

CONTENTS

	PAGE
PREFACE TO THE FOURTH EDITION.	vii
PREFACE TO THE THIRD EDITION.	xi
PREFACE TO THE FIRST EDITION.	xiii
CHAPTER I	
WATER FOR STEAM GENERATION.	1
Impurities in Natural Waters.	1
Hard Water--Acidity of Mine Water—Reports of Water Analysis	
Water Softening.	7
Hot and Cold Lime-Soda Processes—Zeolite or Baae-exchange Processes—Carbonaceous Zeolites	
Boiler Scale and Deposits.	18
Effects of Deposits—Internal Treatment to Prevent Scale	
Cracking of Boilers	26
Wet Steam, Foaming, and Priming	28
Treatment to Prevent Corrosion.	30
CHAPTER II	
FUELS, COMBUSTION, AND LUBRICANTS	33
Fuels.	33
Fuels and Water Power—Classification of Fuels	
Solid Fuels	35
Classification of Coals—Analysis of Coal—Heating Value of Coal— Properties of Coal Ash—Powdered Coal—Charcoal and Coke	
Liquid Fuels	48
Tar—Alcohol—Colloidal Fuel—Fuel Oil—Heating Value of Fuel Oils—Diesel Engine Fuels—Kerosene—Gasoline—Antiknock Motor Fuels	
Gaseous Fuels.	56
Natural Gas—Producer Gas—Water Gas—Blast Furnace Gas— Coke-Oven Gas—Coal Gas--Oil Gas—Bottled Gases	
Principles of Combustion.	61
Ignition Temperature—Explosive Range—Weight and Volume Relations in Combustion—Heats of Combustion—Specific Heats and Heat Capacities--Sensible Heat, Latent Heat, and Potent- ial Heat—Heat and Material Balances—Theoretical Flame Temperatures	
Outline of Petroleum Refining.	78
Constitution of Petroleum—Products from Crude Oil Refinery	

	PAGE
Practice—Skimming or Topping of Crude Oil—Thermal and Catalytic Cracking—Hydrogenation Cracking—Catalytic Reforming—Polymer Gasoline—Alkylation—Gasoline Treating and Blending	
Lubricants	92
Principles of Lubrication—Lubricating Oil Fractions from Crude Oil— Dewaxing — Acid Refining and Solvent Refining of Lubricating Oils—Properties of Refined Oils—Viscosity and Viscosity Index—Addition Agents for Motor Oils—Lubricating Greases—Graphite Cutting Lubricants	
CHAPTER III	
REFRACTORIES	109
Fire Clay—High-alumina Refractories—Silica—Magnesite and Magnesia—Chrome Refractories—Fosterite—Dolomite—Mortar Materials—Pyrometric Cones—Chemical Reactions of Refractories—Acid, Basic, and Neutral Refractories—Physical Behavior of Refractories—Thermal Conductivities and Specific Heats of Refractories — Minor Refractories	
CHAPTER IV	
THE NONFERROUS METALS.	123
Physical Properties	124
Mechanical Properties	125
Tensile Strength—Modulus of Elasticity—Elastic Limit—Yield Strength—Hardness—Fatigue—Ductility—Malleability	
Aluminum	130
Ores—Production of Commercial and Pure Metal—Physical and Mechanical Properties—Chemical Properties—Uses—Thermit	
Copper.	139
Sources and Ores—Concentration of Ores—Roasting, Smelting, and Converting—Refining—Electrolytic Extraction of Lean Ores —Physical and Mechanical Properties—Chemical Properties—Uses	
Lead.	150
Occurrence and Ores—Concentration, Roasting, and Smelting —Refining—Physical and Chemical Properties—Uses	
Tin	157
Occurrence and Ores—Mining and Metallurgy of Tin—Refining—Reclaimed Tin—Physical and Chemical Properties—Uses	
Zinc.	164
Occurrence and Ores—Metallurgy of Zinc—Electrolytic Extraction—Refining of Spelter—Production of Zinc Oxide—Grades of Zinc —Physical and Chemical Properties—Uses	
Cadmium.	172
Occurrence, Ores, and Production of Metal—Physical and Chemical Properties—Uses	
Magnesium.	174
Ores—Metallurgy of Nickel—Extraction from Matte — Monel Metal—Properties and Uses	

	PAGE
Other Nonferrous Metals.	181
Cobalt—Manganese—Chromium—Tungsten—Molybdenum— Vanadium—Bismuth—Antimony—Mercury—Titanium—Gold— Silver	

CHAPTER V

NONFERROUS ALLOYS	205
The Phase Rule.	206
Types of Phase Equilibria in Alloy Systems.	208
Pure Metals as Solid Phases—Formation of Intermetallic Compounds —Solid-solution Formation; Complete Solid Miscibility, Partial- solid Miscibility—Solid Phase Equilibria	
Crystallization, Deformation, and Annealing of Alloys	222
Crystal Size in Metals and Alloys—Cold Working—Hardening by Cold Work—Annealing—Hot Working—"Season" Cracking	
Alloys of Copper	227
Brasses; Classification and Properties—Modified Brasses; Alumi- num Brass, Tin Brass, Manganese Brass, Iron Brass, and Lead Brass —Bronzes; Composition and Properties—Modified Bronzes; Phosphor Bronze, Bearing Bronzes, Aluminum Bronze, Silicon Bronze—Beryllium Copper—Copper-nickel Alloys	
Aluminum Alloys	239
Casting Alloys—Wrought Alloys—Age Hardening	
Magnesium Alloys.	246
Nickel Alloys.	246
Monel Metal—Heat-resisting and Electrical Resistance Alloys— Low Thermal Expansion Alloys—Magnetic Alloys	
Bearing Metals	248
White Alloys; Lead-antimony, Tin-antimony-copper (Babbitt)— Leaded Bronzes	
Solders and Brazing Alloys	251
Structure, Composition, and Properties of Soft Solder—Brazing Alloys—Aluminum Solder — Silver Solders—Copper Alloy Welding Rods—Fluxes for Soldering and Welding	
Die-casting Alloys.	256
Tin-base and Zinc-base Alloys	
Low-melting Alloys	257

CHAPTER VI

PRODUCTION OF IRON AND STEEL	259
Blast-furnace Production of Pig Iron.	259
Raw Materials for Blast Furnace	259
Iron Ores — Coke — Limestone — Air — Water	
Blast-furnace Design, Operation, and Material Balance.	262
Blast-furnace Reactions	266
Reactions in Stock Column—Reactions in Bosh and Hearth	
Products of the Blast Furnace.	273
Pig Iron—Ferroalloys—Slag—Blast-furnace Gas	
Production of Steel	274
Wrought Iron.	275

	Page
Cement and Crucible Steel	277
The Bessemer Process	279
Raw Materials—Chemical Reactions—Deoxidation, Recarburizing and Alloying Additions—Basic Bessemer	
The Open-hearth Process.	286
Furnace Design—Fuels—Raw Materials—Charging and Melting — Refining Reactions—Finishing the Heat—Products of Basic Open-hearth Process —The Acid Open-hearth Process.	
Steelmaking in Electric Furnaces	296
Basic and Acid Electric Arc Furnaces —Raw Materials and Products —Induction Furnace Melting.	
Duplex Steelmaking Processes	300
Deoxidizing and Alloying Additions	301
Principles of Deoxidation—Ferroalloys	
Production of Steel Ingots	304
Teeming ladle—Ingot Molds — Crystallization of Steel and Ingot Defects—Rimming, Semikilled , Capped, and Killed Steels — Segregation — Inclusions	
CHAPTER VII	
ALLOYS OF IRON: CONSTITUTION, TREATMENT, AND USES	312
Iron and the Iron-Iron Carbide Phase Diagram	312
Allotropy of Iron — Solidification of Liquid Iron-carbon Alloys — Transformations in Solid Iron-carbon Alloys—Iron-graphite Phase Diagram	
Heat Treatment of Steels.	325
Critical Points in Steel—Influence of Rate of Heating or Cooling on Critical Points—Austenite Transformation at Constant Subcritical Temperatures—The Bain S Curve — Structures Obtained by Cooling Steel at Various Rates — Annealing and Normalizing—Grain Size, Grain Growth, and Grain Refinement—Hardening and Hardenabil- ity—Tempering and Spheroidizing	
Casehardening	338
Case Carburizing—Pack Carburizing — Gas Carburizing — Nitriding —Cyaniding and Liquid Carburizing	
Scaling, Decarburizing , and Bright Annealing.	345
Protective Atmospheres	
Wrought Iron and Open-hearth Iron.	347
Plain Carbon Steels	348
Influence of Carbon Content on Properties—Influence of Minor Ele ments and Cold Working — S.A.E. Classification — Carbon Steels as Engineering Materials	
Low-alloy Steels	358
Influence of Alloying Elements on Properties—Low-alloy Low- carbon High-strength Steels — S.A.E. Low-alloy Steels as Engineer- ing Materials — Silicon Electrical Steels	
High-alloy Steels	362
S.A.E. High-alloy Steels — Hadfield Manganese Steel —Corrosion- and Heat-resisting Steels—Constitution and Properties of Iron-	

chromium-carbon Alloys—Iron-chromium-nickel Alloys—Resistance of High-chromium Steels to Corrosion and High-temperature Oxidation—Creep Resistance of High-alloy Steels	
Tool and Die Steels	374
Plain High-carbon Tool Steels—Manganese, Low-chromium, Low-tungsten, High-chromium, High-tungsten Tool and Die Steels—High-speed Steel	
Cast Irons	379
Typical Analyses for Various Uses—White and Gray Cast Iron—Alloy Cast Irons—Malleable Cast Iron	

CHAPTER VIII

TECHNOLOGY ON SHAPING METALS AND ALLOYS	383
Casting Processes	386
Melting Ferrous and Nonferrous Materials for Casting—Molding of Sand Castings—Molding Sands—Permanent Mold Castings—Die Casting—Centrifugal Castings—Defects in Castings	
Shaping by Hot or Cold Working	396
Shaping by Cutting and Joining	397
Machinability—Flame and Arc Cutting—Welding, Soldering, and Brazing	
Powder Metallurgy	400
Applications—Production of Metal Powders—Mixing, Compression, and Heat-treatment	

CHAPTER IX

CORROSION ON METALS AND ALLOYS	404
The Electrochemical Mechanism	405
Principles of Electrochemistry	405
Energy Relations and Mechanism of Discharge of Galvanic Cells—Faraday's Law—Electrode Reactions (Half Reactions)—Single Electrode Potentials (Oxidation-Reduction Potentials)—Standard Potentials—Influence of Concentrations on Cell Voltage and on Single Electrode Potentials	
Polarization in Galvanic Cells	417
Concentration Polarization—Overvoltage—Energy Dissipation Due to Resistances—Polarization Due to Films	
The Spontaneity of Corrosion Reactions	420
"Hydrogen" Type and "Oxygen" Type Corrosion Reactions—Anodic and Cathodic Areas	
The Limiting Corrosion Rate	424
Anodic, Cathodic, and Mixed Control—Inhibitors; Classification, Intensity of Attack, Pickling of Iron and Steel	
Other Factors Influencing Corrosion Rate	431
Films on Metals; Passivity, Natural and Artificial Films—Oxygen Concentration Cells and Differential Aeration—Water-line Attack—Influence of Bacteria—Stress and Grain Boundary Corrosion; Corrosion Fatigue, Season-cracking of Brass, Desincification of Brass, Caustic Embrittlement of Boiler Plate—Corrosion in Soils	

— Stray Current Corrosion — Electrolytic Protection — Contacts between Dissimilar Materials— Cathodic Protection — Influence of Temperature	443
Selection of Materials for Specific Uses	443
CHAPTER X	
PROTECTIVE METALLIC AND INORGANIC COATINGS	444
Metallic Coatings	444
Preparation of Metal Surfaces for Coatings—Methods Used in Applying Coatings; Hot-dip, Electrodeposition, Spraying, Cementa- tion, Cladding, Sputtering	
Zinc Coatings	449
Tin Coatings	453
Nickel Coatings	455
Coatings of Other Metals	456
Chromium—Copper—Lead—Aluminum—Cadmium—Cobalt— Noble Metals—Alloys; Brass, Coronite, Stainless Alloys	
Testing Metallic Coatings	460
Nonmetallic Inorganic Coatings	461
Vitreous or Porcelain Enamels—Anodized Coatings on Aluminum— Surface Conversion or Chemical-dip Coatings	
CHAPTER XI	
BUILDING STONES	466
Igneous Rocks	466
Structure—Chemical Composition—Granites—Trap Rock—Ser- pentines	
Sedimentary Rocks	468
Slates—Sandstones—Limestones—Marbles—Deterioration of Stone —Fire Resistance—Cleaning Stone	
CHAPTER XII	
LIME AND GYPSUM PRODUCTS	477
Manufacture of Lime—Structural Lime—Slaking of Lime—Hydrau- lic Limes and Grappier Cement—Lime-sand Mortars and Brick— Gypsum Products—Preparation, Setting, and Hardening of Gypsum Plasters—Plaster of Paris	
CHAPTER XIII	
PORTLAND CEMENT AND CONCRETE	487
Manufacture of Portland Cement—Setting and Hardening of Port- land Cement—High Early-strength and High-alumina Cements— Testing Cements—Concrete—Portland-Pozzolan Cement—Water- proofing Concrete	
CHAPTER XIV	
CLAY AND CLAY PRODUCTS	502
Composition and Plasticity of Clays—Burning of Clays—Color of Clay Products—Brickmaking Methods—Efflorescence on Bricks— Terra-cotta Ware—Other Clay Products—Sanitary Ware	

CONTENTS

xxi
PAGE

CHAPTER XV

✓ ABRASIVES **511**

Hard Abrasives—Siliceous Abrasives—Soft Abrasives—Artificial Abrasives—Grinding Wheels—Coated Paper and Cloth

CHAPTER XVI

GLASS **522**

Reactions in Glass Making—Properties and Compositions of Glasses—Glass Furnaces—Annealing of Glasses—Colored Glass—Special Glasses

CHAPTER XVII

ORGANIC PLASTICS. **529**

Structural Characteristics of Plastics—Condensation and Polymerization—Types of Plastics—Fillers and Plasticizers for Plastics—Forming Articles from Plastic—Uses and Properties of Plastics

CHAPTER XVIII

RUBBER: NATURAL AND SYNTHETIC **537**

Sources of Natural Rubber—Compounding—Vulcanization—Reclaimed Rubber—Articles Directly from Latex—Synthetic Rubbers (Elastomers); Sources of Raw Materials, Types and Properties

CHAPTER XIX

ORGANIC PROTECTIVE COATINGS: PAINTS, VARNISHES, ENAMELS, LACQUERS **544**

Raw Materials **548**

Pigments. **548**

Whites—Reinforcing Pigments—Blues—Greens—Yellows—Reds—Browns—Blacks—Metal Powders—Lake Pigments—Properties of Pigments

Drying Oils and Driers. **560**

Film Formation by Oils—Drying Oils—Semidrying Oils—Properties of Drying Oils—Driers

Resins, Cellulose Derivatives, and Plasticizers. **570**

Solvents and Diluents **575**

Turpentine—Petroleum Hydrocarbons—Coal-tar Distillates—Other Solvents—Paint and Varnish Removers

Special Coatings and Related Materials **581**

Bituminous Coatings—Nondrying Coatings—Wax Polishes—Cold-water Paints—Wood Stains and Fillers

Paint Practices **586**

Coatings for Wood, Metal, Plaster, and Concrete—Light- and Heat-reflecting Properties of Coatings

CHAPTER XX

GLUES AND ADHESIVES. **591**

Colloidal Behavior of Glues—Classification of Glues—Gelatin Glue Technology—Commercial Forms and Grades of Gelatin Glue—Glue

Testing—Casein Glues—Other Adhesives; Albumin Glues, Sodium Silicate, Mucilage, Resin Glue, Nitrocellulose Glues, Gluten, and Rubber Cement Page

CHAPTER XXI

INSULATING MATERIALS	607
Thermal Insulators	607
Heat Transfer by Convection; Conduction, and Radiation—Function of Insulation—Properties of Organic and Inorganic Insulators—Building, Refrigeration, and Furnace Insulation	
Electrical Insulators.	614
Conductance—Breakdown—Strength—Dielectric Constant and Dielectric Loss—Chemical and Physical Properties of Gaseous, Liquid, and Solid Insulators	
INDEX	623