SOLIDIFICATION

Principles of Solidification

By Prof. Bruce Chalmers. (Wiley Series on the Science and Technology of Materials.) Pp. xiv + 319. (New York and London: John Wiley and Sons, Inc., 1964.) 98s.

SOLIDIFICATION is one of the most important phenomena in metallurgy and one about which relatively little is known. It is involved in the life history of the majority of metal components in use, and the way in which it has occurred influences their subsequent properties and behaviour. Crystal structure in the cast state, structural and compositional heterogeneity, the occurrence and distribution of gaseous and solid inclusions, all depend on the manner of solidification. Many of the problems which metal producers associate with solidification are manifestly more serious the larger the mass of metal concerned, and this has led to the conviction that observations on small 'laboratory ingots' have little bearing on what happens in production ingots weighing many tons. Much effort has been devoted in the past to sectioning full-scale ingots, determining composition in agreed 'standard' positions and subjecting the exposed surface to all the skill of the metallographer. Such examinations reveal, on the one hand, weaknesses that make forging and rolling difficult and, on the other, tendencies that might be exploited to increase the yield of usable metal. This approach has produced innumerable data and led to some improvement in production techniques, but it has lost much of its previous popularity and even its most earnest protagonist would not claim that it has thrown much light on the fundamental mechanisms involved in the solidification of large masses.

At the other extreme there is the basic work on solidification, defined as the discontinuous change of state from liquid to crystalline solid. In such work only small melts are normally involved and the alloys are often chosen to simplify the experimental procedures. The book now under review is concerned with this approach to solidification, and the author is specially well-fitted to write it, for he took a leading part in re-invigorating research work on solidification a few years ago, and he has since made many valuable contributions.

Prof. Chalmers has adopted a pattern he has used with success in other recent text-books. An introduction reminds the reader of the scientific concepts relevant to the subject and on which the following chapters are based. The problem of solidification is then broken down into its essential parts and a chapter devoted to each. Chapter headings are: "Solidification as an Atomic Process", "Nucleation", "Microscopic Heat-Flow Considerations", "Redistribution of Solute during Solidification", "Poly-phase Solidification", "Macroscopic Heat-Flow and Fluid Flow", "The Structure of Cast Metals" and "Crystallization from the Molten State", and there is an appendix on "The Production of Single Crystals from the Melt". Under these headings Prof. Chalmers has systematically and selectively reviewed recent experimental work on solidification, and in so doing has provided a clear exposition of the underlying principles. To those specially concerned with solidification on an industrial scale it may seem that he has tended to over-simplify; that he has concentrated on the principles and has not been much concerned with their application. He has, however, made suggestions that should help those who are concerned with the solidification of large masses of complex alloys. Thus, in discussing the structure of cast metals the author has explained why it is not possible to predict the structure and properties of a full-scale ingot or casting from the results of small-scale experiments; why it is not possible to scale down a casting operation so that the result will give geometrical similarity with that of the full-scale

process. His arguments will encourage those who believe that much useful information may still be obtained from sophisticated experiments with full-scale wax models, and should stimulate anew those who have always maintained that solidification must be investigated full size.

The author has also come closer to practice in his discussion of continuous casting, to which he devotes some nine pages. This treatment may serve to inform or remind the more academically minded that such processes exist, but it will be of little help to practising metallurgists. Continuous casting in the steel industry has been made possible only by much costly empirical effort during recent years, and one cannot help reflecting that success might have come earlier had more been known about the application of the principles of solidification under such complex conditions.

Writing with experience and authority on his subject, Prof. Chalmers has produced a book that will be welcomed by all who are interested in solidification but particularly by those of his colleagues with research interests in this field. It will be the natural starting point for future students of the subject. There are numerous clear diagrams, but it is a matter for regret that, in spite of the high price of the book, it has not been found possible to use paper that will do full justice to the half-tone illustrations.

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THIN FERROMAGNETIC FILMS

Thin Ferromagnetic Films

By M. Prutton. Pp. viii + 269. (London: Butterworth and Co. (Publishers), Ltd., 1964.) 80s.

THE speed of operation of a large electronic computer is significantly limited by the rapidity with which it can store information and later make it available. Conventional memory stores require the use of numerous bi-stable elements which can be rapidly switched from one state to another. Until the early 1950's these requirements were satisfied by small ferrite cores. The demand for large computers, capable of handling more complex calculations, coupled with significant advances in electronic techniques, stimulated a search for a more agile element than the rather sluggish ferrite core.

A number of suggestions were made, among them thin ferromagnetic films. Although the subject of sporadic study for many years, their erratic behaviour seemed to preclude a serious consideration of their claims. The situation changed abruptly with the discovery that nickel-iron films containing approximately 80 per cent nickel could be prepared by evaporation *in vacuo*. For these compositions the magnetostriiction is very small and the films are unaffected by the stresses caused by differential contraction of film and substrate. More important, such films reverse their magnetization largely by coherent rotation, a rapid process yielding switching times of about 10^{-9} sec. To the possibility that the planar geometry of thin films might lead to more understandable behaviour than that of the same materials in bulk form was added the inducement of low fabricating costs. Thin films were hastily subjected to an investigational assault comparable with those launched against germanium and silicon.

To-day, despite the successful operation of several thin-film memory stores, their universal adoption scarcely seems in sight. Dr. Prutton's book, in covering every aspect of thin films, supplies many of the reasons. The behaviour of thin films is complicated by factors which are (presumed) insignificant in bulk material. The larger demagnetizing effects associated with components of magnetization normal to the plane lead to complex domain structures peculiar to thin films. The small grain size leads to the phenomenon of magnetization ripple.