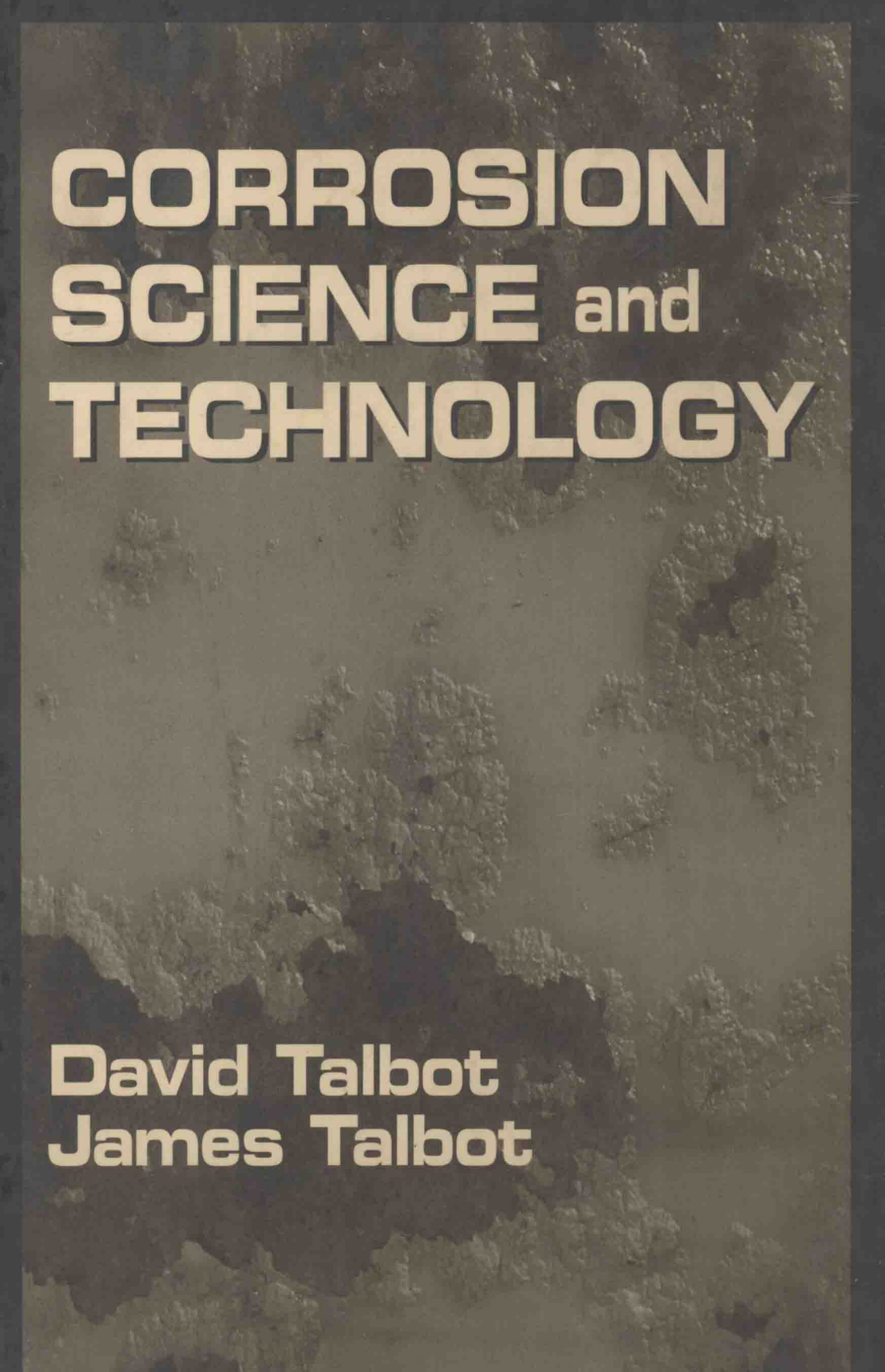
CORROSION SCIENCE and TECHNOLOGY



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Preface

Engineering metals are unstable in natural and industrial environments. In the long term, they inevitably revert to stable chemical species akin to the chemically combined forms from which they are extracted. In that sense, metals are only borrowed from nature for a limited time. Nevertheless, if we understand their interactions with the environments to which they are subjected and take appropriate precautions, degradation can be arrested or suppressed long enough for them to serve the purposes required. The measures that are taken to prolong the lives of metallic structures and artifacts must be compatible with other requirements, such as strength, density, thermal transfer, and wear resistance. They must also suit production arrangements and be proportionate to the expected return on investment. Thus, problems related to corrosion and its control arise within technologies, but solutions often depend on the application of aspects of chemistry, electrochemistry, physics, and metallurgy that are not always within the purview of those who initially confront the problems.

Corrosion is the transformation of metallic structures into other chemical structures, most often through the intermediary of a third structure, i.e., water and a first task is to characterize these structures and examine how they determine the sequences of events that result in metal wastage. These matters are the subjects of Chapters 2, 3, 4, and 5. The information is applied in Chapter 6 to examine the options available for the most usual strategy to control corrosion, the application of protective coatings. Chapters 7 through 9 examine the attributes and corrosion behavior of three groups of metallic materials, plain carbon steels and irons, stainless steels, and aluminum alloys.

The final chapters deal with some practical implications. Corrosion control is only one aspect of the technologies within which it is exercised and the approaches adopted must accommodate other requirements in the most economic way. For this reason, some total technologies are selected to illustrate how the approach to corrosion control is conditioned by their particular circumstances. Aviation is a capital intensive industry in which the imperatives are flight safety, the protection of investment and uninterrupted operation of aircraft over a long design life. In automobile manufacture, the design life is less but retail sales potential through positive customer perception is vitally important. Food handling introduces aspects of public health, biological contributions to corrosion problems, and the mass production of food cans that are low-value corrosion-resistant artifacts. Building construction has a menu of different approaches to

corrosion control from which solutions are selected to suit client requirements, local government ordinances and changing patterns of business under the pressures of competitive tendering.

The form of the present text has evolved from long experience of lectures and seminars arranged for students and graduates drawn into corrosion-related work from a wide variety of different backgrounds.

The Authors

David Talbot graduated with B.Sc. and M.Sc. from the University of Wales and Ph.D. from Brunel University for research on gas-metal equilibria. From 1949 to 1966 he was employed at the Research Laboratories of the British Aluminium Company Ltd., contributing to research promoting the development of manufacturing processes and to customer service. From 1966 to 1994 he taught courses on corrosion and other aspects of chemical metallurgy at Brunel University, maintaining an active interest in research and development, mainly in collaboration with manufacturing industries in the U.K. and U.S.A. He is a member of the Institute of Materials with Chartered Engineer status and has served as a member of Council of the London Metallurgical Society. He has written many papers on chemical aspects of metallurgy, a review on metal–hydrogen systems in *International Metallurgical Reviews* and a section on gas–metal systems in *Smithells Metals Reference Book*.

James Talbot graduated with B.Sc., ARCS from Imperial College, London, M.Sc. from Brunel University and Ph.D. from the University of Reading for research on the physical chemistry of aqueous solutions and its application to natural waters. He is currently employed at the River Laboratory of the Institute of Freshwater Ecology, East Stoke, Wareham, Dorset, U.K. to assess and predict physical chemical changes that occur in river management. He has written papers on the speciation of solutes in natural waters.

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Mr. Ray Cox, U. K. Building Research Establishment — Corrosion control in building.

Mr. Derek Bradshaw, Alpha Anodizing Ltd. — Surface cleaning and chromate treatment of aluminum alloys.

Mr. Alan Mudie, Guinness Brewery — Corrosion control in brewing.

Contents

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Overview of Corrosion and Protection Strategies

Metals in service often give a superficial impression of permanence, but all except gold are chemically unstable in air and air-saturated water at ambient temperatures and most are also unstable in air-free water. Hence almost all of the environments in which metals serve are potentially hostile and their successful use in engineering and commercial applications depends on protective mechanisms. In some metal/environment systems the metal is protected by passivity, a naturally formed surface condition inhibiting reaction. In other systems the metal surface remains active and some form of protection must be provided by design; this applies particularly to plain carbon and low-alloy irons and steels, which are the most prolific, least expensive, and most versatile metallic materials. Corrosion occurs when protective mechanisms have been overlooked, break down, or have been exhausted, leaving the metal vulnerable to attack.

Practical corrosion-related problems are often discovered in the context of engineering and allied disciplines, where the approach may be hindered by unfamiliarity with the particular blend of electrochemistry, metallurgy, and physics which must be brought to bear if satisfactory solutions are to be found. This brief overview is given to indicate the relevance of these various disciplines and some relationships between them. They are described in detail in subsequent chapters.

1.1 Corrosion in Aqueous Media

1.1.1 Corrosion as a System Characteristic

Some features of the performance expected from metals and metal artifacts in service can be predicted from their intrinsic characteristics assessed from their compositions, structures as viewed in the microscope, and past history of thermal and mechanical treatments they may have