Modern
FURNACE
TECHNOLOGY

3rd edition

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ETHERINGTON

Modern
FURNACE TECHNOLOGY

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THIRD EDITION, REVISED

With 85 illustrations, 6 plates, and
numerous tables

CHARLES GRIFFIN & COMPANY LIMITED
LONDON

First published	1938
2nd edition	1944
3rd ,, ...	1961

PRINTED IN GREAT BRITAIN BY
J. W. ARROWSMITH LTD., Winterstoke Road, Bristol 3.

PREFACE TO THE THIRD EDITION

In preparing the Third Edition the authors have taken cognizance of recent progress in furnace technology, and, in anticipation of continuing development, have placed emphasis on the fundamentals which may be applied to any furnace configuration, fuel, or process.

The general purpose of the volume—which is to explain the scientific principles underlying furnace design and operation and to develop the application of these principles by furnace operators, designers and students—has not been changed. The organization of the book and the emphasis on applied examples and simplicity of presentation have been retained.

Within the existing framework an extensive revision has been accomplished. Data and references have been brought up to date. The standard temperature has been changed from 60° F (15° C) to 70° F (21° C) in tables and calculations, since the latter temperature is more representative of conditions adjacent to furnace structures.

A new Chapter 1 has been added with the purpose of describing typical industrial furnaces and of emphasizing their importance. In Chapter 2 the tables of heat combustion and sensible heat are based on new data, and the examples and text have been rewritten to conform. New sections on flames and automatic combustion controls have been included. The tables of sensible heat that comprise a large part of Chapter 3 have also been completely revised, and a section on heat balance diagrams has been incorporated.

An entirely new section on gas friction calculation has been added to Chapter 4, in which the examples and tables have likewise been revised. The nomograms, examples, text and tables of Chapter 5 have also been reworked and the revised section on convection now contains a new section on dimensional analysis.

Chapters 6 and 7 have been revised to conform with the changes in Chapter 5, while Chapter 8 has been largely rewritten in text, tables and examples to include recent data. New sections have been added on refractories which have become commercially important since the last edition.

We wish to thank the various companies and publishers who have given permission to use certain illustrations and data; specific acknowledge-

ments are made in the text. Finally we must thank Mrs. E. R. Etherington, B.Sc. and Mrs. I. J. Etherington, B.Sc., for their assistance rendered throughout the preparation of the manuscript.

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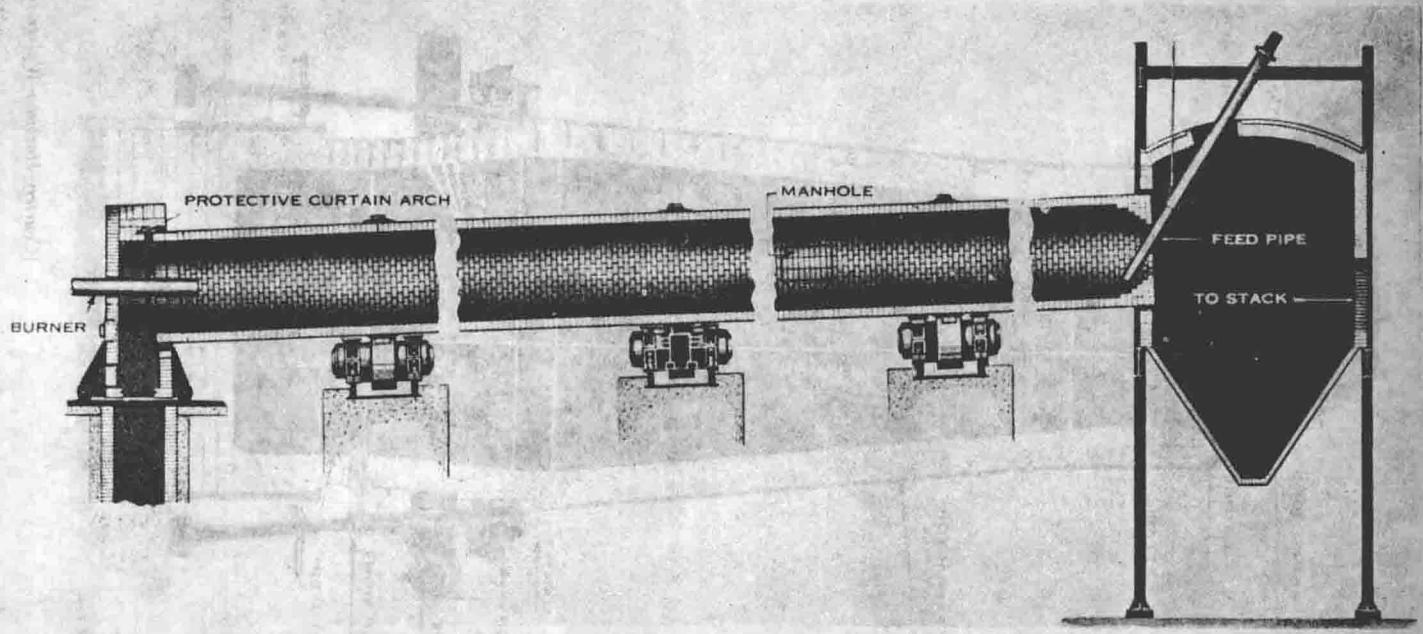
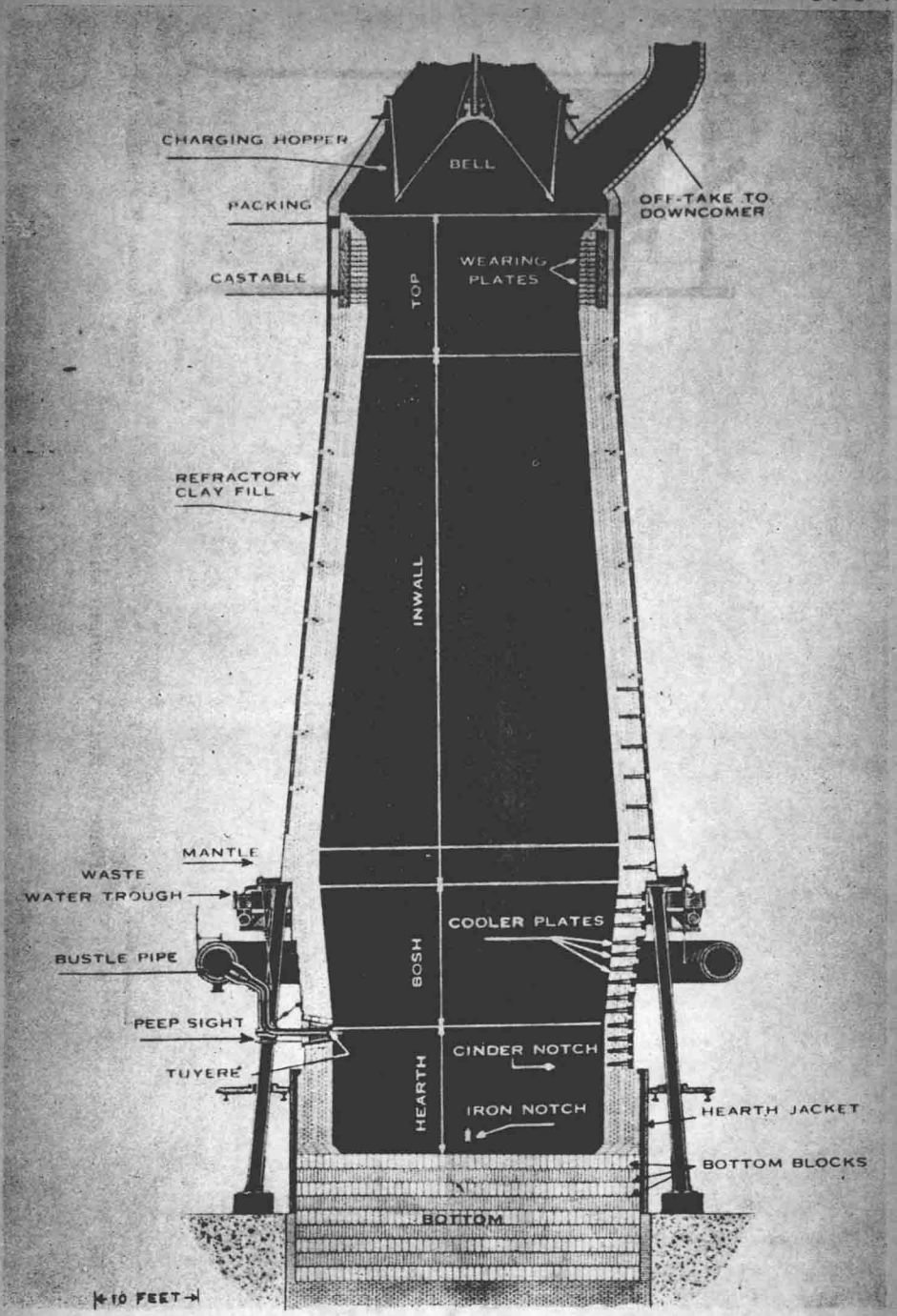


[*Courtesy Harbison–Walker Refractories Co.*

Plate 1—Rotary cement kiln



[*Courtesy Harbison–Walker Refractories Co.*

Plate 2—Section through a typical modern blast furnace

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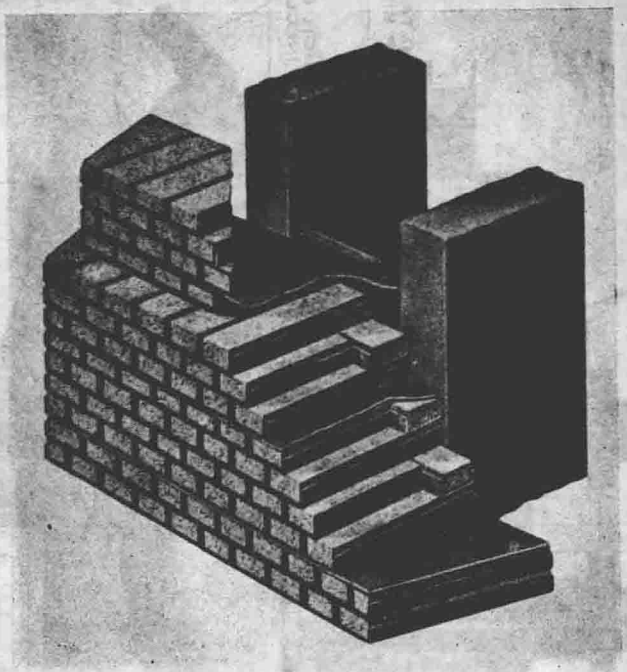
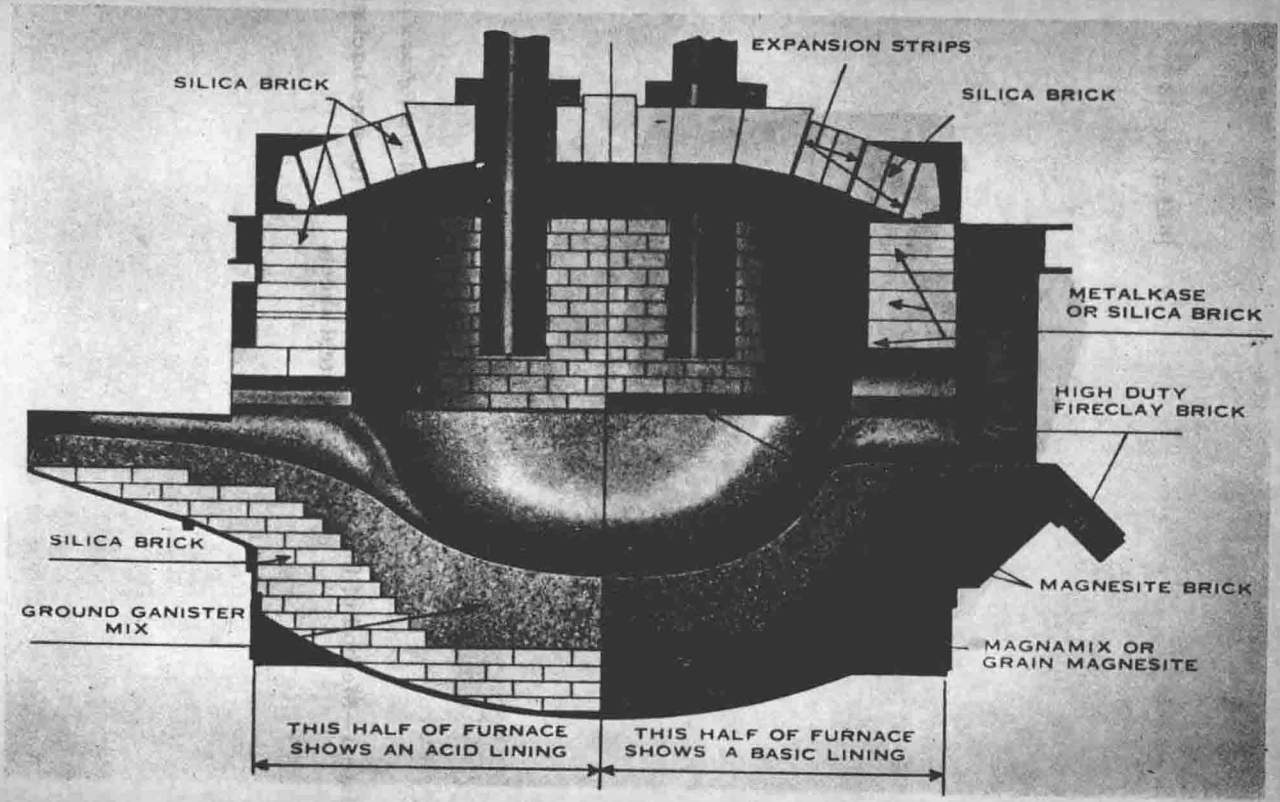


[*Courtesy U.S. Steel Corporation and Harbison–Walker Refractories Co.*

Plate 3—Method of fastening steel-encased brick to furnace buckstays by the use of steel sheets



[*Courtesy Harbison–Walker Refractories Co.*

Plate 4—Electric steel-making furnace

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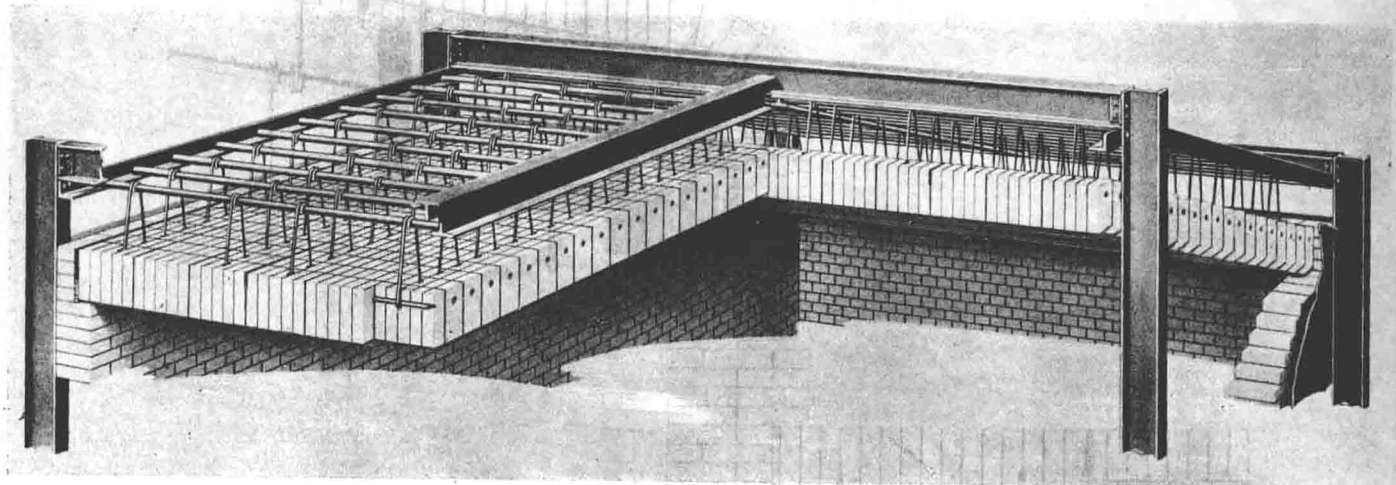
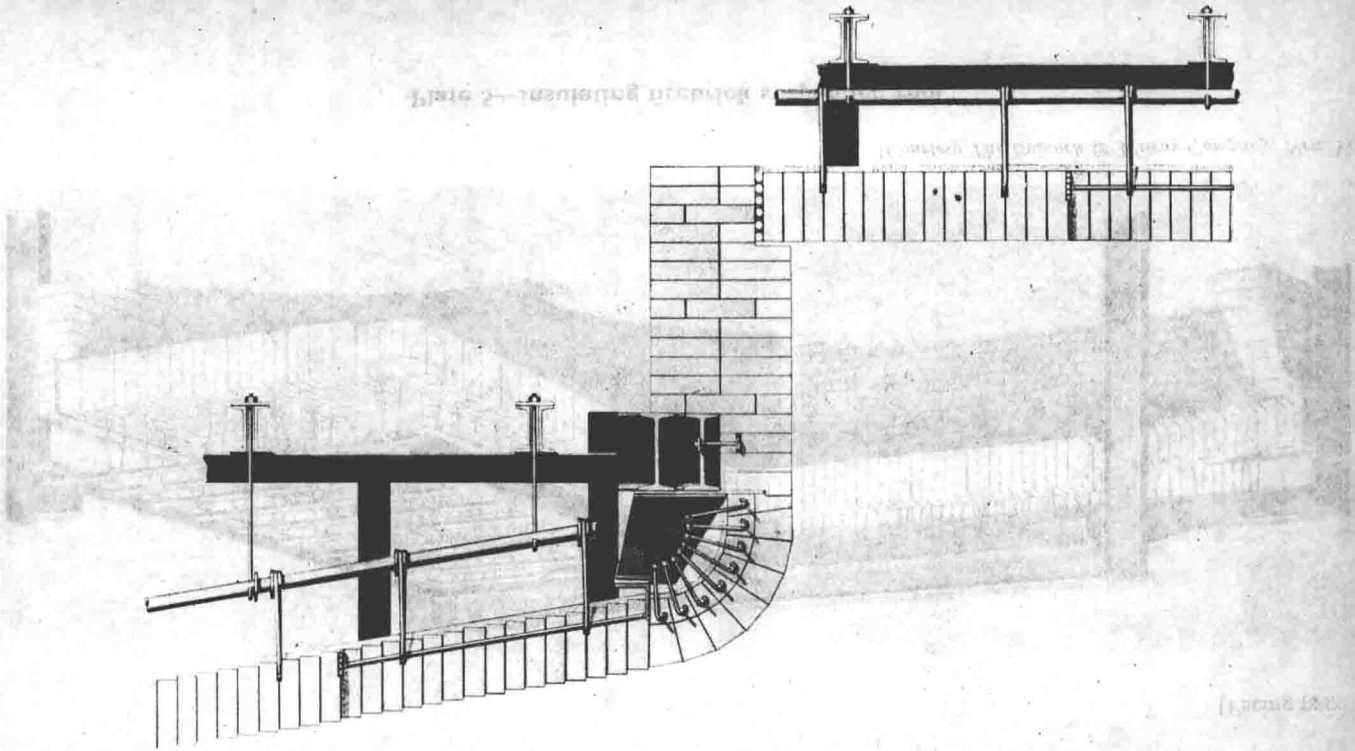


[*Courtesy The Babcock & Wilcox Company, New York*

Plate 5—Insulating firebrick suspended roof



[*Courtesy The Babcock & Wilcox Company, New York*

Plate 6—Insulating firebrick suspended arch

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INTRODUCTION

GENERAL

The word "furnace" is derived from the Latin *fornax*, which means an enclosed structure in which fuel is burned to produce heat. While the meaning has been extended to include electric furnaces and other high-temperature enclosures, the emphasis in this book will be placed on furnaces heated by combustion of fuel.

Furnace technology comprises scientifically applied knowledge of combustion, thermodynamics, gas flow, heat transfer, and the properties of furnace materials; it includes the application of sound engineering principles to the construction and control of furnaces and related equipment. These branches of the technology will be discussed in the following chapters. While the art of furnace-building dates back thousands of years to the early Egyptians, the technology—i.e. the applied science of this ancient art—has evolved only during the past fifty years. Even today many furnaces are patterned after outmoded predecessors. Certainly, good features of successful installations should be retained, but they should be reviewed in the light of modern furnace theory.

There are great differences in furnace construction and operation not only between furnace-using industries, but also between furnace installations in the same industry. Some of these differences are to be explained by local conditions, and the rest perhaps by difference of opinion. Most good furnace operators and designers continually test their views by making changes in furnace operation or design. In this way progress is achieved—also in this way costly mistakes are made. The directive influence of a scientific background may greatly increase the frequency and value of successes, while decreasing the number and the cost of mistakes.

Value of calculations

The modern furnace designer makes more or less free use of calculation. On the other hand, many furnace operators do not make proper use of the very simple calculations which can shed so much light on errors and possible improvements in operation and construction. The notion