

by the colleges of advanced technology and with its implications for postgraduate study and research, education and industrial training generally, while Prof. Wiseman examined the part played by teacher training colleges as 'alternatives' to a university education. Both speakers insisted on the need to provide for some cross-over or transfer from college of technology or teacher training college to university and vice versa and on the importance of a broadly based education. Dr. P. F. R. (now Sir Percy Venables) referred to the necessity for all institutions of higher education to think in terms of university quality in determining their conditions, and in particular there should be adequate opportunities for higher study and research and professional contacts by way of travel, sabbatical leave and attendance at conferences. Prof. Wiseman's contention that the provision of teaching should be under the aegis of the universities was fully supported, but sandwich courses were not generally accepted as advantageous.

Sir Noel Hall thought that up to 1939 contacts between the university world and industry generally were much more limited in number and scope than those in other advanced countries and quite inadequate for the post-war demand, although in finance and public administration a pattern of relations had developed where practitioners welcomed discussion with university men and women on the problems of their own day-to-day responsibilities.

Much re-thinking was now taking place in industry, and probably among university appointments committees, on the placement of graduates in industry, leading to developments which were steadily improving contacts between universities and industry in this respect. He thought that research by qualified university people into the activities of industry itself was likely to continue to be difficult to organize and pursue, though he was not particularly concerned about the problem of secrecy. A greater difficulty was that of deciding the point in time at which important decisions had in fact been taken. This difficulty appeared to be diminishing and much activity was also being devoted to studying the tools of management.

Prof. Quarrell was concerned more with the conduct of research by universities on behalf of industry, discussing more particularly the research contract but emphasizing the value of formal opportunities for personal contacts between industrialists and members of a university through the university court, council and committees of council. In this discussion also the importance of a wider basic training for professional students was emphasized. However, the main stress was laid on the importance of personal contacts, including participation by industrialists in university government at the executive level. The desirability of avoiding the use of the term 'management' was recognized and of referring rather to 'business studies'.

THE BRITISH COAL UTILIZATION RESEARCH ASSOCIATION

THE annual report for 1962 of the British Coal Utilization Research Association* includes a summary of the year's activities and lists of publications and lectures by the staff, information circulars, and membership of advisory committees and of research staff. The total staff of 310 at the end of the year comprised 63 in scientist grades, 115 in research officer and research assistant grades, 46 in clerical and administrative grades and 86 in industrial grades.

The bulk of the report is occupied by an account of research activities from which the following points are selected. A two-year programme on coal-fired boilers fitted with automatically controlled combustion equipment and ash-handling and coal-handling gear indicated that from the point of view of cost of steam generated as well as technically this assembly of coal-fired equipment can be recommended for industrial use in many localities and circumstances. Eight commercially produced solid-fuel boilers with outputs from 33,000 to 60,000 B.Th.U./h have been tested using anthracite and coal under varying conditions to provide basic information for developing more efficient and automatic appliances with high amenity.

* The British Coal Utilization Research Association. Annual Report, 1962. Pp. 67. (Leatherhead: The British Coal Utilization Research Association, 1963.)

Work on deposits and corrosion in large water-tube boilers has already indicated that the composition and structure of deposits are independent of time, and has led to the devising of an infra-red spectrometric method for determining sulphur trioxide and to the investigation of laboratory methods for assessing quantitatively the effects of the nature of the ash and the composition of the flue gases on the corrosion of austenitic steels.

A systematic study of the slagging properties of British coals now nearing completion should assist in the choice of coals for slagging combustion, and basic studies of combustion and gasification have sought to provide basic information on the behaviour and decomposition of coals while being heated. The apparatus for studying pre-ignition and devolatilization of small particles of coal has been further developed, enabling the amount and rate of decomposition at known particle temperatures to be determined under effectively isothermal conditions. Among instrumental advances during the year were the further improvement of the venturi pneumatic pyrometer, the use of a nuclear magnetic resonance method, a microwave method for continuous measurement of moisture in coal, and the use of ciné-photography for studying the operation of the open-screw feeder and the quenching of slag discharged from a gasifier.

TRIBOPHYSICS RESEARCH IN AUSTRALIA

THE Division of Tribophysics of the Commonwealth Scientific and Industrial Research Organization of Australia is a major centre of research on the physics and chemistry of surfaces of solids and on metal physics. The annual report for 1961-62 records that work continued on the friction and lubrication of surfaces*. Molybdenum disulphide has been shown to be superior in lubricating

* Commonwealth of Australia. Commonwealth Scientific and Industrial Research Organization. Annual Report of the Division of Tribophysics for the year ending June 30, 1962. Pp. i+19. (Melbourne: Division of Tribophysics, C.S.I.R.O., 1962.)

ability to many other inorganic compounds of comparable structure, and the effect of atmospheric humidity and water absorbed on the lubricant on burnishing and friction has been examined. Friction is highest at 100 per cent humidity. The theoretical study of how models of the atomic configurations of flat surfaces could, in principle, be constructed has now been applied to a number of different crystal structures and a set of photographs of models of about twenty of the simplest surfaces in each of the face-centred-cubic, body-centred-cubic, sodium chlor-

ide, diamond and hexagonal closed-packed structures has been produced. The preparation of surfaces in high vacuum, the examination by electron microscopy of metal films evaporated on to glass, and the effects of bombarding gold with inert gas atoms have been studied. The oxygen adsorption on, and possible solution in, a clean silver surface at about 200° C, in the range 10^{-3} – 5×10^{-2} mm of mercury pressure was measured and the quantity related to the surface area of the silver determined by the adsorption of krypton at –195° C. The quantity of oxygen sorbed per unit area and the shape of the isotherm depended markedly on the surface to volume ratio of the evaporated film. The surface appeared to be covered with a monolayer at approximately 5×10^{-3} mm of mercury pressure and the amount of oxygen adsorbed at that pressure corresponded to one oxygen atom for every krypton atom absorbed.

For the preparation of metal specimens for X-ray and electron microscope measurements a spark erosion machine was developed and the amount and depth of the damage produced by the machine on nickel was studied. Other investigations included the effects of surface, temperature

and strain rate on the Bauschinger effect and cyclic work-hardening in copper single crystals; the measurement of the electrical resistivity of dislocations; the formation of point defects in plastically deformed metals and the dislocation rearrangements during recovery; and martensite transformations in steel. For the Divisions of Textile Physics and Protein Chemistry proton resonance studies of the kinetics of the absorption of water by wool and the exchange of deuterium for hydrogen in a particular wool-water system were made, and in conjunction with the Division of Applied Mineralogy the properties of inter-layer water in vermiculite crystals were investigated.

The annual report includes details of the publications by the members of staff of the Division and a list of the names of the senior members of staff. Dr. L. M. Clareborough, Dr. M. E. Hargreaves and Mr. M. H. Loretto received the David Syme Research Prize for their work on imperfections in metal crystals and Dr. A. K. Head was visiting professor at Brown University, Rhode Island. Prof. P. P. Ewald, president of the International Union of Crystallography, visited the Division in October 1961.

S. WEINFROUB

CLEAN SURFACES AND SURFACE PHENOMENA IN SEMICONDUCTORS

A RECENT issue of the *Annals of the New York Academy of Sciences* contains the series of papers presented at the conference entitled "Clean Surfaces" held by the Academy during April 5–7, 1962, and, as a supplement, the papers of the symposium on "Surface Phenomena in Semiconductors" held by the American Chemical Society during March 21–29, 1962*.

The conference was divided into four parts, the first of six papers dealing mainly with electron diffraction and the electronic properties of clean surfaces; the second of six papers with cleaved and etched surfaces; the third of three papers with adsorption; and the fourth of six papers with nucleation. E. W. Müller gave a survey of field emission microscopy of clean surfaces with electrons and positive ions. He stressed that the field ion microscope is a research tool for the investigation of clean surfaces, and of the defect structure in the interior of metal crystals exposed at the surface by field evaporation. More detailed information on adsorption can be expected by the operation of the microscope with gases of lower ionization energy, but this will require ultra-pure imaging gases, and the lower field strength will reduce the resolution of the microscope. L. H. Germer discussed the very recent applications of the diffraction of slow electrons to the investigation of surfaces and the new science of two-dimensional crystallography. Experiments described by H. E. Farnsworth of low-energy electron diffraction from a cleaved germanium surface have established that crystal faces other than that desired by cleavage were present, and that a cleaved surface had a larger area of undesired crystal facets than a surface prepared by cutting the crystal with a diamond wheel, ground, etched chemically, and cleaned *in vacuo* by argon ion bombardment and subsequent annealing.

The symposium on "Surface Phenomena in Semiconductors" was suggested and organized by H. van Olphen, the chairman of the division of colloid and surface chemistry of the American Chemical Society. The object was to stimulate discussion among surface chemists and research scientists in the semiconductor surface field. The symposium was tutorial in character and the fourteen papers presented comprise a series of review or tutorial papers each devoted to a particular area of specialization.

* *Annals of the New York Academy of Sciences*, 101, Article 3: Conference on Clean Surfaces, with Supplement: Surface Phenomena in Semiconductors (Symposium). By F. G. Allen et al. Pp. 583–1014. (New York: New York Academy of Sciences, 1963).

The introductory review by W. R. Savage (Texas Instruments Inc.) covers the general field of the properties of semiconductor surfaces. J. N. Zemel (United States Naval Ordnance Laboratory) describes several fundamental physical measurements used in semiconductor surface research and their connexion with some of the main streams of contemporary work. He mentions that the properties of surface states on only five materials (germanium, silicon, zinc oxide, lead sulphide and indium antimonide) have been studied to any extent. The investigation of a clean semiconductor surface is a difficult and challenging pursuit, because whereas a metal surface with a hundredth of a monolayer is considered acceptably clean for thermionic work, such a density of contamination on a semiconductor would produce, if diffused in 10^{-4} cm, a degenerate layer of width equal to the surface space charge region. It is not surprising, therefore, that he concludes that though there is a great deal known about the surfaces of semiconductors, there is little understanding. Field emission as a tool, and the grain boundary as a system, for the study of surfaces are discussed by F. G. Allen (Bell Telephone Laboratories Inc.) and P. Handler (University of Illinois) respectively. Lifetime and conductivity measurements on clean germanium surfaces are reviewed by Y. Margoninski (Raytheon Research Division) and the pulsed field effect method of investigation of surface states on semiconductors by G. Rupprecht (Tyco Laboratories Inc.).

Several papers deal with aspects of surface chemistry and electrochemistry. M. Green (University of Pennsylvania), in a paper entitled "The Configuration of Complexes on Semiconductor Surfaces", discusses a new approach to the problem of the equilibrium configuration of surface layers which should be useful in problems of chemisorption, film nucleation and related phenomena. The reaction between heated germanium and oxygen, and between water and methyl alcohol is reported on by M. J. Spurnay (Philips Research Laboratories), and H. C. Gatos and M. C. Lavine (Massachusetts Institute of Technology) discuss the process of formation of thermal etch figures on germanium single crystals when heated to temperatures of 700°–925° C in the presence of argon-oxygen mixtures.

An interesting and instructive paper of the series, though it did not produce any comment in the final panel discussion session of the symposium, was that of N. J.