

# METALLURGICAL ABSTRACTS

(GENERAL AND NON-FERROUS)

Volume 4

AUGUST 1937

Part 8

## I.—PROPERTIES OF METALS

(Continued from pp. 277-283.)

**The Problem of the Elimination of Gaseous Impurities from Aluminium.** Georges Chaudron (*Found. Trade J.*, 1937, 56, (1087), 509-510, 516; also *Met. Ind. (Lond.)*, 1937, 50, (24), 655-658; and *Aluminium and the Non-Ferrous Rev.*, 1937, 2, (8), 287-290).—See also *Met. Abs.*, this vol., p. 277. French Exchange Paper to the Institute of British Foundrymen. C.'s vacuum discharge method for extracting gases from metals is briefly described, and the results (in the case of aluminium) are compared with those obtained by the vacuum extraction and industrial methods of degasification. It is shown that, although such methods as bubbling chlorine through the molten metal prevent it from exhibiting blowholes after solidification *in vacuo*, there is still a large amount of gas dissolved or occluded in it. Experiments on melting conditions showed that overheating is to be avoided and that the gases of combustion should be kept away from the molten metal.—H. W. G. H.

**\*Mechanical Properties and Micro-Deformation of Single and Multi-Crystalline Specimens of Aluminium.** G. Welter (*Internat. Assoc. Test. Mat. Congr. London, 1937*, Advance Proof, Group A, 112-115).—[In German.] The elastic limits at 0.001% and 0.01% permanent extension, the yield-point at 0.2% permanent extension, and the modulus of elasticity were measured for single crystals of aluminium. In the production of the single crystals from polycrystalline rods, it was established that the purity of the aluminium has an important influence on the form and orientation of the single crystals, and therefore on the mechanical properties of the specimens. In aluminium of 99.8% purity the crystal boundaries are almost always perpendicular to the axis of the rod, while in 99.5% pure aluminium they are normally parallel to the axis of the rod. The percentage extension in a stretched multi-crystalline rod is least at the crystal boundaries.—P. W. R.

**\*Photoelectric Measurements Relating to Metallic Antimony.** V. Middel (*Z. Physik*, 1937, 105, (5/6), 358-377).—An experimental investigation of the photoelectric properties of thin films of antimony is presented.—J. S. G. T.

**\*The Scattering of X-Rays by Conducting Electrons in Beryllium.** W. Scharwächter (*Physikal. Z.*, 1937, 38, (6), 165-176).—Experimental evidence of incoherent scattering of X-rays by beryllium of 98-99.97% purity, in accordance with Debye's theory (see *Met. Abs.*, this vol., p. 324) is presented. The results indicate that in metallic beryllium both electrons in the (2, 0) condition are "free" in the sense contemplated by Debye. The contribution by the two (1, 0) electrons to the scattering effect is less than that anticipated from the theory, but this is probably attributable to neglect of the mutual interaction of these electrons in the theory. It is concluded that incoherent scattering affords a means for investigating the electronic states in metals.—J. S. G. T.

**\*Investigations on Bismuth Single Crystals. IV.—Change of Thermoelectric Power in the Transition from a Transverse to a Longitudinal Magnetic Field.** E. Grüneisen and J. Gielessen (*Ann. Physik*, 1937, [v], 29, (1), 25-32).—The influence of magnetic fields on the thermoelectric power of bismuth crystals

\* Denotes a paper describing the results of original research.

† Denotes a first-class critical review.

varies with the orientation of the crystal to the magnetic flux; values are determined for various orientations (see also *Met. Abs.*, this vol., p. 129).—v. G.

\***Magnetic Analysis of Evaporated Bismuth Deposits.** C. T. Lane (*Phys. Rev.*, 1937, [ii], 51, (10), 863-869).—The magnetic susceptibility of evaporated bismuth films, of thickness from  $0.1 \mu$  to  $4 \mu$ , was measured by a compensated Gouy method in conjunction with a microbalance. Films  $> 0.5 \mu$  in thickness have a susceptibility almost independent of film thickness, and nearly equal to that of a single crystal with trigonal axis parallel to the field. The susceptibility of these films is not affected by ageing in a vacuum at room temperatures, and is independent of the rate at which the film is deposited, and of the nature of the supporting material; films on glass, copper, gold, and tin were studied. With films  $< 0.5 \mu$  in thickness, the susceptibility decreases as the film becomes thinner; the susceptibility of these films increases on ageing. The effects of the presence of gases during deposition were studied. The general conclusion is that films  $< 0.5 \mu$  in thickness possess a microcrystalline film structure which merges into a phase of macrocrystalline structure above this thickness. From microscopic examination Goetz, Stierstadt, and Focke (*Met. Abs.*, 1936, 3, 29) concluded that films of this kind consisted of an outer layer of large oriented crystals on an inner layer of "amorphous" or microcrystalline material about  $100 \mu$  in thickness; there is a wide discrepancy as to the thickness of the inner layer.—W. H.-R.

\***The So-Called "Transition Temperature" of Metallic Films [Cadmium].** Tadao Fukuroi (*Nature*, 1937, 139, (3525), 884).—Curves relating the electrical resistance with temperature are given for thin films of cadmium condensed on glass. A large drop in resistance is shown to take place at the "transition temperature," which varies with the thickness of the film. The ratio of transition temperature at zero thickness to the melting point is shown to be approximately the same for zinc, cadmium, magnesium, and antimony.—B. C.

\***Vapour Pressure of Cæsium by the Positive Ion Method.** John Bradshaw Taylor and Irving Langmuir (*Phys. Rev.*, 1937, [ii], 51, (9), 753-760).—The vapour pressure of cæsium was measured by a positive ion method, in which the positive ion currents from pure tungsten filaments in cæsium vapour at bulb temperatures from  $-35^\circ$  to  $+73^\circ$  C. were measured for filament temperatures from  $1000^\circ$  to  $1800^\circ$  K. The principles of the method are discussed. The vapour pressures in mm. of mercury are given by the equations: solid cæsium ( $T < 302^\circ$  K.),  $\log_{10} p_s = 10.5460 - 1.00 \log_{10} T - 4150/T$ ; liquid cæsium ( $T > 302^\circ$  K.),  $\log_{10} p_l = 11.0531 - 1.35 \log_{10} T - 4041/T$ . These equations give results which are probably accurate to within 1% from  $220^\circ$  to  $350^\circ$  K., within 3% up to  $600^\circ$ , and within about 8% at  $1000^\circ$  K.—W. H.-R.

\***Photoelectric Phenomena of Thin [Cæsium and Rubidium] Films.** R. A. Hull (*Abstracts Dissertations Dr. Phil. Univ. Oxford*, 1937, 9, 123-124).—The effect of passing light through very thin films of cæsium and rubidium was investigated. The results showed that a single cæsium film has a yield of about 0.04 microamp. per lumen of incident light, and absorbs about 1% of this light. Experiments using two cells showed that the light is still photoelectrically active after passing through one cell; it is merely reduced in intensity by the reflection and absorption losses in this first one. The results indicate that a multiple cell consisting of a number of thin semi-transparent films is less efficient than a simple cell using a sensitized film on an opaque base.—C. E. R.

\***Mechanical Properties of Hard-Drawn Copper Wire under Continuous Loading at Elevated Temperature.** V. Jareš and L. Jeníček (*Internat. Assoc. Test. Mat. Congr. London*, 1937, Advance Proof, Group A, 17-20).—[In German.] A study was made of the softening at elevated temperatures of hard-drawn wires of electrolytic copper, with particular reference to the time factor. Hard and semi-hard wires of 5 mm. diameter were heated (unloaded)

for periods of from  $\frac{1}{4}$  to 256 hrs. at temperatures varying from 175° to 400° C., and were then tested to fracture at room temperature. Above 275° C. softening was almost complete after heating for  $\frac{1}{4}$  hr.; below 275° C. the softening depends widely on the duration of heating, and is attained after sufficiently long heating even at 175° C., the softening occurring slightly more rapidly in the harder wires. It is remarkable that the modulus of elasticity does not begin to change until considerable softening has occurred. The softening is accelerated by even a small continuous loading during the annealing process. Above 250° C. the wires begin to flow under the continuous loading, the critical temperature being sharply defined and corresponding with the equicohesive temperature.—P. W. R.

**\*Stress-Strain Characteristics of Copper, Silver, and Gold.** J. McKeown and O. F. Hudson (*J. Inst. Metals*, 1937, 60, 109–130; discussion, 130–132).—A study was made of the stress-strain characteristics of gold and silver of a very high degree of purity, and also of two coppers, one oxygen-free but containing a small amount of silver (about 0.003%), the other containing 0.016% oxygen but free from silver, both having little more than traces of other impurities. Stress-strain curves were obtained to determine limit of proportionality, 0.01% proof stress, and Young's modulus. The materials were tested in the fully-softened condition, after slight tensile overstrain (less than 1%) and after definite larger amounts of tensile overstrain (5–15%), and after re-heating the overstrained specimens at different temperatures. It is generally considered that copper in the fully-annealed condition has no elastic limit, and the present tests have shown, as was expected, that pure gold and pure silver, when fully annealed, also show no proportionality of stress to strain in any part of the stress-strain diagram. The elastic properties induced by cold-working were retained in large measure in all three metals after re-heating for short periods at moderately elevated temperatures, when the amount of cold-working (tensile overstrain) had been small. Low-temperature annealing, as used in the tests described, did not, however, result in raising the limit of proportionality of pure gold and silver and of oxygen-free and oxygen-containing coppers, to the same extent as in other cases, e.g. other kinds of copper (O. F. Hudson, T. M. Herbert, F. E. Ball and E. H. Bucknall, *J. Inst. Metals*, 1929, 42, 221; O. F. Hudson and J. McKeown, *J. Inst. Metals*, 1932, 48, 69). The tests have shown that, when any of the metals, fine gold, fine silver, oxygen-free and oxygen-containing coppers, has been subjected to a small tensile overstrain, the effect of this small overstrain is evident in the stress-strain characteristics, even after re-heating to relatively high temperatures. The tests have shown that the value of Young's modulus ( $E$ ) for this oxygen-free copper is decreased by a small (5%) tensile overstrain to  $15.7 \times 10^6$  lb./in.<sup>2</sup> (mean value). Larger amounts of overstrain appear to result in a recovery in the value of  $E$ , with 15% overstrain, the value of  $E$  found being  $17.6 \times 10^6$  lb./in.<sup>2</sup>. This is in agreement with the results of Kawai's previous work (*J. Inst. Metals*, 1930, 44, 468). Annealing of the overstrained copper tended to restore the value of  $E$  lowered by previous overstrain, and by suitable treatment a value of  $18.2 \times 10^6$  lb./in.<sup>2</sup> was obtained. Similar effects of re-heating after overstrain were found in the cases of fine gold and of fine silver, although the raising of the modulus by heat-treatment was less marked than in the case of copper. Gold, which had a value of  $E$  of  $10.3 \times 10^6$  lb./in.<sup>2</sup> when overstrained 5%, gave  $11.3 \times 10^6$  lb./in.<sup>2</sup> when re-heated for  $\frac{1}{4}$  hr. at 300° C.—J. McK.

**\*A Study in the Metallography and Mechanical Properties of Lead.** Brinley Jones (*J. Inst. Metals*, 1937, 60, 187–196; discussion, 196–200).—Reference is made to the tendencies to structural change in rolled lead at ordinary temperatures, and it is stated that mechanical tests can have little significance unless these changes can be controlled or prevented. Experiments dealing with the relationship between deformation, grain-growth, and recrystallization

in "as rolled" structures are described, and it is shown that grain growth develops as a result of the critical straining of very refined "as rolled" structures. Lead of "medium" refinement is found to be immune from grain-growth and to be affected only by strains severe enough to cause recrystallization. The structures which result from grain-growth and recrystallization, respectively, after rolling, are shown to be different in type. In the former, the grains are well defined, infrequently twinned, and often associated with inter-crystalline cracking; in the latter they are confused and repeatedly twinned. Heavily twinned, recrystallized structures have been found, from experience, to be desirable, and reference is made to large-scale experiments dealing with the production, on a commercial basis, of sheets having such structures.—B. J.

**\*Creep of Lead and Lead Alloys. I.—Creep of Virgin Lead.** J. McKeown (*J. Inst. Metals*, 1937, 60, 201–222; discussion, 223–228).—Tensile creep tests have been made on specimens of virgin lead in the form of extruded rod, extruded pipe, and extruded cable-sheath. The tests on rod have been made at room temperature and at 80° C., while the tests on pipe and cable-sheath have been made at room temperature only. The effect on the minimum creep rate of the working produced in flattening cable-sheath and in bending and straightening pipes has been investigated, and this effect has been found to be very marked. It has been shown that results obtained from worked samples may give an erroneous impression of the creep characteristics of the unworked, extruded product. In the extruded products the effect of initial grain-size on the minimum creep rate has been investigated, and it has been shown that in extruded virgin lead the larger the initial grain-size the higher the resistance to creep at low stresses.—J. McK.

**\*A Partition Function for Liquid Mercury.** John F. Kincaid and Henry Eyring (*J. Chem. Physics*, 1937, 5, (7), 587–596).—From a model for liquid mercury, a partition function has been formulated of sufficient generality to give, by means of the usual statistical mechanical equations, the vapour pressure, equation of state, entropy of melting, and specific heats. The partition function involves 4 parameters characterizing the particular substance concerned. Having chosen these parameters for mercury, it is possible to calculate all the properties mentioned above from the melting point to the boiling point within experimental error, except for a slight divergence of about 2% (0.1 cal./mole/degree) in the specific heat at the melting point. The van der Waals' constants follow from the theory, and when employed in his equation give satisfactory agreement between calculated and observed critical properties. The long liquid range, low melting point, and low viscosity of metals are all in agreement with the authors' model, in which it is assumed that in the liquid the kernels move independently of their valence electrons.—S. G.

**\*The Diffusion of Hydrogen through Nickel and Iron.** W. R. Ham (*Trans. Amer. Soc. Metals*, 1937, 25, (2), 536–564; discussion, 564–570).—H. develops, on the basis of classical thermodynamic and kinetic theory, a diffusion equation of the form  $D = AP_0^y e^{-B/T}$ , where the pressure exponent  $y$  is 0.5 for pure metals, but may be greater than this if impurities are present. Measurements of the rates of diffusion of hydrogen through relatively pure nickel and iron show that the slope of the isotherms is appreciably increased by the presence of nitrogen or carbon in solution, and the increase in slope appears to be approximately proportional to the amount of these elements present. The linear relation between  $\log D$  (diffusion rate) and  $1/T$  is found to hold accurately, except in the region of phase or electronic changes. When such changes occur there is a marked alteration in the slope of the isobar. The magnetic changes at 360° C., in nickel, and 750° C. in iron, are clearly defined by diffusion data. In addition, iron exhibits changes in the isobars at 945°, 900°, and at between 200° and 350° C. A definite difference in temperature is observed between  $A_{r_2}$  and  $A_{c_3}$ , and this appears to be a true hysteresis. The other points are

ascribed to electronic changes of the iron atom, and it is suggested that the well-known maximum in the tensile value of iron at 200°–350° C. is explained in part by one of these electronic shifts.—C. E. R.

**Magnetic Anisotropy in Iron and Nickel Single Crystals.** H. Schlechtweg (*Ann. Physik*, 1936, [v], 27, (7), 573–596).—It is shown that two groups of equations may be employed in research on magnetism of high field strength. Further, it is shown that, in general, a single crystal disc suspended in a magnetic field with its surface parallel to the field, undergoes, at points where equilibrium becomes unstable, an intermittently variable turning moment; an asymptotic formula is given for the turning moment in very powerful fields.

—E. J. G.

**\*On the Change in the Electrical Resistance of Hard-Drawn Platinum on Tempering.** W. Meissner (*Ann. Physik*, 1937, [v], 29, (3/4), 264–272).—The electrical resistance of very pure platinum is increased by 0.14% by drawing, but during storage at room temperature it slowly decreases again. On heating at 700°–900° C., the resistance rapidly reverts to its normal value; at 1100°–1250° C. recovery is practically instantaneous, but on prolonged heating in this range the resistance again slowly increases.—v. G.

**The Effect of Slow Positive Potassium Ions on Metallic Surfaces.** Werner Brummack (*Z. Physik*, 1937, 105, (7–8), 368–369).—The incidence of slow positive potassium ions is found to render the surfaces of metals, e.g. silver, zinc, aluminium, tin, copper, brass, Elektron, silver, and gold, passive against the action of mercury, iodine, and hydrochloric acid vapours.—J. S. G. T.

**\*On the Viscosity of Liquid Selenium.** S. Dobiński and J. Wesolowski (*Bull. Internat. Acad. polonaise Sci.*, 1937, [A], (1/2), 7–14).—[In English.] Between 215.7° and 345.8° C. the viscosity ( $\eta$ ) of liquid selenium is given by the expression:  $\eta = 12.4 \cdot 10^{-6} \cdot v^{-1/3} \cdot e^{\frac{1700}{vT}}$ , where  $v$  is the specific volume and  $T$

the absolute temperature. The curve shows no anomalies such as occur in the temperature-electrical conductivity curve. Considerable molecular association in molten selenium is indicated by the results.—A. R. P.

**Supplement to my Photoelectric and Optical Measurements relating to Silver, Zinc, and Fuchsin.** Franz Hlučka (*Z. Physik*, 1937, 104, (9–10), 653–657).—In continuation of previous work (*Z. Physik*, 1935, 96, 230; 1936, 103, 237, 246), data are given relating to the dispersion curves of zinc (300–700 m $\mu$ ) and silver (0.2–4  $\mu$ ).—J. S. G. T.

**\*On the Specific Resistance of Tellurium.** E. Schmid and F. Staffelbach (*Ann. Physik*, 1937, [v], 29, (3/4), 273–278).—The resistance of single crystals of tellurium perpendicular to and parallel to the principal trigonal axis is 0.061 and 0.028 ohm. cm., respectively.—v. G.

**The Resonance Capture of Slow Neutrons by Tungsten Nuclei, and the Form of the Effective Resonance Level.** Rudolf Jaeckel (*Z. Physik*, 1937, 104, (11/12), 762–778).—Tungsten is shown to possess a resonance level for the absorption or capture of slow neutrons. The absorption coeff. of tungsten for C-neutrons has the value 0.1 cm.<sup>2</sup>/gram.—J. S. G. T.

**Anomalous Expansion of Zinc and Cadmium near the Melting Point.** W. F. Hachkovsky and P. G. Strelkov (*Nature*, 1937, 139, (3521), 715–716).—It is shown that zinc and cadmium single crystals share the property of bismuth (Roberts, *J. Inst. Metals*, 1925, 33, 298) of a change of coeff. of expansion close to the melting point. It is also shown that this change of coeff. is of the same sign as the change of volume on melting.—B. C.

†**The Flow of Metals.** E. N. da C. Andrade (*J. Inst. Metals*, 1937, 60, 427–445).—Twenty-Seventh May Lecture. Flow is most easily observed in the liquid state, but the structure of the liquid state is still obscure. Nevertheless it is possible on simple lines to formulate a theory of liquid viscosity, which both gives the observed viscosity of simple liquids and accounts for the tem-

perature variation. In this connection viscosity of liquid metals is important, on account of the simplicity of the molecular state. The flow of solids is best observed in single crystals of metals. Certain general laws have been formulated, from which it is clear that the velocity of flow is of fundamental significance. The perfect crystal lattice does not offer a basis for any theory of the flow of solids: the only successful attempts to construct a mechanism to explain plastic behaviour are based on the assumption of flaws, or dislocations, in the lattice, which are propagated along preferential directions when external stresses are applied. Thermal fluctuations must also be invoked. Further investigation of the nature of the inherent flaws is of importance, not only for physical theory but also for metallurgical practice.—Author.

**Plastic Deformation.** E. Siebel (*Internat. Assoc. Test. Mat. Congr. London, 1937, Advance Proof, Group A, 131-133*).—[In German.]—P. W. R.

**Absorption of Strain Energy in Metals.** N. A. de Bruyne (*Nature, 1937, 139, (3518), 633*).—de B. points out the existence of an approximately linear relation between the logarithm of  $\phi$ , the ratio of energy stored to energy absorbed in a strained metal, and the Debye temperature  $\theta$ . A suggested explanation is that the process of absorption is due to scattering of strain energy by atoms or molecules vibrating at the Debye frequency.—B. C.

**\*Calculation of Various Physical Constants of Heterogeneous Substances. III.—The Elastic Constants of Quasi-isotropic Aggregates of Isotropic Substances.** D. A. G. Bruggeman (*Ann. Physik, 1937, [v], 29, (2), 160-178*).—Expressions are derived for calculating the elastic constants of polycrystalline bodies from those of single crystals of the same substance.—v. G.

**\*The Effect of Surface Stress on the Wear of Metals.** N. Sawin (*Machinery (Lond.), 1937, 50, (1282), 165-167*).—In the Škoda-Sawin wear-testing machine, a rotating disc of cemented carbide, 30 mm. in diam., is held at constant pressure against the test-piece, lubricant being supplied to remove worn metal. The volume of metal worn away is determined by measuring the length of the impression. Wear tests on steels are described which show that no relationship exists between hardness and wear-resistance, and that internal stresses in the surface layers produced by hardening, grinding, and polishing cause wear to be more rapid.—J. C. C.

**Permeability of Metals to Hydrogen.** C. J. Smithells (*Nature, 1937, 139, (3530), 1113*).—It is shown that, whereas the rates of diffusion of hydrogen in different metals differ by a very large amount at room temperature, the values are very similar at 1000° C., those for iron, nickel, molybdenum, platinum, and copper differing by less than a factor of 10 at this temperature. It is suggested that iron vessels used for high pressure work should be lined with a thin layer of one of the less permeable metals.—B. C.

**The Optics of Thin Metal Films.** H. Wolter (*Z. Physik, 1937, 105, (5-6), 269*).—A method of determining the optical constants,  $n$  and  $k$ , of thin metal films from intensity measurements is developed and illustrated. The method is applicable to the determination of the thickness of thin metallic films.

—J. S. G. T.

**A Photo-Electric Method for the Measurement of the Optical Constants of Metals.** J. Bor (*Nature, 1937, 139, (3521), 716-717*).—A photoelectric method is described for analyzing the elliptically polarized light reflected from metal surfaces in determinations of their optical constants. A compensating method which eliminates the effect of a fluctuating light source is also mentioned.

—B. C.

**\*Definition of the "Curie Point."** A. Kussmann and A. Schulze (*Physikal. Z., 1937, 38, (2), 42-47*).—The Curie point of a substance is customarily defined as that temperature at which the ferromagnetism of the substances vanishes, or, alternatively, that temperature at which the spontaneous magnetization of the material in zero field is nil. Other definitions have been employed in

recent years. It is now shown, by experimental results obtained with nickel and alloys of nickel with copper, chromium, silicon, tungsten, aluminium, cobalt, and iron, that (1) the Curie point is *not* identical with that temperature at which the temperature coeff. of electrical resistance of the material attains its maximum value, (2) the Curie point of an absolutely homogeneous material is a sharply-defined temperature and not, as nowadays commonly assumed, a region of temperatures.—J. S. G. T.

**\*Transverse Thermoelectric Power in Single Crystals.** H. Reddemann (*Ann. Physik*, 1937, [v], 29, (3/4), 286–296).—When a strong current of heat is passed through a bismuth crystal, a small e.m.f. is set up in a direction perpendicular to the direction of heat travel; the magnitude of this effect agrees closely with that calculated theoretically.—v. G.

**The Normal Cathode Fall [of Potential] at Single-Crystal Surfaces of Various Orientations.** Herbert Kurzke (*Z. Physik*, 1937, 104, 735–743).—It is established experimentally that the normal cathode fall of potential in a discharge tube depends on the orientation of the single-crystal cathode used. Thus the difference in the cathode fall at the (111) and (1 $\bar{1}\bar{1}$ ) planes of a bismuth single-crystal is of the order 3–4 v, that at the former planes being the lower.

—J. S. G. T.

**Conduction of Electricity in Solids.** N. F. Mott (*Nature*, 1937, 139, (3527), 951–954).—Lecture to the Royal Institution. A very brief outline is given of the application of the quantum mechanics to the theory of the electrical conductivity of metals. The experimental evidence concerning the number of conduction electrons per atom is outlined and an explanation of the electrical resistance of metals is given in terms of the scattering of electron waves by the atoms of a metallic crystal. The resistance of alloys is considered, and is shown to be due to the scattering effect of impurity atoms in the lattice. The phenomenon of photoconductivity of some insulators is also discussed.—B. C.

**Remanence in Single Crystals.** K. J. Sixtus (*Phys. Rev.*, 1937, [ii], 51, (9), 780).—A note. Experiments with a single crystal ring of silicon steel shows that the true remanence in single crystals is not zero. The results do not afford a direct confirmation of the formula of Kaya (*Z. Physik*, 1933, 84, 705), but are consistent with the formula.—W. H.-R.

**\*Galvanomagnetic Phenomena in Thin Metallic Pellicles.** C. Bellina (*Nuovo cimento*, 1936, 13, 441–450; *Sci. Abs.*, 1937, [A], 40, 529).—Thin pellicles of bismuth, obtained by cathodic sputtering, were investigated, and it was found that, contrary to that which occurs in relatively thick sheets obtained by fusion, in the pellicles the electrical resistance and the coeff. of the Hall effect do not change on variation of the magnetic field. Moreover, pellicles of antimony, tellurium, and nickel were found not to show any variation of electrical resistance through the action of the magnetic field. These phenomena must be attributed to the amorphous condition of the pellicles, because, on remelting the pellicles of bismuth so as to reduce them to the crystalline state, it was observed that both the increase of resistance through action of the magnetic field and the variation of the coeff. of the Hall effect were altered by the field. The results are discussed on the basis of the electronic theory of metals.—S. G.

**†Explorations in the Supraconducting State.** Francis B. Silsbee (*J. Wash. Acad. Sci.*, 1937, 27, (6), 225–244).—Presidential Address. Phenomena associated with the supraconducting state of metals and alloys at temperatures attainable with liquid helium are very interestingly presented. The paper is concerned mainly with magnetic effects, and includes some speculative suggestions by the author. A bibliography of 33 references is given.—J. S. G. T.

**Supraconductivity.** Kurt Mendelssohn (*Phys. Rev.*, 1937, [ii], 51, (9), 781).—A note. The theory of Slater (*Met. Abs.*, this vol., p. 134) is criticized. (a) The electronic specific heat of metals is expressed by Sommerfeld in the form  $c = AT$ . Tantalum and niobium have high  $A$  values, but nevertheless become

supraconductive at comparatively high temperatures. It is unjustifiable, therefore, to conclude that a high  $A$  value diminishes the tendency for a metal to become a superconductor. (b) The magnetic effects at the transition in an external field cannot be explained by persistent currents. Such an explanation holds for the transition from the supraconductive to the normal state, but not for the inverse. (c) Magnesium, on which Slater illustrated his theory, has been found to be non-supraconductive down to very low temperatures ( $0.05^\circ$  K.).—W. H. R.

**\*Structure of the Electron and Superconduction.** J. Stark (*Physikal. Z.*, 1937, 38, (8), 269–276).—The free electron in metals is conceived as possessing the form of a superconducting ring devoid of resistance, possessing an axial structure and a magnetic "eigen"-moment. A number of problems relating to the superconducting state are discussed.—J. S. G. T.

**\*Experiments Carried out in order to Explain Magnetic Induction in Superconductors [Tin; Tin-Cadmium].** J. Stark and K. Steiner (*Physikal. Z.*, 1937, 38, (8), 277–283).—Magnetic induction in superconducting rods and cylindrical annuli of tin (polycrystalline and single-crystal), tin-cadmium alloy containing 1% of cadmium, is investigated experimentally in both homogeneous longitudinal, and circular magnetic fields. The experiments and results require extension before the theory of electronic structure proposed by Stark (preceding abstract) can be considered established in all respects.

—J. S. G. T.

**Thermo-E.m.f. of a Superconductor Against the Same Metal in the Non-Superconductive State.** J. A. Kok (*Physica*, 1937, 4, (4), 276–278; and *Comm. K. Onnes Lab. Leiden, Suppl. No. 84a*).—[In English.] K. points out the similarity of Gorter's cycle and a thermoelectric cycle, consisting of one metal, partially in the supraconductive and partially in the non-supraconductive state. From a plausible assumption, relations are derived for the thermoelectric properties.—S. G.

**\*Electrical Conductivity of a Superconducting [Tin] Sphere in the Intermediate State.** L. Shubnikov and I. Nakhutin (*Nature*, 1937, 139, (3518), 589–590).—Experiments on a single crystal of tin of spherical shape show that in the intermediate state the supraconductivity is anisotropic, and that when the direction of the current is the same as the field direction, supraconductivity persists right up to the field strength  $H_K$ .—B. C.

**Superconductors of small Dimensions [Lead].** R. B. Pontius (*Nature*, 1937, 139, (3529), 1065–1066).—A graph is given showing the relation between the threshold field and diameter for fine lead wires at  $4.21^\circ$  K. It is shown that the size of the wire influences the supraconductivity threshold, and the results indicate a depth of penetration of a magnetic field in a superconductor as  $10^{-5}$ – $10^{-6}$  cm.—B. C.

**\*The Investigation of Free Electrons in Metals by Means of X-Rays.** P. Debye (*Physikal. Z.*, 1937, 38, (6), 161–165).—The possibility of discovering the presence of free electrons in metals by observing the variation of the incoherent scattering of X-rays with the angle of observation is briefly discussed mathematically.—J. S. G. T.

**The Dependence of the Secondary Electron Emission of Some Metals upon the Angle of Incidence of the Primary Cathode Radiation.** Heinz O. Muller (*Z. Physik*, 1937, 104, (7/8), 475–486).—The secondary electron emission from nickel, aluminium, molybdenum, tungsten, copper, and carbon is found to increase rapidly with increase of the angle of incidence of the primary cathode radiation; the mechanism of the emission is discussed.—J. S. G. T.

**Remarks on the Paper by E. B. Baker and H. A. Boltz, "Thermionic Emission into Dielectric Liquids."** Karl Hans Reiss (*Phys. Rev.*, 1937, [ii], 51, (9), 781).—A note. Experiments by R. (*Ann. Physik*, 1937, 28, 325) show that the photoelectric effects with and without fluid are practically identical. For



this reason, an electronic mechanism is inadequate to explain the currents in insulating fluids. A more plausible explanation of the effect of increase in conductivity with the field is given by the "potential dissociation effect" of Wien and Schiele (Lars Onsager, *J. Chem. Phys.*, 1934, 2, 599), whose equation is in better agreement with the facts than that of Baker and Boltz (*Met. Abs.*, this vol., p. 134).—W. H.-R.

**Thermionic Emission into Dielectric Liquids.** Edward B. Baker and Howard A. Boltz (*Phys. Rev.*, 1937, [ii], 51, (11), 989).—A note. The views of K. H. Reiss (preceding abstract) are criticized. The "theoretical" slopes in Reiss' original paper (*Z. physikal. Chem.*, 1936, 178, 37) were incorrectly calculated, and the agreement with experiment which he obtained is spurious. B. and B. do not consider the photoelectric data quoted by R. as conclusive because it may not be possible to measure the true photoelectric work-function in the presence of a liquid, since the free path of an electron in a liquid is only a few hundred Å.—W. H.-R.

**The Intensity of Orbital Interaction in Metals.** R. Forrer (*Compt. rend.*, 1936, 203, (23), 1268-1270).—A calculation is made of the temperature  $F$  in the formula  $T = F\sqrt{N}$ , where  $T$  is the melting point,  $F$  a characteristic temperature indicating the intensity of orbital interaction and  $N$  the number of such interactions for any particular metal. It is found that  $F$  does not vary very greatly from metal to metal, and its values for the lighter metals are deduced.—B. C.

**Theory of Metallic Linking.—IV.** Paul Gombás (*Z. Physik*, 1937, 104, (7/8), 592-603).—The theory of metallic linkages is investigated by a simplified statistical method. The lattice energy, ( $U$ ), of the alkaline earth metals is found to be proportional to  $1/R$ , and their compressibilities, ( $K$ ), proportional to  $R^3$ ,  $R$  denoting the equilibrium value of the radius of the sphere containing each individual ion. Satisfactory agreement is found between experimental and theoretical values of  $U$  and of  $K$  in the case of the alkaline earth metals. The theory requires modification before it can be applied to the discussion of the metals copper, silver, gold, zinc, cadmium, mercury; the significance of this is briefly discussed.—J. S. G. T.

**\*Damped Electron Waves in Crystals [Electron Theory of Metals].** J. C. Slater (*Phys. Rev.*, 1937, [ii], 51, (10), 840-846).—Theoretical. Electrons in solids, as in electron diffraction, suffer inelastic impacts if their energy is great enough to exceed the resonance energy of the atoms of the crystal, resulting in strong damping of the electron beams. The problem is discussed mathematically, and it is shown that the sharp distinction between allowed energy bands and forbidden gaps, which is found in the theory of undamped electrons in periodic lattices, is no longer found when the waves are damped.—W. H.-R.

**\*Wave Functions in a Periodic Potential [Electron Theory of Metals].** J. C. Slater (*Phys. Rev.*, 1937, [ii], 51, (10), 846-851).—Theoretical. A new method for the approximate solution of the problem of the motion of an electron in the periodic potential of a crystal lattice is developed. The potential is assumed to be spherically symmetrical within spheres surrounding each atom, and constant outside these spheres.—W. H.-R.

## II.—PROPERTIES OF ALLOYS

(Continued from pp. 283-286.)

**Notes on the Structure and Characteristics of Aluminium Alloys.** H. C. Hall (*Met. Ind. (Lond.)*, 1937, 50, (26), 705-709; 51, (1), 9-12; and *Found. Trade J.*, 1937, 58, (1088), 523-525; 57, (1089), 7-9).—The metallurgy of aluminium alloys is reviewed, with reference to structure, flowing power and casting properties, and physical strength. The structural characteristics of various constituents of aluminium alloys are described, and the effects of supercooling,

modification, and heat-treatment are pointed out.  $Mg_2Si$  and  $CuAl_2$  are shown to be the most important constituents from the point of view of heat-treatment, and some considerations underlying the choice of composition of the "R.R." alloys are explained. The strength of these alloys, particularly at high temperatures, is compared with that of high-magnesium, high-zinc, and high-silicon alloys. Finally, the determination of fluidity and "life," and the effects of various factors on these properties, are discussed.—H. W. G. H.

**New Aluminium Bearing Metals [Alva].** Eugen Vaders (*Z. Metallkunde*, 1937, 29, (5), 155-158).—The running properties of red brass, and of tin- and lead-base bearing metals are compared with those of Alva 36 (an antimony-lead-aluminium alloy containing copper, iron, and manganese). Alva withstands much higher compression loads and higher running speeds, and can be run as hot as 130° C. without deterioration. Cylinders of Alva can be compressed by 68% before signs of cracking appear, whereas cracking occurs after 55% reduction with red brass, 33% with the tin-base alloy, and 56% with the lead-base alloy. The hardness of Alva at 250° C. is about equal to that of the tin-base alloy at 50° C. but the thermal expansion is somewhat greater than that of red brass, so that a somewhat larger clearance allowance must be made for Alva.—A. R. P.

**\*Effect of Temperature on the Tensile Properties of Aluminium and Aluminium Alloys in the Completely Stabilized State.** Alfred von Zeeleder and Emil von Burg (*Z. Metallkunde*, 1937, 29, (4), 132).—Rods of pure aluminium, Aluman, Peraluman 2, Peraluman 7, Anticorodal, Avional, "Y" alloy and "RR 59" alloy were annealed for 4 hrs. at 550°, 550°, 450°, 450°, 560°, 520°, 520°, and 520° C., respectively, and cooled at 50° C./24 hrs., the tensile properties being determined at intervals of 50° C. during the cooling. In this way the alloys were obtained in a stabilized condition at every testing temperature. The results are shown in a series of graphs, which provide useful indications of the behaviour of the alloys in a maximum degree of softness.

—A. R. P.

**\*The Effect of the Addition of Small Percentages of Iron and Silicon to a High-Purity 4 Per Cent. Copper-Aluminium Alloy.** Marie L. V. Gayler (*J. Inst. Metals*, 1937, 60, 75-98; discussion, 99).—It has not been possible to attain a state approaching equilibrium in 4% copper-aluminium alloys containing up to 0.6% iron and 1.0% silicon, under the conditions of casting and subsequent working and heat-treatment described. The phases  $CuAl_2$ ,  $\alpha FeSi$ ,  $\beta FeSi$ , and silicon have been identified in the alloys, but  $FeAl_3$  was not observed. Silicon is held in solid solution to a limited amount at 500° C., and is precipitated during slow cooling to 190° C. together with  $CuAl_2$ . The addition of 0.1% iron inhibits the age-hardening of a 4% copper alloy at room temperature but not at high temperatures, while the addition of 0.6% iron reduces, to a marked extent, ageing at high temperatures. The addition of 1.0% silicon does not inhibit the effect of 0.6% iron. It would appear that the age-hardening which takes place at high temperatures may be attributed to the precipitation of silicon as well as of  $CuAl_2$ .—M. L. V. G.

**\*Duralumin Studied in Relation to the Rotating-Beam Endurance Limit.** C. Pizzuto (*Internat. Assoc. Test. Mat. Congr. London*, 1937, Advance Proof, Group A, 119-121; and *Aluminium and Non-Ferrous Rev.*, 1937, 2, (6), 212, 214).—[In English.] A new formula, including the resilience of the material, is introduced for the calculation of the rotating-beam endurance limit for Duralumin:  $f = 0.975 (0.1 R \pm \rho \pm 5.5)$ , where  $f$  is the calculated endurance limit for rotating beam in kg./sq. cm.;  $R$  is the ultimate tensile strength in kg./sq. mm., and  $\rho$  is the resilience in kg./sq. mm. (Mesnager). The numerical constants are deduced empirically. This formula permits a much more accurate calculation of the endurance limit than is possible when only static characteristics are employed.—P. W. R.

**On Super-Duralumin and Super-Duralclad.** Isamu Igarashi (*Sumitomo Kinzoku Kogyō Kenkyū Hōkoku (Res. Rep. Sumitomo Metal Ind., Ltd.)*, 1937, 2, (10), 991–1020).—[In Japanese.] A collection of data (tabulated) obtained in I.'s laboratory on the chemical composition, forgeability, heat-treatment, forming, corrosion, and some mechanical properties of these materials.—S. G.

**The Present Position of the So-Called Super-Duralumin.** Tomojiro Tanabe (*Sumitomo Kinzoku Kogyō Kenkyū Hōkoku (Res. Rep. Sumitomo Metal Ind., Ltd.)*, 1937, 2, (10), 1021–1040).—[In Japanese.] A review of the present status of Super-Duralumin, in Japan and abroad. Test results (tabulated) are described for the alloys "24 S," "681 ZB," "DM 31," etc. It is shown that a German propeller blade (V.D.M.) is made of "681 ZB," and a French (Ratier) controllable-pitch propeller blade is made of D.T.D. 252 alloy. The Japanese Super-Duralumin is known as "SD," "SDC" (Super-Duralclad) and "SDHT." The mechanical properties of "SD" and "SDC" are given in a paper by Igarashi (preceding abstract); those of "SDHT" are dealt with in this paper.—S. G.

**\*On the Decrease of Fatigue Limit of Duralumin and Super-Duralumin by Sea-Water Corrosion.** Isamu Igarashi and Seikichi Fukai (*Sumitomo Kinzoku Kogyō Kenkyū Hōkoku (Res. Rep. Sumitomo Metal Ind., Ltd.)*, 1937, 2, (10), 1041–1055).—[In Japanese.] By means of Ono's repeated bending machine, a determination was made of the fatigue limits of Duralumin and Super-Duralumin which had been immersed for a definite period in sea-water. The results, which are tabulated, showed that corrosion damage by sea-water was very great, in spite of the short period of immersion.—S. G.

**\*On the Modification of Aluminium Alloys.** M. Gotō and S. Sugiura (*Internat. Assoc. Test. Mat. Congr. London, 1937, Advance Proof, Group A*, 121–122; and *Aluminium and Non-Ferrous Rev.*, 1937, 2, (6), 223).—[In English.] Experiments on magnesium-aluminium and copper-aluminium alloys, and on Duralumin, indicate that: (1) Atoms of copper or magnesium or both in alloys at high temperatures occur in positions causing no internal stress. When the temperature is decreased, the atoms (copper, magnesium, silicon) change their positions, so that they can combine easily with aluminium or silicon, or both. (2) When the solid solution is supersaturated with copper, the copper (or magnesium, or both) segregates as  $\text{CuAl}_2$  (or  $\text{Mg}_2\text{Si}$ , or both) and the segregated compound agglomerates at the temperature at which segregation takes place. The transformation (1) is accompanied by an increase, and (2) by a decrease, in hardness, strength, and electrical resistance. At normal temperatures (1) alone occurs, but at higher temperatures the modification is due to the combined effects of (1) and (2) occurring together. The authors believe that these observations provide a basis for the explanation of the phenomena associated with the modification of aluminium alloys.—P. W. R.

**\*On the Mechanism of Age-Hardening in Al-MgZn<sub>2</sub> Alloys.** M. Gotō and Sadajiro Kokubo (*Internat. Assoc. Test. Mat. Congr. London, 1937, Advance Proof, Group A*, 111; and *Aluminium and Non-Ferrous Rev.*, 1937, 2, (6), 213).—[In English.] The age-hardening at room temperature of an Al-MgZn<sub>2</sub> alloy containing 15% MgZn<sub>2</sub> is attributed to the distortion of the lattice caused by the migration of magnesium and zinc atoms to form groups in the proportion required for the compound MgZn<sub>2</sub>. At above 100° C., precipitation of the compound occurs, with a marked decrease in electrical resistance and hardness. Above 300° C., part of the precipitated MgZn<sub>2</sub> redissolves in the aluminium, and the remainder coagulates.—P. W. R.

**\*Note on the Influence of Small Amounts of Titanium on the Mechanical Properties of Some Aluminium Casting Alloys.** T. H. Schofield and C. E. Phillips (*J. Inst. Metals*, 1937, 60, 101–105; discussion, 105–107).—A summary is given of the results of an investigation on the influence of small amounts of titanium on the mechanical properties of some commercial alu-

minium casting alloys ("Y," "L 11" and "L 5"). This influence is found to be small with amounts of titanium up to 0.1%.—T. H. S.

**Industrial Metallic Materials at Elevated Temperatures, with Special Reference to the Behaviour of Aluminium and Its Alloys.** A. von Zeerleder and R. Irmann (*Internat. Assoc. Test. Mat. Congr. London, 1937*, Advance Proof, Group A, 23-26).—[In German.] The mechanical properties of pure aluminium, Avional, Anticorodal, and other industrial aluminium alloys, were measured between 20° and 250° C., after annealing the test-specimens at the same temperatures for various periods up to 540 days.—P. W. R.

**\*New Strong Light Alloys.**—I. Isamu Igarashi and Goro Kitahara (*Tetsu to Hagane (J. Iron Steel Inst. Japan)*, 1937, 23, (5), 447-451).—[In Japanese.] See *Met. Abs.*, this vol., p. 181.—S. G.

**\*On the Light Emitted by Burning Aluminium-Zinc and Aluminium-Cadmium Alloys.** J. A. M. van Liempt and J. A. de Vriend (*Rec. trav. chim.*, 1937, 56, (5), 594-598).—[In German.] Additions of cadmium or zinc to aluminium increase considerably its combustibility in oxygen. The combustion velocity and light-output are increased, but the colour of the light is not appreciably altered.—E. J. G.

**Application of Physico-Thermal Methods to the Study of Light Alloys.** Pierre Chevenard and Albert Portevin (*Internat. Assoc. Test. Mat. Congr. London, 1937*, Advance Proof, Group A, 105-109).—[In French.] A summary of the authors' previous publications on this subject.—P. W. R.

**Development of Aluminium Alloys and Their Properties.** A. v. Zeerleder (*Internat. Assoc. Test. Mat. Congr. London, 1937*, Advance Proof, Group A, 122-124).—[In German.] An historical review.—P. W. R.

**Recent Progress in Aluminium Casting Alloys.** A. G. C. Gwyer and H. G. Dyson (*Internat. Assoc. Test. Mat. Congr. London, 1937*, Advance Proof, Group A, 117-119; and *Aluminium and Non-Ferrous Rev.*, 1937, 2, (6), 215-216).—[In English.]—P. W. R.

**Some Recent Developments in the Field of Wrought Aluminium Alloys.** W. Stenzel (*Internat. Assoc. Test. Mat. Congr. London, 1937*, Advance Proof, Group A, 169-171).—[In German.]—P. W. R.

**Progress in Wrought Aluminium Alloys in Great Britain.** S. L. Archbutt (*Internat. Assoc. Test. Mat. Congr. London, 1937*, Advance Proof, Group A, 116-117; and *Aluminium and Non-Ferrous Rev.*, 1937, 2, (6), 214-215).—[In English.]—P. W. R.

**Recent Progress in Aluminium Alloys in America.** E. H. Dix, Jr., and Zay Jeffries (*Internat. Assoc. Test. Mat. Congr. London, 1937*, Advance Proof, Group A, 124-125; and *Aluminium and Non-Ferrous Rev.*, 1937, 2, (6), 209-210).—[In English.]—P. W. R.

**\*Cadmium-Silver-Copper Alloys for Engine Bearings.** C. F. Smart (*Trans. Amer. Soc. Metals*, 1937, 25, (2), 571-603; discussion, 603-608).—Data from laboratory tests indicated that the ternary cadmium-silver-copper alloys possessed desirable properties for bearing metal. Bearings tested in engines under severe operating conditions showed approximately three times the life of Babbitt bearings. The alloy offers no undue manufacturing difficulties. Interesting data are given of the physical properties of alloys of cadmium with silver, copper, magnesium, nickel, and zinc, and of ternary alloys of cadmium with these metals. Structural diagrams of cadmium alloys, on which the investigation was based, are also shown. Bearings of this type are subject to two objections: (a) their susceptibility to corrosion by organic acidic compounds in lubricants, and (b) the prohibitive price of cadmium.—I. J.

**\*An X-Ray Study of the Chromium-Aluminium Equilibrium Diagram.** A. J. Bradley and S. S. Lu (*J. Inst. Metals*, 1937, 60, 319-337).—X-ray powder photographs were made from more than 70 slowly cooled and quenched chromium-aluminium alloys. These were used to provide a basis for a tenta-

tive equilibrium diagram. Nine phases exist after slow cooling from 800° C. to room temperature, and two other phases were found in alloys quenched from 1000° and 1100° C. The  $\alpha$  body-centred cubic structure formed by the solution of aluminium in chromium exists from 0 to 30 weight % of aluminium at temperatures above 850° C. Below this temperature alloys containing about 75% of chromium change to a tetragonal  $\beta$ -structure. This is a superlattice made by stacking three body-centred cubes above each other. Three phases with crystal structures resembling that of  $\gamma$ -brass were found after slow cooling to room temperature, and a fourth phase of similar type was found in alloys quenched from 1100° C. These all appear to be distorted forms of the  $\gamma$ -type of structure.  $\gamma_2$  exists around the composition  $\text{Cr}_5\text{Al}_8$ , which formula agrees with structure analysis. This phase is derived from a body-centred cubic structure of the  $\gamma$ -type by elongation in the direction of a trigonal axis, so that the symmetry is rhombohedral. It decomposes at about 890° C.  $\gamma_3$  exists around the composition  $\text{Cr}_4\text{Al}_9$  at temperatures between 700° and 870° C. Below 700° C. it gradually transforms into the related  $\gamma_4$  structure. At still lower temperatures, the composition range of  $\gamma_3$  is more limited, whereas that of  $\gamma_4$  increases, until at room temperature  $\gamma_3$  is restricted to a very narrow range of compositions. At each temperature below 700° C.,  $\gamma_3$  contains just a little more chromium than  $\gamma_4$ . There are three closely related phases  $\theta$ ,  $\eta$ , and  $\epsilon$ , with the approximate formulæ  $\text{CrAl}_7$ ,  $\text{Cr}_2\text{Al}_{11}$ , and  $\text{CrAl}_4$ . They melt at 725°, 900°, and 1011° C., respectively. A phase with the approximate formula  $\text{CrAl}_6$  exists in alloys quenched from temperatures exceeding 850° C., and melts at 1180° C.—A. J. B.

**\*The Resistance of Some Special Bronzes to Fatigue and Corrosion-Fatigue.** H. J. Gough and D. G. Sopwith (*J. Inst. Metals*, 1937, 60, 143-153; discussion, 154-158).—Fatigue and corrosion-fatigue tests on four types of special bronzes have been carried out to ascertain the suitability of these materials for special aircraft purposes. The materials tested were: phosphor-bronze, aluminium bronze (9% aluminium), beryllium bronze (2.25% beryllium), and Superston L189 bronze. The results show that the corrosion-fatigue resistance of the bronzes compares favourably with that of stainless steels, the beryllium bronze in particular having the highest corrosion-fatigue resistance of any material so far investigated by the authors. The fatigue resistance in air of Superston is exceptionally high for a non-ferrous material but the material appears to be somewhat susceptible to stress-concentration effects.—H. J. G.

**\*On Some Strong, Anti-Corrosive Wrought Aluminium Bronzes.** Tomojiro Tanabe and Goro Koiso (*Tetsu to Hagane (J. Iron Steel Inst. Japan)*, 1937, 23, (5), 439-447).—[In Japanese.] See *Met. Abs.*, this vol., p. 140.—S. G.

**\*Copper Castings Alloyed with Beryllium and Titanium. Hardness and Conductivity after Heat-Treatment.** G. F. Comstock (*Metals and Alloys*, 1936, 7, (10), 257-260; and (summary) *Metallurgia*, 1936, 15, (85), 19-20).—The hardness of beryllium- and silicon-titanium-copper alloys after various heat-treatments is shown in tables and graphs. Additions of cobalt, nickel, zinc, or aluminium have no beneficial effect. An alloy of copper with silicon 0.23-0.4 and titanium 0.5-0.9% has a conductivity of 70% of that of pure copper after quenching from 915° C. and re-heating at 580° C., combined with a yield-point of 17,700 lb./in.<sup>2</sup>, and a Rockwell E hardness of 67-74. Beryllium-copper alloys with similar properties have a much lower conductivity. Addition of titanium to beryllium-copper alloys has no effect on the properties after hardening, but it stabilizes the precipitation-hardness at high temperatures, and over periods of prolonged heating.—A. R. P.

**\*Certain Age-Hardenable Copper Alloys. Lattice Changes Due to Heat-Treatment.** L. R. van Wert and B. W. Gonser (*Metals and Alloys*, 1936, 7, (10), 269-270).—Two alloys were examined containing: (A) copper 96.8, nickel 2.43, silicon 0.57% (equivalent to 2.95% of  $\text{Ni}_2\text{Si}$ ), and (B) copper 89.29,

nickel 4.42, aluminium 5.31, silicon 0.98% (equivalent to 5.07% of Ni<sub>2</sub>Si). The results obtained are given in the table (in which † indicates that no accurate measurements were possible).

Treatment.	Brinell hardness.		Conductivity. (copper = 100%).		Lattice parameter.	
	A.	B.	A.	B.	A.	B.
Quenched from 830° C.	56	67	18.3	8	3.6054	3.6294
Fully aged at 450° C.	173	214	41.0	12	†	†
Furnace cooled	85	106	34.2	11.7	3.6085	3.6331

—A. R. P.

\*The Effect of Manganese on the "Annealing Brittleness" of Cupro-Nickel. B. K. Bose (*J. Inst. Metals*, 1937, 60, 133-141; discussion, 141).—An investigation has been made of the effect of manganese on the brittleness which may appear in the cupro-nickel alloy (copper 75 : nickel 25%) when annealed at temperatures exceeding 700° C. Previous observations that this brittleness, in the absence of manganese, is caused by the precipitation of graphitic carbon at the grain boundaries have been confirmed. The elimination of this tendency to brittleness by the addition of manganese has been investigated by measurements of its effect on the physical properties as determined by elongation, tensile strength, and impact tests. These tests have been supplemented by chemical analyses and by an examination of the microstructure.—B. K. B.

\*On the Optical Constants of Alloys of the Copper-Zinc System. H. Lowery, H. Wilkinson, and D. L. Smare (*Proc. Phys. Soc.*, 1937, 49, (4), 345-353).—Values of the refractive index, reflection and absorption coeffs. are given for copper-zinc alloys containing 32.75-93.42 wt.-% of copper for the spectral range 4358-6800 Å. Curves showing the variation in the optical constants with composition for wave lengths 5000, 5800, and 6600 Å. for alloys containing 0-25 atomic-% of zinc are also given.—J. S. G. T.

\*The Theoretical Interpretation of the Optical Constants of Copper-Zinc Alloys. N. F. Mott (*Proc. Phys. Soc.*, 1937, 49, (4), 354-356).—The results of the experiments of Lowery, Wilkinson, and Smare (preceding abstract) relating to the optical constants of copper-zinc alloys are interpreted in terms of the electron theory of metals.—J. S. G. T.

\*On the Solubility of Cadmium in Lead in the Solid State, and the Resultant Non-Variability of the Lattice Parameter of Lead. E. Jenckel and H. Mäder (*Metallwirtschaft*, 1937, 16, (21), 499-502).—Hardness measurements on quenched alloys and electrical resistance measurements on cadmium-lead alloys indicate that the solubility of cadmium in lead is 1.2, 1.7, 2.3 and 3.1%, respectively, at 100°, 150°, 200° C., and the eutectic temperature. The lattice constants of lead remain unchanged by dissolution of cadmium in the lead. This is confirmed by density measurements.—v. G.

Recent Developments in Magnesium Alloys. John L. Haughton (*Internat. Assoc. Test. Mat. Congr. London*, 1937, Advance Proof, Group A, 129-130; and *Aluminium and Non-Ferrous Rev.*, 1937, 2, (7), 244-245).—[In English].—P. W. R.

Technology of Magnesium Alloys. G. Siebel (*Internat. Assoc. Test. Mat. Congr. London*, 1937, Advance Proof, Group A, 126-129).—[In German].—P. W. R.

\*The Heat-Treatment and Properties of Magnesium Alloys. I. G. Shulgin (*Legkie Metally (Light Metals)*, 1936, (12), 35-39).—[In Russian.] The mechanical properties of alloys of magnesium with (a) zinc 1, cobalt 0.26, beryllium 0.11, and aluminium 6%, and (b) the same constituents in the ratio

1, 0.6, 0.16, and 11% were tested after extrusion, annealing at 400° C. for 48 hrs. and quenching, and after subsequent normalizing at 175° C. for 48 hrs. Alloy (a) after pressing, has a tensile strength of 31 kg./mm.<sup>2</sup>, an elongation of 12%, and a Brinell hardness of 65; after quenching and normalizing, the corresponding values are 35.3 kg./mm.<sup>2</sup>, 5.3%, and 72. For alloy (b), the corresponding values are: before quenching, 32 kg./mm.<sup>2</sup>, 12%, and 66; after quenching, 34 kg./mm.<sup>2</sup>, 3.5%, and 67; and after quenching and normalizing, 43 kg./mm.<sup>2</sup>, 5%, and 112. The hardness of the second alloy is barely affected by the quenching temperature between 320° and 420° C., but after a subsequent annealing the hardness is a maximum when quenching is done at 400° C. The hardness increases with increase of normalizing temperature between 100° and 175° C. and time between 6 and 78 hrs. but decreases after 48 hrs. at 200° C.—D. N. S.

**\*Formation of Solid Solutions and Grain-Refinement in Magnesium Alloys.** Heinrich Hanemann and Wilhelm Hofmann (*Z. Metallkunde*, 1937, 29, (5), 149–152).—The formation of coarse radial crystals in magnesium sand-castings is entirely prevented by addition of about 1% aluminium, 0.6% lithium, 0.7% zinc, 9% cadmium or 9% lead; these values correspond with atomic percentages of 0.9, 2.05, 2.1, and 1.15, respectively. An explanation of the differences in the grain-refining effects of these metals based on Tammann's theory is advanced.—A. R. P.

**\*Alloys of Magnesium. V.—The Constitution of the Magnesium-Rich Alloys of Magnesium and Cerium.** J. L. Haughton and T. H. Schofield (*J. Inst. Metals*, 1937, 60, 339–344; discussion, 344).—The constitution of the magnesium-rich alloys of magnesium and cerium has been determined. The eutectic point is found to be at 21% cerium and 590° C., compared with about 27% and 585° C. observed by Vogel (*Z. anorg. Chem.*, 1915, 91, 277), who used much less pure metals than were employed in the present investigation. Vogel did not determine the solubility of cerium in magnesium, which is now shown to be about 1.6% at the eutectic temperature, and probably less than 0.15% at 337° C. The existence of the peritectic observed by Vogel has been confirmed, though at a slightly lower temperature (614° C.). Some of the alloys are found to be very feebly magnetic.—J. L. H.

**\*Researches on Magnesium Alloys. I.—On the Mechanical Properties and Corrosion-Resistance of Magnesium-Manganese and Magnesium-Manganese-Zinc Alloys.** Hiroshi Imai, Hiromu Tanimura, and Hidewo Mikashima (*Tetsu to Hagane (J. Iron Steel Inst. Japan)*, 1937, 23, (5), 452–465).—[In Japanese.] Up to 2.5% manganese improves the mechanical properties and corrosion-resistance of magnesium, the effect on the corrosion-resistance being remarkable. In the case of the mechanical properties, additions of up to 4% zinc are more effective than additions of manganese. The effects of quenching and tempering were studied.—S. G.

**\*The Solubility of Silver and Gold in Solid Magnesium.** William Hume-Rothery and Ewart Butchers (*J. Inst. Metals*, 1937, 60, 345–350).—The solid solubility of silver in solid magnesium has been investigated above 300° C., and the solidus and solid solubility curves of the magnesium-rich solid solution have been determined. The maximum solubility of silver in magnesium is 3.9 atomic-% (15.3% by weight) at the eutectic temperature (471° C.), and the solubility decreases with decreasing temperature to 0.9 atomic-% (3.9% by weight) at 300° C. The maximum solubility of gold in solid magnesium is of the order 0.1 atomic-% at 576° C., and the solubility decreases with decreasing temperature.—W. H.-R.

**\*Alloys of Magnesium. IV.—The Constitution of the Magnesium-Rich Alloys of Magnesium and Silver.** R. J. M. Payne and J. L. Haughton (*J. Inst. Metals*, 1937, 60, 351–356; discussion, 357–364).—The form of the liquidus and the values obtained for the eutectic and peritectic temperatures by other workers

have been checked in magnesium-silver alloys containing up to 60 weight-% of silver. It was found that solid magnesium can hold in solution up to 15 weight-% of silver at the eutectic temperature, but less than 1 weight-% of silver at 200° C. The alloys should, therefore, be capable of precipitation-hardening. In the joint discussion of this paper and one by Hume-Rothery and Butchers (preceding abstract) *N. Ageew* and *V. G. Kuznetsov* give results of a recent X-ray study of the system silver-magnesium; the results, which are ready for publication, are in good agreement with those of *H.-R. and B. and P. and H.*—*R. J. M. P.*

**\*The Constitution of the Alloys of Silver, Tin, and Mercury.** *Marie L. V. Gayler* (*J. Inst. Metals*, 1937, 60, 379-400; discussion 400-406).—The constitution of the ternary alloys of silver, tin, and mercury has been determined, except for a range of composition extending from the tin corner to a composition of 6% mercury. Five invariant reactions have been found, while two others are deduced from experimental and theoretical evidence. The invariant reactions starting from the tin corner of the diagram and their temperatures are:

- |  |                          |
|--|--------------------------|
| (1) $\alpha_2 + \text{liq.} \longrightarrow \gamma + \beta_2$                    | Between 217° and 221° C. |
| (2) $\beta_2 + \text{liq.} \longrightarrow \gamma + \gamma_2$                    | 217° C.                  |
| (3) $\gamma + \text{liq.} \longrightarrow \beta_1 + \gamma_2$                    | Probably about 210° C.   |
| (4) $\beta_1 + \text{liq.} \longrightarrow \gamma_1 + \gamma_2$                  | 84° C.                   |
| (5) $\gamma_2 + \text{liq.} \longrightarrow \gamma_1 + \delta_2$                 | 80° C.                   |
| (6) $\delta_2 + \text{liq.} \longrightarrow \gamma_1 + \epsilon_2$               | - 36° C.                 |
| (7) $\epsilon_2 + \text{liq.} \longrightarrow \gamma_1 + \epsilon_2 + \text{Hg}$ | - 38.8° C.               |

Isothermal sections for temperatures of 100°, 84°, and 70° C. have been plotted from the experimental data.—*M. L. V. G.*

**\*Dental Amalgams.** *Marie L. V. Gayler* (*J. Inst. Metals*, 1937, 60, 407-419; discussion, 419-424).—A theory of the setting of dental amalgams is submitted which is based on a study of the constitution of the ternary alloys of silver, tin, and mercury (see preceding abstract), together with the results of published data on the correlation between the dimensional changes occurring during the setting of these amalgams with (a) the composition of the dental alloys from which they are made; (b) the composition of the dental filling itself; and (c) the disappearance and appearance of the  $\gamma_2$ (Sn-Hg) phase in the amalgam or, *vice versa*, the appearance and disappearance of the  $\gamma_1$ (Ag-Hg) phase. The changes taking place on setting are attributed to complex reactions which probably do not proceed to completion. These may be summed up briefly as: (1)  $\text{Ag}_3\text{Sn} + \text{Hg} \longrightarrow \beta_1 + \gamma_2$ ; (2)  $\beta_1 + \gamma_2 \longrightarrow \beta_1 + \gamma_1 + \gamma_2$ . No explanation for the marked contraction or expansion can be obtained from X-ray analysis, but the former is attributed to the formation of a solid solution of mercury in  $\text{Ag}_3\text{Sn}$ .—*M. L. V. G.*

**The Use of Nickel in Non-Ferrous Alloy Castings.** *J. O. Hitchcock* (*Foundry Trade J.*, 1937, 56, (1087), 513-516; (1088), 528-529; also *Met. Ind. (Lond.)*, 1937, 50, (24), 659-664; (26), 710-713; *Engineer*, 1937, 164, (4252), 54-56; (4253), 83-84; and (summary) *Mech. World*, 1937, 101, (2634), 643-644).—Read before the Institute of British Foundrymen. In most cases, the effect of adding nickel is to raise the melting point, increase strength and hardness at all temperatures, decrease grain-size, and improve corrosion-resistance. These effects, as shown in bronze and gun-metal, are discussed in some detail. In aluminium-bronze, nickel prevents self-annealing and, in certain circumstances, confers precipitation-hardening properties. The useful effects of nickel in brasses, and the characteristics of high nickel brasses, or nickel silvers, are described, with particular reference to the production of sound castings. Small additions of nickel to zinc-base alloys are said to reduce the liability to inter-crystalline corrosion; in tin-base, lead-base, and cadmium-base alloys, it is also a useful constituent for bearing



service. A large number of aluminium alloys containing nickel are enumerated, the improvement in mechanical properties, especially at high temperatures, being pointed out. Alloys having nickel as their base, such as cupro-nickel, Monel metal, and Hastelloy, are also described.—H. W. G. H.

†**The Toughness at Low Temperatures of Metals Containing Nickel.** A Critical Survey of the Literature. R. Hanel (*Z. V.d.I.*, 1937, 81, (14), 410-414).—Gives the mechanical properties of nickel alloys at low temperatures.—v. G.

\***The Precipitation-Hardening of Beryllium-Nickel Alloys.** Walther Gerlach (*Z. Metallkunde*, 1937, 29, (4), 124-131).—The Curie point of beryllium-nickel alloys quenched from 1000°-1100° C. decreases linearly with increase in atomic-% of beryllium to 50° C. with 14 atomic-% beryllium. Addition of manganese to the alloys reduces the effect of beryllium, 2 atoms of manganese appearing to combine with 1 atom of beryllium to form a compound insoluble in nickel. From determinations of the Curie point of alloys annealed to equilibrium at various temperatures, the solid solubility of beryllium in nickel is shown to increase linearly from 1.5 atomic-% at 400° C. to 16 atomic-% at 1150° C. Magnetic measurements during the ageing of quenched alloys indicate that precipitation occurs simultaneously in a homogeneous and a heterogeneous manner, the preponderating type depending on the degree of supersaturation and on the ageing temperature, precipitation becoming more homogeneous, at constant ageing temperature, with increasing supersaturation and, at constant degree of supersaturation, with increasing ageing temperature. The heat of activation of the homogeneous precipitation is 54,000 grm.-cal./grm.-mol. Maximum coercivity is shown by the stable  $\alpha$ -phase produced at the beginning of heterogeneous precipitation.—A. R. P.

**The Variation of the Electrical Resistance of Beryllium-Nickel Alloys during Precipitation-Hardening.** Walther Gerlach and Karl Hammer (*Z. Metallkunde*, 1937, 29, (5), 145-149).—Temperature-resistance curves are given for alloys of nickel with 1.2-2.5% beryllium, with and without 0.5% manganese, after various heat and mechanical treatments. The course of precipitation in alloys quenched from a high temperature can be deduced from the contour of the curves; in all cases a marked inflection occurs at the magnetic transformation point, and, in the case of hard-worked alloys, also around the recovery temperature. The results confirm the magnetic observations on the occurrence of homogeneous and heterogeneous precipitation, but afford no evidence of a preliminary "preparatory state" prior to the commencement of precipitation.—A. R. P.

\***Notes on Heating Wires.** W. A. Kerkham (*Electrician*, 1937, 118, (3076), 641-642).—The results of sag, tensile, and life tests at different temperatures are recorded for several unspecified commercial iron-chromium and nickel-chromium wires of various diameters.—J. C. C.

\***An Anomaly in the Expansion of Platinum-Iron Alloys.** A. Kussmann (*Physikal. Z.*, 1937, 38, (2), 41-42).—Platinum-iron alloys containing 50-60% of platinum are found to have very small coeffs. of thermal expansion at room temperatures; in some cases, e.g., in the case of the alloy containing 56% of platinum, the coeff. has a negative value.—J. S. G. T.

\***Contributions to the Systematic Study of Affinity.** LXXIII.—On the Combining Powers of Rubidium and Gold. Hans-Joachim Ehrhorn, Friedrich Weibke, and Wilhelm Biltz (*Z. anorg. Chem.*, 1937, 232, (3), 307-312).— $Au_2Rb$  is a dark olive-green compound giving a different X-ray pattern from  $Au_2K$ , and being much more sensitive to exposure to air than  $Au_4K$ . Unlike the corresponding potassium and sodium compounds, it has only a narrow range of composition and is much less stable.—A. R. P.

\***The Constitution of the Silver-Rich Antimony-Silver Alloys.** Peter W. Reynolds and William Hume-Rothery (*J. Inst. Metals*, 1937, 60, 365-374; discussion, 375-377).—The liquidus curve of the system silver-antimony is determined accurately in the range 0-25 atomic-% of antimony. A new peri-

tectic horizontal is found at  $702.5^{\circ}\text{C}$ ., at which temperature the  $\alpha$  solid solution reacts with the liquid to form the  $\beta$  solid solution which has a close-packed hexagonal structure. The phase boundaries of the  $\alpha$  and  $\beta$  solid solutions are determined accurately at temperatures above  $300^{\circ}\text{C}$ . The general form of the diagram when drawn in terms of electron concentration resembles that of the system silver-tin. The critical points determined are examined from the point of view of Stockdale's theory of integral atomic ratios.—P. W. R.

\*Contributions to the Systematic Study of Affinity. LXXXII.—On the Compounds of Sodium and Potassium with Gold. Udo (Frhr.) Quadt, Friedrich Weibke, and Wilhelm Biltz (*Z. anorg. Chem.*, 1937, 232, (3), 297–306).—The compound  $\text{Au}_2\text{Na}$  crystallizes in the cubic system and, like  $\text{Cu}_2\text{Mg}$ , has 24 atoms in the unit cell,  $a = 7.79\text{ \AA}$ .; the colour is a pale brass yellow and the compound, which is very brittle, is remarkably stable in the air, becoming moist only after prolonged exposure. At high temperatures, *in vacuo* or in a current of argon, it loses sodium slowly. Solid solutions are formed with sodium containing up to 38–40 atomic-% of the latter. With potassium, gold forms two compounds:  $\text{Au}_2\text{K}$ , violet needles of similar structure to  $\text{Au}_2\text{Na}$ , and  $\text{Au}_4\text{K}$ , fine olive-green needles, very unstable in air. Both compounds are brittle, and lose potassium when heated above  $310^{\circ}\text{C}$ . *in vacuo*, although the last traces are difficult to remove in this way.—A. R. P.

A New [Tungsten] Alloy of High Density. Paul Bergsøe (*Nature*, 1937, 139, (3525), 886).—B. directs attention to the fact that a process resembling that described by Smithells (*Met. Abs.*, this vol., p. 186) for the production of a tungsten alloy was used by the Pre-columbian Indians of the Esmeraldas coast in South America for producing coherent platinum, using the platinum-gold eutectic.—B. C.

\*Physico-Mechanical Properties of Metallo-Ceramic Hard Alloys [Pobedit] at High Temperatures. I. S. Brohin (*Vestnik Metallopromishlennosti (Messenger Metal Ind.)*, 1936, 16, (14), 63–71; (15), 20–25).—[In Russian.] The mechanical properties of Pobedit were studied at high temperatures. The Rockwell hardness at  $20^{\circ}\text{C}$ . is 87.5–89.5 while the Herbert hardness decreases from 90 to 72 with increase in temperature from  $20^{\circ}$  to  $600^{\circ}\text{C}$ ., but returns to its original value on cooling. The tensile strengths at  $20^{\circ}$  and  $900^{\circ}\text{C}$ . are 60 and 20 kg./mm.<sup>2</sup>, respectively, the resistance to bending is 125 kg./mm.<sup>2</sup> up to  $500^{\circ}\text{C}$ . but then decreases rapidly to 80 kg./mm.<sup>2</sup> at  $800^{\circ}\text{C}$ . Destructive effort at  $20^{\circ}$  and  $900^{\circ}\text{C}$ . = 5300 and 3500 kg., respectively, while the bending moment is 66,500 kg./mm.<sup>2</sup> at  $20^{\circ}\text{C}$ . and 46,500 kg./mm.<sup>2</sup> at  $900^{\circ}\text{C}$ . The impact strength (0.2 kg./mm.<sup>2</sup>) is little affected by temperature and the resistance to compression to about 260 kg./mm.<sup>2</sup> at  $20^{\circ}\text{C}$ . All the properties undergo more or less sharp changes at about  $500^{\circ}\text{C}$ . and a transformation accompanied by a change in volume occurs at  $550^{\circ}$ – $750^{\circ}\text{C}$ . connected with the phase-change of cobalt. The average coeff. of linear expansion between  $20^{\circ}$  and  $1000^{\circ}\text{C}$ . is  $5.3 \times 10^{-6}$ .—D. N. S.

\*Fatigue Properties of Non-Ferrous Sheet Metals. C. H. Greenall and G. R. Gohn (*Amer. Soc. Test. Mat. Preprint*, 1937, (June), 32 pp.).—Continuation of an investigation previously described (*J. Inst. Metals*, 1929, 41, 467). Results are given—very fully in the form of tables—of fatigue tests on 9  $\alpha$ -brass alloys, 1 nickel-brass, 2 phosphor-bronzes, 3 beryllium-copper alloys, 1 copper-nickel-silicon alloy, copper, Everdur, 3 nickel alloys, and 3 aluminium alloys. The effect of grain direction on the fatigue properties of nickel-brass and 3 aluminium alloys is shown. The effect of surface treatment and electroplated finishes on the fatigue properties of phosphor-bronze and the effect of grain-size and surface treatment on the fatigue properties of nickel-brass sheet are discussed. The data show that nickel-brass sheet of 0.015 to 0.017 mm. average grain-size has a higher endurance limit than similar material of larger grain-size. The data also confirm the conclusions of the previous paper, that

dispersion-hardening of  $\alpha$ -brass by the addition of nickel silicide increases the endurance limit, and that cold-work increases the endurance limit but not proportionally to the increase in tensile strength. Age-hardening markedly increases the endurance limit of K Monel metal, 17S aluminium alloy and beryllium-copper alloys. The ratio of endurance limit to tensile strength for the alloys investigated varies from 0.136 to 0.403, depending on composition, heat-treatment, and amount of cold-work. The highest endurance limits were observed for nickel and alloys of high nickel content. Little difference was observed between the endurance limits for heat-treated copper-base alloys such as beryllium-copper and cold-worked alloy C phosphor-bronze.—S. G.

**Developments in Bearings and Bearing Materials.** A. B. Willi (*Machinist (Eur. Edn.)*, 1937, 81, (18), 268–270E).—Cadmium-silver bearings can be used under loads of 2000 lb./in.<sup>2</sup> and pressure-velocity values of up to 70,000 ft.-lb., as opposed to 1400 lb./in.<sup>2</sup> and 40,000 ft.-lb. for the better tin-base Babbitts. In addition, this cadmium-silver alloy has a higher melting point, a lower coeff. of friction and hence cooler running, higher physical properties at all operating temperatures, and prolonged high temperature operation has little effect on its strength and hardness. The developments in high lead and in tin-base Babbitts are briefly outlined, and the applications of various bearing metals for car engine bearings are described.—J. H. W.

**\*The Reduction of Abrasion by Compound Contact Pieces or Powder.** Seizo Saito (*Internat. Assoc. Test. Mat. Congr. London, 1937*, Advance Proof, Group A, 152–156).—[In English.] The wear of brake shoes, tyres, and trolley wires was determined when various pairs of solid materials were in abrasive contact with the same metal surface and when various powders were smeared on the surfaces of steel wheels in abrasive contact. It was found that the dry abrasion of a ductile metal in sliding contact with another ductile metal decreases remarkably when a non-greasy soft material is brought into sliding contact with the metal surface. Thus cast iron or carbon in contact with a steel surface almost completely prevent the abrasion of a steel member in contact with the same surface. No relation was found to exist between abrasion and the coeff. of friction, although it is generally accepted that low wear corresponds with a small coeff. It is suggested that the soft material becomes finely divided and the particles fill up the irregularities produced by the abrasion of the hard materials, thus giving a smooth surface and a corresponding decrease in wear. The investigation suggests a new method of preventing wear in cases where a lubricant would decrease a desirable high coeff. of friction.—P. W. R.

**\*The Theory of Age-Hardening.** Marie L. V. Gayler (*J. Inst. Metals*, 1937, 60, 249–267; discussion, 267–283).—A general theory of age-hardening is put forward, based on data relating mainly to the age-hardening of alloys of the Duralumin type and of beryllium-copper and silver-copper alloys. Age-hardening takes place by two processes: (i) diffusion, and (ii) precipitation, the second overlapping the first. Both processes take place within wide temperature limits which are peculiar to every alloy system, i.e. the "temperature range." The rate at which each process takes place depends, apart from other factors, on the temperature of ageing. The limits of the temperature range are indeterminate, but approximations can be obtained for all practical purposes. If the temperature of ageing be close to the lower limit, both stages of the ageing will take place excessively slowly; if the temperature of ageing be close to the upper limit, the first stage will proceed so rapidly that its effect will not be detected. Each of the two processes is characterized by changes in physical properties which will present maxima, or minima, depending on the ageing temperature, the characteristics of the first being gradually replaced by those of the second. The softening which occurs when an alloy is aged at a higher temperature, after being previously aged at a lower temperature, is now

explained in the light of the new theory. Curves are given representing the relationships between (i) hardness and duration of ageing, (ii) maximum hardness and temperature of ageing, and (iii) time of attaining maximum hardness and temperature of ageing. The paper is followed by a full discussion.

—M. L. V. G.

\*Remarks on the Laws of Metallic Heat Conduction. G. Borelius (*Ann. Physik*, 1937, [v], 29, (3/4), 251-255).—The fraction of the heat conductivity of a metal due to lattice conduction can be calculated from measurements of the heat conductivity of its alloys.—v. G.

\*On the Dia- and Para-Magnetism in Metallic Solid Solutions. IV.—On the Method of Evaluating the Measurements of the Paramagnetism of Dissolved Transition Metals. Eckhart Vogt (*Ann. Physik*, 1937, [v], 29, (3/4), 358-368).—Theoretical and mathematical.—v. G.

High Permeability and Plastic Flow [of Ferromagnetic Alloys] in Magnetic Fields. J. F. Dillinger (*Ann. Postes Télégr. Téléph.*, 1937, 26, (1), 59-65).—See *Met. Abs.*, 1936, 3, 202.—R. T.

### III.—STRUCTURE

(Metallography; Macrography; Crystal Structure.)

(Continued from pp. 286-290.)

Progress in Metallurgical Microscopy. — Köster (*Internat. Assoc. Test. Mat. Congr. London*, 1937, Advance Proof, Group A, 59-60).—[In German.]

—P. W. R.

Progress in the Technique of the Determination of Equilibrium Diagrams. W. Köster (*Internat. Assoc. Test. Mat. Congr. London*, 1937, Advance Proof, Group A, 86-88).—[In German.] 24 references are given to the literature.

—P. W. R.

†Microchemical Examination of the Surface of Metallic Materials. M. Niessner (*Internat. Assoc. Test. Mat. Congr. London*, 1937, Advance Proof, Group A, 51-54).—[In German.] A review of the subject, with a bibliography of 14 references.—P. W. R.

\*The Estimation of Grain-Size in the Region Above  $10^{-3}$  cm. R. A. Stephen and R. J. Barnes (*J. Inst. Metals*, 1937, 60, 285-296; discussion, 296-301).—X-ray methods proposed for determining grain-sizes above  $10^{-3}$  cm. are critically examined. It is shown that to be generally applied in practice any such method must use the same specimens as are used by the metallurgist for microscopic examination. This necessitates the use of back reflection photographs, except in the case of thin sheets. A new method for determining a value for average grain-size solely from X-ray results is described. An empirical method too is considered for determining average sizes from a graph. The graph is derived from plotting spots on a given (*hkl*) reflection against the grain-size of standard specimens.—R. A. S.

\*On an Etching Method for the Determination of the Structure of Molten Boron Carbide. Walter Dawihl and Rosa Flühöh (*Z. Metallkunde*, 1937, 29, (4), 135-137).—A section is polished with diamond dust and etched by immersion for several minutes in fused potassium nitrate at 380° C. followed by washing first in water, then in dilute hydrochloric acid. Characteristic structures of the fused product "Norbide" and of sintered boron carbide products are illustrated. Certain of the "Norbide" products have a structure which contains free graphite, indicating that  $B_2C$  has some tendency to decompose into a lower carbide on cooling.—A. R. P.

\*The Control of Composition in the Application of the Debye-Scherrer Method of X-Ray Crystal Analysis to the Study of Alloys. William Hume-Rothery and Peter William Reynolds (*J. Inst. Metals*, 1937, 60, 303-312; discussion, 313-317).—The application of the Debye-Scherrer method to the

study of alloys is discussed critically, with special reference to errors due to uncertainty of the exact composition of the filings comprising the specimen. It is concluded that, where practicable, it is desirable to analyze the actual filings from which the representative small sample used in the preparation of the specimen has been sieved. Methods are described for the preparation of perfectly clean filings suitable for accurate chemical analysis. It is shown that, in the determination of phase boundaries from lattice spacing measurements of two-phase alloys, misleading results may be obtained if the temperature of the preliminary anneal of the material in lump form is not suitably related to that of the final annealing of the filings.—W. H.-R.

**The Size of Nuclei in Solid Metal Reactions.** Gerhard Derge (*J. Chem. Physics*, 1937, 5, (6), 462-464).—If, in a solid metal, there is a phase change  $A \rightarrow B$ , the orientation of  $B$  is always dependent on that of  $A$ ; the near matching of atomic positions on specific planes of the two phases is a principal factor in determining the orientation. The formation of  $B$  will take place in two stages: (a) the formation of nuclei, and (b) the subsequent growth of these nuclei. The size of a stable nucleus will be determined by the relative atomic spacings of the two phases, and, from geometric considerations, it is shown that 100, or possibly even fewer, atoms of  $B$  are actually sufficient to form an active centre.—C. E. R.

**\*Some Observations on the Distribution of Impurities in Metal Crystals.** Michael Śmiałowski (*Z. Metallkunde*, 1937, 29, (4), 133-135).—When a large amount of 99.98% zinc is allowed to cool very slowly in a spherical vessel, the outer layers solidify as pure zinc, the impurities collecting in the inner zone and eventually crystallizing in eutectic layers. When the metal is allowed to crystallize as a single crystal, the principal hexagonal axis of which is perpendicular to the axis of cooling, the impurities collect along layers parallel to the direction of cooling; these layers are inclined to the basal plane at a very small angle. When the hexagonal axis is parallel to the direction of cooling, an etched surface transverse thereto shows apparently regular and frequently hexagonal cells. More complicated patterns are obtained when the hexagonal axis is inclined at an intermediate angle to the direction of cooling. The layer-like structure produced by the impurities is remarkably stable, being unaffected by prolonged annealing at just below the melting point and by a slight degree of cold-work. Redistilled zinc of 99.999% purity does not exhibit any of the above phenomena. When a single crystal of copper is etched with 10% ammonium persulphate solution, a cellular structure is developed the cell boundaries consisting of a series of small inclusions of cuprous oxide-copper eutectic. These results show that the distribution of impurities in single crystals prepared from liquid metal affords no confirmation of the existence of a regular, well-defined mosaic structure since it depends more on the cooling conditions than on crystallographic factors.—A. R. P.

**The Application of Electron Interference to the Study of Metallic Surfaces.** F. Kirchner (*Internat. Assoc. Test. Mat. Congr. London, 1937*, Advance Proof, Group A, 74-77).—[In German.]—P. W. R.

**What Electrons Can Tell Us About Metals.** C. J. Davisson (*J. Applied Physics*, 1937, 8, (6), 391-397).—A comparison is made of the relative applications of X-ray and electron diffraction methods to crystal analysis. Whereas X-ray technique necessitates the use of thick material to obtain an appreciable scattering of the rays, to be suitable for examination by electrons by transmission a specimen must be no more than a few hundred Å. in thickness. Massive specimens can be examined by electrons by reflection, which reveals the crystalline state of a surface layer of excessive thinness. X-rays and electrons are complementary, rather than coincident, in their uses. Three examples are given of the application of electron diffraction to crystal analysis: (a) the work of Preston and Bircumshaw on the oxidation of aluminium, which

shows the gradual change of the oxide from the amorphous condition at room temperature to the crystalline state at temperatures above 700° C.; (b) an investigation by Germer on the crystalline state of the cleavage face in single crystals of galena after the face had been smoothed by filing; (c) the work of Nelson on the patterns produced when iron is vaporized on to flat surfaces, and the resulting effect of exposure to air. A gas discharge type and a filament type of electron diffraction camera are described in detail.—I. J.

**X-Ray Interference Investigation in Metallurgy.** U. Dehlinger (*Internat. Assoc. Test. Mat. Congr. London, 1937*, Advance Proof, Group A, 63-65).—[In German.] A review of recent progress with 22 references.—P. W. R.

**\*Electronic Energy Bands in Metallic Calcium.** Millard F. Manning and Harry M. Krutter (*Phys. Rev.*, 1937, [ii], 51, (9), 761-764).—Theoretical. The electronic energy bands in metallic calcium were investigated by the Wigner-Seitz-Slater cellular method. The conductivity is due to an overlap between the lowest *s* band, and the *d* band. The bearing of the results on optical properties, and on the abnormal pressure coeff. of resistance is discussed.

—W. H.-R.

**\*X-Ray Crystal Analysis of Alloys of Copper.** G. F. Lewin (*Abstracts Dissertations Dr. Phil. Univ. Oxford, 1937*, 9, 137-138).—The lattice distortion curves of zinc, gallium, and germanium in copper had initial slopes of  $2.05 \pm 0.08$ ,  $2.78 \pm 0.03$ , and  $3.4 \pm 0.15 \times 10^{-3}$  A. per atomic-%, respectively. The curves could be superimposed on one graph by plotting the lattice parameters against the atomic compositions multiplied by the numerical factors 2, 2.61, and 3.22, respectively, i.e. the lattice distortion appeared to increase by approximately equal steps with increase of the solute valency. The lattice parameter of pure copper was found to be 3.60705, and that of pure silver 4.0771 A., at 10° C.—C. E. R.

†**Transformations of Atomic Arrangement in Alloys.** E. J. Williams (*Sci. Progress, 1937*, 32, (125), 15-28; and (summary) *Metallurgia, 1937*, 16, (93), 96).—An exceedingly clear account is given of recent developments of the theory of order-disorder changes in alloys.—W. H.-R.

**Electronic Structure of Alloys.** J. C. Slater (*J. Applied Physics, 1937*, 8, (6), 385-390).—The zone theory of energy distribution of electrons in crystals is outlined, and the electrical conductivity and the ductility of metals are discussed in the light of this theory. A particular example, discussed in detail, is the application of the theory of energy bands to the ferromagnetic elements and their alloys. A feature of this group of metals is that there are two distinct bands of electrons overlying each other; an outer shell of 4*s* electrons which can be readily removed, and an inner 3*d* shell very active in conduction. The most characteristic property depending on the 3*d* electrons is that of ferromagnetism. It is shown that the number of empty spaces in the 3*d* shell multiplied by the moment for one electron per atom equals the saturation magnetic moment. Phase equilibrium diagrams for binary alloys of the iron group are given as a function of the number of vacant spaces in the shell of 3*d* electrons. This method is only applicable to substitution solid solutions in which the substituted atoms are almost of the same size. The theory of energy bands suggests that structures consisting of two or more types of atoms of different sizes would tend to form compounds rather than purely metallic solid solutions. The theory is still in an early stage, where it suggests, rather than works out, answers to problems; contrary to thermodynamics, however, it does give a clear picture of what metallic solid solutions and intermetallic compounds really are, and with further progress in the theory, a clearer interpretation of their properties must follow.—I. J.

†**The Crystal and the Engineer.** William Henry Bragg (*M. Proc. Inst. Civil Eng.*, 1937, (7), 181-202; *Engineering*, 1937, 143, (3720), 499-501; *Engineer*, 1937, 153, (4243), 530-532; (4244), 560-561; and (summaries) *Mech. World*, 1937, 101, (2527), 473-474; *Machinery Market*, 1937, (1908), 19-20).—The

subject of crystalline structure is discussed with particular reference to the materials used by the engineer. The extent to which X-ray powder photographs of metals and alloys have given information on the phases of both binary and ternary alloys is dealt with, and consideration is given to the "structure-sensitive" properties of metals, such as plasticity, toughness, and hardness, and the application of X-rays in dealing with problems connected with them, special reference being made to the work done on fatigue. The crystal growth and orientation of aluminium foil on heating as dealt with by recent methods of electron-diffraction, and also the application of such methods to the study of surface conditions, are also considered.—J. W. D.

**\*Powder Patterns on Ferromagnetic Crystals.** K. J. Sixtus (*Phys. Rev.*, 1937, [ii], 51, (10), 870-877).—The patterns formed by a suspension of iron oxide ( $\gamma\text{Fe}_2\text{O}_3$ ) on large crystals of 3.5% silicon-iron have been studied during the magnetization of the crystals. Three different types of patterns, Types I, II, and III were observed at low, medium, and high fields, respectively. Types I and II consist of straight lines, and Type III of bands of irregular length and appearance. The direction of the lines of Types I and II is determined by crystal orientation, whilst that of Type III is nearly always normal to the applied field. Type I patterns are formed only when the surface is strained either by polishing or by external stress. Type II patterns are little affected by stress, and are probably formed at the intersections of magnetic sheets, lying in dodecahedral (110) planes, with the surface. Type III patterns are formed near to surface inhomogeneities.—W. H.-R.

**\*Properties of the Surface Magnetization in Ferromagnetic Crystals.** W. C. Elmore (*Phys. Rev.*, 1937, [ii], 51, (11), 982-988).—A model was made consisting of 100  $\frac{1}{2}$ -in. steel cubes packed together in square array, each cube being permanently magnetized in one direction. Iron filings were sprinkled on these, and the patterns noted for different arrangements of the cubes. The results were then compared with the patterns formed by suspensions of colloidal ferric oxide when allowed to settle on the surfaces of single crystals of iron. Experiments on polished and unpolished single crystals of iron are described, and indicate that the "maze" type of patterns originates in the polishing operation, but that other than magnetic causes must be responsible for the regularity of the patterns.—W. H.-R.

**Precision Measurement of Lattice Constants.** M. C. Neuburger (*Internat. Assoc. Test. Mat. Congr. London, 1937*, Advance Proof, Group A, 61-63).—[In German.] A brief review of the subject with 18 references.—P. W. R.

**\*The Quantitative Estimation of Lattice Distortions associated with Debye-Scherrer Photographs.** R. Brill (*Z. Physik*, 1937, 105, (5-6), 378-388).—If the atomic centres of gravity of a crystal lattice are anomalously displaced from their normal positions, the effect is made evident in X-ray photographs in similar manner to that associated with thermal agitation. The effect is made evident by an increasing weakening of the intensities of the interference lines as the angle of diffraction is increased, and is the more marked the greater the displacement of the atoms. A method of estimating the atomic displacement from these decreases of intensity is given.—J. S. G. T.

**Crystalline Structure and the Properties of Materials.** E. Schmid (*Internat. Assoc. Test. Mat. Congr. London, 1937*, Advance Proof, Group A, 67-69).—[In German.] A brief survey of the subject.—P. W. R.

#### IV.—CORROSION

(Continued from pp. 290-292.)

**Aluminium and its Alloys in the Design of Corrosion-Resistant Machinery and Equipment.** E. H. Dix, Jr., and R. B. Mears (*Mech. Eng.*, 1936, 58, (12), 784-792).—The authors state the requirements of a corrosion-resistant material. The chemical composition and typical mechanical properties of

wrought, sand-cast, permanent-mould, and die-casting aluminium alloys are tabulated. Notes are given on alloys suitable for resistance to atmospheric exposure, fresh water, sea-water, and other salt solutions, mineral acids, organic acids, alkaline solutions, organic solvents, and gases. Alloys are cited suitable for use in the preparation and distribution of foods, transportation, electrical industry, chemical industries, refrigeration and air-conditioning, and architecture. There is a *bibliography* of 33 references.—R. Gr.

**An Aluminium Statue of 1893: Gilbert's "Eros."** R. S. Hutton and Richard Seligman (*J. Inst. Metals*, 1937, 60, 67-71; discussion, 72-74).—The freedom from serious corrosion of the statue of "Eros" in Piccadilly Circus, London, after 38 years' exposure, and the fact that it is made of un-alloyed aluminium, are recorded. Whether the metal used in 1893 was produced by the old chemical or new electrolytic process is undecided, but the results of analyses of specified examples of old aluminium are reported.—R. S. H.

**\*The Formation of Atacamite by the Incorporation of Copper Powder in Magnesium Oxochloride Compositions.** Dean S. Hubbell (*J. Amer. Chem. Soc.*, 1937, 59, (1), 215-216).—Addition of copper to magnesium chloride cements produces a blue-green colour, with increase in strength and reduction in solubility. X-ray examination showed the compound which was formed to be identical with atacamite (cupric oxochloride). This agrees with the observations of Bengough and May (*J. Inst. Metals*, 1924, 32, 131) and others that copper is corroded by certain chloride solutions to give basic chloride resembling atacamite. The formation of the new phase in magnesium oxochloride cement does not proceed in the absence of oxygen or water vapour.

—R. G.

**Copper and Copper-Base Alloys; Their Use in the Construction of Corrosion-Resisting Equipment and Structures.** R. A. Wilkins (*Mech. Eng.*, 1936, 58, (12), 809-822).—The physical and mechanical properties, and corrosion data (expressed as penetration in inches per year) are tabulated for copper (electrolytic, phosphorized, arsenical, and argentiferous), and brasses and bronzes (cast and wrought). Curves show the relationship between the annealing temperature and the mechanical properties of 80:20 brass sheet, Admiralty condenser tubing, Muntz metal condenser tubing, copper-silicon sheet, and 20% nickel-brass condenser tubing. Grain-size-annealing temperature relationships are also included on these graphs. Applications of the various alloys for corrosion-resistance are cited. In the section dealing with design and mechanical factors, it is suggested that the elastic limit should be determined by plotting equal increments of stress against corresponding increments of strain on the stress-strain curve. The elastic limit is the point at which the graph shows a marked change in slope. It is stated that, after excessive cold-working, the brasses, aluminium bronzes, and silicon-copper alloys may be liable to rapid failure due to stress-corrosion cracking under even mild corrosive attack, and "relief annealing" is advocated. Jointing of parts is dealt with in its relation to corrosion-resistance. Impingement corrosion may cause premature failure. Hot-rolled alloys have a much higher endurance limit in fatigue than similar extruded alloys. A number of other considerations are cited as guides to the choice of constructional materials. There is a *bibliography* of 117 references.—R. Gr.

**Corrosion-Testing Methods for Copper Alloys.** D. K. Crampton and N. W. Mitchell (*Amer. Soc. Test. Mat. Preprint*, 1937, (June), 11 pp.).—Corrosion phenomena are classified according to cause and result. The desirability of incorporating the causes and forms of corrosion test is pointed out. Details are given of the alternate-immersion and water-line tests, and it is shown that all known forms of corrosion are obtained. The factors influencing the accuracy of the tests are discussed. Actual test data are given by way of illustration, and the importance of proper interpretation of test results is stressed.—S. G.



\*The Decrease of the Corrosion in Iron and Brass Tubes During the Post-Season Removal of Incrustations with Hydrochloric Acid. I.—Experiments with Pure Reagents. II.—Experiments with Technical Materials. J. Forman (*Z. Zuckerind. čechoslovak. Rep.*, 1937, 61, 193–197; *C. Abs.*, 1937, 31, 3730).—See *Met. Abs.*, this vol., p. 244.—S. G.

\*The Decrease of the Corrosion of Iron and Brass Tubes During the Post-Season Removal of Incrustations with Hydrochloric Acid. II.—Experiments with Technical Materials. J. Forman (*Z. Zuckerind. čechoslovak. Rep.*, 1937, 61, 209–213; and *Listy Cukrovar*, 1936, 55, 129–133; *C. Abs.*, 1937, 31, 3730).—Previous experiments indicated that inhibitors of corrosion are to be found among raw materials, such as crude sulphonic acids, yeasts, heavy oils, glue, gelatin, starches, &c. Substances with an intense surface activity (cyclanone, octyl alcohol, igepon, emulfor) in concentrations up to 0.1 grm. decreased the corrosion of iron in 100 c.c. of 10% hydrochloric acid; in concentrations of 0.1–1.0 grm. these substances increased the corrosion until it exceeded that of unadulterated hydrochloric acid. Additions of 0.5 grm. of sweet slices, extracted slices or triamylamine to 100 c.c. of 10% hydrochloric acid decreased the corrosion of iron to 10–30% of the rate of corrosion in free hydrochloric acid; further additions of slices up to 5 grm. had only a slight additional inhibitory effect. In an acid containing an optimal concentration of 0.001% copper sulphate, the copper deposited a thin film on the iron and diminished the corrosion by 10% in the free acid and 30% in the acid-containing slices. Experiments repeated in 1% hydrochloric acid confirmed the preceding results; the maximum effect was attained with a 1% addition of beet slices. Since a 1% hydrochloric acid solution does not dissolve the beet slices completely, F. places 1 kg. of sweet or extracted slices in 2.5 litres of concentrated hydrochloric acid, adds 0.5 grm. of copper sulphate, allows the mixture to stand for 12 hrs., and then adds enough water to produce 100 litres of solution; such a preparation decreases the corrosive effect of the free acid 90%. For studying the effect of his preparations on incrustations, F. determined the loss in weight of marble cubes immersed for 15 minutes in a 10% hydrochloric acid solution with or without an inhibitor. Substances which retarded the solution were: commercial pyridine 83%, pure quinoline 45%, and commercial quinoline 10%; purified pyridine hastened the solution 1.3%, beet slices hastened the solution 2–4%. A foam is present only during the solution of the beet slices in the hydrochloric acid; it disappears in the prepared solution. Similar results were obtained in experiments with brass plates exposed to the solutions mentioned above.—S. G.

\*Studies in the Corrosion Problem of Condenser Tubes.—IV. Tomojiro Tanabe, Goro Koiso, and Masuo Yata (*Sumitomo Kinzoku Kōgyō Kenkyū Hokoku (Res. Rep. Sumitomo Metal Ind., Ltd.)*, 1937, 2, (10), 1056–1080).—[In Japanese.] Cf. *Met. Abs.*, 1936, 3, 536, 669. A study was made of the corrosion-resistance of some condenser tubes inserted in the authors' model condenser, the conditions being the same as described in the previous report. The materials tested were: Albrac (copper 78.5, aluminium 2.0, silicon 0.3, arsenic 0.05%; zinc remainder); modified Albrac Nos. 1–4 (copper 78–79, aluminium 2.0, tin 0.0–0.02, silicon 0.1–0.3, arsenic 0.03–0.12, phosphorus 0.0–0.05%, zinc remainder); aluminium-brass (copper 82.47, aluminium 3.30%, zinc remainder); special aluminium-brass (copper 81.82, aluminium 4.20, nickel 1.5, chromium 0.05%, zinc remainder); Admiralty metal (copper 70, zinc 29, tin 1%). After running for 6360 hrs. the results were as follows: (1) Two of 10 Admiralty tubes were perforated by erosion after about 1500 hrs. running, the remainder also eroded badly; (2) The aluminium-brass and special aluminium-brass tubes suffered severe dezincification; (3) The Albrac and modified Albrac tubes were almost all sound, and good even in the severe conditions of the test, the temperature on the steam side being 80°–90° C. and the mean velocity of the cooling water 4 m./second.—S. G.

**Corrosion-Resistant Lead Equipment.** George O. Hiers (*Mech. Eng.*, 1936, 58, (12), 793-798; and *Nat. Lead Co. Lab. Bull.*, 1937, 3, (20), 267-287).—The composition, physical, and mechanical properties of the standard grades of lead are tabulated and commented on. The available commercial forms of lead are cited. Results are given in mg./dm.<sup>2</sup>/day of the rate of attack on lead of aqueous ammonia, salt solutions, caustic solutions, phosphoric acid (quiet and aerated), sulphuric mixtures, and other acids (with oxygen, hydrogen, or air present). Typical applications of the various grades of lead for corrosion-resistance are described. A bibliography of 29 references is appended.—R. Gr.

**\*The Rate of Reaction of Magnesium with Acids in Ethyl Alcohol.** Martin Sclar and Martin Kilpatrick (*J. Amer. Chem. Soc.*, 1937, 59, (3), 584).—When magnesium dissolves in solutions of acids in ethyl alcohol, the predominant reaction is between the metal and the alcohol. The production of ethylate ion is sufficiently rapid to prevent other acids from reaching the metal.—R. G.

**Nickel and Nickel-Base Alloys: Their Use in the Design of Corrosion-Resistant Machinery and Equipment.** F. L. LaQue (*Mech. Eng.*, 1936, 58, (12), 827-843).—The chemical composition, physical constants, mechanical properties, results of short-time tension tests on hot-rolled rods at various temperatures, and forms in which the materials are available, are tabulated for nickel, regular, *K*, *H* and *S* Monel metal, Hastelloys, and Illium. Creep data on Monel metal and Hastelloys are also tabulated. The corrosion-resistance characteristics are stated of nickel, Monel metal, Inconel, and Hastelloy alloys A, C, and D in atmospheres at various localities, fresh water, salt water, neutral, and alkaline salts, acid salts, oxidizing acid salts, oxidizing alkaline salts, mineral acids, oxidizing acids, organic acids and compounds, alkalies, and wet and dry gases. The corrosion of Monel metal by fruit juices is also dealt with. The corrosion-resistance characteristics of Illium in mineral acids, oxidizing acids, organic acids, acid salts and oxidizing acid salts are discussed. As a general rule, oxidizing conditions favour corrosion of nickel, but a passive oxide film protects it from certain forms of attack. Monel metal is more resistant than nickel under reducing conditions, and more resistant than copper under oxidizing conditions. The choice of grades of Monel metal should be determined mainly by mechanical properties rather than by corrosion resistance.—R. Gr.

**Zinc in the Chemical Industries.** E. A. Anderson (*Mech. Eng.*, 1936, 58, (12), 799-802).—A. states that, in 1934, 42% of the total production of zinc was used for coating steel. Results are quoted of tests on zinc-coated steel specimens situated at various places in America. The need for heavy coatings is emphasized, and curves are plotted connecting the amount of rusting with the time of exposure for various thicknesses at the different localities. It is shown graphically that, over a period of 3 years in various localities, zinc is more protective for iron than aluminium, tin, lead, copper, or nickel. The corrosion of zinc in water is at a minimum in weakly alkaline water of 6-12  $p_H$  value. The commercial applications of zinc coatings are described. It is stated that the use of solid zinc sheets for roofing is prohibitive, owing to the increased number of supports necessary; a zinc alloy is available, however, for the purpose.—R. Gr.

**Corrosion, Oxidation, and Stability to Sulphur of Non-Ferrous Metals at High Temperatures.** W. Rohn (*Internat. Assoc. Test. Mat. Congr. London*, 1937, Advance Proof, Group A, 42-44).—[In German.] A brief review of the subject with a bibliography of some 40 references.—P. W. R.

**Corrosion-Resistant Metals.** F. N. Speller (*Mech. Eng.*, 1936, 58, (12), 781-783).—Introductory paper to a symposium on the use of corrosion-resistant metals in the design of machinery and equipment. S. discusses broadly the factors involved in corrosion and protection, and refers to factors associated with the metal and factors associated with the environment, such

as primary and secondary reactions, average and localized attack and presence or otherwise of oxygen. Corrosion, it is stated, can be classified according to the environment. Preventive measures are indicated.—R. Gr.

**Corrosion Danger in the Sugar Industry.** Fritz Tödt (*Deut. Zuckerind.*, 1936, 61, 1129–1131; *C. Abs.*, 1937, 31, 3730).—In cane mills, corrosion due to sulphur dioxide and carbon dioxide occurs mainly on the steam side of the heating tubes; in beet houses both sides are attacked. Traces of  $\text{NH}_3$  will attack brass, and so does oxygen of the air. Where the battery waste and pulp-press water are returned to the presses, there is an additional hazard owing to the entrained air and low  $p_{\text{H}}$ . In steam boilers, corrosion due to improperly prepared feed-water or the presence of sugar can largely be prevented.—S. G.

**Electrochemical Technique in Corrosion Study.** R. M. Burns (*J. Applied Physics*, 1937, 8, (6), 398–403).—Useful information concerning the nature of corrosion processes in the presence of moisture may be obtained by utilizing certain techniques of high sensitivity, in place of the common and more cumbersome corrosion life tests. It is no longer necessary to resort to the practice of accelerating reactions in order to measure them, a method which often leads to erroneous conclusions. Observations of the potentials of materials in known environments and changes of these potential values with time which may be determined by means of a potentiometer or vacuum tube electrometer, show whether the metal surface is in a corroding or a passive state. A trend in the electronegative direction, characteristic of cathodic polarization, is associated with active corrosion, whilst an electropositive trend of potential is indicative of passivation. The existence and stability of passive surface films may be investigated advantageously by oscillographic measurements. Rates of corrosion may be readily measured by the use of the polarograph which is especially suitable for determining the initial rates of reaction.—I. J.

**Recent Progress and Applications of Methods of Investigating Gaseous Corrosion.** A. Portevin, E. Prétet, and H. Jolivet (*Internat. Assoc. Test. Mat. Congr. London*, 1937, Advance Proof, Group A, 167–169).—[In French.] 17 references are given.—P. W. R.

[Discussion on] **Corrosion-Resistant Metals.** E. S. Taylerson. L. W. Hopkins. R. M. Burns. F. L. Hunter. M. H. Curley. R. A. Wilkins (*Mech. Eng.*, 1937, 59, (3), 194–197).—Discussion on papers by Speller, Hiers, Anderson, and Wilkins (see abstracts *Met. Abs.*, this vol., pp. 340, 342) read at a symposium on corrosion-resistant metals in the design of machinery and equipment.—S. G.

**Fourth General Meeting of the (Mixed) International Research Committee on the Protection of Telegraphic Conductors and Underground Lines.** C. F. R. (*J. Télécommunications*, 1936, 3, (3), 88–92).—See *Met. Abs.*, this vol., p. 8.  
—R. T.

## V.—PROTECTION

(Continued from pp. 292–293.)

\***Galvano-Thermal Production of Protective Coatings for Copper-Nickel Alloys.** P. P. Beliaev and A. A. Sladkov (*Vestnik Metallopromishlennosti (Messenger Metal Ind.)*, 1936, 16, (9), 95–98; (10), 76–84).—[In Russian.] Sheet iron plated with layers of copper and nickel each  $12 \mu$  thick was annealed at  $500^\circ$ – $1000^\circ \text{C}$ . for varying periods and the depth of diffusion of the plated metals determined by the reaction to dimethylglyoxime in successive layers obtained by polishing. After a 6 hrs.' anneal the depth of penetration of nickel into copper was at  $500^\circ \text{C}$ .  $2 \mu$ , at  $600^\circ \text{C}$ .  $3 \mu$ , at  $700^\circ \text{C}$ .  $6 \mu$ , at  $800^\circ \text{C}$ .  $24 \mu$ , at  $900^\circ \text{C}$ .  $42 \mu$ , and at  $1000^\circ \text{C}$ .  $66 \mu$ ; in all cases this depth was proportional to the square root of the annealing time. The rate of iron diffusion through

the plating increases above 900° C. and structural changes in the alloy obtained occur above 800° C. Diffusion conditions in four-layer platings and resistance of platings to corrosion were also studied.—D. N. S.

**\*Protection of Magnesium from Atmospheric Corrosion under Storage and Transport Conditions.** B. Rimmer (*Legkie Metally (Light Metals)*, 1936, (8-9), 48-52).—[In Russian.] Of the different mineral, vegetable, and animal fats and oils tested, a mixture of vaseline and paraffin proved to be the best preservative for magnesium ingots from corrosion in moist atmosphere (98% R.H.) and in 3% sodium chloride between -10° and +40° C. The ingots should be dipped for 1-2 minutes in 5% nitric acid before greasing. Magnesium should not be stored in wooden cases or on wood shelves, and should preferably be wrapped in moisture-proof paper impregnated with vaseline-paraffin mixture.—D. N. S.

**The Decoration of Tinplate by Printing and Varnishing.** W. E. Hoare (*Tech. Publ. Internat. Tin Res. Develop. Council, Series B*, 1937, (4), 24 pp.).—An account of the development and principles of tinplate printing. Modern processes are described in detail. The composition, properties, and methods of application of tin printing inks and varnishes are described together with the requirements of stoves and drying ovens for their treatment. The effect on the printing process of mottle, veining, grease, moisture, surface irregularities, uneven substance, and other tinplate defects are considered, and suggestions are made concerning the design of the container.—W. D. J.

**Galvanized Sheets and Galvannealed Sheets.** J. L. Schueler (*Metal Progress*, 1937, 31, (5), 499-502).—Hot-dipped galvanized sheet which has been heat-treated immediately after dipping ("galvannealed" sheet) possesses a fine-grained matt surface, which forms a satisfactory base for paint; the adhesion of the zinc is improved by the uniform degree of diffusion of the zinc-iron compounds. A discussion of the optimum thickness of coating for various types of work is included in a brief summary of modern galvanizing practice.—P. M. C. R.

**The Galvanizing Plant in the Four-Year Plan.** Arthur Roller (*Illust. Zeit. Blechindustrie*, 1937, 66, (24), 709-710).—Methods of economizing material in the various processes of hot-galvanizing are suggested.—P. M. C. R.

**On the Determination of the Uniformity of a Zinc Coating.** A. R. Matthis (*Internat. Assoc. Test. Mat. Congr. London, 1937*, Advance Proof, Group A, 54-56).—[In French.] M. finds method A 90-33 of the American Society for Testing Materials completely satisfactory for the determination of the surface density of zinc in galvanized articles. None of the methods in use for the determination of the uniformity of the coating, however, is considered satisfactory in industrial practice. The Preece test, which is most frequently employed, is subject to numerous errors arising from uncertainties in the concentration of the copper sulphate solution, and the temperature and acidity of the bath, while the size of the specimen tested is normally out of all proportion to that of the material from which the sample is taken. Recommendations are set forth for a more rational procedure whereby these difficulties may be overcome.—P. W. R.

**Effect of Temperature and Density of Cupric Sulphate Solution on Preece Test.** Kiyosi Hisano and Kesanobu Matsuura (*Nippon Elect. Communication Eng.*, 1937, (5), 80).—[In English.] A short abstract of an article (in Japanese) appearing in the *J. Inst. T.T.E. (Japan)* for 1936.—E. V. W.

**Measurement of the Thickness of Electrodeposits.** — (*Nickel Bull.*, 1937, 10, (6), 121-125).—Describes and comments on the following methods of measuring the thickness of electrodeposits, chiefly nickel: chemical analysis, slow, and only gives the average thickness; Mesle's chord method, accuracy from  $\pm 5$  to  $\pm 11\%$ ; micro-examination of cross-section, preferably after etching; drop test, rather slow; B.N.F. jet test, similar to the drop test. This last test is described in detail; it is non-destructive, rapid (1-2 min.),

applicable to flat or curved surfaces, the apparatus is simple and portable, and the accuracy is within 15%.—J. H. W.

**\*Metal Spraying: Processes and Some Characteristics of the Deposits.** E. C. Rollason (*J. Inst. Metals*, 1937, 60, 35–57; discussion, 57–66).—Spraying pistols using wire, powder, and molten metal are described, together with comparative details. The nature of the sprayed deposit is discussed. A few corrosion tests using intermittent salt-spray have been made on zinc and aluminium deposits and on painted zinc coats. Using the three types of pistol, comparative tests of aluminized surfaces have been made and heat-treated nickel–chromium–iron coatings were found to have good resistance to oxidation at elevated temperatures. Data are also given for porosity, oxide content of sprayed copper, and hardness of sprayed metals. A selected bibliography of 69 references is appended, covering the literature since 1925.

—E. C. R.

**Longer Life for Diesel Valves.** R. K. Kennedy (*Power Plant Eng.*, 1937, 51, (5), 281–283).—Detailed directions are given for the Stelling of Diesel valves and valve seats. Grinding wheels, the source and catalogue reference number of which is given, are recommended for various classes of valve.—P. M. C. R.

## VI.—ELECTRODEPOSITION

(Continued from pp. 293–294.)

**\*Chromium Plating from Non-Chromic Acid Solutions with Chromium Anodes.** M. Schlötter (*First Internat. Electrodeposition Conf. London, 1937*, Advance copy, 3 pp.).—Chromium anodes were prepared by vacuum melting, in magnesia crucibles in an induction furnace, from metal produced electrolytically or aluminothermally. Dissolution of the anodes in the trivalent form is induced by superimposition of an a.c. several times as great as the d.c. With sulphate electrolytes operated at 20° C., with more than 6 amp./dm.<sup>2</sup>, a cathode current efficiency of 30% may be obtained. The throwing power is as good as that of chromic acid baths; the colour of the deposits may be varied from a dark grey to a highly lustrous chromium colour by adjustment of the  $p_{\text{H}}$  and current density.—A. R. P.

**An Introduction to Chromium Plating.** Harold Saenger (*C. and A. Bull.*, 1936, 1, (3), 14–16).—An elementary description of the operation of the chromic acid bath, with practical hints for obtaining good plates.—A. R. P.

**\*Electrolytic Coating with Lead Without Immersing in the Electrolyte.** N. P. Fedotieff, B. P. Artamonoff, and N. J. Rasmerova (*First Internat. Electrodep. Conf. (London), 1937*, Advance copy, 15 pp.).—The value of borofluoride, phenolsulphonate, plumbite, acetate, nitrate, and perchlorate baths for the deposition of lead on iron by “electro-rubbing” has been examined. In all cases the best results are obtained with soluble anodes, insoluble anodes causing insoluble films of lead peroxide or basic lead salts to be formed and the solution to be rapidly denuded of lead. The electrolyte contains hydrofluoric acid (100%) 120, boric acid 106, basic lead carbonate 142, and glue 0.2 grm./litre, and the anode consists of an ebonite box containing granulated lead above a perforated plate carrying the brush for distributing the electrolyte over the work. Good microcrystalline deposits are obtained with current densities of 20–500 amp./dm.<sup>2</sup>; they adhere well to thoroughly degreased iron and have a resistance to corrosion equal to that of deposits of equal thickness produced in still baths. A thickness of about 0.1 mm. can be built up in about 30 minutes with 500 amp./dm.<sup>2</sup>.—A. R. P.

**Bright Nickel Plating.** A. H. Beebe (*Metals and Alloys*, 1936, 7, (10), 273–274).—The objects, characteristics, and advantages of bright nickel-plating are discussed, and the essential characteristics of a good bright plating bath are reviewed.—A. R. P.

**\*Cathodic Current Distribution in Galvanic Electrolytes. II.—Investigation of Nickel Baths.** E. Mantzell (*Z. Elektrochem.*, 1937, 43, (3), 174–186).—See *Mct. Abs.*, 1936, 3, 263. The current distribution in five fundamental types of nickel baths was investigated, namely, nickel baths with high chloride and with high sulphate contents, nickel sulphate–ammonium chloride baths, citrate baths, and nickel ammonium sulphate baths. It was found that in the nickel baths, polarization and conductivity have a decisive effect on the degree of dispersion. The effect of the current efficiency is, in general, not so great as might be supposed from Haring and Blum's measurements (*Trans. Amer. Electrochem. Soc.*, 1924, 46, 107). The experiments with the nickel chloride–ammonium chloride bath showed that with a continuous increase of the conductivity, the dispersibility of the bath does not increase to the same extent, but that at a certain point a stabilization occurs. No considerable improvement of the current distribution by the raising of the temperature or the nickel sulphate concentration can be obtained in the rapid nickelling baths with high nickel–iron concentration without the addition of conducting salts. By the addition of conducting salts the current distribution of these baths can be greatly improved.—J. H. W.

**Nickel and Zinc Electroplate Finishes for Iron and Steel Components.** E. E. Halls (*Metallurgia*, 1937, 16, (91), 9–11).—A preliminary nickel plating improves the quality of electro-zinc coatings from the point of view of durability and of appearance. The reason for the first is probably associated with the natural inertness of nickel, which adds to the protective quality of the coatings in areas where the zinc throws poorly, and the explanation of the second is the superior covering power of the nickel, and the better washing characteristics of sulphate deposits as compared with cyanide coatings. The additional cost of applying the nickel underlay is practically negligible, as the nickel substitutes the zinc flash normally applied prior to the main zinc deposition direct on steel.—J. W. D.

**Rhodium Plating.** A. W. Scott (*C. and A. Bull.*, 1936, 1, (3), 10–11).—A description is given of the operation of rhodium plating baths, and of the properties of rhodium plate.—A. R. P.

**\*On Electrolytic Tinning.** F. Marshak (*Vestnik Metallopromishlennosti (Messenger Metal Ind.)*, 1936, 16, (10), 84–89).—[In Russian.] The effects of various concentrations of stannous sulphate, sulphuric acid, glue, and *m*-cresol on the operation of the tin-plating bath using iron and brass cathodes were studied. The best results were obtained with stannous sulphate 7–10, sulphuric acid 5–10%, and small amounts of glue and *m*-cresol. Pyrogallol, albumen, gelatin, and gum arabic spoil the deposit.—D. N. S.

**Black and White Patterns on Tin Plate.** — (*Illust. Zeit. Blechindustrie*, 1937, 66, (20), 594–595).—Methods and bath compositions are given for the production of black and white patterns by the selective anodic deposition of tin oxide on tin plate, and of nickel or molybdenum on galvanized zinc.—P. M. C. R.

**Ductile Zinc Coating. Deposited on Wire by Electrolysis.** Ernest E. Thum (*Metal Progress*, 1937, 31, (5), 524–528, 544).—The electrogalvanizing process of "Bethanizing," which is described and illustrated, permits accurate control of the thickness of the deposit, which retains its ductility up to considerable thicknesses owing to the purity of the electrolyte (zinc sulphite).—P. M. C. R.

**Barrel Polishing.** Richard Smetham (*C. and A. Bull.*, 1936, 1, (3), 9–10; (4), 2–4).—The advantages of barrel plating in mass production work are discussed.—A. R. P.

**Notes on Modern Electroplating Generators.** Andrew Allison (*C. and A. Bull.*, 1936, 1, (3), 3–7; (Anniv. No.), 7–11; correspondence, (4), 4–5).—The operation and efficiency of motor generators and rectifiers are compared.—A. R. P.

## VII.—ELECTROMETALLURGY AND ELECTROCHEMISTRY

(Other than Electrodeposition.)

(Continued from pp. 294-295.)

\*Production of Aluminium-Copper Alloys in a Bath for Alumina Electrolysis. M. I. Kopelman (*Trudi Aluminievogo-Magnievo Instituta "VAMI"* (*Trans. Inst. Aluminium Magnesium*), 1936, (13), 95-97).—[In Russian.] Addition of copper during ordinary electrolytic production of aluminium does not alter the normal course of the electrolysis but slightly increases the current yield and enables alloys with up to 50% of copper to be obtained. The quantity of copper required to give an alloy of desired composition can be fairly accurately calculated.—D. N. S.

\*Electrode Potential Phenomena. E. C. R. Spooner (*Abstracts Dissertations Dr. Phil. Univ. Oxford*, 1937, 9, 166-177).—The development of a general theory of the electrode potential behaviour of metals in aqueous solutions. Time is of fundamental importance in determining electrode potential at any instant, and the influence of electrode and solution factors upon time: electrode potential curves, is illustrated for many commercial metals. Stages in the approach to equilibrium between the electrode metal and the solution, are termed (a) "the steady state," *i.e.* when the leakage current is small and the change of potential with time is very slow, and (b) "the stationary state," *i.e.* when the change in potential due to changes in the chemical composition of the electrode and/or solution, are negligible. Non-homogeneity of the electrode surface gives rise to surface fields and "local-action currents" which considerably influence the electrode potential. A complete knowledge of the nature and distribution of these fields and of the velocities of possible reactions at each surface is discussed in the light of experimental data, but due to the complexity of the problem, a complete solution is not possible. Results obtained with aerated and oxygen-free solutions are given, and metals are classified according to the nature of the sole cathodic process, *e.g.* (1)  $O_2 \rightarrow OH^-$ , (2)  $H^+ \rightarrow H_2$ , (3) where (1) and (2) occur simultaneously. In general, for metals in aqueous aerated solutions, the magnitude and surface distribution—as patches—of the anodic (clear metal) and cathodic (adsorbed  $O_2$ ) field areas and the magnitude of the local action process vary according to the nature of the system conditions. Examples are given. Oxygen-free solutions give analogous results in that two fields again predominate, one being a cathodic field of adsorbed H atoms or hydride film. Some 800 references are stated to be quoted in the text of the original dissertation.—I. J.

## IX.—ANALYSIS

(Continued from p. 295.)

†Spectroscopy in Industry. A. Fowler (*J. Sci. Instruments*, 1937, 14, (5), 153-161).—Presidential Address to the Institute of Physics. Much of the address deals with the applications of spectrographic analysis to metallurgical problems.—W. H.-R.

\*Spectrographic Method of Quantitative Analysis of Crude Aluminium and Its Alloys. L. E. Vedenski (*Zavodskaya Laboratoria (Works' Lab.)*, 1936, 5, (11), 1349-1352).—[In Russian.] The analysis of Si-Al and Cu-Al alloys for Si, Fe, Cu by photometric interpolation with the aid of a Pt graded filter is described (see L. E. Vedenski and S. L. Mandelshtam, *Met. Abs.*, this vol., p. 54).—D. N. S.

\*The Quantitative Spectro-Analysis of Aluminium-Magnesium Alloys. W. Seith and A. Beerwald (*Z. Elektrochem.*, 1937, 43, (5), 342-350; and (summary)

*Light Metals Research*, 1937, 5, (18), 408-410).—When Al and Mg are brought into contact and heated, diffusion takes place (see W. Bungardt, *Luftfahrtforschung*, 1937, 14, 204-208), and the section contains the four phases,  $\alpha$ ,  $\beta$ ,  $\gamma$ ,  $\delta$  of Hanson and Gayler's equilibrium diagram. The apparatus and method of spectroanalysis for the quantitative determination of these four phases are described. Alloys of from 0-14% Mg in Al and 0-4% Al in Mg were quantitatively analyzed by this means, provided that those of higher contents were made homogeneous by quenching. The effect of the presence of copper was investigated by applying the method to the analysis of Duralumin. The spontaneous ageing effect and the influence of spark on the results were also studied.—J. H. W.

**\*The Polarographic Analysis of Brass. The Principles of Rapid Series Analysis of Alloys, Carried Out with the Dropping-Mercury Cathode.** Hans Hohn (*Z. Elektrochem.*, 1937, 43, (2), 127-139).—Polarographic analysis involves certain difficulties, such as those connected with the presence of diffusion currents, the small surface of the drops which will fall with the desired frequency, poor contacts due to the reaction of the electrolyte with the anode, surface tension, the presence of foreign ions and interfering constituents of the solution, and wave coincidence. For the polarographic analysis of brass, the sample is dissolved in concentrated  $\text{HNO}_3$ , treated with concentrated  $\text{NH}_4\text{OH}$  and normal  $(\text{NH}_4)_2\text{CO}_3$ , and filtered, the solution containing the Cu, Zn, and Ni. The Fe and Pb in the precipitate are dissolved in  $\text{HNO}_3$ , and the residue is weighed ( $\text{SnO}_2$ ). Portions of the first filtrate are treated with special solutions containing  $\text{NH}_3$  for the polarographic determination of the Cu, and KCN for the determination of the Ni. The second filtrate is treated with a special solution containing  $\text{NH}_4\text{Cl}$  for the determination of the Pb and Fe. The details of the method, the preparation of the special solutions and the interpretation of the polarographic results are explained.—J. H. W.

**\*Separation of Beryllium in the Presence of Complex Tartrates.** Hoke S. Miller (*Indust. and Eng. Chem. (Analyt. Edn.)*, 1937, 9, (5), 221).—Be may be separated from Al by double precipitation with an excess of  $M\text{-NH}_4\text{OH}$  (16 c.c. per 50 c.c. of solution) from a solution containing 20-30 c.c. of 0.5M-K tartrate; the mixture is set aside overnight at 25° C. before filtration.—A. R. P.

**The Determination of the Oxygen Content of Metals.** Wilhelm Jander and Alfred Krieger (*Z. anorg. Chem.*, 1937, 232, (1), 57-60).—The metal is mixed with an equal weight of Sb, previously melted in  $\text{H}_2$ , and the mixture is heated in  $\text{H}_2$  at above the melting point of the resulting alloy. The  $\text{H}_2\text{O}$  formed is condensed to snow by a  $\text{CO}_2$  freezing mixture, and the  $\text{H}_2$  removed from the apparatus by the vacuum pump. The snow is then vaporized, and the pressure of the resulting  $\text{H}_2\text{O}$  vapour measured at a standard temperature.—A. R. P.

**\*A Comparison of Quantitative Methods for the Determination of Copper.** H. W. Foote and John E. Vance (*Indust. and Eng. Chem. (Analyt. Edn.)*, 1937, 9, (5), 205-206).—Very accurate results for Cu are obtained by buffering the solution with  $\text{NH}_4\text{HF}_2$  and determining the metal iodometrically; quite large amounts of As, Sb, and Fe do not interfere in this procedure which is superior, therefore, to the electrolytic method in speed and accuracy.—A. R. P.

**\*The Potentiometric Method of Copper Determination.** N. M. Miloslavski and J. I. Dolgina (*Zavodskaya Laboratoria (Works' Lab.)*, 1936, 5, (10), 1289-1296).—[In Russian.] In the potentiometric determination of Cu by reduction of  $\text{Cu}^{++}$  to  $\text{Cu}^+$ , the end-point is clearly registered with an indicator electrode, when  $\text{Br}'$  or  $\text{CNS}'$  is present to precipitate the  $\text{Cu}^+$  ion as it is formed. With a powerful reducing agent, e.g. a  $\text{Cr}^{++}$  salt, in the presence of  $\text{Br}'$ , both stages of the reduction  $\text{Cu}^{++} \rightarrow \text{Cu}'$  and  $\text{Cu}' \rightarrow \text{Cu}$  can be equally well determined. With less active reducing agents, e.g. Mohr's salt, reduction is quantitative in the presence of  $\text{CNS}'$  only in the presence of complex-forming agents, e.g.  $\text{CH}_3\text{CO}_2\text{Na}$ ,  $\text{Na}_4\text{P}_2\text{O}_7$ , or  $\text{NH}_4\text{F}$ .—D. N. S.



**\*New Method for Determining Copper in a Copper Cyanide [Plating] Bath.** B. S. Tsibina (*Zavodskaya Laboratoria (Works' Lab.)*, 1936, 5, (11), 1310-1311).—[In Russian.] The solution (20 c.c.) is treated with 2 c.c. of formaldehyde and 20 c.c. of 10%  $H_2SO_4$ . The precipitate is collected, washed with water, and dissolved in a  $H_2SO_4$  solution of  $Fe_2(SO_4)_3$ , the resulting  $FeSO_4$  being titrated with  $KMnO_4$ .—D. N. S.

**\*Electroanalytical Determination of Copper Without the Use of Platinum Electrodes.** V. M. Shalfeev and A. P. Bezzabotnova (*Zavodskaya Laboratoria (Works' Lab.)*, 1936, 5, (11), 1311-1313).—[In Russian.] Cu can be satisfactorily deposited on Ag or graphite cathodes, but in the latter case  $HNO_3$  must be absent from the solution.—D. N. S.

**\*Spectrographic Determination of Magnesium, Copper, Titanium, and Iron in Aluminium Alloys.** K. A. Suhenko (*Zavodskaya Laboratoria (Works' Lab.)*, 1936, 5, (11), 1347-1349).—[In Russian.] Mg is determined by comparing the Mg line 5183.6 A. with the Fe line 5227.7 A., Cu by comparing the Cu line 5105.5 A. with the Fe line 5107.4 A., Ti by comparing the Ti line 1991 A. with the Fe line 5012.7 A., and Fe by comparing the Fe line 5269 A. with the Cu line 5292.5 A. in the spark spectrum between the electrodes used for the spark spectrum of the alloy under determination and Fe (or Cu for determining Fe). The results obtained were compared with chemical analysis data.—D. N. S.

**\*Determination of Silicon in Aluminium and Aluminium Alloys.** H. V. Churchill, R. W. Bridges, and M. F. Lee (*Indust. and Eng. Chem. (Analyt. Edn.)*, 1937, 9, (5), 201-202).—*Acid method*: the metal (1 grm.) is dissolved in 35 c.c. of a mixture of  $H_2SO_4$  115, HCl 200,  $HNO_3$  200, and  $H_2O$  485 c.c.; the solution is evaporated to fumes of  $SO_3$ , the salts are dissolved in a mixture of 100 c.c. of  $H_2O$  and 10 c.c. of 1:3  $H_2SO_4$ , and the residue collected, washed, ignited, and fused with  $Na_2CO_3$ . The melt is dissolved in  $H_2O$  and the  $SiO_2$  separated by two evaporations with  $H_2SO_4$  and tested for purity by the usual  $HF-H_2SO_4$  procedure. *Alkali method*: the metal is dissolved in a Monel beaker in 15 c.c. of 30% NaOH and a little  $H_2O_2$ , the solution evaporated to 5 c.c. and poured into 80 c.c. of 1:1  $H_2SO_4$ , and the mixture evaporated to fumes; the  $SiO_2$  residue is collected and the analysis finished as usual.  $HClO_4$  may be used instead of  $H_2SO_4$  for separating the  $SiO_2$ .—A. R. P.

**\*The Use of Conductometric Methods with Visual Observation in Microchemical Investigations. The Titration of Extremely Small Amounts of Lead, Cadmium, Copper, Silver, and Bismuth with Hydrogen Sulphide.** H. Immig and G. Jander (*Z. Elektrochem.*, 1937, 43, (4), 207-211).—The conductometric titration of very dilute solutions of silver nitrate containing from 20  $\gamma$  to 1  $\gamma$  of silver is described in detail. The errors of the method are 0.5-1% with 20  $\gamma$  of silver, about 3% with 5  $\gamma$ , and between 5 and 10% with 1  $\gamma$ . The determination of other heavy metals, such as Cu, Cd, Pb, and Bi, is effected directly by comparing the  $H_2S$  solution with a very dilute solution of  $AgNO_3$  of known composition.—J. H. W.

**\*The Use of Conductometric Methods with Visual Observation in Microchemical Investigations. The Titration of Extremely Small Amounts of Silver Salts in the Presence of Large Amounts of Lead Salts with Silver Chloride Solution.** Gerhart Jander and Heinz Immig (*Z. Elektrochem.*, 1937, 43, (4), 214-215).—The procedure is similar to that previously described (cf. preceding abstract) with the use of hydrogen sulphide solution. In the presence of 500 times as much Pb as  $Ag$ , the errors in the determination of the Ag do not exceed  $\pm 3\%$ . The method can be applied to the determination of Ag in the presence of large amounts of the salts of other metals whose chlorides are sufficiently soluble.—J. H. W.

## X.—LABORATORY APPARATUS, INSTRUMENTS, &amp;c.

(See also "Testing" and "Temperature Measurement and Control.")

(Continued from p. 296.)

**A Big Improvement in the Small Polisher.** — (*Laboratory*, 1937, 8, (5), 76-77).—The polisher is driven by a 2-speed  $\frac{1}{2}$  h.p. motor giving speeds of 550 or 1150 r.p.m. and is mounted in a cast iron housing which serves as a bracket for fastening the polisher to the wall. The rotating disc is surrounded by a 2-piece cast aluminium bowl, the upper half being arranged to turn the splash down into the bowl and removable for changing the polishing cloth. The polishing head is of hard rubber with a groove along the edge to hold the polishing cloth.—A. R. P.

**\*A Polarization Spectrometer for Investigation of Surface Films on Metals.** A. B. Winterbottom (*J. Sci. Instruments*, 1937, 14, (6), 203-207).—A polarization spectrometer provided with a Sénarmont compensator, and a balanced ellipticity half-shade system is described. The instrument is the latest type used at Trondheim for the optical study of surface films, and the construction, adjustment, and calibration are described. Methods for the preparation and polishing of metallic surfaces are also discussed.—W. H.-R.

**Deposition of Metals by Cathodic Sputtering.** G. L. d'Ombrain and C. L. Fortescue (*Rep. Brit. Elect. Res. Assoc. L/T 72*; and *World Power*, 1936, 26, (46), 176-177; *Sci. Abs.*, 1937, [B], 40, 109).—A description is given of a practical method for depositing such metals as platinum, gold, silver, or copper by cathodic sputtering on surfaces up to about 10 cm. diameter. The apparatus is contained in a bell jar bedded on a stiff brass plate, the joint being made air-tight. The anode is a plate of aluminium of about the same size as the surface to be covered, the cathode being a parallel plate of the material to be deposited, and of about the same size. An atmosphere of argon is used at a pressure giving a cathode dark space of 1 to 2 cm., and the supply voltage is adjusted so that the current is about 3 ma./cm.<sup>2</sup> of the cathode surface. The surface to be covered should be about 1 cm. beyond the end of the cathode dark space on the side of the cathode remote from the anode. About 1000 v. is required for the discharge, and for proper control a series resistance down which there is a similar decrease of voltage is necessary. If the surface to be coated is placed between cathode and anode, the coating obtained is by no means uniform. The rate of deposition was not accurately determined, but with copper the deposit reaches a thickness of  $1.5 \times 10^{-6}$  cm. in about 10 minutes with the vacuum and current density employed. For gold the rate of deposition is only about  $\frac{1}{10}$  that of copper.—S. G.

**\*Sensitivity Variation of X-Ray Photographic Films.** Wm. H. George (*Proc. Phys. Soc.*, 1937, 49, (4), 357-363).—An experimental study of the local variation of sensitivity of X-ray films is detailed. It is found that if X-ray films are used in accordance with the technique described, and are blackened until they transmit about half the incident light, then the variations of sensitivity may lead to max. deviations in individual measurements of X-ray intensities of the order  $\pm 6\%$  in single-film exposures, and of  $\pm 3\%$  in double-film exposures. The mean deviations are of the order  $\pm 2\%$ .—J. S. G. T.

**An Adjustable Specimen Holder for a Debye-Scherrer Camera.** F. W. Jones and H. Lipson (*J. Sci. Instruments*, 1937, 14, (5), 177-178).—An adjustable specimen holder is described by means of which a specimen in a Debye-Scherrer camera can be accurately centred in a very short time.—W. H.-R.

**\*Improvements in the Integrating Photometer for X-ray Crystal Analysis.** R. H. V. M. Dawton (*J. Sci. Instruments*, 1937, 14, (6), 198-200).—Improvements in the integrating photometer of Robinson (*J. Sci. Instruments*, 1933, 10, 233) are described.—W. H.-R.

## XI.—PHYSICAL AND MECHANICAL TESTING, INSPECTION, AND RADIOLOGY

(Continued from pp. 296-298.)

**\*Experiments on the Abrasion of Metals.** H. E. Smith (*Internat. Assoc. Test. Mat. Congr. London, 1937*, Advance Proof, Group A, 148-149; and *Found. Trade J.*, 1937, 56, (1082), 388).—[In English.] S. gives a brief summary of unpublished work on "wear oxidation" performed at the National Physical Laboratory. It was considered probable that work-hardening played an important part in this process, so that a mild steel with considerable work-hardening properties was selected for the investigation. The specimens, in the form of machined rings, were tested in a machine capable of producing pure sliding abrasion, pure rolling abrasion, and rolling abrasion with a small percentage of slip. Results of a series of experiments with a given pair of specimens showed very large variation. The most important factors in producing this variation are probably unequal abrasive action, due to the adhesion of debris to the specimens, and variations in atmospheric humidity. A high atmospheric humidity was associated with a low rate of wear. Attempts to repeat the experiments of Fink, whereby wear was prevented by testing the specimens in an oxygen-free atmosphere, were unsuccessful, the wear being greatly increased. S. considers that his results are due to inadequate exclusion of oxygen, and to a very low humidity. It is concluded that, while useful practical information may be obtained by experiments which produce the same kind of abrasion as in practice but in an accelerated form, the fundamental principles upon which scientific abrasion testing should be based have yet to be discovered.—P. W. R.

**The Analysis of Wear Processes as the Starting Point in the Wear-Testing of Metals.** Hans Meyer (*Internat. Assoc. Test. Mat. Congr. London, 1937*, Advance Proof, Group A, 146-147).—[In German.] The fundamental considerations underlying the wear-testing of metals are reviewed, and the important points to be considered before adopting a testing technique in any given case are discussed.—P. W. R.

**On the Creep of Solids at Elevated Temperatures.** A. Nadai (*J. Applied Physics*, 1937, 8, (6), 418-432).—A mathematical interpretation is given of the behaviour of a solid under the action of combined stresses, when the steady state of creep is assumed to exist. A material is said to be in a steady state of creep if it yields with a constant speed under a given constant stress, as illustrated in the ordinary creep test, when the "creep curve" becomes a straight line. This is explained mathematically by saying that the stress is a function of the rate of strain and is independent of the amount of strain. Examples are quoted where the stress *v.* rate of strain relationship is a simple power function, but this can be applied to various types of flow (*e.g.*, purely plastic and viscous flows) by changing the value of the exponent in the power function relation. Several specific examples are worked out, and equations developed which show the steady state stresses in such cases. Expressions for the stress concentration factors in creep are also obtained.—I. J.

**A Comparison of the Methods Used for Interpreting Creep Test Data.** Joseph Marin (*Amer. Soc. Test. Mat. Preprint, 1937*, (June), 7 pp.).—There have been a number of methods developed for the interpretation of tension creep test data for the purpose of determining working stresses. All methods require extrapolation of test results beyond the times covered by the tests, and various procedures have been used in making such extrapolations. M. compares the working stress values as determined by the various methods. A comparison of results shows that there are appreciable differences in the working stresses as obtained by different methods of interpretation.—S. G.

**New Equipment for Creep Tests at Elevated Temperatures.** P. G. McVetty (*Amer. Soc. Test. Mat. Preprint, 1937, (June), 19 pp.*).—A creep testing machine is described which provides from 12 to 60 tests at different stresses in the same furnace. The furnace consists of a large cylindrical mass of alloy steel containing 12 vertical holes 30° apart for the test-specimens under stress, and a larger central hole for pre-treatment of specimens without stress. Test-specimens are supported on knife-edges at the top, and loaded by 12 radial levers and weights which hang in an annular space around the foundation. The wall of the furnace, consisting of concentric shells of polished nickel and aluminium, with powdered Silocel between, rotates on ball bearings to facilitate creep measurements. Two methods of creep measurement are provided. One consists of comparison rods extending to the top of the furnace from both ends of the 20-in. gauge-length. The relative vertical displacement of these rods is measured by a dial gauge reading to 0.0001 in. The furnace is surrounded by a track on which a specially-designed micrometer-microscope carriage moves. This permits measurements on suitably marked platinum targets at the ends of the 20-in. gauge-length, or any intermediate points. The shell carries quartz windows, which may be adjusted vertically, and the central steel column is slotted to make the reference-marks visible. Automatic control of voltage and temperature have been provided, and room temperature control may be added.—S. G.

**Examination of the Behaviour of Metals under Mechanical Stress at Elevated Temperatures.** Anton Pomp (*Internat. Assoc. Test. Mat. Congr. London, 1937, Advance Proof, Group A, 12-15.*).—[In German.] A brief description of the most important points in the procedure adopted.—P. W. R.

**\*Fatigue Properties of Metals Used in Aircraft Construction at 3450 and 10,600 Cycles.** T. T. Oberg and J. B. Johnson (*Amer. Soc. Test. Mat. Preprint, 1937, (June), 9 pp.*).—A description is given of a ball-bearing rotating-beam machine operating at 10,600 cycles, and of the results of comparative tests on these machines and on ball-bearing and plain-bearing machines operating at 3470 and 1725 r.p.m., respectively. Plain and notched specimens were used, and operating temperatures are discussed. The materials tested were steels and chromium-nickel alloys, Inconel, and Alcoa 27 S and Alcoa X 164 aluminium alloys. It is concluded that the fatigue limits determined on ball-bearing machines operating at 10,600 r.p.m. are comparable with those obtained on ball-bearing machines operating at a lower number of cycles. The shape of the S-N diagram may be affected at stresses above the fatigue limit; this was not established by these tests. The increase in temperature in the section of the specimen subjected to the maximum stress increases with an increase in frequency, but the fatigue limit is not affected. The forged aluminium alloy 27 S-T has a fatigue limit which has been found to be as satisfactory as the fatigue limits of other metals.—S. G.

**A Fatigue Machine for Testing Metals at Elevated Temperatures.** F. M. Howell and E. S. Howarth (*Amer. Soc. Test. Mat. Preprint, 1937, (June), 10 pp.*).—Describes and discusses, in some detail, a fatigue machine for testing metals at elevated temperatures. The specimen used is part of a cantilever beam, one end of which is fixed in the electrically-heated furnace. While the specimen is entirely within the furnace, the deflected beam assembly extends outside the furnace wall and is revolved in a circle by a variable eccentric driven at 3600 r.p.m. A unique calibration apparatus is used to load the specimen and to measure the resulting deflection while the machine is in operation. From the load-deflection relationship thus obtained, the stress in the test-specimen can be calculated. The method of temperature control is described. Specimen temperatures from room temperature to 600° F. (316° C.) can be controlled within  $\pm 2^\circ$  F. ( $\pm 1^\circ$  C.). Errors due to speed effect, misalignment, variation in specimen size, and method of stress calculation are dis-

cussed. These errors indicate that the maximum stress in the specimen can be calculated within 3%. Calibration curves and results are included of fatigue tests on one of the commercial aluminium alloys (17S-T) representative of the type of data obtainable.—S. G.

**Endurance Bending and Tension-Compression Testing and Observations on the Influence of Temperature.** G. Welter (*Internat. Assoc. Test. Mat. Congr. London, 1937*, Advance Proof, Group A, 29-32).—[In German.] A brief account of machines developed by W. for endurance testing, and a few of the results obtained. (See also *Met. Abs.*, this vol., p. 109.)—P. W. R.

**Torsion of "17 ST" Extruded Angles and Channels.** Loreto Lombardi (*J. Aeronaut. Sci.*, 1937, 4, (6), 260-261).—The torque on any section may be expressed as the product of the "torsion constant," the modulus of rigidity and the unit angle of twist in radians per inch. Experimental values of the torsion constant are tabulated in comparison with those calculated from the formulae of Timoshenko and of Fryer and March.—P. M. C. R.

**\*Studies in Impact Testing.** E. J. Warlow-Davies (*Abstracts Dissertations Dr. Phil. Univ. Oxford, 1937*, 9, 187-188).—The usual types of impact testing machine and specimen are unsatisfactory, owing to small variations in the test-piece dimensions having a large, and often anomalous, effect. Much confusion has been created as various types have been standardized in different countries. An Oxford impact testing machine and specimen are described, and it is claimed that more consistent results are obtained owing to the elimination of "stray losses" from the energy account. The energy of fracture is proportional to the area of fracture, and results show a close relationship between the Oxford and Izod impact values. It is suggested that the Oxford technique could be internationally standardized, without wasting experience hitherto gained from Izod tests. Contrary to theory, it is shown that the relation for tests of one material is of the form  $E = aL^2 + bL^4$ , where  $E$  is the energy of fracture and  $L$ , the length parameter for similar specimens.—I. J.

**\*Contribution to the Study of Impact Tensile Testing of Metals.** Vicente I. Garcia (*Internat. Assoc. Test. Mat. Congr. London, 1937*, Advance Proof, Group A, 32-33).—[In French.] From the results of many hundreds of impact tensile tests on steel, brass, and aluminium, G. has deduced a general formula expressing the laws of the experiment. The cylindrical test-specimens used were of diameter  $D$ , turned down over a length  $l$  in the centre to a diameter  $d$ . The diameter decreased gradually from  $D$  to  $d$  over a length  $r$  at each end of this central region, and the specimens were such that  $d < 0.8 D$  and  $r > 0$ . Then if  $T$  is the total work of impact required to break the specimen at one blow:

$$T = \tau \left[ \frac{\beta(d^3 + 2r^3) \{(D - 2d)^2 + Dd\}}{(D + 1.5l)^2} + \left\{ \left(1 + \frac{l}{2d}\right)^4 - 1 \right\} \pi d^3 \right]$$

where  $\beta$  is a coeff. characteristic of the metal, and  $\tau$  is the specific work of the metal. For soft steels  $\beta = 0.74$  and  $\tau = 25.0$  to  $28.4$  kgm./mm.<sup>3</sup>; for brass (Cu 58%, Zn 39%)  $\beta = 0.59$  and  $\tau = 18.9$  to  $20.2$  kgm./mm.<sup>3</sup>; for aluminium (99.2%)  $\beta = 1.90$  and  $\tau = 2.5$  kgm./mm.<sup>3</sup>.—P. W. R.

**\*Analysis of the Brinell Hardness Test.** R. H. Heyer (*Amer. Soc. Test. Mat. Preprint, 1937*, (June), 23 pp.).—Certain features of the Meyer hardness test are reviewed. A method is proposed for expressing a shear yield-strength which bears a definite relationship to tensile or compressive yield-strengths. An explanation is offered, based on relative strength, in shear and compression, for the differences commonly observed in the surface contours of Brinell impressions. Other differences in the nature of the plastic deformations below the surface of the impression are studied by means of a split hardness test-specimen. Relations are established between depth of visible plastic deformation, rise of metal above the original surface, and the Meyer  $n$  coeff. The rate

of increase of depth of plastic deformation with diameter of indentation is determined for 4 series of metals. The published work on thickness requirements is reviewed from the point of view of the present determinations. Data are presented on the effect of annealing on many of the hardness properties of a cold-drawn silicon-bronze. Plastic deformations under cyclical and spherical indentors are compared. [The materials tested in this work were Armco iron, steels, Monel metal, Herculoy, leaded brasses, aluminium alloys, Dowmetal, and zinc.]—S. G.

### RADIOLOGY.

**Radiographic Examination of Welds.** V. E. Pullin (*Weld. Ind.*, 1937, 5, (3), 104-114; discussion, 115-117).—Read before the Institute of Welding. The difficulties in interpretation of radiographs are explained, the experience of the observer being regarded as the most important factor. The A.S.M.E. code is strongly criticized, it being emphasized that standard radiographs are required for different thicknesses of weld, and that the penetrometer is useless for defining the size of internal flaws. Many illustrations of welds in steel are given. —H. W. G. H.

## XII.—TEMPERATURE MEASUREMENT AND CONTROL

(Continued from p. 299.)

**A New Colour Pyrometer. I.—Principles. II.—Measurement of High Temperatures.** Kurt Guthmann (*Arch. tech. Messen*, 1937, (71), T57, T58-59).—(I.—) The possible error of ordinary radiation pyrometers is shown to depend on the radiating power of the hot object. Other subjective and objective sources of error are enumerated. The Naeser and Hase "colour-brightness" instrument is described and its optical system illustrated. (II.—) The close agreement between the readings of the Naeser-Hase "colour-brightness" pyrometer and those of a platinum/platinum-rhodium thermocouple is illustrated by a tabulated comparison, which also gives the corresponding readings of a "glowing-filament" instrument. The "colour-brightness" instrument is recommended for work in connection with blast furnaces, mould temperatures at different levels of filling, pouring temperatures, &c., on account of its accuracy and rapidity in use.—P. M. C. R.

**\*Resistance Thermometry below 1.0° K.** J. F. Allen and E. S. Shire (*Nature*, 1937, 139, (3525), 878-879).—Resistance-temperature curves are given for a phosphor-bronze resistance thermometer down to a temperature of 0.027° K., the temperatures being measured by means of the susceptibility of iron ammonium alum. It is shown that the resistance method is suitable for temperature measurements in this range.—B. C.

**Phototube Temperature Control.** R. A. Powers (*Electronics*, 1937, (April), 12-15).—Several examples are given of the application of photo-electric cells for measuring temperature, including the control of resistance heating of steel parts, indication of the pouring temperature of iron foundry cupolas, and the continuous recording of the temperature of sheets in steel mills. The development of the technique of temperature control by means of photo cells is outlined, and brief descriptions are given of the numerous photo-electric cell outfits now available. In order to overcome inaccuracies in measurement due to sunlight falling on the photo cell, the best outfits employ an optical system in which is incorporated an infra-red filter. By this means only infra-red rays emanating from the hot object fall on the photo cell. The infra-red rays from sunlight, because of their poor reflection by the usual objects to be found in a works, are barely registered. An accuracy of  $\pm 5^\circ$  F. is claimed over a temperature range of 985° to 3300° F.—E. V. W.

**A Potentiometer for the Measurement of Small Electromotive Forces and Resistances.** C. H. Johansson (*J. Sci. Instruments*, 1937, 14, (6), 194-198).—A slide-wire potentiometer is described which is modified so as to reduce the disturbing thermoelectric forces. A special switch is described in which all current-carrying parts are made of pure copper in order to avoid thermoelectric forces.—W. H.-R.

### XIII.—FOUNDRY PRACTICE AND APPLIANCES

(Continued from pp. 299-302.)

**Physical Factors in Casting of Metals.** C. H. Desch (*Found. Trade J.*, 1937, 56, (1087), 505-508; *Met. Ind. (Lond.)*, 1937, 50, (25), 680-686; and (summary) *Metallurgia*, 1937, 16, (92), 65-66).—Third Edward Williams Lecture to the Institute of British Foundrymen. The factors which influence "flowing power" are analyzed, and it is shown that the viscosity is of relatively minor importance compared with the mechanism of freezing, surface tension, gas content, and the effect of surface tension and non-metallic impurities. Factors which influence the quality of the casting are freezing range, volume change on solidification, crystal thrust, latent heat, and thermal conductivity. The methods used to determine some of these physical properties are described and tables of surface tension and volume change on freezing are given.—H. H.

**Wasters—Their Cause and Cure.** — (*Iron Steel Ind.*, 1937, 10, (8), 335-339; (9), 375-378; and (11), 479-482).—Wasters in castings are discussed from the points of view of design, pattern making, and moulding. Under design, wasters due to porous castings are considered, also the disadvantage of added metal and the difficulties experienced from restricted outlets for cores. Pattern-making problems include dimensional errors, pattern allowances, the problem of core enlargement, location of loose pieces, and patterns and moulding methods; with wasters due to moulding, consideration is given to moulding sands, incorrect ramming, the importance of venting, scabbing, and mould joints.—J. W. D.

**The Removal of Aluminium and Iron from Copper and Copper Alloys.** Hans-Otto von Samson-Himmelstjerna (*Z. Metallkunde*, 1937, 29, (5), 152-154).—Aluminium and iron can be rapidly removed from copper by melting the metal under a flux of sodium and cuprous chlorides; to avoid unduly high losses of the latter it is better to add this in small portions at a time to the flux and to stir the mixture thoroughly into the metal. To remove aluminium from brass or nickel silver the molten metal is stirred under a zinc oxide-borax flux; every 1% aluminium is replaced by 3.0% zinc and there is very little loss of zinc by volatilization so that the composition of the alloy must be appropriately adjusted after refining. Since the heat of formation of zinc oxide is greater than of iron oxide it is impossible to remove iron from brass in this way.—A. R. P.

**The Production of Dense Aluminium Bronzes.** — (*Giesserei-Praxis*, 1937, 58, (13/14), 136-140).—The properties of aluminium bronzes, and especially the effect of addition metals on those properties, are discussed. The alloys consisted of: (1) copper 90, aluminium 10%; (2) copper 79-94, aluminium 7, iron + nickel + manganese + tin + silicon up to 12%; (3) copper 76-94, aluminium 10%, other metals as before. The melting practice, preparation of the copper-aluminium pre-alloy, and the moulding procedure in the production of these alloys are described.—J. H. W.

**Trends in the Non-Ferrous Foundry.** L. B. Hunt (*Found. Trade J.*, 1937, 56, (1086), 470-472; also *Met. Ind. (Lond.)*, 1937, 50, (25), 687-691; and (abridged) *Machinery Market*, 1937, (1911), 21-22; (1913), 25).—Read before the Institute of British Foundrymen. Developments in materials, methods, and products are reviewed. Under the first heading, the increased purity of virgin

metals, the secondary metal problem, new and improved alloys, and recent research in moulding materials, are discussed. Increasing precision and control are thought to be shown in foundry practice, and the development of foundry engineers or metallurgists, capable of planning operations to a greater degree of refinement, is regarded as a tendency to be encouraged. Improvement in foundry products is shown to depend on fundamental research into melting practice, pouring practice, and more scientific application of purification methods.—H. W. G. H.

**Treatment of Graphite Melting Crucibles.** E. T. Richards (*Feuerungstech.* 1937, 25, (5), 154-158).—Failures can be reduced, and life lengthened, by preliminary drying out and ignition of new crucibles, which should not be used at first for very high temperatures. Cold metal charged into an empty crucible may burst the walls by its expansion. Damage to the bottom may result from introducing fluxing material into the empty crucible or from resting it on a cold surface during or after pouring. Tongs must fit the crucible. All fuels should be as free as possible from sulphur. Coke should be of uniform size (40-60 mm.) dry and not exceeding 7% in ash. Oil or gas flames should not be allowed to impinge on the crucible.—A. R. Pe.

#### XIV.—SECONDARY METALS: SCRAP, RESIDUES, &c.

(Continued from p. 302.)

**\*Regeneration of Secondary Aluminium from Dross in the Baths at the Volkhov Aluminium Works.** F. M. Rabinovich and L. N. Lisenko (*Trudi Aluminiumovogo-Magnievo Instituta "VAMI"* (*Trans. Inst. Aluminium Magnesium*), 1936, (13), 85-94).—[In Russian.] Industrial metal scrap containing 30-60% of metallic aluminium mixed with oxide and sand cannot be treated for the recovery of the metal by adding it to the ordinary production bath (molten cryolite).—D. N. S.

#### XV.—FURNACES AND FUELS

(Continued from pp. 302-304.)

**The Mechanization of Industrial Furnaces.** George Charles Matthews (*J. Record Trans. Junior Inst. Eng.*, 1936, 47, (3), 93-100; and *Mech. Handling*, 1937, [ii], 24, (1), 3-6).—Methods of handling charges through heat-treatment furnaces by pusher rams, by trays rolling on cast iron balls, by charging machines, endless chains, roller or disc hearths, walking beams, and rotary or moving hearths are described.—J. C. C.

**Some Electric Furnaces for Aluminium Alloys.** G. B. Lamb (*Metallurgia*, 1937, 16, (92), 39-41).—L. briefly discusses the problems experienced in the accurate heat-treatment of strong light alloys in order to produce the best physical properties. Consideration is given to electric furnaces used for such purposes, which include batch-type furnaces, both horizontal and vertical, with forced air circulation for heat-treatments, salt baths for similar treatments, and conveyer and continuous furnaces of the roller-hearth type for heating aluminium alloy billets prior to forging.—J. W. D.

**Electric Heating in Industry.** U. Riegger (*Elekt. Betrieb*, 1936, 34, 85-89; *Sci. Abs.*, 1937, [B], 40, 74).—The use of electricity for industrial heating purposes is considered. Among the examples given are trough furnaces for light alloys and tower furnaces for annealing strip iron and steel.—S. G.



## XVIII.—WORKING

(Continued from pp. 305-306.)

**The Determination of Working Time on a Steckel Mill.** — (*Metallurgia*, 1937, 16, (92), 43-44).—A practical method, which can be applied to suit the conditions in any particular works, is developed for calculating the time involved in rolling strip on a Steckel mill. An equation is given for the rolling time and is derived from the average rolling speed, the original thickness of the strip, the demanded thickness, the average percentage of reduction per pass, and the weight and width of the coil. The factor given for the average rolling speed includes 12.5% allowed for lost time in the operation of the mill.—J. D.

**\*Directional Properties in Rolled Brass Strip.** Maurice Cook (*J. Inst. Metals*, 1937, 60, 159-172; discussion, 172-185).—The tensile properties of brass strip in directions parallel, normal, and at 45° to the rolling direction, have been determined after progressively increasing rolling reductions up to more than 90%. When the rolling reduction has been sufficient to induce a directional effect, the greatest strength and least ductility are obtained normal to the rolling direction, while the converse obtains in the rolling direction. When cold-rolled brass strip is finally annealed, it may show directionality which is revealed both by tensile tests and by the occurrence of ears or waves on the edges of cups cut from the strip. In annealed strip showing directionality, the tensile strength is least and the ductility greatest at 45° to the rolling direction, and it is in this position that ears are formed. The extent to which directionality exists in rolled and annealed strip is largely determined by the conditions of the penultimate and final annealings and by the magnitude of the rolling reduction between these two annealings. A study of the orientation of twinning planes in rolled and annealed 70 : 30 brass strip showing appreciable directionality in tensile properties and in the tendency to form ears on cups, indicates that the frequency of orientation of the twinning planes is lowest at about 45° to the direction of rolling. The direction of maximum frequency of orientation of twinning planes appears to be fortuitous in strip not showing directionality in other respects. The paper is followed by a very full and valuable discussion.—M. C.

**\*The Effect of Cast Structure on the Rolling Properties of Zinc.** L. Northcott (*J. Inst. Metals*, 1937, 60, 229-244; discussion, 244-247).—Preliminary work on zinc of 99.99% purity showed that the casting temperature of ingots cast by the Durville method has little effect on the structure, density, tensile strength, notched-bar impact value, or rolling properties. The examination of ingots made by utilizing directional solidification showed that the directional properties of the zinc crystals are such that in columnar form the strength measured in the direction of growth is about four times that at right angles to it. Less pronounced differences were observed in the notched-bar impact values. The selective weakness of the metal along one set of crystal planes was also demonstrated by the tearing action of the cutting tool when machining in certain directions, and resulted in the development of a number of surface cracks. The weak plane was shown by X-ray examination to be the basal (0001) plane of the hexagon. The connection between cold-working and the absence of columnar crystals was investigated by determining the degree of hot-working necessary to permit subsequent cold-working and correlating the results with the accompanying changes in structure. Provided that the initial hot reduction was not less than about 40%, rolling could be completed satisfactorily in the cold. Hot-rolling was found to be associated with recrystallization and consequent release of internal stress; recrystallization was almost complete after about 40% hot reduction, although much of the cast structure was obliterated after half this amount of reduction. The importance of the equi-axial structure in cold-working was confirmed by tests on specially

prepared ingots of equi-axial structure. Columnar crystal aggregates may be completely cold-rolled if the direction of rolling between light passes is changed according to a crystallographic plan provided that the plane of growth of the crystals is in the rolling plane. No indication has been found that any of the peculiarities of zinc in working are due to boundary effects. Failure in zinc at atmospheric or moderate temperatures takes place by characteristic transcrystalline cracking in which the cracks tend to occur along the basal plane in any one crystal. This form of failure would appear to be limited to a small range of metals and alloys, possibly mainly of the hexagonal crystal type. The effect is greatly intensified by the powerful tendency of zinc to form large columnar crystals, since in an ingot of rectangular section the columnar crystals developed from one mould face have their directions of weakness in the same planes. The addition of 0.75% cadmium to the zinc produced a small crystal structure but increased the recrystallization temperature so that complete cold-rolling was no longer possible. The total reduction before cracking started was, however, greater when the rolling direction was changed than when rolling was carried out in one direction only. An account is also given of the conditions under which zinc ingots can be initially rolled during cooling after casting; satisfactory strip was obtainable provided the temperature of the ingot at the commencement of rolling was within the range 350°–100° C., which, when 16 lb. ingots were used, entailed an interval of from 2½ minutes to 1 hr. after the completion of solidification.—L. N.

**The Production of Coils from Tubing.** — (*Machinery (Lond.)*, 1937, 50, (1284), 217–220).—Methods of producing coils of brass and copper tubing in large quantities for heating and refrigerating equipment are described. The coils are wound on a mandrel in a lathe, the unwound straight length of tubing being supported by a long round-ended arbour set with its nose slightly in advance of the centre of the lathe mandrel. With large tubing, a ball toggle is attached to the nose of the arbour as an additional support against buckling. Fixtures for producing coils of two concentric tubes and for making “U” bends are also described.—J. C. C.

**A Lead Extrusion Phenomenon.** P. Dunsheath (*Nature*, 1937, 139, (3522), 755–756).—If the lead stream is divided by means of a steel support on its way to extrusion, a line can be revealed by etching the extruded lead. This line does not appear to influence the crystal structure, since the crystals are continuous across it, and it does not reduce the bursting strength of lead pipes in which it occurs. It is suggested that it is due to segregation of oxide or other impurities in small quantities.—B. C.

**A Lead Extrusion Phenomenon.** Brinley Jones (*Nature*, 1937, 139, (3529), 1071–1072).—A microphotograph is given of a transverse section of a lap weld in lead sheet. Very pronounced lines across the section are shown to be due to oxide skins formed on each successive layer of lead.—B. C.

**Powder Metallurgy.** J. C. Chaston (*J. B'ham. Met. Soc.*, 1937, 17, (1), 9–24; discussion 24–30).—A full and historical account of the development of manufacture of metal powders, dealing with ductile materials such as copper alloys, aluminium and magnesium, made from small pieces, and with brittle metals, such as antimony and bismuth. Certain metals, for instance iron, can be produced from the brittle, electrodeposited form, while nickel-iron alloys are melted and cast by methods giving a brittle alloy. Atomized metal powders are produced from the molten state by steam blast or water, and aluminium powder for Thermit may be made by agitation of the metal during solidification. Fine powders result from condensation and from chemical reduction of compounds, such as oxides or carbonyls, and directly by electrodeposition under suitable conditions. The character and uses of sintered powder alloys and possible developments are briefly discussed.—R. G.

**Free-Cutting Light Alloys.** — (*Metallurgia*, 1937, 16, (91), 25–27; also *Light Metals Rev.*, 1937, 3, (18), 418–425; and *Light Metals Research*, 1937, 5, (19), 430–437).—A review of recent work on the development of light alloys for free machining deals with the value of the alloying element, lead, tin, cadmium, bismuth, antimony, &c., on the production of such properties and their effect on the structure of the various alloys. Consideration is also given to the machining properties as regards the cutting speed, cutting power, cutting temperature, and lubrication while cutting, of various light alloys.—J. W. D.

**Working of Nickel-Base Alloys. Heat-Treatment, Machining, and Welding of Monel, Nickel, Inconel, and Hastelloy.** F. L. LaQue (*Mech. Eng.*, 1937, 59, (3), 175–177, 181).—Instructions are given for cold-working, heat-treating, pickling, machining, welding, soldering, and brazing of nickel, Monel metal, Inconel, Hastelloy, and Illium. Particular reference is made to deep-drawing, and brief suggestions are given for suitable reductions and die materials. It is emphasized that the alloys must be charged into a hot furnace, with a reducing atmosphere free from sulphur, and the article not soaked. The articles should be free from lubricants, &c. Tables are given of recommended cuts, feeds, and speeds for machining R-Monel, Inconel, and Hastelloy.—R. Gr.

**\*Internal Stresses in Machined Surfaces.** E. K. Henriksen (*Internat. Assoc. Test. Mat. Congr. London, 1937*, Advance Proof, Group A, 171–174).—[In English.] Experiments on steel show that the primary internal stress set up in the surface layer when cutting with moderate cutting speeds and without cooling is a tension. For a specimen of cast iron investigated, the corresponding internal stress was a compression, but the extreme variability of composition and properties of cast iron preclude a generalisation without further investigation.—P. W. R.

**Cutting Properties of Metals.** O. W. Boston (*Internat. Assoc. Test. Mat. Congr. London, 1937*, Advance Proof, Group A, 141–142; and *Met. Ind. (Lond.)*, 1937, 50, (22), 601–602).—[In English.] A brief statement of the variables involved in the complex factors which determine the cutting properties of metals. 9 references are given.—P. W. R.

**Some New Results Regarding the Cutting of Metals.** Ragnar Woxén (*Internat. Assoc. Test. Mat. Congr. London, 1937*, Advance Proof, Group A, 139–140).—[In English.] A brief summary of W.'s recent progress.—P. W. R.

**Nature of Lapped and Polished Surfaces.** Francis W. Shaw (*Machinery (Lond.)*, 1937, 50, (1289), 389–392).—The belief that abrasive is retained by a lapped surface, and particularly that the flowed layer can bury particles of abrasive is vigorously contested.—J. C. C.

**Maintenance and Use of Cemented Carbide Tools.** Leo J. St. Clair (*Mech. Eng.*, 1936, 58, (11), 725–727).—St. C. recommends a procedure for grinding, finishing and re-sharpening cemented carbide tools, and advocates the use of double clearance angles, in which case the supporting shank material is rough ground  $2^{\circ}$  to  $5^{\circ}$  greater than the finished angle; only the carbide tip is finish-ground to the desired final clearance. The care of the grinding wheels is outlined. Alternate grinding of the carbide tip and steel shank of the tool is recommended, so that the carbide tip dresses the silicon carbide wheel which may be loaded by the steel. The principles are given of the proper application of cemented carbide tools, from consideration of size of tool, size of tip, and tool support or overhang. Recommendations are made for suitable steel for tool shanks.—R. Gr.

**Grinding of Cemented-Carbide Milling Cutters.** Hans Ernst and Max Kronenberg (*Mech. Eng.*, 1937, 59, (4), 221–226).—Contributed by the Subcommittee on Cutting of Metals of the American Society of Mechanical Engineers. Instructions are given for the selection of silicon carbide grinding wheels. Speeds of running, shape, and composition of wheel are given. It is stated that the harder the material to be ground, the softer and finer must be

the grinding wheel, softness referring to the bond. Dry grinding is recommended. A finishing grind with a diamond wheel results in a keener edged cutter. Cutting angles are suggested to which cemented-carbide milling cutters should be ground, and the method of doing so is outlined.—R. Gr.

## XIX.—CLEANING AND FINISHING

(Continued from pp. 263-264.)

\***Electrolytic Cleaning in Alkaline Solutions.** R. S. Ashelrod and M. E. Eruhimova (*Vestnik Metallopromishlennosti (Messenger Metal Ind.)*, 1936, 16, (16), 82-84).—[In Russian.] In the electrolytic degreasing of brass in an alkaline degreasing bath the work becomes covered with a silvery film of an alloy of copper 30-40, zinc 50-63, and iron 5-9% when the bath has been in use for some time. This effect is attributed to dissolution of the iron anodes and of pieces of brass which had fallen to the bottom of the bath. With more than 15 grm./litre of sodium hydroxide degreasing is accelerated, but becomes more rapidly contaminated and films appear on the work. Addition of 5 grm./litre of sodium phosphate tends to reduce the solubility of iron sediments while 10 grm./litre of sodium silicate improves the work of the bath in depth, 0.3 grm./litre of dextrin accelerates degreasing, and 0.7 grm./litre of sodium tartrate improves the degreasing of deeply recessed sections. The usual composition of the bath is sodium hydroxide 15, sodium carbonate 10, sodium phosphate 5, and dextrin 0.3 grm./litre.—D. N. S.

**Some Further Points on Cleaning Work Prior to Plating.** Harold Saenger (*C. and A. Bull.*, 1936, 1, (3), 15-16).—Procedures are tabulated for the cleaning of tin, lead, zinc, and aluminium and their alloys.—A. R. P.

**Hints on Degreasing.** W. F. Jesson (*C. and A. Bull.*, 1936, 1, (4), 6-8).—Practical hints are given for the efficient operation of vapour degreasers.

—A. R. P.

**Uses of Organic Finishes for Metals Extended.** J. Mitchell Fain (*Metal Cleaning and Finishing*, 1937, 9, (2), 125-128, 130).—Resins made by polymerizing acrylic acid esters and mixtures of vinyl compounds have recently found numerous applications in the manufacture of metal lacquers. Methods of testing the permeability of lacquer films to moisture and their resistance to abrasion are described and some new developments in pigments for metal paints are discussed.—A. R. P.

## XX.—JOINING

(Continued from pp. 306-308.)

**Electric Soldering Iron.** — (*J. Sci. Instruments*, 1937, 14, (6), 214-215).—A note, describing briefly a 125 W. industrial type soldering iron with angle pencil bit introduced for rapid quantity production soldering work in the radio industry, where the 65 W. model does not provide the necessary reserve of heat.—W. H.-R.

**Aluminium Chairs.** — (*Oxy-Acetylene Tips*, 1937, 16, (6), 131).—Describes the construction of a welded aluminium household chair, with illustrations showing the finished chair and the location of the welds.—H. W. G. H.

\***Influence of Kind of Sheet and After-Treatment of Seam on the Properties of Welds in K.S.-Seewasser Sheets.** M. Maier (*Autogene Metallbearbeitung*, 1937, 30, (7), 97-102).—Oxy-acetylene welds were made in 4 mm. thick sheets in the soft, medium hard, and hard conditions. The strengths obtained were found to be independent of the initial hardness of the sheet and of hot or cold hammering of the seam, but approximated to the strength of the annealed zones. The

strength of the annealed sheet, at the sides of the weld, was increased by cold-rolling, but to an extent which was compensated by the reduction in cross-section.—H. W. G. H.

**Paper Mill Piping.** — (*Oxy-Acetylene Tips*, 1937, 16, (4), 83-84).—Trouble was experienced with foreign matter lodging in the crevices of mechanical joints in the pipe line from beaters to paper machines. This was eliminated by making the pipes of bronze-welded copper.—H. W. G. H.

**The Application of Electric Resistance Welding to Non-Ferrous Metals.** — (*Machinery (Lond.)*, 1937, 50, (1285), 257-259).—The advantages of decreasing the electrode pressure at the moment the current is passed when spot-welding non-ferrous metals of low electrical resistance are described, and reference is made to the Sciaky automatic spot-welding machine.—J. C. C.

**A New Factor in Electric Resistance Welding.** — (*Weld. Ind.*, 1937, 5, (3), 83-84).—A high-speed recording ammeter is connected so as to trace on a chart the successive values of current produced during the making of a resistance weld. A master chart having been made of a satisfactory weld, departures from this indicate a change in welding conditions. Further information is obtained by a recording voltmeter. Brief particulars of the instruments are given.—H. W. G. H.

**Pressure Measuring Device for Resistance Welding Machines.** P. Blundell (*Weld. Ind.*, 1937, 5, (3), 84).—Describes an indicating device to be placed between the electrodes.—H. W. G. H.

**Alloys for Electrodes for Use in Electric Welding.** J. Delmonte (*Weld. Eng.*, 1937, 22, (4), 33-34).—Five complex copper alloys are tabulated with particulars of their strength (cold) and electrical conductivity, and some brief remarks on applications.—H. W. G. H.

**Notes on the Selection of Electric Arc Welding Equipment.** W. M. Higgins (*Modern Eng.*, 1937, 11, (3), 149-152).—The nature of the work to be done is shown to be an important factor in choosing the most suitable and most economic type of welding plant. Single-operator and multi-operator machines, motor-generators, and transformer sets are discussed with regard to rating, capital cost, load on the supply line, and behaviour in service.—H. W. G. H.

**What Happens During Welding and Cutting?** George V. Slatman (*Power Plant Eng.*, 1937, 51, (6), 364-366).—The suitability of acetylene for welding and cutting is attributed to the high flame temperature, associated with a reducing atmosphere, which accompanies its combustion. The composition of combustion or dissociation products of acetylene, hydrogen (molecular), carbon monoxide, carbon dioxide, and water vapour at various temperatures is summarized graphically; compositions of the primary combustion cone of the oxy-acetylene flame are given for several compositions of mixture, and suitable proportions are suggested for different types of work.—P. M. C. R.

## XXI.—INDUSTRIAL USES AND APPLICATIONS

(Continued from pp. 308-313.)

**Heat Insulation: The Selection of Suitable Materials for Various Purposes.** J. S. F. Gard (*J. Inst. Fuel*, 1937, 10, (52), 223-244; discussion, 244-250).—Aluminium foil in the form of reinforced sheets arranged with an air space of  $\frac{1}{4}$ - $\frac{3}{4}$  in. on either side is a good insulator for use in roofs and between floor and ceiling.—A. R. Pe.

**[Lead-Coated Iron for] Flues for Gas Water-Heaters.** L. Friedman (*Gas J.*, 1937, 218, 420-425, 561-565, and 864-867).—Among other structural materials lead-coated iron is recommended.—A. R. Pe.

**Alloys for Tools and Wear Resistance.** Zay Jeffries (*J. Applied Physics*, 1937, 8, (6), 380-384).—An outline of the development of high speed steel and

of cemented carbides for use as cutting tools. The application of tool material, in particular the carbide type, to machine parts where resistance to wear is of prime importance, is discussed. J. stresses the great possibilities of tungsten, tantalum, and titanium carbides as structural materials.—I. J.

**Die-Castings Used for Automotive Parts.** C. R. Maxon (*Machinist (Eur. Edn.)*, 1937, 81, (12), 275-277).—Abstract of a paper read before the Detroit Section of the Society of Automotive Engineers. The advantages of die-castings are given, and the application of zinc alloy die-castings for the manufacture of various parts of motor cars is described.—J. H. W.

**American Standard Specifications for Dry Cells and Batteries.** — (*Circ. Nat. Bur. Stand.*, 1937, (414), 11 pp.).—S. G.

**Spraying of Molten Metal.** L. E. Kunkler (*Mech. Eng.*, 1936, 58, (10), 639-640).—A brief description is given of the spray gun, the preparation of the surface for spraying, and the nature of the deposits. The advantages of metal spraying over welding for building up machine parts are stated. Wet grinding is recommended for finishing. The bond strength of a coating is determined by inserting a mild steel rod through a hole in a cross-piece, and spraying the flush surface of the rod and cross-piece. The rod is loaded until it pulls away from the cross-piece. Applications of the spraying process are cited.—R. Gr.

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## XXII.—MISCELLANEOUS

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(Continued from p. 313.)

**Some Aspects of Industrial Hygiene.** Howard E. Collier (*J. B'ham. Met. Soc.*, 1937, 17, (1), 4-6; discussion, 6-8).—A brief paper on health of workers in the metal industries. In reply to questions, the affections peculiar to the metal industries, such as zinc and cadmium oxide ague, pickling dermatitis, chrome poisoning, etc., were dealt with.—R. G.

**The Contribution of Josiah Willard Gibbs to Electrochemistry.** Duncan A. MacInnes (*Electrochem. Soc. Preprint*, 1937, (April), 8 pp.).—S. G.

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## XXIII.—BIBLIOGRAPHY

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(Publications marked \* may be consulted in the Library.)

(Continued from pp. 270-273.)

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[The statistics issued by the American Bureau will be found most valuable because of the obvious care that is taken in their compilation. They are clearly printed on large pages on good paper. The present volume, covering the year 1936, deals in the greatest detail with copper (34 pp.), lead (22 pp.), zinc (25 pp.), and gold and silver (13 pp.); the remaining pages deal with platinum, antimony, arsenic, nickel, tin, aluminium, cadmium, cobalt, brass, and bronze, and the metal consumption per person in the principal countries from 1919 to 1936, average prices of the principal metals (New York and/or St. Louis and/or London) from 1887 to 1936, and yearly average prices from 1882 to 1936 for copper, lead, zinc, and silver. For the principal metals, the particulars given include world's production and consumption, refined metal production, mine production, producers, smelting and refining plants, smelter output, stocks, deliveries, ore reserves, imports and exports, metal available for consumption, use in U.S.A., and prices.]

\***American Institute of Physics.** *Physics in Industry.* Cr. Svo. Pp. xiv + 290, illustrated. 1937. New York: The Institute, 175 Fifth Ave. (\$1.50.)

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[Contents: O. W. Roskill: "The European and World Zinc Situation in 1936"; W. B. Timm: "The Zinc Industry in Canada"; J. O. Elton: "Zinc Mining in the Rocky Mountains Region"; R. B. Paul: "Zinc Mining in the Eastern Region (including Virginia)"; E. Just: "Zinc Mining in the Mississippi Valley Region"; R. Ammon: "Retort Smelting Operations"; C. R. Ince: "Electrolytic Operations."]
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- Berdrow, Wilhelm.** *Alfred Krupp und seine Geschlecht. 150 Jahre Krupp-Geschichte 1787 bis 1937 nach d. Quellen d. Familie u.d. Werks.* Pp. 229. 1937. Berlin: Verlag für Sozialpolitik, Wirtschaft und Statistik. (M. 2.50.)
- Bourgoin, Louis.** *Métaux.* Pp. 688. Montreal: L'École polytechnique de Montreal. (\$4.00.)
- \***Brenner, Abner.** *Magnetic Method for Measuring the Thickness of Nickel Coatings on Non-Magnetic Base Metals.* (National Bureau of Standards, Research Paper No. 994). Med. 8vo. Pp. 565-583, with 5 illustrations. 1937. Washington, D.C.: Superintendent of Documents. (10 cents.)  
[See *Met. Abs.*, this vol., p. 293.]
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- \***British Oxygen Company, Ltd.** *Hints on Oxy-Acetylene Welding.* Fcap. 8vo. Pp. 68, illustrated. [1937.] London: The Company, Thames House, Millbank, S.W.1. (*Gratis.*)
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[From *Physica*; see *Met. Abs.*, this vol., pp. 94 and 95.]
- \***Chase Brass and Copper Company, Inc.** *Commercially Important Wrought Copper Alloys.* 8 × 10½ in. Pp. 60, illustrated. 1936. Waterbury, Conn.: The Company.
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- \*Gohn, G. R. *The Forming Properties of Some Non-Ferrous Sheet Materials*. (Bell Telephone System Technical Publications, Metallurgy, Monograph B-987.) Demy 8vo. Pp. 14, with 4 illustrations. 1936. New York: Bell Telephone Laboratories, Inc., 463 West St.  
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- Gratschew, Konstantin Fedorowitsch. *Text-Book of Metallurgy*. Volume II.—*The Heat-Treatment of Alloys*. [In Russian.] Pp. 55. 1937. Moscow: Steklogr. N.P.A.
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[Items of metallurgical interest are: R. A. Hull: "Photoelectric Phenomena of Thin Films" (*Met. Abs.*, this vol., p. 318); G. F. Lewin: "X-Ray Crystal Analysis of Alloys of Copper" (*Met. Abs.*, this vol., p. 338); E. C. R. Spooner: "Electrode Potential Phenomena" (*Met. Abs.*, this vol., p. 347); E. J. Warlow-Davies: "Studies in Impact Testing" (*Met. Abs.*, this vol., p. 353); W. J. Busschau: "The Theory of Gold Supply with Special Reference to the Problems of the Witwatersrand."]
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- \*Reinert, Guido G. *Praktische Mikrofotografie.* Pp. 123, with 159 illustrations. 1937. Halle (Saale): Wilhelm Knapp. (Geb., R.M. 4.20; geb., R.M. 4.80; Ausland Preis, geh., R.M. 3.15; geb., R.M. 3.60.)
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- Welding.** *La Soudure autogène oxy-acétylénique du plomb.* Pp. 47. 1937. Paris: Office central de l'acétylène et de la soudure autogène. (5 francs.)
- Wol, A. E., S. S. Wassenin, O. I. Ver, I. K. Kagan, M. M. Romanov, M. T. Slawinski, G. T. Fomin, and M. Sch. Chaschchoshew.** *Silicon Bronzes and their Industrial Application.* [In Russian.] Pp. ii + 172. 1937. Moscow and Leningrad: Onti. (Rbl. 3.)

## XXIV.—BOOK REVIEWS

(Continued from pp. 313-316.)

**Heimische Werkstoffe für Warmwasserbereiter für Einzelheizung mit Kohle, Gas, und Elektrizität.** Von M. Mengerlinghausen. 15 × 21 cm. Pp. iii + 73, with 55 illustrations. 1937. Berlin: V.D.I.-Verlag G.m.b.H.

This booklet relates the progress made in an investigation, carried out by a central laboratory, in collaboration with various manufacturers and interested bodies, with the object of reducing the quantities of copper and brass used in the manufacture of domestic hot-water appliances. The author explains, in a foreword, the urgency of the problem, emphasizing that the investigations are by no means complete, but that the booklet forms an interim report which, it is hoped, manufacturers will use as a basis for their own development work. Of the materials investigated, copper-steel and copper-aluminium bimetal have been found satisfactory, providing the thickness of copper is not less than 0.25 mm. Methods for fabricating these materials are described. High-strength alloys of copper, of the Everdur type, were an obvious choice, the increased strength permitting thinner material to be used. Resistance seam welding was found to be an excellent method of jointing these alloys (and also the copper-steel). Zinc and zinc-coated steel gave very varied results according to the type of water used, whilst aluminium was quite unsuccessful. Enamelled steel is recommended for coal-fired boilers, provided that certain precautions are taken in design and in testing of the enamel. Alloy steels, glass, porcelain, and synthetics are still under investigation and it is also proposed to explore the possibilities of treating the water with inhibitors.

One suspects a certain conservatism or lack of enthusiasm on the part of manufacturers, architects, or, perhaps, housewives for the rapid changes which this booklet is intended to accelerate.—H. W. G. HIGNETT.

**Raw Materials and International Control.** By H. R. G. Greaves. Pp. vi + 166. 1936. London: Methuen and Co., Ltd. (5s.).

This book is partly political propaganda; it contains a most interesting and well-written discussion of means for ensuring better distribution and control of raw materials of production and of primary foodstuffs. Various government and private control schemes put into operation during the great slump are critically analyzed and suggestions are put forward for replacing them with schemes of wider application. The subjects covered include coal, petroleum, iron and steel, non-ferrous metals, tin, rubber, timber, wheat, sugar, cotton, and shipping. Although many will not agree with the author's ideas, all interested in political economy will find plenty of food for thought in a close study of the book.—A. R. POWELL.

**The Goldsmith's Handbook.** Containing Full Instructions for the Alloying and Working of Gold. By George Gee. Revised Edition. Cr. 8vo. Pp. xxiv + 263. 1936. London: The Technical Press, Ltd. (6s. net.)

The first edition of this book appears, from internal evidence, to have been written about 50 years ago; this seems to be a third edition which differs from the first only by the addition of a 30-page appendix consisting of a heterogeneous collection of practical hints under the naive title of "Details of Modern Processes." Our knowledge of gold and its alloys has made vast strides during recent years—what, therefore, can be the practical value to the modern craftsman, of a book of purely historic interest?—A. R. POWELL.

**Textbook of Quantitative Inorganic Analysis.** By I. M. Kolthoff and E. B. Sandell. Demy 8vo. Pp. xv + 749, with 116 illustrations. 1936. New York: The Macmillan Co. (\$4.50); London: Macmillan and Co., Ltd. (20s. net).

The aim of this addition to the innumerable textbooks of inorganic analysis is to present the student with material to make him familiar with the fundamental theories, practical procedures, and the most important classical methods of analysis; to this end the authors have presented a well-balanced combination of theoretical principles and practical details which should provide the conscientious student with a thorough insight into the fundamentals of analytical chemistry and teach him to think for himself when approaching a problem of analysis the solution of which cannot be found in detail in any book available at the moment.

The subject matter covers gravimetric, volumetric (including electrometric), colorimetric and spectrographic analysis, the use of the newer organic reagents, and the application of these procedures to the analysis of complex materials such as brass, steel, and rocks.

The authors are to be congratulated on presenting their subject matter in such a novel and interesting manner and the theoretical discussions in such a lucid way that the reader can quickly grasp the basic principles on which the practical methods are built up. For such an excellent book the price asked is very reasonable.—A. R. POWELL.

**Quantitative Analyse.** Von Otto Brunck. Med. 8vo. Pp. viii + 223, with 8 illustrations. 1936. Dresden and Leipzig: Theodor Steinkopf. (Geb., R.M. 9.)

This is essentially a textbook of gravimetric analysis for students preparing for their degree. It is based on notes prepared by Clemens Winkler, one of the "Grand Old Men" of analytical chemistry. The text contains a judicious selection of methods for the determination of all the more common metals and non-metallic elements, arranged in groups according to the general scheme of qualitative analysis. At the end of each group are given procedures for separating the group from the neighbouring groups and for separating the individual members of the group from one another. The arrangement of the text in numbered paragraphs facilitates ready reference to the various procedures. Some electrolytic methods are included, but volumetric and colorimetric methods are omitted.

The book can be thoroughly recommended to those desiring a good grounding in the classical methods of gravimetric analysis, a field which, however, is already covered by numerous well-known standard textbooks both in English and in German.—A. R. POWELL.