unlike zirconium, there is little hope that further removal of metallic impurities or oxygen will result in greater ductility. Alloying and the use of oxygen scavenging elements has led nowhere. The cost of the metal has been borne primarily by the beryllium-copper industry; but it is anticipated that the nuclear power industry will now cheapen production. It is interesting to learn that long exposure of the metal in the materials testing reactor (Idaho) caused no significant changes in properties.

The first half of this volume is devoted to the ores of uranium and thorium and the production of the metals, and makes interesting reading to the non-specialist. We learn that the ion-exchange methods are revolutionizing uranium ore processing plants and yield high-grade concentrates directly from the leach liquors. Florida processes ore in the form of phosphate for artificial fertilizer manufacture, so that 100 gm. of uranium per ton results as a by-product. Yugoslavia shales treated for mercury yield 136 gm. of uranium per ton as a by-product. Rich zircon ores of Brazil contain up to 4 per cent uranium. Many of the Witwatersrand ores mined for gold contain uranium (but no quantitative figures are given), and as the cost is borne by gold it is likely that uranium will now be extracted from low-grade ores. The Canadian and South Australian rich ores are mined solely for uranium, and no figures are given for these. The U.S.S.R. tells us nothing.

Thorium content of Brazilian monazite averages 6 per cent and uranium 0.3 per cent; a very far-reaching paper (850) from the United States points out that due to the ionic radii of uranium and thorium these elements are localized in a small fraction of igneous rocks and that a high percentage can be leached from granite without digesting the rock as a whole. This opens up the possibility of extracting millions of tons of uranium; interesting, but will not thermo-nuclear reactions save us from dissolving up the world's granite?

T. E. ALLIBONE

METALLURGY OF ZIRCONIUM

The Metallurgy of Zirconium

Edited by Benjamin Lustman and Frank Kerze, Jr. (National Nuclear Energy Series. Division 7—Vol. 4.) Pp. xviii+776. (London: McGraw-Hill Publishing Company, Ltd., 1955.) 75s.

IN 1948 the production of zirconium in the United States was measured in hundreds of pounds; by 1953 it was measured in hundreds of tons. "The Metallurgy of Zirconium" is not only a reference book, but also gives some account of the extremely rapid scientific and technological development over this short period of time. It is an exhaustive treatise, and the editors are to be congratulated for assembling the efforts of more than fifty authors into a coherent whole.

The extraction methods, and in particular the Kroll and iodide large-scale processes, are dealt with in detail. A full chapter devoted to the latter process gives an excellent account of the development of an extraction method from virtually the laboratory scale to the full-scale production plant. This type of information is all too rare in technical literature.

Metals of interest in the field of nuclear energy are characterized by the stability of their oxides, carbides, nitrides, etc. Because of this, difficulties arise in the

development of fabrication techniques; neutral heating atmospheres are normally needed, and the choice of container materials for the molten metals is very limited. In the case of zirconium, the development of arc-melting techniques capable of producing 1,000-lb. ingots has circumvented the container problem and is described in detail. Additional small-scale methods for melting are also described—namely, auto-crucible, skull, drip and levitation melting—all of which must be of interest where very reactive metals are concerned. Potential users of zirconium would do well to pay attention to the section of Chapter 6 on the recovery of scrap, which points out the many difficulties associated with reclamation of machine scrap. Powder metallurgy techniques which have proved of great value in the fabrication of beryllium and thorium, and to a lesser extent uranium, appear to be of less use in the case of zirconium but are obviously well developed. Zirconium of high purity is very ductile at room temperatures, and an account is given of a wide range of cold-working operations. Despite the great affinity of zirconium for oxygen at elevated temperatures, hot-working operations can apparently be carried out without the use of protective furnace atmospheres. Pickling in acid is afterwards required to remove the contaminated surface layers.

The chapter on the physical metallurgy of zirconium and its alloys leaves little to be desired, the only physical constant which proved difficult to find being the X-ray density. Partial or complete equilibrium diagrams are given in the appropriate section for thirty-two binary alloy systems, and brief results are given for a further five systems. Engineering data are given at length in the chapter on mechanical properties, and the marked effect of minor amounts of contaminants upon these properties is emphasized. These contaminants have an equally marked effect upon the corrosion behaviour of zirconium, as detailed in Chapter 11. Most of this latter information is made available for the first time, having been previously placed in the category of 'Classified' material. This is also true of a good deal of the information in other chapters, as is stated in the introduction.

It is difficult to find fault with this book. The overall impression it leaves is one of admiration for the technological achievements described; perhaps this feeling is tinged with envy for the scientific resources of the United States, where an effort involving at least fifty senior scientists and technologists, complete with supporting staffs, could be mounted to investigate the metallurgy of just one metal.

J. WILLIAMS

INTRODUCING GEOLOGY

Geology and Ourselves

By F. H. Edmunds. Pp. 256+12 plates. (London: Hutchinson's Scientific and Technical Publications, 1955.) 21s. net.

MR. F. H. EDMUNDS in his long experience on the staff of the Geological Survey of Great Britain has met with a lively interest in his science and its economic applications. Accordingly, he has written this introduction for the layman to show the importance of geology in everyday life.

Almost half the book is devoted to a simple general survey of geology. A short account of the early