and retained its full strength. Other exhibits showed the effectiveness of these compounds on timbers exposed to attack by *Teredo* and other marine organisms. Another type of organo–tin compound has exceptional ability to stabilize polyvinyl chloride plastics. Curiously, the same type of compound is used extensively in veterinary medicine as a worm cure and prophylactic for chickens and turkeys. The chemistry of organo–tin compounds is being rapidly extended by the Institute's research team.

Other departments shown included metallography, analytical chemistry, photographic studios, engineering workshop and a specialized library. Cinematograph films of processes devised in the laboratories were available for continuous showing to the visitors.

FULMER RESEARCH INSTITUTE

OPEN DAY

THE Fulmer Research Institute held an open day on July 2, to mark the tenth anniversary of the official opening by Sir Stafford Cripps on July 2, 1947. About 260 guests, representing industry, government departments and other research organizations, were present and were shown details of research work in progress.

The principal guest was Mr. R. Harmar Nicholls (Parliamentary Under-Secretary, Ministry of Works), who deputized for the Right Hon. Reginald Maudling. In a brief speech after lunch, Mr. Nicholls congratulated the Institute on its steady growth during the past ten years, and, in reflecting on the sources of the Institute's income, Mr. Nicholls was particularly gratified by the increasing number of dollar-earning research contracts, now constituting about one-third of the Institute's total income. He considered, however, that much greater use could be made by British industry of the facilities for research and development which are available at the Institute.

During the past ten years the Institute's effort has been principally devoted to some one hundred and fifteen major research programmes, and about thirty of these are in progress at the present time.

In the physical chemistry division of the Institute, headed by Dr. P. Gross, fundamental work on extraction processes relating to aluminium and titanium has continued. Pilot-plant work in industry on the catalytic distillation of aluminium has been in progress for some time and processes for titanium extraction which have been successfully demonstrated on the laboratory scale are now ready for extension to the next stage. A method of purification of silicon is now under experimental study and apparatus for the preparation of large single crystals of this element (by drawing from the melt) has been developed and is in use.

The work on extraction and purification processes is, of course, dependent upon accurate thermodynamic data, and specialized techniques have been used to study the equilibria of important industrial reactions and to establish activity data for various metallic systems. Accurate calorimetry has established the heats of formation of various compounds, in particular metallic halides, and new values for several of these important compounds have been published. Various reactions which might form the basis of new extractive methods have been studied in apparatus requiring highly efficient vacuum techniques. In the analytical laboratories, polarographic, absorptiometric, microchemical and spectrographic methods in addition to the more conventional techniques of analysis were demonstrated.

A study of the mechanism of precipitation hardening with particular reference to light alloys has always been a major item in the Institute's research programme. It was partly as a result of this work, much of which has been published, that Dr. H. K. Hardy, who has since joined the Atomic Energy Authority, gained the Beilby Award and Rosenhain Medal of the Institute of Metals. The X-ray techniques developed by the Institute's investigators for studying precipitation processes are well known internationally to specialists in the field. Trace elements have been shown to exercise a profound effect on ageing behaviour in some systems, and the influence of small quantities of cadmium, for example, on aluminium–copper alloys has resulted in the development of a series of alloys which, while free from room-temperature ageing after solution treatment, can be aged at elevated temperatures to yield properties approaching those of the duralumin type alloys. The effect of radiation on precipitation and ageing behaviour in aluminium alloys is now being studied, while in titanium and zirconium alloys attention is being paid to the crystallographic changes associated with the formation of the embrittling omega-phase. To assist this latter work and more particularly for studies on transformations in alloys of reactive metals, a special X-ray camera has been developed. It can operate with the specimen at temperatures up to 1,000° C. in a vacuum of 1×10^{-7} mm. of mercury.

Other X-ray studies have been concerned with the structure of liquid metals, and interesting results have been obtained with sodium and potassium (including binary alloys of these metals) and also gallium. The fundamental structure of glass is also being examined. Although in glasses the atoms are not arranged in a regular crystalline manner characteristic of metals, the arrangement is not completely random. On the slight degree of regularity which does obtain, an explanation of the variation of the properties of glass with heat treatment is sought. The problem is closely linked with that of liquid metals, and somewhat similar techniques of X-ray diffraction and refined interpretation are being applied.

A recent addition to the equipment of the physics section is the Metropolitan-Vickers electron microscope type *EM3A*. This instrument, which has a resolution of 20 A. under favourable conditions and which can also be readily adapted for electron diffraction, is being used principally to study the mechanism of oxidation of low-alloy steels and to supplement the X-ray and metallographic investigations on age-hardening phenomena. A detailed investigation of the slip characteristics of certain metals is also in progress.

New equipment on view in the physical metallurgy section included a Reichert metallurgical microscope, a precision dilatometer for use in isothermal transformation studies and a high-temperature (up to 2,000° C.) vacuum heat treatment furnace. The last two items, together with much of the other equipment in use, were constructed in the laboratory workshops.

While considerable attention is still being paid to aluminium alloys, developments in the atomic energy

field in particular have been reflected in the increased amount of work on the 'newer' metals, and uranium, titanium, zirconium, hafnium, niobium and vanadium all figure prominently in the current work of the Institute. A number of research programmes are concerned with the physical metallurgy of uranium and its alloys, and they include the determination of constitutional diagrams for certain binary alloys, the study of phase transformations, and determination of the crystal structure of uranium compounds. A metallographic study of the allotropic transformation in binary titanium zirconium alloys has recently been concluded.

In the work on materials for possible application at high temperatures, comprehensive investigations on binary and ternary chromium-based alloys have been followed more recently by an examination of the pure metal. Experimental and pilot-plant work on electrolytic processes has been concerned with identifying and controlling commonly occurring impurities and this has been coupled with an examination of the effects of these impurities on mechanical properties. Results of impact tests obtained on material which has been obtained by the lubricated extrusion of sheathed compacts have shown that this extrusion method has an effect of increasing the ductility and lowering the ductile/brittle transition temperature in chromium. A new retractable hearth argon-arc melting furnace for the production of chromium and chromium alloy ingots has recently been built.

Further attention has been paid to the low alloy oxidation-resistant steels. A recently published report (Fulmer Research Institute: Special Report No. 2. "Oxidation Resistant Silicon–Aluminium Steels") describes fully the properties of these low-carbon steels containing silicon and aluminium developed at the Institute, which in air at temperatures up to about 950° C. exhibit a degree of scaling resistance comparable with the well-known austenitic stainless steels. Other work in the field of ferrous metallurgy has included an examination of the causes of failure of high-speed steels with special attention to the susceptibility of this complex material to overheating. Some short-term programmes have been concerned with nodular cast iron.

Long-term corrosion and stress corrosion tests are in progress on the various aluminium alloys, and particular attention has been paid to the effect of directionality of metallurgical structure on the initiation and rate of corrosion attack. Fundamental aspects of stress corrosion cracking and layer corrosion are under investigation and more recently a research programme to determine the effect of various metal coatings on the fatigue and corrosion fatigue properties of high-strength aluminium alloys has begun. The development of corrosion-resistant aluminium-base structural alloys, the development of oxidation and shock-resistant coatings for high-temperature materials, the assessment of a new material for domestic hot-water boilers, and an examination of coatings for the protection of high-strength aluminium alloys are other subjects under active investigation. The high-temperature corrosion of zirconium, a matter of importance for the application of that metal in nuclear reactors, is also the subject of a major research programme.

The primary interests of the engineering and mechanical testing laboratories lie in the fields of creep and fatigue. Fundamental programmes are concerned, for example, with assessing the importance of rest periods and cumulative damage on fatigue life. A specially designed high-temperature fatigue machine has proved particularly useful in studying the effect of various heat-resisting coatings on the high-temperature fatigue properties of the basis metal. High temperature and corrosion fatigue studies are also being made using alternating tension and compression machines of the Haigh or 'slipping clutch' type.

Apart from the more usual tensile creep testing, small compression creep machines have proved particularly useful for the study of uranium and other highly reactive metals. A comprehensive investigation of the creep characteristics of certain binary alloy systems is also in progress to ascertain the effect on creep properties associated with changes in the solid state occurring at or near phase boundaries. Titanium alloys, aluminium alloys, magnesium alloys (for 'canning' uranium fuel elements), structural steels and cast iron are other materials on which creep-testing programmes have been carried out.

Facilities for mechanical testing have been adapted so that tests can be carried out at very low or high temperatures. Results have been obtained, for example, for sponsors interested in designing for low-temperature applications, such as the transport of liquid methane. The mechanical and thermal properties of various insulating materials have also been examined and another investigation has been concerned with the determination of the characteristics of oil filters by measurement of the pressure drop at various flow-rates of fluids of varying viscosities.

While much of the Institute's work remains confidential to the sponsors, more than one hundred papers and technical articles (in addition to a number of patents) have been published with the sponsors' permission. Reprints of most of these were available in the Institute's library, together with a large number of translations of foreign scientific papers, including many translated from the original Russian. A recently published booklet which was issued to visitors (and which is now available from the Institute) gives details of the organization and current activities of the laboratories.

COAL SCIENCE

THE Second International Conference on Coal Science was held during May 1–4 at Valkenburg, a holiday centre in Limburg, The Netherlands. In keeping with the atmosphere, meetings were held in a conference hall attached to one of the newer hotels, and members were entertained by the Burgomaster, F. A. A. H. Breekpot, at a reception in the Municipal Grotto. The purpose and background of the present biennial series of conferences have already been set out in *Nature* (176, 103; 1955).

The response to the requests for contributions showed that interest in the subject is still increasing. Ten countries were represented as compared with eight on the previous occasion, including the first from the Eastern bloc, namely, Poland, which sent four delegates headed by Prof. Roga, of Glowny Instytut Gornictwa, Katowice. Dr. M. Samec, director of the Kemični Inštitut "Borisa Kidriča", Ljubljana, attended as official delegate of the Slovene