tyne) and P. J. Bray (Brown).

COLOR CENTERS in ALKALI HALIDES

By ***Robert J. Maurer***

AN International Symposium on Color Centers in Alkali Halides was held at Oregon State College, Corvallis, Oregon, on September 8–11, 1959. Allen B. Scott of the Oregon State College Chemistry Department assumed the major responsibility for the organization of the symposium, which was sponsored by Oregon State College, the Office of Naval Research, the Air Force Office of Scientific Research, and the National Science Foundation. This meeting was one of a series held at Oregon State College in commemoration of the Oregon Centennial, and the welcoming address by President A. L. Strand of the College, in which he reviewed the State's history, was a model of interest and brevity.

Sixty papers were presented to the 125 physicists and chemists from Canada, England, Germany, Israel, Italy, Japan, The Netherlands, and the United States who participated in the symposium. Czechoslovakia was represented by a paper read for A. Bohun of Prague who was unable to be present. Three Russian physicists were expected, but unable to attend. The symposium was en-

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livened by the vigorous participation of Robert W. Pohl of Göttingen whose pioneering work on color centers created this flourishing area of solid-state research.

The breadth of color-center research is far greater than the name implies. The narrowest definition that one would wish to propose is the study of trapped electrons and holes in ionic crystals. All electronic phenomena in ionic crystals are obviously relevant to such a field of research. Since lattice imperfections frequently act as hole or electron traps, the investigation of typical defects, such as vacancies, interstitial ions, dislocations, and impurities, is of critical importance for the solution of color-center problems. As the prototypes of ionic crystals, the alkali halides are the favored subjects of color-center research, but the silver halides, the alkaline earth halides, and quartz contributed important topics to the symposium. It is the complexity of color-center phenomena, not lack of interest, that has tended to confine investigations to the simplest ionic crystals, the alkali halides.

The proceedings of the symposium fully reflected the breadth of interest of the color-center investigators. Fumi of Pavia discussed the modern developments of the Born theory of ionic crystals. Lidiard of Reading reviewed the experimental and theoretical methods that permit a determination of the mechanism of ion mobility by virtue of lattice defects. Martienssen of Göttingen presented new data on the fundamental electronic absorption of ionic crystals with emphasis upon the characteristics of exciton absorption lines. The theory of excitons was the subject of papers by Inui of Tokyo, Knox and Inchauspé of Illinois, and Stumpf of Stuttgart. Brown and Inchauspé presented recent data on the temperature dependence of the mobility of electrons in the alkali halides. This data is in good agreement with a theory of electron scattering by the optical modes of vibration of the lattice. Near helium temperature, the electronic mobility is greater than 10^4 cm^2/sec-volt so that semiconductor-type experiments become feasible.

The F center was the target of theoretical papers by Adrian, Gourary and Maradudin, and Simpson. Markham and Konitzer of Zenith made a detailed analysis of the experimental information concerning the shape of the F-center optical-absorption band. In an important paper by Lüty of Stuttgart, a series of weak ultraviolet optical absorption bands that are associated with the F center was described. These absorption bands are the cause of the well-known ultraviolet photoconductivity of additively colored crystals. Lüty also announced the discovery of a new color center which he believes to be an electron trapped at a vacancy pair. Pick of Stuttgart reviewed the current models of F centers and proposed an intriguingly simple set of alternatives.

The unique ability of spin resonance studies to unveil the structure of color centers has made this type of research of paramount importance. Känzig of GE described the analysis of a new and complex V center in lithium fluoride, and suggested that polymorphic centers, in which a unique hole wave function is not associated with a trapping site, may exist.

A closely linked group of papers by Bray, Lord, and Schneider examined the difficult and confusing picture of spin resonance in radiation-damaged lithium fluoride. The theory and measurement of the spin relaxation time of F centers in sodium chloride were the subject of a paper by Blumberg of Berkeley. Delbecq, Hayes, and Yuster of Argonne combined resonance and optical absorption data to explain the effect of silver upon the color-center behavior of potassium chloride.

Two papers on crystal purity by Anderson and Scott reviewed recent attempts to improve the quality of alkali-halide crystals. A major impediment to research with the alkali halides is the impurity content of available crystals. Chemical purification, recrystallization, zone refining, and distillation are techniques that have been successfully used to yield improved purity, but the standards of the best semiconductor materials will be difficult to achieve.

A relatively new and exciting topic, the trapping of electrons by dislocations, was the subject of papers by Kawamura and Okura of Osaka and Davidge and Pratt of Birmingham. Kawamura described an experiment in which the effect of dislocation trapping upon the temperature dependence of the F-center photoconductivity was observed. Although the role of dislocations in the generation of F centers by ionizing radiation has been the subject of theoretical speculation, there have been few experiments involving this lattice defect. Clean experiments are difficult to devise, but it is an inviting area which must be explored.

The kinetics of the formation and destruction of color centers by various means is, perhaps, the most complex subject in the entire field of color-center research. The numerous papers bearing upon this topic indicated that substantial progress is being made, but the subject still remains most puzzling. The role of imperfections and impurities in determining or modifying the observed reactions is not understood, and the symposium permitted a welcome exchange of ideas and speculations.

After the termination of the formal sessions, the symposium transferred itself from the campus of Oregon State College to Timberline Lodge on the slopes of Mount Hood. Here the symposium banquet was held with Professor Pohl as the guest of honor. Alexander Smakula of Massachusetts Institute of Technology, in introducing Professor Pohl, presented a vivid and humorous account of the graduate student's life in Göttingen during the 20's and 30's. Professor Pohl, who has celebrated his seventy-fifth birthday this year, described the genesis of color-center research at Göttingen. In so doing, he presented a vivid contrast between the simple instrumentation and meager facilities of the early research and the sophisticated techniques of present-day activity, while making it abundantly clear that honest industry and intellectual effort is still the price of discovery.