

INDEX.

- ABBOTT, 30.
Abel, Sir F., 134, 151.
Absorption of gases, 37, 47, 48.
 liquids, 47, 60.
Abstrich, 425, 426.
Acetic acid, surfusion of, 39.
Achard, 70, 71.
Acid refractories, 317-319.
Acoustic properties of metals, 38, 41.
Addy, 207.
Ados apparatus, 369.
Agents, metallurgical, 295, 296.
Agricola, G., 3.
Air supply to furnaces, 365-382.
 thermometer, 181-184.
Aitken coke-oven, 262.
Alkaline metals as reducing agents, 109.
Allotropic modifications, 72, 140,
 225, 226.
Allotropy, 48, 70.
Alloys, 69-125.
 action of electric current on molten, 88.
 aluminium-magnesium, 226.
 -zinc, 233, 237.
 antimony-bismuth, 227, 228, 238.
 -lead, 226, 233, 235, 236.
 bismuth, 125.
 chemical examination of, 229.
 classification of, 235-239.
 colour of, 117-121.
 conduction at varying temperatures, 89.
 conductivity of, 229.
 constitution of, 225-235.
 copper, 122, 123.
 detection of free metals in, 226.
 effect of annealing, 157.
 of composition on conductivity, 90-93.
 of work on, 158.
 of temperature on strength of, 105-108.
 electro-motive force of, 228.
 for coinage, 125.
Alloys, formation of, by cementation, 58.
 by compression, 59, 75.
 by electro-deposition, 76.
 by fusion, 73.
gold-lead, 226, 233.
 -platinum, 227-238.
 -silver, 227.
 -thallium, 228, 233, 235.
hardness of, 18, 229.
ideal, 84.
iron-manganese, 227, 238.
lead, 124.
 -tin, 227, 235.
 -silver, 227.
methods of investigating, 72.
 of producing, 73.
of industrial importance, 121-125.
silver-copper, 227, 233.
 -tin, 227, 233.
sodium-tin, 235.
solution theory of, 220-225.
thermal analysis of, 227, 228.
 treatment of, 156, 159.
tin, 124.
 -magnesium, 238, 239.
unreal, 84.
zinc, 124.
 -cadmium, 226, 233.
Alumina polishing powder, 213.
Aluminium, action of, on zinc in
 Parke's process, 388
contraction of, 15.
effect of low temperatures on,
 25.
 pressure on, 74.
 silicon on, 109.
effect of, on segregation in steel, 81.
 on zinc-silver alloys, 110.
electrical resistance of, 65.
 hardness of, 18.
influence of, on copper, 102.
oxidation of, 110.
reduction of rarer metals by,
 109-111.
strength of, 26.

Aluminum bronze, effect of annealing, 157.
of quenching, 158.
strength of, at high temperatures, 107.
structure of, 212.
-copper alloys, 102-103.
effect of casting temperature on, 156.
-gold alloy, colour of, 118.
-magnesium alloys, 226.
-zinc alloys, 233, 237.
Amalgam, diffusion of, in mercury, 60, 61.
Amalgamation, 312.
Ammonia, 48.
yield of, in producers, 285.
Anaconda furnaces, 337, 338.
Anderson, Sir W., 148, 206, 207.
Andrew, 22.
Andrews, 25, 382.
Annealing, 126, 127.
effect of, 151, 157.
Anthracite, 246, 255.
Anthracitic coals, 254.
Antimony, contraction of, 15.
crystallisation of, 37.
effect of, on copper, 100.
of pressure on, 74.
hardness of, 18.
mode of eliminating, 9, 10.
used for ornaments, 70.
Antimony-bismuth alloys, 227, 228, 238.
-copper alloy, 39.
colour of, 118.
-lead alloys, 226, 233, 235, 236.
Application of slags, 298, 299.
Appolt coke oven, 263.
Aquinas, St Thomas, 453.
Arc furnaces, 359, 363, 364.
Armour-plate, 114.
Armstrong, 13.
Arndt's Oekonometer, 369.
Arnold, 13, 57, 58, 94, 99, 136, 211.
Arsenic, crystallisation of, 37.
effect of, on copper, 10, 11.
on steel, 99.
elimination of, 9, 10, 11.
Assay furnace, 358.
Atomic volume, 104, 105.
Atoms, 12.
Aubertöt, 293.
Augustin's process, 312, 428.
Austenite, 136.
hardness of, 18.
Autolysator, 369.
Automatic analysis of furnace gases, 369.

Automatic apparatus for stress-strain diagrams, 30.
Autographic recorder of temperatures, 177-179.
Available hydrogen, 247.
BACON, FRANCIS, 130, 141.
Roger, 3.
Bairstow, 36.
Baker, Sir B., 44.
H. B., 282.
Ball, E. J., 39, 77.
Balling, Prof., 300, 304, 305, 307, 311.
Baly, 163.
Bannister, 16.
Barba, 206.
Barium, oxidation and deoxidisation of, 6.
Barrett, Prof., 142, 143, 145.
Barus, 142, 143, 147, 148, 152, 154, 155, 163, 172, 182, 183, 184.
Barytes, 295.
Basic refractories, 319.
Baudrimont, 24.
Bauer, 57.
Bauxite, 317, 319, 320.
Becher, 4, 130.
Beck's illuminator, 218.
Becquerel, 172, 192.
Beehive coke-oven, 260, 261.
Behn, 66.
Behrens, 211.
Belgian zinc furnace, 354.
Bell, Sir L., 191, 315, 378, 379, 459, 460.
Bell metal, hardness of, 18.
Bengough, 158.
Bergman, 131, 132, 141.
Berthelot, 70, 128, 382, 383, 384, 386.
Berthier, 115, 134.
Berthollet, 131.
Bessemer, Sir H., 82.
converter, 321, 355-357.
slag, utilisation of, 299.
Bett's process, 450, 451.
Bibliography of alloys, 122.
of metallography, 240-245.
of pyrometry, 208-209.
of thermal treatment of steel, 159-161.
of thermo-chemistry, 403.
Binary alloys, classification of, 235-239.
Biringuccio, 3, 70.
Bismuth, crystallisation of, 37.
density of, 14, 15.
effect of, on copper, 100.
effect of pressure on, 74.
extraction of, 354.
regulation in, 46.

Bismuth, volatilisation of, 62.
Bismuth alloys, 125.
-antimony alloys, 227, 228, 238.
Bituminous coal, 254.
lignite, 252.
Black, J., 2, 132.
Blast-furnace gases, 293.
Blast-furnaces, 323, 328-338.
classification of, 329.
development of copper, 337.
dimensions of, 329, 331.
outlines of, 330.
Pilz, 335-338.
Raschette, 333-335.
Washoe, 337, 338.
Blowing engines, 369-373.
Blue metal, 11, 411.
Boghead mineral, 256.
Bomb calorimeter, 383, 384.
Bone, Prof., 284.
Boshes, 328.
Bottone, 17.
Boudouard, 48, 282.
Boyle, R., 4, 61.
Boyle's law, 183.
Boynton, 18.
Bramwell, Sir F., 458.
Brand, 100.
Brass, contraction of, 15.
hardness of, 18.
structure of, 212.
Braune, 12.
Brinell, 13, 16, 32, 33, 35, 150, 151.
hardness, 17.
machine, 33, 34.
number, 95.
Briquettes, 257.
British thermal unit, 248.
Brittleness, 19.
Bromine, 316.
Brouncker, Lord, 4.
Brown, Orum, 5.
Sir T., 150.
Brown's furnace, 349, 350.
Brückner cylinder, 347, 348.
Brunck coke oven, 265, 272-275.
Burgess, 201.
Busek, 154.
Butte, matting furnace, 340, 341.

CADMIUM, density of, 14.
volatilisation of, 62.
-zinc alloys, 226, 233.
Caesalpinus, 3, 4.
Cailletet, 48, 368.
Caird, 457.
Caking coals, 253, 254.
Calcination, 3, 5, 312.
Calculation of furnace charges, 299-311.

Chill casting, 157.
Chloridising roast, 313.
Chlorination of gold ores, 430.
Chlorine, 316.
Chorley, 163.
Chrome-iron ore, 317, 320.
-steel projectiles, 115.
-steels, 117.
Chromium, effect of, on iron, 150.
melting of, in electric furnace, 113.

Chronstet, 437.
Clapp-Griffiths converter, 355.
Classification of binary alloys, 235-239.
of coals, 253.
of fuels, 246.
of principles of pyrometers, 163, 164.
of processes, 311, 312, 405.
of slags, 297.
of steel, 153-155.
Claudet's process, 395, 429.
Clausius, 46.
Clay, 66.
Clémendot, 129.
Closed-vessel furnaces, 353-357.
Clonet, 132, 133.
Coal, 246, 253-255.
Coarse metal, 11.
Cobalt ores, treatment by wet processes, 433-436.
Coffin, 59, 148.
Cohen, 4.
Cohesion, 75.
Coinage alloys, 125.
Coining, 42, 44.
Coke, 259-281.
ovens, Aitken, 262.
Appolt, 263.
Beehive, 260.
Brunck, 272-275.
Coppée, 272.
Hüssener, 267-271.
Jameson, 262.
Otto-Hilgenstock, 272, 273.
Otto-Hoffman, 271, 272.
Pernolet, 261.
Schaumburg, 260.
Semet-Solvay, 266, 267.
Simon-Carves, 265, 266.
von Bauer, 275, 280.
Cold-short, 16.
Coleman, 437.
Colloid state, 38.
Colouring power of metals, 118.
Colour of alloys, 117-121.
of metals, 36.
Colours, in relation to temperature, 37.
tempering, 127, 154.
Colson, A., 56, 57.
Combustion, 5.
Composition of producer gas, 290.
Compound armour plate, 115.
Compounds of metals with non-metals, 231-232.
intermetallic, 225, 227-231.
Compressed coke, 280.
Compression, changes due to, 41-45.
fosteel ingots, 82.

Compression, union of metals by, 45, 59, 73, 77.
Conchooidal lignite, 252.
Conduction of electricity by alloys, 89.
Conductivity, 71.
of alloys, 229.
Cones, Seger, 165.
Constitution of alloys, 225-235.
microscopic, 212.
views as to the, 70.
Constituents of steel, hardness of, 18.
special note on, 161.
Contraction of metals, 15.
Coppée coke oven, 265, 271.
Copper bottoms, 411.
Copper, colour of, 36.
contraction of, 15.
converter, 357, 358.
crystallisation of, 37.
density of, 15.
ductility of, 17.
effect of antimony on, 100.
arsenic on, 10, 11.
bismuth on, 100.
low temperature on, 25.
pressure on, 74.
sulphur on, 100.
electrical resistance of, 65.
hardness of, 18.
influence of aluminium on, 102.
malleability of, 17.
occlusion of hydrogen by, 48.
price of, 461.
production of, 460.
pyrites, 316.
treatment of, 7.
strength of, 25, 26, 106, 107.
Welsh smelting, 408-413.
Copper alloys, 123.
-aluminium alloys, 102-103.
-antimony alloy, 39.
colour of, 118.
-nickel alloys, 123.
-silver alloys, 227, 233.
freezing of, 222.
-tin alloys, 100-102, 122.
-zinc alloys, 122.
Coppet, 39.
Cornu, 192.
Corrosion of steels containing sulphur, 99.
Cort, 340.
Cowper stove, 376.
Cracks in steel, 212.
Cramer, 130.
Critical curves, 85.
points of iron and nickel, 64.
temperature, 64.
Crova, 192.

Crucibles, 320, 321.
Cryohydrates, 220.
Crystalline state, 212.
structure, 13.
Crystallisation, 37.
Crystallites, 13, 226.
Cup and cone, 332, 333.
Cupellation, 3, 4, 5, 426.
furnace, 340, 341, 342.
Cyanide process, 431-433.
D'ARCET, 78.
Dark body, 197.
David, 357.
Davy, Sir H., 155.
Dawson, 378.
Deacon process, 205.
Definitions of constituents of steel, 135, 136, 161.
Dellwik-Fleischer producer, 291, 292.
Demarçay, 61, 62.
Density, 72.
of metals, 14.
Desch, 227, 229.
Desiccating blast, 380, 381.
Despretny, 112.
Detection of free metals in alloys, 226.
of oxide of iron by microscope, 49.
Deville, H. Ste Claire, 5, 6, 47, 110, 181, 382, 389.
Devonshire, Duke of, 378.
Dewar, 89, 108.
Dia-magnetic bodies, 62.
Die-steel, 154.
Differential curves, method of obtaining, 179-181.
Diffusion, 49-61.
of amalgams in mercury, 60.
of elements in iron, 58.
of silver as chloride, 57.
of solid metals, 54.
Dinas rock, 317, 318.
Direct method of copper smelting, 412.
Dissociation, 5, 6.
Distillation, 311.
Ditte, 382.
Dixon, Prof., 282.
Dolomite, 295, 317, 319.
Double bell, 333.
Douglas, 312.
Dowlais works, blowing-engines in, 370.
Draught, methods of producing, 365-373.
Dry blast, 378-381.
Ductility, 17.
of carbon steels, 94, 95.
Duffield, 431.
Duhamel, 72.

Duhem, 388.
Dulong and Petit's law, 66.
Dumas, 69.
Dürre, 264.

EARTHY lignite, 252.
Eccles, 81.
Eck, 3.
Economic considerations, 452-463.
Edwards furnace, 351-353.
Effect of temperature on the properties of metals, 24, 25.
Efficiency of gas producer, 284.
Ejection of impurities on crystallisation, 39.
Elasticity, 19.
Electric current, action of, on molten alloys, 88.
reduction of rare metals by, 109.
furnaces, 112, 322, 357-364.
resistance of silicon steel, 97.
Electro-deposition, union of metals by, 76.
Electrolytic fusion, 111-113.
refining of base bullion, 450, 451.
Electro-motive force of alloys, 228.
Elongation, determination of, 32.
Endelmann, 388.
Endothermic reaction, 393.
Energy, 5, 130, 382.
Equilibrium, chemical, 8, 9, 389.
Ercker, 78.
Ermann, 72.
Etching, methods of, 214.
Eutectic alloy, 77.
mixtures, 225, 232-235.
Everard, 116, 130.
Evolution of gas during solidification of metals, 37.
Ewing, 13, 149.
Exothermic reaction, 393.
Extensibility, 19.
Extension, specific, 20.
Extensometer, 32.
Eyepieces, 219.

FABER DU FAUR, 374.
Faraday, 39, 45, 46, 59, 154.
Ferrite, 135.
hardness of, 18.
Ferry, 319.
Féry absorption pyrometer, 195.
radiation pyrometer, 199.
Fick's law, 52.
Filter presses, 432.
Fire-bridge, 338.
-clays, 317, 318.
testing of, 320.
Fleischer, 291.
Fleming, 89.

Flow of metals, 41-45.
Flowing furnace, 340, 341.
Flue gases, 368.
Fluid metals, density of, 14, 15.
Fluorspar, 295.
Fluxes, 294, 295
selection of, 296.
Ford and Moncur stove, 377.
Forge, 321.
Forth Bridge, 44, 153.
Fortschaffungsofen, 341.
Fossil wood, 252.
Fracture, 13, 16.
François, 210.
Franz, 72.
Freezing-point curves, 220, 221, 222.
Freezing-points of alloys, determination of, 176.
Freiberg process, 416-427.
Fremont, 33.
Freminville, 19.
Frémy, 255.
Fryer, W. H., 378, 379.
Fuel, 246-293.
carbonised, 257-281.
classification of, 246.
compressed, 257.
dried, 257.
gaseous, 256, 281-293.
liquid, 255, 281.
natural, 246, 250-257.
Furnace charges, calculation of, 299-311.
Furnaces, 317-364.
arc, 359, 363, 364.
assay, 353.
blast, 323, 328-338.
Brown, 349, 350.
Brückner, 347, 348.
Catalan forge, 326.
cementation, 354, 355.
classification of, 321.
closed-vessel, 322, 353.
Edwards, 351, 353.
electric, 112, 322, 358-364.
Gjers kiln, 322, 323, 327, 328.
hearts, 321, 323-326.
Héroult, 361-363.
Hoffmann kiln, 324-326.
induction, 359, 360, 361.
Keller, 361.
Kjellin, 360, 361.
M'Dougal, 353.
Mansfeld, 338, 339.
Merton, 353.
open-hearth, 342, 344-346.
ore-hearth, 324.
Orford, 337, 338.
Pearce turret, 348, 349.
Pilz, 335, 336, 337, 338.

Furnaces, puddling, 338, 340.
Raschette, 333-335.
resistance, 359, 360, 361-363.
retort, 321.
reverberatory, 321, 322, 323, 338-353.
Roehling-Rodenhauser, 360.
shaft, 321, 322, 326-338.
Stassano, 363, 364.
Stetefeldt, 346, 347.
supply of air to, 365-382.
tube, 354.
zinc, 354.
Fusibility, 36.
of slags, 297.
Fusible metal, 125.
effect of low temperatures on, 108.
Fusion, electrolytic, 111-113.
union of metals by, 73.

GANISTER, 317, 318.
Gas, determination of calorific value of, 386.
blowing engines, 371-373.
coal, 254.
producers, 285-293.
Mond, 287-290.
Siemens, 285-287.
Wilson, 286-288.

Gaseous compounds, heat of formation of, 396.
Gases, occlusion of, 47.
Gautier, F., 21, 97, 238.
Gayley, J., 379, 380, 381.
Gay-Lussac, 56, 61.
Geber, 2, 11, 56, 162.
Gellert, 70, 71, 130.
Genzen, 369.
Gerardin, 88.
Gilbert, 150.
Gill, T., 129.
Gjers kiln, 322, 323, 327, 328.
Glass, flow of, 41.
Gmelin, 104.
Gold, colour of, 36, 76.
crystallisation of, 37.
density of, 14.
diffusion of, in lead, 50, 52-55.
ductility of, 17.
effect of impurities on, 100.
effect of temperature on, 26.
hardness of, 18.
malleability of, 17.
occlusion of gases by, 48.
ores, treatment of, 430-433.
production of, 460.
resistance of, 65.
strength of, 25, 26, 41.
surfusion of, 39.
Gold-aluminium alloy, colour of, 118.

Gold-copper alloys, liquation in, 79, 80.
lead alloys, 226, 233.
platinum alloys, 227, 238.
silver alloys, 227.
thallium alloys, 228, 233, 235.
Gollner's testing machine, 28.
Gordon-Cowper-Whitwell stove, 378.
Gore, 142, 143.
Gosselin, 235.
Gowland, 79, 335, 342.
Graham, 47, 48, 49, 52, 133.
Grain, 13.
Graphite, 317, 320.
Gray, 14.
Greenwood's testing machine, 27.
Grey iron, contraction of, 15.
Growth of grains, 13.
Grüner, 253, 315, 452.
Guertler, 90.
Guillaume, 448.
GUILLET, 57, 117.
Gulliver, 235.
Gun-metal, effect of casting temperature on, 156.
steel, 153.
GUNTRY, 111.
Guthrie, 39, 60, 77, 155, 220, 227, 232.
Guyton de Morveau, 132.

HADFIELD, R. A., 25, 95, 96, 97, 108, 149.
Hahn, 283.
Hallock, 59.
Hampe, 100.
Harbord, F. W., 36, 94, 99.
Hardening, 126, 127, 128.
by compression, 129.
of projectiles, 116.
of steel, 70.
Hardness, 17.
number, 18.
of alloys, 229.
Harker, 67.
Harmet, 82.
Harvey, 116.
Hatchett, 69, 100.
Hearth, 321, 323-326.
Heaton process, 314.
Heat-tinting, 215.
Heat units, 382.
Heats of formation of gaseous compounds, 396.
Helmholtz, 46.
Hempel, 184.
Henckel, 130.
Henderson process, 429.
Henning, 61.
Héroult furnace, 361-363.

Iron, crystallisation of, 37.
diffusion of carbon in, 57.
elements in, 58.
ductility of, 17.
effect of carbon on, 94, 95.
of low temperatures on, 25.
elasticity of, 22.
fluidity of, 37.
hardness of, 18.
malleability of, 17.
-manganese alloys, 227, 238.
occlusion of carbonic oxide by, 133.
of gas by, 48.
pig, 37.
price of, 460.
production of, 460.
pyrites, 296.
resistance of, 65.
strength of, 24, 26.
of electro deposited, 94.
Isomeric elements, heats of change of, 397.
Izod, 34, 35.

JAGGAR, 18.
Jameson coke-oven, 262.
Jamin, 36.
Japanese art metal-work, 45, 118-121.
Jars, 78.
Jenkins, H. C., 307.
Johnson, J. E., jun., 381.
Johoda, Stracho, 369.
Jones, Grenville, 331.
Joule, 14, 141.
Jude, 16, 33, 35.
Jullien, 142.
Jung, 369.

KARSTEN, 134.
Keep, 15, 17.
Keller, 100.
furnace, 361.
Kelvin, Lord, 41, 47.
Kemp, H., 64.
Kennedy, Prof., 19, 20, 26.
Kenward, 456.
Kernel-roasting, 55.
Kerpey, 264.
Kindling temperature, 247.
Kinetic energy, 387.
Kirchoff, 197.
Kirkaldy, 26, 35.
Kirwan, 131.
Kiu-shibū ichi, 119.
Kjellin furnace, 360, 361.
Koga, 79.
Kopp, 2.
Krafft, 61.
Krell, 369.
Kuromi, 120.

LANG, ANDREW, 454.
Langen, 333.
Langer, 438, 439.
Laplace, 132.
Lavoisier, 4, 131, 132.
Law, 19, 48.
Lead, contraction of, 15.
crystallisation of, 37.
density of, 15.
diffusion of gold and platinum
in, 50, 52, 53, 54, 55.
ductility of, 17.
effect of low temperatures on, 25.
of pressure on, 74.
fluidity of, 41, 42.
fracture of, 16.
hardness of, 18.
malleability of, 17.
oxidation of, 2, 3, 4, 5.
oxide, reduction of, by alumini-
um, 110.
price of, 462.
production of, 460.
resistance of, 65.
sonorous, 40, 41.
strength of, 26.
Lead alloys, 124.
-antimony alloys, 226, 233, 235,
236.
-gold alloys, 266, 233.
-silver alloys, 227.
-tin alloys, 227, 235.
Leadville, 335.
Lebasteur, 19.
Le Chatelier, A, 24.
H, 89, 99, 137, 143, 172, 175,
191, 192, 195, 205, 213, 388.
Ledebur, 24, 118, 140.
Lehmann, 59.
Lemery, 4, 40, 41, 129.
Lencauchez, 82.
Length of flame, 247.
Le Play, 56.
Leo XIII, 453.
Leroy-Beaulieu, 456.
Levol, 76, 78, 79.
Lignite, 246, 252, 253.
Lime, 295, 319.
roasting, 313.
Limiting point, 86.
Limit of elasticity, 19, 21, 31, 45.
of proportionality, 20.
Liquation, 76-83, 311.
-furnace, 354.
Liquid fuels, 255.
Liquidity, 37.
Lisbonne, 130.
Litharge, 4.
Lithium, density of, 14.
Lockyer, 155.

Lodge, Sir O., 89.
Longmaid's process, 429.
Longmuir, 156.
Low temperatures, effect of, on pro-
perties of alloys, 107, 108.
Lüdeking, 15.
Lully, 141.
Lupton, 69.
Lustre of metals, 36.
Lux gas-balance, 369.

MACARTHUR-FORREST process, 431.
M'Dougal furnace, 353.
M'Dermott, 431.
Macquer, 130.
M'William, 57, 58.
Magnesite, 317, 319.
Magnesium, resistance of, 65.
-aluminium alloys, 226.
-tin alloys, 238, 239.
Magnetic permeability, 63.
properties, 62-65.
properties of iron, loss of, on
heating, 150.
Magnetism, loss of, on heating, 64.
Magnus, 141.
Mahler, 384.
Maitland, 23.
Malleability, 16.
Mallet, 14, 101.
Manganese, effect of low temperatures
on, 25.
effect of, on iron, 149.
on sulphur in steel, 98.
influence of, on steels, 95.
-iron alloys, 227, 238.
sulphide in steel, 99.
steel, 149.
effect of low temperatures on, 108.
Manhès, Pierre, 357.
Margueritte, 133.
Marsden, 57.
Martens, Prof., 19, 210, 211.
Martensite, 136.
hardness of, 18.
Massick and Crookes stove, 378.
Matthey, E., 80.
Mathieson, 71, 72, 90.
Maxwell's theory, 148.
Maxwell, Clerk-, 152.
Mayer, 5.
Mayo, J., 4.
Mears, 431.
Mendeléeff, 104, 155, 396.
Mendeléeff's theory of solution, 78.
Merklein, 78.
Mercury, diffusion of metals in, 60.
Eck on oxide of, 3.
effect of, on tin, 47.
freezing of, 12.

Mercet, 61.
Merton furnace, 353.
Metallography, 210-245.
bibliography of, 240-245.
definition of, 210.
history of, 210.
microscopic, 212-220.
Metallurgical agents, 295-296.
processes, typical, 405-451.
Metals, flow of, 41-45.
immiscible, 86.
influence of foreign elements on
the properties of, 93-103.
price of, 460-463.
production of, 460.
specific heat of, 66.
thermal treatment of, 126-161.
Methods of increasing density, 14.
Meunier, 368.
Meyer, Lothar, 12, 104, 105, 387.
Victor, 394, 438.
Mhos, 68.
Microsclerometer, 18.
Microscope and its accessories, 215-
220.
use of the, 134.
Microscopic analysis, 228.
constitution of alloys, 212.
metallography, 212-220.
history of, 210.
plant, 216.
Mills, S. D., 379.
Millstone grit, 318.
Modulus of elasticity, 20.
Mohr, 73, 75.
Moissan, 111, 112, 113, 359.
Mokumé, 120.
Molecular change, 70, 143.
constitution of alloys, 72.
structure of metals, 12.
Moltenke, 64.
Mond, 438, 439, 440, 447.
producer, 284, 287-290.
Mond's nickel process, 311, 436-449.
Monge, 131.
Mouret, 387.
Moutier, 389.
Müller, 48.
Muntz metal, effect of annealing, 158.
effect of casting temperature on,
156.
tests of, at various temperatures,
105, 106, 107.
Musschenbroek, 70, 71.

NATURAL FUELS, 246, 250-257.
gas, 256.

Neilson, 374.
Nernst, 54, 382.
Neutral refractories, 319-321.
Neville, 39, 102.
Newlands, 104.
Newmann, 130.
Niccolai, 66, 90.
Nickel carbonyl, 311, 439.
 coinage, colour of, 118.
 ductility of, 17.
 effect of low temperatures on, 25.
 extraction by Mond process, 436-
 449.
 malleability of, 17.
ores, treatment of, by wet processes,
 433-436.
 resistance of, 65.
 uses of, 448.
Nickel and copper, separation of, 449.
Nickel-steel, density of, 117,
 effect of low temperatures on, 108.
plates, 116.
Nies, 15.
Nitrogen, 48.
Noble, 151.
Non-caking coals, 253, 254.
Nouel and Mesuré pyrometer, 199.

OBACH, 88.
Object of metallurgist, 452.
Objectives, 219.
Oblique illumination, 217.
Occlusion of carbonic oxide by iron,
 133.
 of gases, 47.
Odling, 5, 297.
O'Hara furnace, 348.
Oil-immersion lenses, 220.
Onchosimeter, 14, 15.
Onnes, 66.
Open-hearth furnace, 342, 344-346.
Optical pyrometry, 191-205.
Ore-hearth, 324.
Ores, 294.
Orford furnace, 337, 338.
Orientation, 13.
Osmium, density of, 14.
Osmond, 13, 21, 135, 136, 137, 138,
 139, 143, 145, 146, 148, 150,
 205, 211.
Osmondite, special note on, 161.
Osmotic pressure of solids, 54.
Ossan, B., 381.
Ostwald, 49, 226, 382.
Otto-Hilgenstock coke-oven, 265, 272,
 273.
Otto-Hoffman coke-oven, 265, 271,
 272.
Oxidation, 2-11.
Oxide of iron in steel, 48.

Oxidising agents, 313, 314.
 roast, 313.

PALLADIUM, occlusion of hydrogen
 by, 48.
 strength of, 25.
Palliser, Colonel, 114, 115.
Paracelsus, 3, 127.
Paramagnetic bodies, 62.
Parry, 81.
Pattinson process, 426.
Payment, modes of, 454-459.
Pearce, R., 413.
 turret, 348, 349.
Pearlite, 136.
 hardness of, 18.
Pease, Sir J., 454.
Peat, 246, 251.
Péclét, 367.
Peligot, 79.
Penetration of metals by mercury, 47.
Pepys, W. H., 133, 154.
Percy, J., 1, 93, 253.
Periodic law, 104.
Permanent magnetism, 64.
 set, 19.
Pernolet coke-oven, 261.
Person, 72.
Peters, 324.
Petroleum, 255, 256.
Pettus, Sir J., 69.
Pfeiffer, 369.
Phase rule, 239.
Phlogiston, 4, 5, 130.
Phrone, 76.
Phosphor-bronze, hardness of, 18.
 tests of, at various temperatures,
 105.
Phosphorus, effect of, on steel, 99.
Photo-micrographs, examples of, 184-
 189.
 preparation of, 213.
Photographic recorder of tempera-
 tures, 177.
Physical properties of metals, 12-68.
Picard, 109.
Pilz furnace, 335, 336, 337, 338.
Pimple metal, 411.
Pionchon, 143.
Pickling solutions, action of, on
 alloys, 119-120.
Pitch, 41.
Pitkin, Messrs, 176.
Pittsburg, 246.
Planck, 196.
Plasticity of clays, 318.
Plastic state of metals, 37.
Platinum, alloying of, with steel, 59.
 crystallisation of, 37.
 density of, 14.

Platinum, diffusion of, in lead, 53, 54.
 ductility of, 17.
 gold alloys, 227, 238.
 malleability of, 17.
 occlusion of hydrogen by, 47.
 purification of, 433.
 resistance of, 65.
 strength of, 25, 26.
 welding of, 59.
Plattner, 7.
Plattner's process, 430.
Pliny, 56, 128.
Plumbago crucibles, 320, 321.
Polish attack, 215.
Polishing, methods of, 213.
Polymerisation, 11.
Porter, 369.
Potassium cyanide, 316.
Potassium, volatilisation of, 62.
Potential energy, 5, 387,
Pot-roasting, 313.
Pouillet, 172, 192.
Prepared fuels, 246, 257-293.
Pressure, effect of, on recalcitrance
 points, 147.
Price of metals, 460-463.
Prinsep, 181.
Principles of pyrometers, classification
 of, 163, 164.
Processes, classification of, 311, 312.
Production of metals, 460.
Projectiles, 114, 116, 154.
Properties common to fluids and
 metals, 38.
 of eutectics, 233.
Puddling-furnace, 338, 340.
Purification of platinum, 433.
Puschin, 228.
Pyrometer, Le Chatelier's optical,
 192, 193.
 Carnelly and Burton, 168.
 Féry absorption, 195.
 radiation, 199.
 Nouel and Mesuré, 199.
 Siemens resistance, 168-170.
 water, 166, 167.
 thermo-electric, 172, 174-181.
 Wanner, 196.
 Uehling pneumatic, 185-191.
Pyrometers, optical, 191-205,
 principles of, 163.
 types of, 164.
Pyrometry, 162-209.
 bibliography of, 208-209.
 differential, 179-181.
QUENCHING, fluids, 129.
 in oil, 151.
 temperatures, effect of, 158.
Quincke, 438, 439.

RALEIGH, H., 302.
Ramsay, Sir W., 40.
Rankine, 248.
Raoult, 39.
Rarer metals, alloys of the, 109-111.
 effect of, on strength of metals,
 113.
 industrial use of, 114-117.
 reduction of, 109-111.
Raschette furnace, 333-335.
Rate of diffusion of carbon in iron,
 57.
Rayleigh, Lord, 111.
Réaumur, 39, 40, 41, 70, 129, 130,
 210.
Recalcitrance, 142, 145.
 points, effect of pressure on, 147.
Red-short, 17.
Reducing agents, 315, 316.
 roast, 313.
Reduction, 311.
 of area, 21.
 measurement of, 32.
 of rare metals, 109-111.
Refractory materials, 317-321.
Regulation, 45, 46.
Regenerative steel furnace, 344, 345.
Regnard, 48.
Regnault, 72.
Reiser, 154.
Relief-polishing, 215.
Résal, J., 19.
Residual magnetism, 64.
Resistance, electric, of alloys at low
 temperatures, 89, 90.
furnaces, 359, 360, 361-363.
of metals, 65.
and alloys, 72.
Retentivity, 64.
Retort-furnaces, 321.
Reuvens, 2.
Reverberatory furnaces, 321, 322,
 323, 338-353.
 development of, 342-343.
Revivication, 130.
Rey, J., 3.
Reynolds, O., 41.
Rhodium, loss of, on heating, 61.
Riemsdijk, Van, 39.
Riley, 115.
Rinman, 130, 131.
Roasting, 7, 312, 313.
 furnace, 339.
Roberts-Austen, 14, 49, 57, 59, 78,
 80, 89, 94, 104, 109, 118,
 162, 172, 177, 184, 192,
 206, 207, 232, 368, 436, 454.
Robinson, 82.
Rodger, 82.
Rodman, 207.

Roechling-Rodenhauser furnace, 360.
 Roessler, H., 388.
 Rose, T. K., 80, 431.
 Rose's alloy, hardness of, 18.
 Rosenhain, 13, 16, 213, 235.
 Rossignol, 2.
 Rothholz, 257.
 Rudberg, 72.
 Rumford's calorimeter, 248.
 SAHLIN, 371.
 Salt, 296, 316.
 solution, freezing of, 220-222.
 Sandberg, C. P., 96.
 Sand castings, 157.
 Saponification, 4.
 Sarco apparatus, 369.
 Sauveur, 136, 139, 146, 211.
 Savelsburg process, 313.
 Savot, 56.
 Schaumburg coke-ovens, 260.
 Scheurer-Kestner, 368.
 Schliemann, 2, 70.
 Seaton, 16, 33, 35.
 Seger, Dr H., 165.
 Segregation, 76-83.
 Selection of fluxes, 296.
 Semet-Solvay coke-oven, 264, 266, 267.
 Sexton, 319.
 Shaft-furnaces, 321, 322, 326-338.
Shaku-do, 119.
 Shells, Palliser, 115.
 Shepherd, 237.
Shibu-ichi, 119.
 Shrinkage curves, 15.
 Siegert, 369.
 Siemens, Sir W., 111, 163, 285, 342, 357, 364, 459.
 and Halske, 432.
 gas-producer, 285-287.
 resistance pyrometer, 168-170.
 water pyrometer, 166, 167.
 Silicate cotton, 299.
 Silicates, classification of, 297.
 Silicon, effect of, on aluminium, 109,
 influence of, on steel, 96, 97.
 steels, 117.
 Silver, absorption of oxygen by, 37, 47, 48.
 colour of, 36.
 crystallisation of, 37.
 density of, 15.
 diffusion of, in lead, 54.
 ductility of, 17.
 hardness of, 18.
 malleability of, 17.
 melting of, in electric furnace, 113.
 price of, 463.
 production of, 460.

Silver, resistance of, 65.
 strength of, 25, 26.
 surfusion of, 39.
 volatilisation of, 62.
 Silver-copper alloys, 227, 233.
 segregation in, 77-79.
 -gold alloys, 227.
 -lead alloys, 227.
 -tin alloys, 227, 233.
 -telluride, 229.
 Simmance-Abady combustion recorder, 369.
 Simon-Carvès coke-oven, 264, 265, 266.
 Simon, Jules, 457.
 Slag cement, 298.
 patches, 212.
 wool, 299.
 Slags, 296-299.
 classification of, 297.
 application of, 298, 299.
 Slip-bands, formation of, 213.
 Smelting of gold and silver ores, 413.
 Snelus, 81.
 Soaps, 4.
 Sodium, cyanide, 316.
 volatilisation of, 62.
 -tin alloys, 235.
 Solder, effect of low temperatures on, 107, 108.
 Solid solutions, 225, 226, 227, 234.
 Solution theory of alloys, 220-225.
 Solutions of metals in metals, 225, 226, 227.
 in metals in fluid state, 83-87.
 Sonorous lead, 40.
 Sorbite, 136.
 hardness of, 18.
 special note on, 161.
 Sorby, 134, 139, 210.
 Beck reflector, 217.
 Specific extension, 20.
 heat, 72
 of metals, 66.
 Spectroscopic work, 155.
 Spencer, J. W., 152.
 Speise, treatment of, 420, 424.
 Sphagnum, 251.
 Spiegeleisen, crystallisation of, 37.
 Spinning of metals, 45.
 Spring, Prof. W., 14, 46, 57, 59, 62, 72, 73, 76, 149.
 Stahl, 4, 130.
 Stansfield, 87, 184.
 Stanton, 36.
 Stassano furnace, 363, 364.
 Stead, 13, 19, 81, 83, 99, 211, 215, 218, 232.
 Steam-turbine blowing engines, 371, 373.

Steel, absorption of gases by, 37, 48.
 alloying of, with platinum, 59.
 brittleness of, 19, 36.
 cemented, 212.
 changes during cooling, 143-147.
 chrome, 117.
 classification of, 153-155.
 colour of, 36.
 ductility of, 94, 95.
 effect of arsenic on, 99.
 low temperatures on, 108.
 phosphorus on, 99.
 sulphur on, 97, 98, 99.
 elasticity of, 20, 22.
 for motor-car construction, 117.
 fracture of, 16.
 hardening of, 70.
 hardness of, 18.
 influence of manganese on, 95.
 silicon on, 96.
 internal constitution of, 130-150.
 magnetism of, 62.
 modes of existence and reactions of carbon in, 139.
 nickel, 117, 448.
 rails, 153.
 saturation point of carbon in, 95.
 strength of, 26.
 tenacity of, 94, 95.
 working of, 150-153.
 Stefan-Boltzmann radiation law, 201.
 Steinbart recording gauge, 186, 188-191.
 Stetefeldt furnace, 346, 347.
 Stodart, 59.
 Stokes, Sir G. G., 84.
 Strain, 20, 21.
 Strength of metals, 19, 24, 25.
 Stress, 20, 21.
 Strouhal, 143, 152, 154.
 Structure of eutectics, 233.
 Stubbs, 81.
 Sublimation, 311.
 Sudbury nickel ore, 437.
 Sulphating roast, 313.
 Sulphide of iron in steel, 99.
 Sulphur, allotropy of, 140.
 effect of, on copper, 100.
 effect on, of steel, 97, 98, 99.
 surfusion of, 39.
 Surface tension, 47.
 Surfusion, 39.
 TACHEN, O., 4, 129.
 Tait, Prof., 142, 172.
 Talbot, 81, 345.
 Tammann, 40, 227.
 Telluride of silver, 229.
 Temperature, effect of high, 24.
 effect of low, 25.

Temperature, effect of, on resistance of metals, 65.
 on strength of alloys, 105-108.
 indicator, Whipple, 170.
 influence of, on specific heat, 66.
 of casting, effect of, on strength of alloys, 156.
 of kindling, 247.
 recorder, Callendar, 170-173.
 Tempering, 126, 127.
 colours, 154.
 Tenacity, 17, 71.
 of carbon steels, 94, 95.
 Tensile strength, 21.
 Test pieces, 32.
 gauging of, 31.
 Testing machines, 26-30.
 Tests, details of, 31.
 Thallium-gold alloys, 228, 233, 235.
 Theophilus, 128.
 Thermal analysis, 227.
 equations, 391-396.
 treatment of industrial alloys, 156-159.
 of metals, 126-161.
 of steel, bibliography of, 159-161.
 units, 382.
 Thermo-chemistry, 382-404.
 Thermo-electric couple, 143.
 pyrometers, 172, 174-181.
 Thompson, 83.
 Thomsen, Julius, 382.
 Thread recorder, 177-179.
 Tilden, 66.
 Tillet, 4.
 Tin, contraction of, 15.
 crystallisation of, 37.
 density of, 15.
 ductility of, 17.
 effect of pressure on, 74.
 low temperatures on, 25.
 mercury on, 47.
 hardness of, 18.
 malleability of, 17.
 price of, 462.
 production of, 460.
 sound emitted by, 38.
 strength of, 26.
 surfusion of, 39.
 Tin alloys, 124.
 -copper alloys, 100-102.
 -lead alloys, 227, 235.
 -magnesium alloys, 238, 239.
 -silver alloys, 227, 233.
 -sodium alloys, 235.
 Toughness, 17.
 Traces of matter, effect of, 6, 13.
 Treatment, thermal, of metals, 126-161.

- Tresea, 41, 43, 44.
 Tressider, Captain, 116.
 Trismosin, 141.
 Troost, 5, 47, 136, 181.
 Troostite, 136.
 hardness of, 18.
 special note on, 161.
 Tropenas converter, 356.
 Truran, 333.
 Tube furnace, 354.
 Tucker, 99.
 Tungsten, effect of, on iron, 150.
 Turner, Prof. T., 15, 17, 36, 97.
 Tyndall, 46.

 UEHLING pneumatic pyrometer, 185-191.
 -Steinhardt gas composimeter, 369.
 Union of metals by compression, 73-76.
 by electro-deposition, 76.
 by fusion, 73.
 Unwin, Prof., 18, 19, 20, 21, 105, 106.
 Unreal alloys, 84.

 VACUUM filter presses, 432.
 Vandermonde, 131.
 Van't Hoff, 54, 386.
 Vaporisation, 61.
 Vautin, 109.
 Vertical illumination, 217.
 Viole, 57, 192.
 Virchow, 70.
 Volatility of metals, 61.
 Von Bauer coke-oven, 265, 275-280.
 Von Hoff, 333.

 WAHLBERG, 17, 94, 95, 97.
 Waidner, 201.
 Wanner optical pyrometer, 196.
 Washoe furnace, 337, 338.
 Waste gases, use of, 328, 329.
 Water, freezing of, 38, 39.
 -gas, 290-293.
 -jackets, 333, 335.
 Wax, flow of, 41.
 Webb, 153.
 Wedding, 211.
 Wedgwood, Josiah, 162, 163.
 Welding, 37, 55, 149.
 Wellman furnace, 345.
 Wells, W. A., 460.
 Welsh method of copper smelting, 408-413.
 Werder testing machine, 26.
- Werth, 211.
 Westover, 369.
 Wet processes, for treating argenti-ferous copper ores, 427.
 of extraction, 312.
 Weyl, 215.
 Wheeler, 284.
 Whipple, 164.
 temperature indicator, 170.
 White iron, contraction of, 15.
 metal, 411.
 Whitwell stove, 377.
 Whitworth, 82.
 Wiborgh, 184.
 Wicksteed testing machine, 27, 28, 29, 30.
 Wiedemann, 72.
 Wien, 196, 198.
 Wien's formula, 197.
 Williamson, 458.
 Wilson, Carus, 21.
 gas-producer, 286-288.
 Wingham, A., 311.
 Winkelmann, 15.
 Winkler, 109.
 Wogan, 60.
 Wöhler, 109.
 Wood, 246, 250, 251.
 Working of steel, 150-153.
 Wright, C. R. A., 83, 87.
 Wrightson, T., 14, 46, 142.
 Wurtz, 5.
- YOUNG's modulus, 20.
- ZEISS, 215, 219.
 Zenghelio, 62.
 Ziervogel's process, 7-11, 312, 428.
- Zinc, brittleness of, 17.
 colour of, 36.
 contraction of, 15.
 crystallisation of, 37.
 density of, 15.
 ductility of, 17.
 effect of aluminium on, 109, 110.
 of pressure on, 74.
 hardness of, 18.
 malleability of, 17.
 prevention of oxidation by alu-minium, 388.
 production of, 460.
 separation of, from lead, 77.
 sound emitted by, 38.
 volatilisation of, 62.
- Zinc-alloys, 124.
 aluminium alloys, 233, 237.
 -cadmium alloys, 226, 233.

1

SIBLIOTECA

CAPILLA ALFONSINA

U. A. N. L.

Esta publicación deberá ser devuelta
antes de la última fecha abajo indi-
cada.

DEVUELTO
DEVUELTO
DEVUELTO
RECIBIDO

127456
TN665
R64
1910

AUTOR

127456

