

P.100/35

Contains papers 718 (Teed) and 719 (Blazey)
to be printed in the half-yearly volume:

Journal of the Institute of Metals,
1935, Vol. LVIII.

Vol. 2.

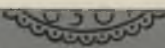
Part 11.

The Monthly Journal of the

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and

METALLURGICAL ABSTRACTS

NOVEMBER, 1935

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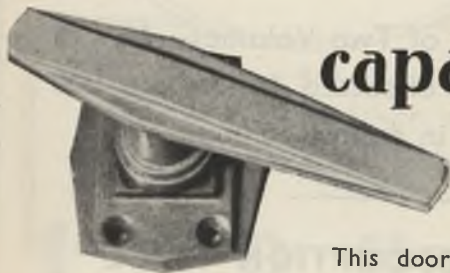
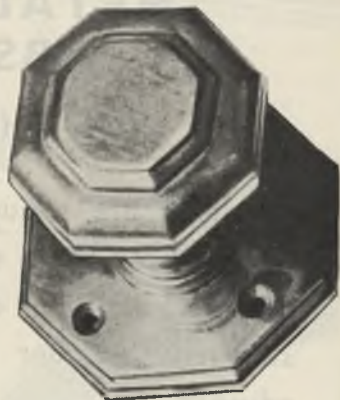
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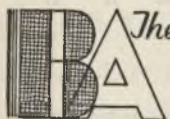
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Vols. 26 (1921) to 55 (1934)

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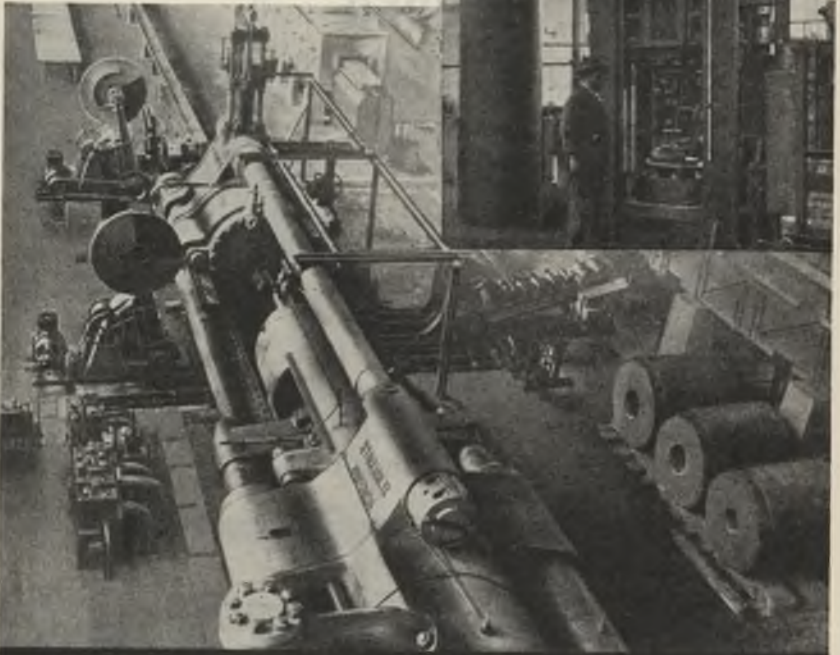
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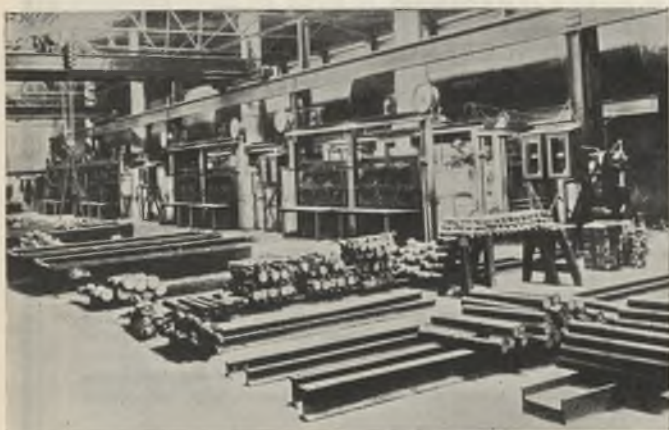
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VICTOR O. HOMERBERG, S.B., P.D., Sc.D.

Associate Professor of Physical Metallurgy, Massachusetts
Institute of Technology

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This book was written to meet the needs of engineers not specialising in metallography but who wish to use it to a limited extent in their work. It is also a discussion that will prove practically indispensable to the understanding of the more highly specialised books. The book lays greater emphasis on the applications of metallography than on the physico-chemical principles, though the fundamental ideas upon which the science is based have been given sufficiently full treatment for the purposes of the book. In this edition the book has been largely rewritten and rearranged to cover the technical and scientific advances of recent years in this field. Outstanding points in this revision are: much new material has been added to the discussion of aluminium alloys, alloy steels, including stainless steels, and laboratory methods; the sections on X-ray methods, magnetic testing, and the optics of metallography have been rewritten and extended; a brief discussion of the increasingly important subject of corrosion has been added.

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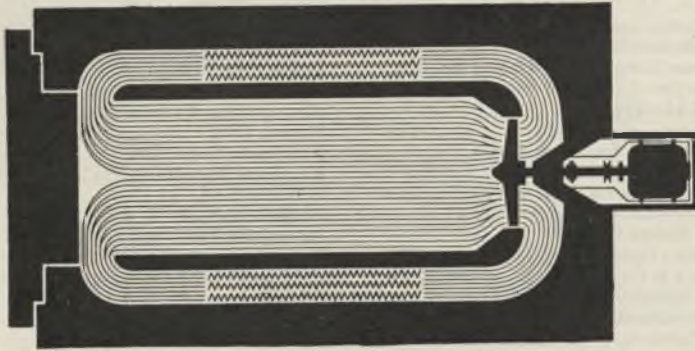
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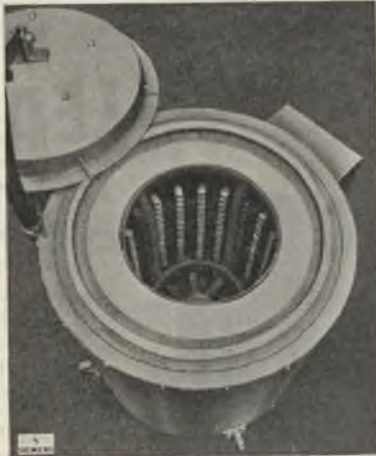
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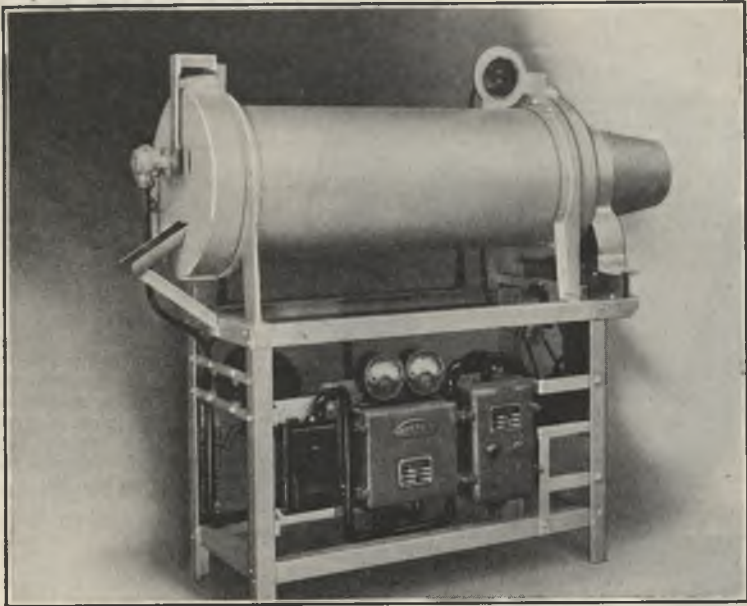
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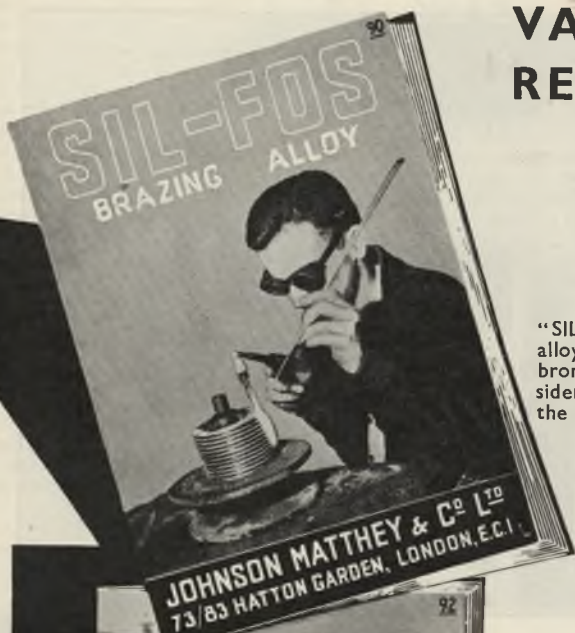
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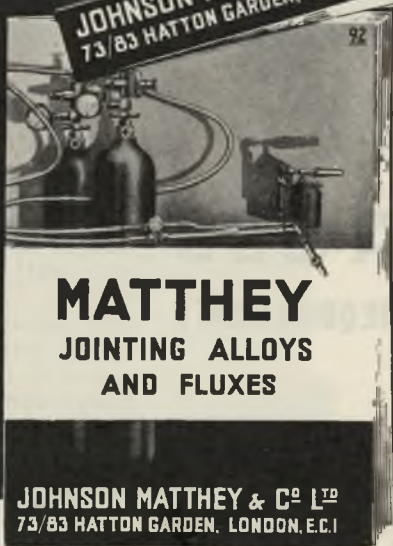
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Volume 2

NOVEMBER, 1935

Part 11

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The monthly issue of *Metallurgical Abstracts* may be cut up for card indexes, as members will receive early in 1936 the year's abstracts in bound form.

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INSTITUTE NEWS AND ANNOUNCEMENTS

Supper-Dance.

As previously announced, the Council has arranged, in co-operation with the London Local Section of the Institute, to hold a Supper-Dance on Wednesday, November 27, 1935, at Thames House, Millbank, S.W.1. Dancing will begin at 7.30 p.m. and will conclude at midnight. Tickets, price 6s., are now available and can be obtained from Mr. S. V. Williams, B.Sc. (Honorary Secretary of the London Local Section), Research Laboratories of The General Electric Company, Ltd., Wembley, Middlesex; from the Honorary Secretary of any other Local Section; or from the Secretary of the Institute.

It is hoped that members of provincial Local Sections who may be in London on November 27 will support the London Local Section by their attendance at what, judging by last year's experience, is likely to be a pleasant and interesting function.

Membership Election.

On December 12 the Council will consider applications for ordinary and student membership of the Institute.

Members are invited to make this fact known to friends who are eligible for membership; a copy of the necessary application form is included in the present issue of the *Monthly Journal*. The Secretary will be glad to send a specimen of the *Monthly Journal* to any member who desires to receive one for handing to a person interested in the Institute's work.

It is expected that there will shortly be a considerable influx of new members who desire to participate in the Institute's Autumn Meeting in Paris in 1936.

Membership Additions.

The following were elected on October 31, 1935:

As Members.

CLAISSE, Arnold James, London.
DAWE, Reginald William, Swindon.
FIELD, Gordon Harvey, Banbury.
LEGGE, Elmer Earle, B.S., Worcester, Mass., U.S.A.

MUSTED, George Gordon, Birmingham.

ROCQUET, Paul, Boulogne-Billancourt, France.

TURNER, Richard, Assoc.Met., Glasgow.

WEILL, Robert, Paris, France.

WHITNEY, Leslie Clifton, M.E., Glassport, Pa., U.S.A.

As Student Member.

WEARE, Arthur Thomas, Coventry.

Armourers and Brasiers Company's Bursaries.

The Company of Armourers and Brasiers in the City of London grant Senior Bursaries to British subjects, under the age of 24 years, who have completed a three years' course in Engineering, Metallurgy, Mining, or Electricity at a School in London, approved by the Company, and have obtained their degree with Honours at the final examination of the University of London for the degree of B.Sc. (Eng.), (Mining), or (Metallurgy).

The Bursaries are intended to enable students who have been regular in attendance during their course of study and have given evidence of exceptional ability and earnestness of character, to continue their course of *practical* training if their means and earnings are not sufficient to enable them to do so without this assistance.

The applications will be considered by an Advisory Committee, who will make their recommendation to the Court of the Company of Armourers and Brasiers, by whom the Bursaries will be awarded. Intending candidates may lodge their applications before taking their degree, but in such event the award will be made subject to the candidate fulfilling the necessary qualifications before the 1st of September immediately following his application.

In the case of a candidate who lives at home, the amount of the Bursary will not exceed £130 per annum; if the candidate takes an appointment away from his home, the amount may be increased to £160.

Applications for a Bursary must be received before May 31. A form

Institute News and Announcements

of application for a Bursary, and further particulars with regard to Bursaries, can be obtained from the Secretary of the Institute of Metals.

Rosenhain Memorial Laboratory.

Professor J. NEILL GREENWOOD, Corresponding Member to the Council for Australia, has sent to the Library a booklet issued on the occasion of the inauguration of the Rosenhain Memorial Laboratory, University of Melbourne Metallurgy School. The laboratory was opened on July 3, 1935, by Mr. Essington Lewis, President of the Australasian Institute of Mining and Metallurgy. The School began in 1874 as a sub-branch of the Chemistry School. The Chair of Metallurgy was created in 1924, the first occupant being Professor Greenwood. The Professor has been largely responsible for the equipment of the Rosenhain Memorial Laboratory, which has facilities for carrying out metallurgical research in many directions. Included in the laboratory is the gift of a book-case containing a complete set of the *Journal of the Institute of Metals*.

Mr. G. W. Mullins' Business Jubilee.

Mr. G. W. MULLINS, M.B.E., who has been a member of the Institute since 1920, and is Director of the Cold-Rolled Brass and Copper Association, was the recipient last month, at a largely attended meeting of representatives of the brass and copper industries, of a presentation to celebrate the fiftieth anniversary of his entry into the non-ferrous metals industry.

In 1885 Mr. Mullins entered the brass and copper trades as a clerk in the offices of the Adderley Park Mills of the then Birmingham Small Arms & Metal Company, Ltd., and in 1891 he joined the staff of the newly-formed King's Norton Metal Company, Ltd., with which he remained until 1919.

Mr. Mullins began his connection with the Metal Trade Associations in 1912, and he represented the King's Norton Metal Company on the newly-formed Cold-Rolled Brass and Copper Association, of which, in 1918, he became Chairman. During his Chair-

manship he was invited to give his whole time to the work of the Association, as Director, and he entered upon that office in 1920.

Mr. Mullins was Honorary Local Secretary of the Birmingham Meeting of the Institute of 1921, and when the Institute visited Birmingham again in 1933, for its Silver Jubilee Meeting, he was the acting Chairman of the Local Reception Committee. Mr. Mullins is a Member of the Council of the British Non-Ferrous Metals Research Association; is closely connected with the work of the British Standards Institution; is on the Management Board of the Copper Development Association; and is also a member of the Grand Council of the Federation of British Industries. It was as a member of the latter, and also as Chairman of the Fiscal Policy Joint Committee of the Metal Trades, that he was present at Ottawa in 1932 as one of the F.B.I. team available there for consultation as required.

For eight years immediately prior to 1935 Mr. Mullins was President of the Midland Institute Scientific Society, and he is a Vice-President of the Birmingham Business Club.

Coal Hydrogenation.

Members interested in the hydrogenation of coal are invited by the Institute of Fuel to attend the presentation of a paper, by Mr. Kenneth Gordon, on "The Development of Coal Hydrogenation by the Imperial Chemical Industries, Ltd." The paper will be read in the Lecture Theatre of the Institution of Electrical Engineers on Friday, November 22, at 6 p.m. Any member who requires an advance copy of the paper should apply to the Secretary of the Institute of Metals.

PERSONAL NOTES

MR. ANTON ČTVRTEČKA left London last month to take up an appointment as Assayer for Asembo Mines, Limited. Correspondence may be forwarded to him c/o H. J. D. Penhale, Esq., Standard Bank of S. Africa, Kisumu, Kenya Colony.

Local Sections News

Mr. J. M. R. HORA has taken up an appointment as metallurgist with the St. John del Rey Mining Company, Ltd., Morro Velho, Nova Lima, Estado de Minas, Brazil, South America.

MR. G. W. MUIR, M.B.E., is leaving India for England on November 30. During the following nine months letters can be addressed to him *c/o* The Institute of Metals.

DR. C. H. SAMANS has been appointed Instructor in Metallurgy in

charge of Theoretical Metallurgy and X-Ray Research in the new department at Rensselaer Polytechnic Institute, Troy, New York, U.S.A.

Death.

MR. PALMER H. LANGDON, an Original Member of the Institute, died on September 18. He was the founder and publisher of *Metal Industry* of New York.

LETTER TO THE EDITOR

Unemployed Scientific Workers.

A joint committee nominated by the Association of Scientific Workers, the Institute of British Executives, and the Engineers' Study Group on Economics has undertaken an investigation into the problem of the unemployed scientific, technical, and executive workers. The information at present available is fragmentary and we therefore ask the courtesy of your columns to request such of your readers as are unemployed to send in a letter or post-card to Mr. Evans, Institute of British Executives, Swan House, 133 Oxford

Street, London, W.1, giving (a) name and address, (b) age, (c) qualifications and field of work, (d) unemployed since

There is reason to believe that various schemes of national development will be created and it is, therefore, important to know of available scientific and technical ability.

BERNARD W. HOLMAN,
*Hon. General Secretary, The
Association of Scientific
Workers.*

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London, S.W.5.

LOCAL SECTIONS NEWS

SYNOPSIS OF PAPERS TO BE READ AT COMING MEETINGS *

Birmingham Section.

Recent Developments in Refractories. By Christopher E. Moore. (*December 17.*)

The paper will deal with improvements in existing refractory materials and with the newer materials recently introduced. An account will be given of recent advances in the refractories industry, with the aim of showing some of the industry's problems, and the way they are being met.

London Section.

Die-Casting of Non-Ferrous Alloys. By N. D. G. Robertson. (*Joint meeting with the London Branch of The Institute of British Foundrymen. December 12.*)

The paper will deal with the whole industry of die-casting. Pressure and gravity or permanent die-casting processes will be considered. The incorporation of sand cores in permanent moulds; choice of suitable metals and alloys, and their relative advantages in manufacture and use will be discussed. The subject will be dealt with mainly from a commercial rather than from a scientific point of view.

* For places and times of meetings the green folder programmes already issued should be consulted.

Local Sections News

North-East Coast Section.

The Manufacture and Uses of Metal Powders. By J. C. Chaston, B.Sc., A.R.S.M. (December 10.)

A general review will be given of the principles which have from time to time been utilized for producing metals and alloys in the form of powder, and an account will be given of the characteristics of the resulting products. A number of modern processes will be dealt with in more detail, including: the stamp mill and the recent "Hametag" ball-mill processes for paint powders, the eddy-mill process, methods involving the initial production of a fine-grained brittle aggregate, and the carbonyl powder process. Reference will be made to the methods of "powder metallurgy" by which ingots and finished parts are made by compressing and sintering metal powders, and their scope will be briefly discussed.

Scottish Section.

The Addition of Non-Ferrous Metals to Cast Iron. By J. E. Hurst. (December 16.)

The changes in properties and outstanding advantages of considerable commercial value which have arisen from the addition to cast iron of non-ferrous metals will be described. "To-day alloy cast irons of high strength properties, capable of being heat-treated by hardening and tempering . . . are familiar to every moulder." The non-ferrous metals used in the production of alloy cast irons are nickel, chromium, copper, molybdenum, aluminium, vanadium, and titanium. The various commercial alloy cast irons will be described under the headings: (1) high-duty alloy cast irons; (2) alloy cast irons for hardening and tempering; (3) alloy cast irons for nitrogen hardening; (4) martensitic cast irons; (5) austenitic cast irons. Reference will be made to the addition of non-ferrous elements to cast iron in the rôle of deoxidizers or scavengers.

The new alloys are being extensively used in the electrical trades on account of their non-magnetic and high-resistivity properties, and in the engineering and chemical industries because of their resistance to corrosion; their potential value for decorative castings is important.

Sheffield Section.

The Adhesion of Electrodeposited Nickel. By A. W. Hothersall, M.Sc.Tech. (December 13.)

The nature of adhesion of electrodeposited metals (in particular nickel) will be discussed with special reference to continuation by an electrodeposit of the microstructure of the base. Examples of tests for adhesion and of typical quantitative results will be given. The chief causes of poor adhesion will be examined and the lines on which improvement in adhesion is to be sought in practice will be indicated. The practical importance of adhesion in applications for protective or decorative as well as for mechanical purposes will be considered, and attention will be directed to the importance of distinguishing between differences in actual adhesion and changes in the forces tending to cause flaking or peeling. The lecture will be illustrated by lantern slides.

Swansea Section.

Oxy-Acetylene Welding. By L. C. Percival, B.Sc. (December 10.)

Applications of oxy-acetylene welding to new work and to repair or reconditioning work will be indicated. Advantages of oxy-acetylene welding will be mentioned, and welding technique for metals and alloys briefly dealt with. Fusion and non-fusion welding will be considered, and the flexibility of the oxy-acetylene flame will be shown to advantage.

The choice of welding rod according to the material and circumstances in which the material is to be welded will be dealt with in respect of some materials. Microstructures of weld-metal and welded joints will be shown and typical mechanical test figures given.

PLASTIC DEFORMATION AND AGE-HARDENING OF DURALUMIN.*

By Major P. L. TEED,† A.R.S.M., MEMBER.

SYNOPSIS.

Plastic deformation of the type employed in the experiments described, produces, *with the freshly normalized, cold-water quenched alloy*, an acceleration of the normal age-hardening process, a marked increase in the proof stresses ultimately developed by the material after prolonged subsequent storage at atmospheric temperature, a slight *decrease* in its ultimate stress, and a relatively greater *decrease* in its shear stress. Similar deformation of specimens from the same sheet, *but fully age-hardened prior to deformation*, gives rise to an immediate increase in hardness which is virtually stable and *increases* in the proof and ultimate stresses.

INTRODUCTION.

DURING the last 3 years, the author and his staff have been studying a considerable number of problems connected with the heat-treatment of Duralumin, with the consequence that a very large amount of information, some new, at least to them, has been got together. The present paper is but a small fragment from these accumulated results, which would not have obtained its present publicity but for Jenkins and Bucknall's bold and comprehensive paper, read before this Institute, on "The Inter-Relation of Age-Hardening and Creep Performance." With regard to a small portion of that work, the experiments now described are, in some measure, related, certainly not by way of criticism, but rather as an elaboration of a theme, perhaps already uncomfortably elaborate.

In the earlier portion of the investigation now dealt with, it was found that the rate of air temperature age-hardening and the hardness ultimately reached of freshly normalized, cold-water quenched specimens from the same sheet of Duralumin were uninfluenced by the application of stresses during the ageing period of the order of 3 tons/in.², which would be well below the elastic limit of the freshly quenched alloy.

In the present paper is considered the influence of plastic deformation on the air temperature age-hardening of test-pieces from the same 16-gauge sheet of Duralumin, which were normalized at 490° C. for 30

* Manuscript received July 26, 1935.

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Note to Abstractors and Other Readers.—This paper will be published, in permanent form, in the *Journal of the Institute of Metals*, Vol. LVIII, 1936. Reference should accordingly be as follows: *J. Inst. Metals*, 1936, 58 (Advance copy).

Teed : Plastic Deformation and

minutes, cold-water quenched, and then plastically deformed to varying extents. Each specimen (in the form of a standard 4 in. gauge-length test-piece) was normalized and quenched, and its hardness at once determined; then all the specimens, with a few exceptions, were stretched in a testing machine to give a *permanent* elongation, which was later determined. Directly after this deformation, the hardness of each test-piece was again measured, a procedure which was repeated at different periods during subsequent storage at air temperature up to 250 hrs. after deformation, with the results given in Tables I, III, and

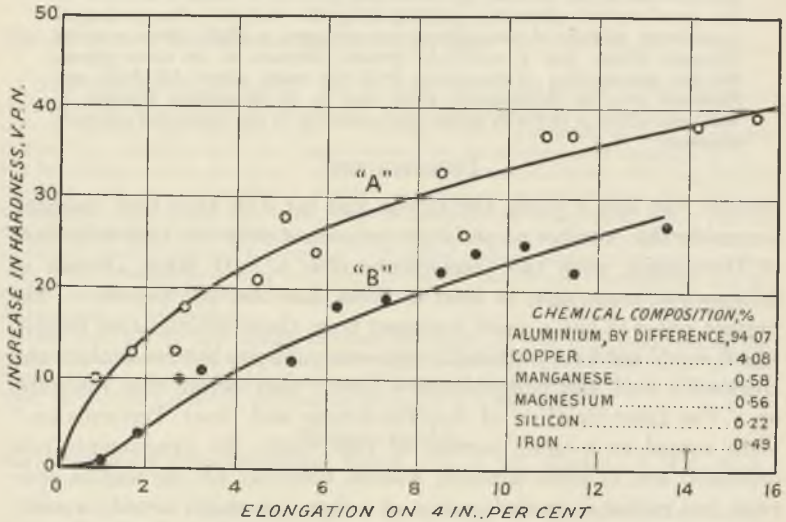


FIG. 1.—Immediate Increase in Hardness of 16-Gauge Duralumin with Plastic Deformation.

“A.” Directly after Normalizing. “B.” After Fully Age-Hardening.

IV, and in part shown graphically in Fig. 1. At the end of this time the mechanical properties of each test-piece were measured and found to be as recorded in Table II.

The results of this experiment indicate that this type of plastic deformation immediately after normalizing and cold-water quenching produces :

- (1) An instantaneous increase in hardness roughly proportional to the measure of deformation employed (Tables I, III, and Fig. 1).
- (2) An acceleration of age-hardening during subsequent storage at atmospheric temperature as compared with the rate of age-hardening of specimens of identical composition and

Age-Hardening of Duralumin

TABLE I.—Influence of Plastic Deformation on the Air Temperature Age-Hardening of Freshly Normalized,¹ Cold-Water Quenched Test-Pieces Made from the Same 16-Gauge Sheet of Duralumin.

Chemical Composition.—Aluminium (by difference), 94.07; Copper, 4.08; Manganese, 0.58; Magnesium, 0.56; Silicon, 0.22; Iron, 0.49 Per Cent.

Mach.	Cl.	5.	4.	1.	26.	E.	27.	3.	2.	28.	D.	29.	G.	F.	30.	
Hardness immediately after normalizing (V.P.S., 10 kg. load) Plastic Deformation: Elongation on 4 in., per cent. Hardness: Immediately after deformation	73(5) ¹	72(5)	74(5)	72(5)	74(5)	73(5)	72(5)	73(5)	70(5)	72(5)	73(5)	74(5)	73(5)	72(5)	74(5)	
	None	0.8*	1.6*	2.7*	2.8*	4.4*	5.0*	5.7*	6.0*	8.5*	9.6*	10.8*	11.4*	14.2*	15.5*	
	72(10)	82(10)	87(10)	85(10)	92(5)	94(10)	100(5)	97(10)	96(10)	108(5)	96(5)	111(5)	110(10)	110(10)	113(5)	
	75(10)	106(10)	103(10)	101(10)	102(10)	106(10)	108(10)	107(10)	107(10)	108(10)	107(10)	111(10)	117(10)	114(10)	118(10)	
	78(10)	101(10)	107(10)	106(10)	107(10)	107(10)	108(10)	108(10)	107(10)	107(10)	113(10)	115(10)	117(10)	119(10)	119(10)	
	101(10)	104(10)	107(10)	104(10)	108(10)	110(10)	111(10)	108(10)	109(10)	114(10)	114(10)	120(10)	120(10)	119(10)	123(10)	
	108(10)	111(10)	113(10)	112(10)	113(10)	112(10)	112(10)	111(10)	112(10)	113(10)	114(10)	114(10)	118(10)	118(10)	120(10)	
	111(10)	106(30)	109(10)	109(10)	110(10)	114(10)	112(10)	111(10)	112(10)	113(10)	114(10)	118(10)	120(10)	120(10)	120(10)	
	112(10)	112(10)	112(10)	112(10)	112(10)	112(10)	112(10)	112(10)	112(10)	112(10)	112(10)	112(10)	112(10)	112(10)	112(10)	
	111(20)	106(20)	109(20)	112(20)	110(20)	113(20)	115(20)	112(20)	111(20)	111(20)	116(20)	116(20)	121(20)	120(20)	121(20)	123(20)

¹ The figures in parentheses indicate the number of determinations on which the mean has been based.

* Measured by means of an extensometer.

² Measured with dividers.

⁴ Heated in salt-bath for 30 minutes at 490° C.

TABLE II.—Influence of Plastic Deformation Applied Directly after Normalizing⁶ on the Mechanical Properties of 16-Gauge Sheet Duralumin about 250 Hrs. after Deformation.

Mark.	Cl, 2, 3, 4, 5, and 6.	5.	4.	1.	26.	E.	27.	3.	2.	28.	D.	29.	G.	F.	30.
<i>Plastic Deformation:</i>															
Elongation on 4 in., per cent.	None	0-8*	1-6*	2-7*	2-3*	4-4*	5-0*	5-7*	6-0*	8-5*	9-0*	10-8*	11-4*	14-2*	15-5*
<i>Mechanical Properties:</i> ⁴															
0-1% Proof stress, tons/in. ²	15-7(0) ¹	17-7(1)	18-8(1)	18-5(1)	20-1(1)	20-1(1)	20-4(1)	20-4(1)	20-7(1)	22-6(1)	22-6(1)	22-6(1)	22-5(1)	23-5(1)	23-5(1)
0-2% " "	16-4(0)	18-1(1)	19-2(1)	18-9(1)	20-8(1)	20-8(1)	20-7(1)	20-7(1)	20-9(1)	22-6(1)	22-6(1)	22-6(1)	23-2(1)	23-7(1)	23-7(1)
0-3% " "	16-8(0)	18-2(1)	19-3(1)	19-0(1)	20-4(1)	20-4(1)	20-4(1)	20-8(1)	21-0(1)	22-8(1)	22-8(1)	22-8(1)	23-2(1)	23-8(1)	23-8(1)
Ultimate stress, " "	26-3(0)	24-3(1)	24-6(1)	25-2(1)	25-3(1)	25-3(1)	24-8(1)	24-8(1)	25-1(1)	25-7(1)	25-7(1)	25-7(1)	25-5(1)	25-8(1)	25-8(1)
Young's modulus, lb./in. ² /10*	29-3(0)	10-2(1)	10-3(1)	10-4(1)	10-3(1)	10-3(1)	10-3(1)	10-5(1)	10-2(1)	10-0(1)	10-0(1)	10-0(1)	9-9(1)	10-2(1)	10-2(1)
Elongation on 1 in., per cent.	37-8(0)	22-0(1)	18-0(1)	22-0(1)	16-0(1)	16-0(1)	16-0(1)	13-0(1)	13-0(1)	16-0(1)	16-0(1)	16-0(1)	11-0(1)	9-0(1)	9-0(1)
" " 2 " "	37-8(0)	17-5(1)	14-6(1)	16-5(1)	11-0(1)	11-0(1)	11-0(1)	10-0(1)	10-0(1)	11-0(1)	11-0(1)	11-0(1)	8-0(1)	6-5(1)	6-5(1)
" " 3 " "	37-8(0)	17-5(1)	14-6(1)	16-5(1)	11-0(1)	11-0(1)	11-0(1)	10-0(1)	10-0(1)	11-0(1)	11-0(1)	11-0(1)	8-0(1)	6-5(1)	6-5(1)
" " 4 " "	37-8(0)	15-0(1)	12-7(1)	14-5(1)	10-0(1)	10-0(1)	10-0(1)	9-8(1)	9-8(1)	10-3(1)	10-3(1)	10-3(1)	6-7(1)	5-3(1)	5-3(1)
" " 5 " "	37-8(0)	14-0(1)	11-8(1)	13-5(1)	15-7(2)	15-7(2)	15-3(2)	9-8(1)	9-8(1)	15-3(2)	9-5(1)	14-0(2)	4-5(1)	4-0(1)	4-0(1)
Shear stress, tons/in. ²	65-9	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Hardness, V.P.N.	111(30)	106(30)	108(30)	112(30)	110(30)	113(30)	115(30)	112(30)	111(30)	116(30)	116(30)	121(30)	120(30)	121(30)	123(30)
Hardness factor	0-21	0-23	0-23	0-23	0-22	0-22	0-22	0-22	0-23	0-22	0-22	0-21	0-21	0-21	0-21
0-1% Proof stress/ultimate stress, per cent.	59-7	71-1	76-4	73-4	79-8	79-8	79-8	82-2	82-5	87-9	87-9	88-2	88-2	91-1	91-1

1 The figures in parentheses indicate the number of determinations on which the mean has been based.
 2 Measured by means of an extensometer.
 3 Measured with dividers.
 4 The stresses have been calculated on the basis of the dimensions of the test-pieces after plastic deformation.
 5 Broke outside gauge-marks.
 6 Heated in salt-bath for 30 minutes at 490° C.

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TABLE III.—*Analysis of Hardness Changes Arising from Plastic Deformation Immediately after Normalizing and from Subsequent Storage at Atmospheric Temperature.*

Mark.	Cl.	5.	4.	1.	26.	E.	27.	3.	2.	28.	D.	29.	G.	F.	30.
Deformation: Elongation, per cent.	None	0.8	1.6	2.7	2.8	4.4	5.0	5.7	6.0	8.5	9.0	10.8	11.4	14.2	15.5
Change in hardness owing to deformation, V.P.N.	...	10	13	13	18	21	28	24	26	33	26	37	37	38	39
Change in hardness owing to subsequent age-hardening, V.P.N.	...	24	22	27	18	18	15	15	15	11	17	10	10	11	10
Total change in hardness, V.P.N.	38	34	35	40	36	39	43	39	41	44	43	47	47	49	49

TABLE IV.—*Mean Hourly Increase in Hardness During the 5 Hrs. Following Plastic Deformation.*

Mark.	Cl.	5.	4.	1.	26.	E.	27.	3.	2.	28.	D.	29.	G.	F.	30.
Deformation: Elongation, per cent.	None	0.8	1.6	2.7	2.8	4.4	5.0	5.7	6.0	8.5	9.0	10.8	11.4	14.2	15.5
Mean rate of change in hardness, (V.P.N./hr.)	0.4	3.6	3.2	3.2	2.0	2.4	1.6	2.0	2.2	0.8	2.4	1.2	1.2	1.4	1.2

TABLE V.—Influence of Plastic Deformation on the Hardness and Mechanical Properties of Fully Age-Hardened Test-Pieces from the Same 16-Gauge Sheet of Duralumin as was Used for Experiments Recorded in Table I.

Mark.	Cl. 2, 3, 4, 5, and 6.		21.	22.	23.	1 F.	2 F.	24.	6.	3 F.	25.	7.	4 F.	5 F.
	Hardness before deformation, V.P.N.	111(35)	110(10)	111(10)	111(10)	111(10)	111(10)	111(10)	110(1)	111(5)	110(10)	109(10)	111(6)	113(10)	108(10)
Deformation: Elongation, per cent.	8.02*	1.0*	3.5*	1.8*	9.7*	3.2*	3.2*	6.2*	7.3*	8.5*	9.3*	10.4*	11.5*	13.5*
Hardness immediately after deformation, V.P.N.	...	111(10)	122(10)	116(10)	121(10)	122(10)	123(10)	128(10)	130(10)	132(10)	133(10)	136(10)	138(10)	135(10)
Immediate change in hardness due to deformation, V.P.N.	...	1	11	4	10	11	12	18	19	22	24	25	22	27
Mechanical properties about 174 hrs. after deformation:														
0-1% Proof stress, tons/in. ²	15.7(4) ¹	18.4(3)	22.3(1)	20.3(1)	22.3(1)	22.2(1)	22.2(1)	24.8(1)	26.1(1)	26.3(1)	26.5(1)	27.4(1)	27.7(1)	28.2(1)
0.2% "	16.4(4)	18.4(3)	22.3(1)	20.3(1)	22.3(1)	22.2(1)	22.2(1)	24.8(1)	26.1(1)	26.3(1)	26.5(1)	27.4(1)	27.7(1)	28.2(1)
0.5% "	16.8(4)	18.6(3)	22.3(1)	20.4(1)	22.3(1)	22.2(1)	22.2(1)	24.9(1)	26.1(1)	26.3(1)	26.5(1)	27.4(1)	27.7(1)	28.2(1)
Ultimate stress,	26.3(4)	26.4(3)	27.0(1)	27.0(1)	27.3(1)	26.7(1)	27.2(1)	27.6(1)	27.9(1)	28.6(1)	28.4(1)	28.8(1)	28.8(1)	29.1(1)
Young's modulus, lb./in. ² /10*	22.8(4)	21.0(3)	22.0(1)	22.0(1)	22.0(1)	22.0(1)	22.0(1)	22.0(1)	22.0(1)	22.0(1)	22.0(1)	22.0(1)	22.0(1)	22.0(1)
Elongation on 1 in., per cent.	21.2(2)	19.0(1)	18.7(1)	18.7(1)	18.7(1)	18.7(1)	18.7(1)	18.7(1)	18.7(1)	18.7(1)	18.7(1)	18.7(1)	18.7(1)	18.7(1)
" "	19.8(4)	17.5(1)	18.0(1)	18.0(1)	18.0(1)	18.0(1)	18.0(1)	18.0(1)	18.0(1)	18.0(1)	18.0(1)	18.0(1)	18.0(1)	18.0(1)
" "	19.2(4)	16.6(1)	16.5(1)	16.5(1)	16.5(1)	16.5(1)	16.5(1)	16.5(1)	16.5(1)	16.5(1)	16.5(1)	16.5(1)	16.5(1)	16.5(1)
Hardness, V.P.N.	111(35)	117(10)	129(10)	117(10)	122(10)	123(10)	123(10)	129(10)	133(10)	132(10)	135(10)	134(10)	137(10)	137(10)
Hardness factor	0.24	0.24	0.23	0.23	0.22	0.22	0.21	0.21	0.21	0.22	0.21	0.21	0.21	0.21
0-1% Proof stress/ultimate stress, per cent.	59.7	69.7	81.3	79.2	81.3	80.2	87.1	89.8	93.3	92.0	93.3	95.2	96.2	96.9

1 The figures in parentheses indicate the number of determinations on which the mean has been based.

2 Measured by means of an extensometer.

3 Measured with dividers.

4 Broke outside gauge-marks.

5 The figures in this column indicate the mechanical properties of the undeformed material 250 hrs. after normalizing, but all other figures in the Table were obtained about 174 hrs. after deformation.

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thermal antecedents, not subjected to plastic deformation (Table IV). Further, the hardening of deformed specimens is virtually completed more rapidly than in the case of undeformed material (Table I).

- (3) A marked *increase in the proof stresses* bearing a relationship to the degree of deformation. A slight decrease in *ultimate stress* and a relatively rather greater *decrease in shear stress*, both apparently unrelated to the measure of deformation. A *decrease in elongation* roughly proportional to the amount of deformation (Table II).

In the hope of throwing some further light on the part played by plastic deformation (which must have at least a two-fold rôle, for in addition to its special influence revealed in Table IV, as with all, or almost all, metallic materials, it is productive of work-hardening), tensile test-pieces from the same sheet of Duralumin used for the preceding experiments were similarly normalized at 490° C., cold-water quenched, and then allowed over a week at atmospheric temperature in which to age-harden, after which they were plastically deformed with the results given in Table V, and shown in part in Fig. 1.

From Table V it is clear that the *immediate* increase in hardness arising from equal deformation, is considerably greater when this is carried out on the *freshly normalized*, as opposed to the *fully age-hardened* alloy. Further, reverting to Table III, it will be observed that while the increase in hardness of the undeformed specimen, from freshly normalizing to fully age-hardening is 38 units, the total increase of the most severely deformed one only exceeds this figure by 11 units; consequently, it is reasonable to assume that the larger portion of this immediate increase in hardness occurs owing to the deformation very greatly accelerating the mechanism of age-hardening.

CONCLUSIONS.

(1) Plastic deformation immediately following normalizing and cold-water quenching produces :

- (a) An instantaneous increase in hardness roughly proportional to the measure of deformation employed.
- (b) An acceleration of age-hardening during subsequent storage at atmospheric temperature as compared with the rate of age-hardening of specimens of identical composition and thermal antecedents, *not subjected to plastic deformation*; further, the hardening of deformed specimens is virtually completed more rapidly than in the case of undeformed material.

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- (c) A marked increase in the proof stresses bearing a relationship to the degree of deformation. A slight decrease in ultimate stress and a relatively rather greater decrease in shear stress both apparently unrelated to the measure of deformation. A decrease in elongation roughly proportional to the amount of deformation.
- (2) Plastic deformation after complete air temperature age-hardening, produces :
 - (a) An instantaneous increase in hardness roughly proportional to the measure of deformation employed, which increase is virtually stable and smaller in amount than is brought about by the same degree of deformation applied immediately after normalizing.
 - (b) A large increase in proof stress and a smaller one in ultimate stress roughly related to the measure of deformation, giving rise to a material having better mechanical properties than if the same degree of deformation had been carried out directly after normalizing.
 - (c) A decrease in elongation approximately proportional to the degree of deformation.

DISCUSSION.

While the numerous determinations which have been cited are not wholly free, in spite of many precautions, from certain anomalies, particularly as regards the hardness determinations recorded in Table I, the author submits that his conclusions have experimental justification. For the user of Duralumin for structural purposes, the results emphasize the desirability of carrying out plastic deformation, *subsequent* to age-hardening, whenever this is possible, for the resulting mechanical properties of the alloy will be markedly superior to those obtained if this deformation *precedes* ageing. From the point of view of one attempting the by no means simple nor uncontentious task of constructing a wholly satisfactory theory of age-hardening, the experiments described are certainly not opposed to the thesis of precipitation from supersaturated solution, indeed, in the author's opinion, which he offers with a diffidence justified by experience, they may be regarded as giving support to this now generally accepted view.

ACKNOWLEDGMENTS.

The author desires to express his thanks to Sir Robert McLean for permission to publish this paper, and to his assistants Messrs. J. H. Cork, H. M. Kemp, and F. D. Collyer, for their help and collaboration in the numerous experiments on which it has been based.

EXPERIMENTS ON THE ELECTRICAL RESISTANCE OF COPPER AND SOME COPPER ALLOY WIRES.*

By CLEMENT BLAZEY,† M.Sc., MEMBER.

SYNOPSIS.

The electrical resistances of wires made from 7 samples of H.C. wire-bar copper, 2 samples of cadmium-copper, a furnace-refined copper, and various specially-prepared samples were measured after annealing in carbon dioxide over the range 300°–950° C. Two methods of cooling from the annealing temperature were used: quenching in water, and slow cooling in the furnace; slow cooling was sometimes replaced by reheating at a fixed temperature, such as 500° C.

It was found that, in general, minimum resistance is obtained on annealing at about 500° C., and that a steady increase in resistance occurs when the wires are quenched from temperatures above 500° C. This increase, however, tends to disappear when slow cooling is adopted or when the quenched wires are reheated at 500° C. In wire-bar copper the increase due to quenching from 950° C. varies from about 0.5 to 1 per cent. It is not greatly affected by variations in cold-drawing methods or by heat-treatment of the rolled rod before drawing.

With cadmium-copper, quenching from a high temperature does not increase the resistance to an unusual degree, but with fire-refined copper it causes an increase of nearly 10 per cent.

Wires drawn from wire-bar copper that has been remelted under charcoal show a greater increase in resistance on quenching from a high temperature than those made from the original wire-bars. When, however, the remelting takes place in conditions that permit an increase in oxygen content, the resulting wires show only slight differences in resistance with variations in annealing treatment.

Additions of sulphur and selenium to copper of low oxygen content cause marked increases in resistance on quenching from high temperatures. In these instances the slowly cooled samples contain numerous small inclusions, but the quenched samples are free from them.

The following causes for the increase in resistance on quenching from high temperature are briefly considered: (a) the nature of the furnace atmosphere, (b) alterations in dimensions of the wires, (c) quenching stresses, (d) the presence of blowholes, (e) chemical composition, and (f) grain structure.

INTRODUCTION.

It is generally believed that when hard-drawn high-conductivity copper is annealed at a temperature of about 500° C. the minimum value for electrical resistance is obtained. Up to 500° C. the sharp decrease to

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this minimum is due to the recovery of the metal from the work-hardened state, whilst the gradual increase in resistance on annealing at temperatures progressively higher than 500° C. is, for want of a better explanation, usually ascribed to "over-annealing." In experiments by various investigators to determine the change in resistance on annealing, the samples have been quenched from the annealing temperatures on the assumption that the rate of cooling is of little importance. Several years ago some experiments by the author showed that for annealing temperatures above 500° C. the rate of cooling affected the resistance, slow cooling resulting in values either equal to or only slightly greater than those obtained on annealing at 500° C. As this result was obtained repeatedly on wire made from a certain brand of wire-bar, experiments were carried out to ascertain if it applied to other brands and if it could be influenced by variations in composition and in melting and working conditions.

EXPERIMENTAL METHODS.

The wires were drawn from hot-rolled 0.3 in. diameter rod by standard reductions to 0.064 in. nominal diameter. The samples for annealing were 20 in. long and were wound to helical form at the middle portion in order to provide a middle length of 13.1 in. for resistance measurements and straight ends 3.45 in. long for inserting in the clamps of a bridge. Annealing was carried out in an electrically-heated silica tube furnace which was supported at an angle of 30° from the horizontal and immersed in a water tank at the lower end. The wires were pushed through the water-seal to the tip of a thermocouple at the middle of the tube, heated for the prescribed time, and then either quenched in the tank or slowly cooled in the furnace to 300° C. and then quenched. With slow cooling the cooling rate was of the order of 2° C. a minute. Frequently, slow cooling was replaced by a re-heating at a fixed temperature such as 500° C. Control of annealing was simple because of the compact nature of the samples and the ease with which the middle coiled portions could be pushed over the tip of the thermocouple. The usual procedure was to heat each sample for a definite time at 300°, 400°, 500°, 600°, 700°, 800°, 900°, and 950° C., oxidation being prevented by the use of an atmosphere of carbon dioxide. Resistance measurements were carried out on a Kelvin bridge (Leeds and Northrup pattern) with the samples immersed in an oil-bath.

As a check on this method of annealing and to test the wires in works' annealing conditions, duplicate 4 ft. lengths of each wire were annealed for 1 hr. at 500° C. in a Bates and Peard furnace (steam atmosphere). Density determinations were carried out on these wires and conductivity per cent. calculated from weight, density, resistance,

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and the International Standard for annealed copper of 0.15328 ohm per metre-grm. at 20° C. At intervals, check determinations were also made, with satisfactory results, on a Hoopé's bridge (Leeds and Northrup pattern) graduated in conductivity per cent. Chemical analyses were carried out on the wires, and sections of rods and wires were examined under the microscope to check oxygen contents.

Each resistance recorded in the tables is the average of four measurements. The maximum variation in any one set of readings was 0.000003 ohm, whilst the average was reproducible to within ± 0.000001 ohm. There was no means available to check the absolute accuracy of the results.

PART I.—EXPERIMENTS ON WIRES MADE FROM H.C. WIRE-BAR COPPER, CADMIUM-COPPER, AND FIRE-REFINED COPPER.

1. *Experiments on H.C. Wire-Bar Copper.*

A selection was made of 7 commercial wire-bars, ranging in weight from 220 to 275 lb. each. Two bars, marked ESA-749 and ESA-751, respectively, from their routine furnace charge numbers, were cast at the works of The Electrolytic Refining and Smelting Co., Ltd., Port Kembla. Melting and casting conditions were identical for both charges, but whereas charge 749 was composed of cathodes made at this refinery, charge 751 was composed of cathodes made at the refinery of the Mount Lyell Mining and Railway Co., Ltd., Tasmania. Each charge consisted of about 120 tons of copper. The other 5 bars, marked CCC, T, LNS, CCR, and UMK, were purchased on the London market early in 1933, and were included as examples of European and American refinery output. They were the only bars of extra-Australian origin available for these experiments.

Cross-sections 2 in. thick, were cut from each bar 18 in. from one end. Density determinations were made on the full sections, but the results recorded for these and other *castings* to be described later are apparent densities only. A piece was then cut vertically from the side of each section, hot-rolled to rod, annealed in air at 800° C. for several minutes, quenched, and cold-drawn to wire. During this working the set surfaces were brought to one end of the rods and discarded.

Details of analyses and annealing tests are given in Tables I and II. The treatments listed in Table II were applied in succession; for instance, after slowly cooling the samples from 950° C. (treatment 12), three separate annealings were then given at that temperature (treatments 13, 14, and 15). In order to avoid the inclusion of unnecessary detail, the complete results are given for only one brand of copper,

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TABLE I.—Composition of Wires Made from Wire-Bar Sections.

	Brand of Bar.						
	CCC.	T.	LNS.	CCR.	UMK.	ESA-749.	ESA-751.
Apparent density of bar section . . .	8-38	8-44	8-43	8-42	8-50	8-39	8-42
Density of annealed wire, gm./c.c. at 20° C.	8-912	8-907	8-912	8-908	8-908	8-911	8-907
Electrical conductivity, % (B. and P. anneal)	101-9	101-6	101-9	101-8	101-6	101-8	101-7
Composition (%):							
Oxygen	0-034	0-036	0-035	0-030	0-030	0-026	0-029
Silver	0-00020	0-00133	0-00128	0-00086	0-00233	0-00077	0-00083
Gold	trace	trace	0-00003	0-00006	trace	0-00003	0-00003
Sulphur	<0-001	<0-001	<0-001	<0-001	<0-001	<0-001	<0-001
Iron	0-0018	0-0018	0-0018	0-0019	0-0019	0-0020	0-0015
Nickel	nil	0-0012	trace	0-0004	0-0008	0-0004	0-0005
Arsenic	0-0003	0-0003	0-0003	trace	0-0005	nil	0-0004
Antimony	nil	nil	nil	nil	0-0002	trace	0-0004
Bismuth	nil	nil	trace	nil	nil	nil	nil
Selenium plus Tellurium	nil	trace	trace	trace	trace	0-0003	0-0006
Lead	0-0003	0-0009	0-0003	trace	0-0008	0-0005	0-0006

TABLE II.—Annealing Experiments on Wires Made from Wire-Bar Sections.

	Annealing Treatment.	CCC.		Differences in Resistance in Ohm × 10 ⁻⁸ at 20° C. based on Minimum Resistance after Annealing at 500° C.					
		Ohm at 20° C.	Difference.	T.	LNS.	CCR.	UMK.	ESA-749.	ESA-751.
		1	Hard-drawn	0-002777	70	65	72	72	71	70	71
2	Then 30 minutes at 300° C. and quenched	0-002708	1	2	7	3	8	3	5
3	Then 30 minutes at 400° C. and quenched	0-002708	1	1	5	2	1	0	3
4	Then 30 minutes at 500° C. and quenched	0-002707	0	0	0	0	0	0	0
5	Then 30 minutes at 600° C. and quenched	0-002709	2	2	5	1	2	1	2
6	Then 30 minutes at 700° C. and quenched	0-002709	2	4	6	9	4	4	6
7	Then slowly cooled from 700° C.	0-002708	1	3	0	2	1	2	4
8	Then 10 minutes at 800° C. and quenched	0-002715	8	9	10	22	7	6	9
9	Then slowly cooled from 800° C.	0-002707	0	2	5	2	0	0	6
10	Then 5 minutes at 900° C. and quenched	0-002719	12	12	13	25	15	10	20
11	Then 5 minutes at 950° C. and quenched	0-002719	12	18	15	28	18	11	25
12	Then slowly cooled from 950° C.	0-002709	2	7	7	3	2	2	10
13	Then 5 minutes at 950° C. and quenched	0-002724	17	18	17	28	18	13	28
14	Then 5 minutes at 950° C. and quenched	0-002734	17	17	20	28	17	13	30
15	Then 10 minutes at 950° C. and quenched	0-002724	17	18	19	28	18	14	30
16	Then 5 minutes at 1000° C. and quenched	0-002722	15	17	17	28	18	14	30

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CCC, the actual resistances for the other brands being omitted and differences alone tabulated (*i.e.* increases above the minimum values obtained by annealing at 500° C.).

The results show a definite increase in resistance after annealing at and quenching from temperatures above 500° C. An increase of the order of 0.000027 ohm (27 in the difference column of Table II) is equivalent to a decrease in conductivity of the order of 1 per cent. When the coils were slowly cooled from a high temperature their resistances generally decreased to values only slightly greater than those obtained after annealing at 500° C. A feature of interest was the relatively high increase in resistance in CCR and ESA-751 after annealing at high temperatures and the sudden increase in CCR after the annealing at 800° C. This peculiarity in CCR was shown in repeat tests on other sections cut from this bar and rolled and drawn in the manner already described. There is, however, no reason to suppose that it is a feature of CCR bars as a whole.

2. The Effects of Variations in the Physical Condition of the Bars and of Rolling and Drawing Methods.

In the first experiment under this heading six 250 lb. bars of ESA brand were selected from a charge, 913, cast some time later than charges 749 and 751. Bars 913A and B were selected at a stage in casting when the set was low; bars 913C and D were selected later after a pole had been inserted and when the set was rather high and porous; and bars 913E and F were taken still later when the set had returned to normal and the porosity had disappeared. All bars were rolled to 0.3 in. rod and drawn in a high-speed tandem machine to 0.083 in. diameter. At that stage a portion was cut from each coil of wire and annealed at 500° C. in a Bates and Peard furnace, after which the 12 coils (6 hard and 6 annealed) were drawn to 0.064 in. diameter and tested in the manner described for the wires in Section 1.

The oxygen content varied from bar to bar, corresponding with set in only a general way, and then in a manner the reverse of that anticipated from the appearance of the bars. It is necessary to add, however, that oxygen determinations were made on the samples used for annealing experiments and not on the bars as a whole before rolling. Conductivity and density varied in keeping with oxygen content. In Table III the average results for each pair of bars are recorded.

In the carbon dioxide annealing experiments the increase in resistance after quenching from a high temperature did not vary markedly with variations in set or working methods, but it was slightly higher in



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TABLE III.—The Effects of Variations in Set of Bar and Methods of Working.

	Low Set Bars A and B.		High Set Bars C and D.		Normal Set Bars E and F.	
	Drawn hard to 0.064 in.	Annealed at 0.083 in.	Drawn hard to 0.064 in.	Annealed at 0.083 in.	Drawn hard to 0.064 in.	Annealed at 0.083 in.
Composition (%) :						
Oxygen	0.046	0.044	0.055	0.050	0.041	0.042
Sulphur	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Electrical conductivity, % (B. and P. anneal)	101.6	101.6	101.5	101.5	101.5	101.6
Density of annealed wire, grm./c.c. at 20° C.	8.900	8.900	8.896	8.898	8.901	8.900
<i>Coils Annealed in Carbon Dioxide. Results are Stated in Ohms at 20° C.</i>						
Resistance as hard-drawn	0.002773	0.002735	0.002774	0.002737	0.002796	0.002751
Resistance after annealing at 500° C.	0.002698	0.002688	0.002698	0.002688	0.002719	0.002700
Decrease on annealing . . .	0.000075	0.000047	0.000076	0.000049	0.000077	0.000051
Decrease on annealing, %	2.8	1.8	2.8	1.8	2.8	1.9
Resistance after quenching from 950° C.	0.002708	0.002700	0.002710	0.002702	0.002728	0.002713
Increase on quenching from 950° C.	0.000010	0.000012	0.000012	0.000014	0.000009	0.000013
Increase on quenching, %	0.4	0.4 ₅	0.4	0.5	0.3	0.5

samples annealed at 0.083 in. than in those drawn without annealing. The duplicate bars of each series gave fairly concordant results.

In the second experiment another normal set bar from charge 913 was rolled to 0.75 in. rod, cut in 3 pieces, and drawn to 0.064 in. in 3 different ways : (a) drawn hard from 0.75 to 0.064 in., *i.e.* given 99.2 per cent. reduction in area without annealing ; (b) drawn hard from 0.75 to 0.083 in., annealed at 500° C. for 1 hr., and then drawn to 0.064 in., *i.e.* given a final reduction in area of 40.5 per cent. in two passes ; (c) drawn hard from 0.75 to 0.3 in. and then annealed at 500° C. for 1 hr. at every second pass, *i.e.* at 0.3, 0.192, 0.132, 0.104, and 0.083 in. A final reduction in area of 40.5 per cent. was given in two passes.

When given the usual series of ½-hr. anneals at increasing temperatures, all three wires reached minimum resistance at 500° C., the decrease from the hard-drawn state to the 500° C. anneal amounting to 3.3 per cent. for method (a), 1.9 per cent. for (b), and 1.8 per cent. for (c). The increase on quenching from 950° C. was 0.4 per cent. for (a), 0.5₅ per cent. for (b), and 0.6 per cent. for (c). Considering the differences in methods of drawing, these variations were slight, but, as in the first experiment, increase in resistance due to quenching from 950° C. increased slightly with the amount of annealing at 500° C. given during drawing.

In order to test whether ½-hr. anneals would be insufficient to provide

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to 500° C. Based on a conductivity of 88.8 per cent. for the hard wire, the conductivity after treatment 9 was 97.1 per cent. The greatest resistance was not obtained in the hard-drawn wire, but in the soft wire after quenching from 950° C., when it was 9.7 per cent. above the minimum value compared with 8.8 per cent. for the hard wire. In view of the effect of heat-treatment of the CCR rod before drawing (see Section 2) it is probable that the resistance of the hard Wallaroo wire was affected by the hot-working operations prior to drawing. There was not sufficient rod available to test this point. Once the wire had been heated above 800° C. it was a difficult matter to regain the minimum value for resistance by heating at 500° C. (or even by very slow cooling, as was proved in check tests).

PART II.—EXPERIMENTS ON WIRES MADE FROM SMALL CASTINGS.

1. *The Effect of Remelting Wire-Bar Copper.*

Pieces 9 lb. in weight were cut from a number of wire-bars and melted in a graphite crucible in an oil-fired furnace. In each case a charcoal cover was maintained over the melt, and stirring was carried out with a

TABLE VIII.—*Wires Made from Remelted Wire-Bars.*

	ESA-749.		ESA-751.	
	E2, Cast as a Billet.	E3, Solidified in Crucible.	L2, Cast as a Billet.	L3, Solidified in Crucible.
Apparent density of the casting	7.49	7.51	7.21	7.47
Density of annealed wire, gm./c.c. at 20° C.	8.922	8.922	8.921	8.918
Electrical conductivity of annealed wire, %	102.1	102.1	102.1	101.8
Loss of weight in hydrogen, %	0.013	0.011	0.015	0.011
Sulphur, %	0.001 ₃	0.001 ₃	0.002 ₆	0.002 ₄
Iron, %	0.0015	0.0033	0.0011	0.0018
<i>Coils Annealed in Carbon Dioxide. Results are Stated in Ohm at 20° C.</i>				
Resistance as hard-drawn	0.002762	0.002762	0.002770	0.002772
Resistance after annealing at 500° C.	0.002683	0.002687	0.002690	0.002689
Decrease on annealing	0.000079	0.000075	0.000080	0.000083
Decrease, %	2.9	2.8	3.0	3.1
Resistance after quenching from 950° C.	0.002717	0.002724	0.002734	0.002734
Increase due to quenching	0.000034	0.000037	0.000044	0.000045
Increase, %	1.3	1.4	1.6	1.7
Resistance after slowly cooling from 950° C.	0.002692	0.002694	0.002705	0.002691
Amount in excess of minimum resistance	0.000009	0.000007	0.000015	0.000002

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stick. A billet, 2 lb. in weight, was cast into a cylindrical mould dressed with bone ash, and the remainder of the melt was then allowed to solidify in the crucible in the furnace, the charcoal cover being maintained during cooling. All billets and slowly-cooled melts were of low density owing to the presence of clean blowholes. They were hot-worked to rod and drawn to wire in the usual way. In Table VIII a summary is given of the test results on wires made from two of the bars. Similar results were obtained on other bars.

Although remelting, in the conditions described, caused low density in the metal, both as cast and slowly cooled, it gave relatively high density in the worked metal because of reduction in cuprous oxide content. Remelting also caused an increase in sulphur content, presumably because of absorption of sulphur-bearing gases from the burning oil.

In all cases the increase in resistance on quenching from 950° C. was greater than in the original wire-bars. After slow cooling from high temperatures, the resistance was only slightly greater than that obtained after the 500° C. anneal.

2. The Effect of Variation in Oxygen Content.

To study the effect of oxygen content from another point of view, although in conditions involving overpoling and slight variations in sulphur content, experiments were carried out with cathode copper consisting of starting sheet, made in unusually favourable conditions, comprising the use of high-grade anodes and new, clean electrolyte. This sheet was cleaned in nitric acid, well washed with water, and melted under charcoal in a graphite crucible in an oil-fired furnace. The first melt, ES1, was allowed to solidify in the crucible under charcoal; it set to a comparatively solid mass with a concave top and with an exceptionally low oxygen content. From the second melt 3 billets were obtained. The first, ES2, was poured under charcoal. As it came in contact with air during pouring, its oxygen content was greater than that of ES1. The charcoal cover was then removed to expose the copper to air for a few minutes, and a second billet, ES3, was cast. After an interval of a few minutes for further oxidation, a third billet, ES4, was cast. The four castings were rolled and drawn to wire and given the routine annealing. The salient features are recorded in Table IX.

With regard to composition, sulphur content decreased with increase in oxygen content in the case of the three billets. Microscopic examination of sections confirmed the results of analysis for oxygen. The usual effect of oxygen in increasing the density of the casting while decreasing that of the worked metal is apparent.

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TABLE IX.—*The Effect of Variation in Oxygen Content.*

	ES1, Cooled in Crucible.	Cast from One Melt.		
		ES2.	ES3.	ES4.
Apparent density of casting	8.70	7.69	8.28	8.80
Density of annealed wire, grm./ c.c. at 20° C.	8.927	8.913	8.904	8.872
Electrical conductivity, % (B. and P. anneal)	102.3	102.1	101.9	101.3
Composition:				
Loss in weight in hydrogen, %	0.004	0.015	0.033	0.077
Sulphur	<0.001	0.001 ₅	0.001	<0.001
<i>Coils Annealed in Carbon Dioxide. Results are Stated in Ohm at 20° C.</i>				
Resistance as hard-drawn	0.002765	0.002769	0.002766	0.002786
Resistance after annealing at 500° C.	0.002695	0.002701	0.002692	0.002714
Decrease on annealing	0.000070	0.000068	0.000074	0.000072
Decrease on annealing, %	2.6	2.5	2.7	2.7
Resistance after quenching from 950° C.	0.002719	0.002737	0.002709	0.002722
Increase due to quenching	0.000024	0.000036	0.000017	0.000008
Increase, %	0.9	1.3	0.6	0.3
Resistance after slowly cooling from 950° C.	0.002695	0.002715	0.002696	0.002716
Amount in excess of minimum resistance	0.000000	0.000014	0.000004	0.000002

In the annealing experiments, increase in oxygen content and decrease in sulphur content coincided with decrease in resistance differences in the case of the three wires made from billets. The resistance difference for ES1 was intermediate between that of ES2 and ES3.

Similar results were obtained on repeating the experiments with another lot of cathode produced by a different refinery, but a slowly-cooled melt was not included in the series.

3. The Influence of Lead, Selenium, and Sulphur.

Wire-bar and cathode copper were used in these experiments. In the first series lead and selenium were added to copper taken from wire-bar furnace charge ESA-751, details of which have already been given. During the casting of this charge a number of 2 lb. billets was cast by means of a hand-ladle at the poling door. Billet L29 was ladled out without any additions. Billets L33, L34, and L35 were cast in a manner similar to that for L29 except that lead was added to L33, selenium to L34, and lead and selenium to L35. The amount of selenium that actually entered the copper was not as great as was intended. From Tables I and X, it will be seen that L29 contained more oxygen, as measured by loss in weight when heated in hydrogen, than the corre-

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TABLE X.—*The Influence of Lead, Selenium, and Sulphur.*

	Charge BSA-781.					Mt. Lyell cathode.				
	L39.	L33.	L34.	L35.	L44.	L45.	L46.	L47.	L48.	L49.
Apparent density of casting	8.58	8.69	8.73	8.75	7.13	7.60	6.91	8.49	8.49	8.49
Density of annealed wire, gm./c.c. at 20° C.	8.893	8.870	8.863	8.839	8.923	8.919	8.908	8.918	8.918	8.918
Electrical conductivity of annealed wire, %	101.1	100.6	100.2	99.6	100.9	101.1	101.4	101.4	101.4	101.4
Composition (%):										
Loss of weight in hydrogen	0.056	0.169	0.091	0.199	0.040	0.025	0.059	0.051	0.051	0.051
Sulphur	<0.001	<0.001	<0.001	<0.001	0.006	0.005 ₅	0.035	0.041	0.041	0.041
Selenium	0.0006	0.0006	0.008	0.008	0.022	0.020	0.0006	0.0006	0.0006	0.0006
Lead	0.0006	0.116	0.0006	0.088	0.0057	0.0057	0.0043	0.0043	0.0043	0.0043
Iron	0.0033	0.0033	0.0033	0.0033	0.0029	0.0029	0.0031	0.0031	0.0031	0.0031
<i>Coils Annealed in Carbon Dioxide. Results are Stated in Ohm at 20° C.</i>										
Resistance after annealing at 500° C. (= lowest resistance in all cases)	0.002729	0.002745	0.002741	0.002757	0.002705	0.002709	0.002710	0.002704	0.002704	0.002704
Resistance after quenching from 950° C.	0.002738	0.002770	0.002807	0.002817	0.002907	0.002876	0.002848	0.002830	0.002830	0.002830
Increase due to quenching	0.000009	0.000025	0.000066	0.000060	0.000202	0.000167	0.000138	0.000126	0.000126	0.000126
Increase, %	0.3	0.9	2.4	2.2	7.5	6.2	5.1	4.7	4.7	4.7
Resistance after slowly cooling from 950° C.	0.002729	0.002747	0.002751	0.002770	0.002730	0.002724	0.002725	0.002704	0.002704	0.002704
Amount in excess of minimum	0.000000	0.000002	0.000010	0.000013	0.000025	0.000015	0.000015	0.000000	0.000000	0.000000

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sponding wire-bar ESA-751, a difference that was supported by micro-examination. The increase can be attributed to a greater absorption of oxygen during hand ladling than during the mechanically-operated ladling on the casting wheel, and to the fact that the set surface of the wire-bar was discarded after rolling. Micro-sections also demonstrated that the other billets, L33, L34, and L35, contained more inclusions, oxide and other, than the corresponding wire-bar. With these billets "loss in weight in hydrogen" must be interpreted with due regard to the loss of volatile elements and to variations in oxygen content inherent in the method of stirring in the impurities.

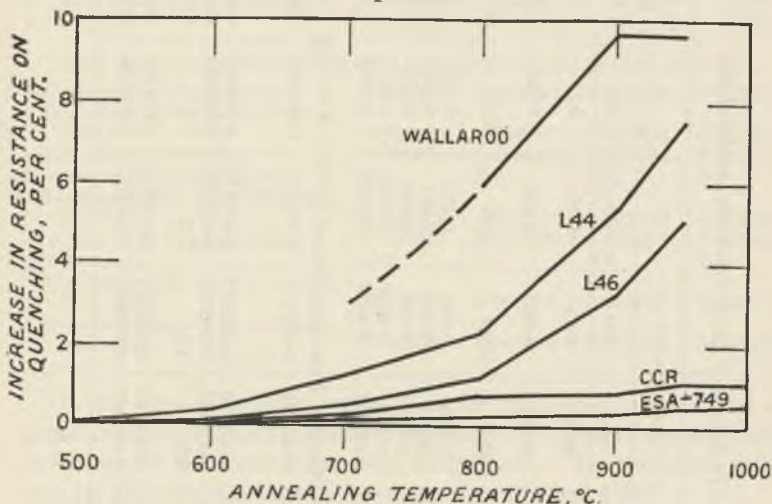


FIG. 1.

Similar experiments were carried out with charge 749 made from a different lot of cathodes, the results being in general agreement with those on charge 751.

Attention was then directed to the production of small billets from cathode copper similar to that used for charge 751. The cathode was cleaned in nitric acid and melted under charcoal in the usual manner. Selenium was added to one melt (from which samples L44 and L45 were obtained) and sulphur to another (from which samples L46 and L47 were obtained), each melt being divided into two, one portion being cast as a billet (L44 and L46 in the respective cases), and the other being allowed to solidify in the crucible under charcoal (L45 and L47 in the respective cases).

The castings containing lead cracked in hot-rolling, but not so seriously that wires could not be obtained from them. Those con-

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taining selenium and sulphur rolled without trouble. The test results are summarized in Table X, only the salient features after annealing in carbon dioxide being recorded.

After the carbon dioxide annealing tests had been completed, new samples of L44 and L46 were annealed at 950° C. for different periods of time up to 6 hrs. and quenched to see if the resistances were constant. A decrease of the order of 10 per cent. occurred in both cases after heating for 1 hr., but thereafter the resistances were constant.

The points of interest in this series of experiments were : (a) a slight effect of impurities in retarding softening in the early stages of annealing (not shown in Table X); (b) the effect of impurities in increasing resistance differences, particularly in the case of the cathode samples L44 and L47; (c) a tendency in all instances to revert to minimum resistance with slow cooling.

The results on quenched samples of L44, L46, Wallaroo, ESA-749, and CCR wires are plotted in Fig. 1.

PART III.—DISCUSSION OF RESULTS.

In attempting to explain the resistance differences it is necessary to consider (a) the influence of the furnace atmosphere, (b) alterations in dimensions of the samples, (c) quenching stresses, (d) the presence of blowholes, (e) chemical composition, and (f) grain structure.

(a) Some difference of opinion exists regarding the solubility of carbon dioxide in solid copper. According to Sieverts and others it is insoluble, but Iwasé records a slight solubility increasing from practically zero at 500° C. to about 1.5 c.c. per 100 gm. copper at 1080° C. Recent work by Röntgen and Möller¹ supports Sieverts' conclusion. As a check on the influence of carbon dioxide, typical experiments were repeated, using nitrogen as a furnace atmosphere. The results agreed with those obtained with carbon dioxide. As a final check the following experiment was carried out. Coils of hard-drawn ESA-751 and L44 wires were annealed in air for several minutes at 920° C., quenched in water, freed from oxide scale, and measured for resistance. They were then heated in carbon dioxide for 2 hrs. at 500° C., quenched, and again measured. As no alteration in diameter through oxidation occurred in the carbon dioxide anneal, the resistances after the 920° and 500° C. anneals may be compared. They were as follows :

	Ohm.
ESA-751 after quenching from 920° C.	0.002877
" " reheating at 500°	0.002868
Difference	0.000009
L44 after quenching from 920° C.	0.003017
" " reheating at 500°	0.002877
Difference	0.000140

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As these differences correspond fairly closely with those obtained when either carbon dioxide or nitrogen was used for both anneals, the solubility of carbon dioxide cannot very well be regarded as the cause of the differences in resistance.

It is possible that, in most annealings, the furnace atmosphere contained a small amount of water vapour owing to the trapping of some water in the outlet end of the silica tube after the samples were inserted; but that this vapour, if present at all in the vicinity of the coiled portion of the sample, had no effect on resistance was proved by check experiments in a dry tube, the tank being introduced only for quenching.

(b) In view of the dependence of resistance on cross-sectional area, it is necessary to consider alterations in dimensions on heating. Various samples of both wire and rod were measured for length and diameter as hard-drawn, after heating in carbon dioxide for 30 minutes at 500° C., and after heating at 950° C. for 10 minutes and quenching. The slight changes in dimensions were somewhat irregular and might have been connected with the presence of flattened-down blowholes. In general, the samples decreased in length and increased in diameter on annealing at 500° C. and showed further changes in the same sense on reheating at 950° C., but decrease in length at most was of the order of 0.02 per cent., while increase in cross-sectional area at most was of the order of 0.2 per cent. (e.g. L44 measured after the 500° and 950° C. anneals). As the change in cross-section was positive, it could not in itself account for an increase in resistance.

(c) The existence of quenching stresses might conceivably cause variations in resistance. If this were so it would not be practicable to remove such stresses in soft coils by mechanical treatment, but it should be possible to remove them by low-temperature heat-treatment. Coils were prepared from two different wires containing selenium in which the increases in resistance on quenching from 950° C. after a preliminary annealing at 500° C. were 0.000235 ohm and 0.000216 ohm, respectively. No change in resistance was detected on reheating these coils for 1 hr. at 300° C. and only a slight change on reheating for 1 hr. at 400° C. These treatments would be expected to remove internal stresses in copper.

(d) Although blowholes in the castings should not in themselves cause resistance differences in wires of the nature described, they might be a rough measure of the presence of a gas which might affect the resistance at different temperatures. A comparison of densities and resistance differences, however, reveals no definite relationship between the two. Nevertheless, the influence of dissolved gases cannot be ruled out on this account.



FIG. 2.—Wire L44, Containing Added Selenium, Annealed at 950° C. and Quenched.
× 1000.

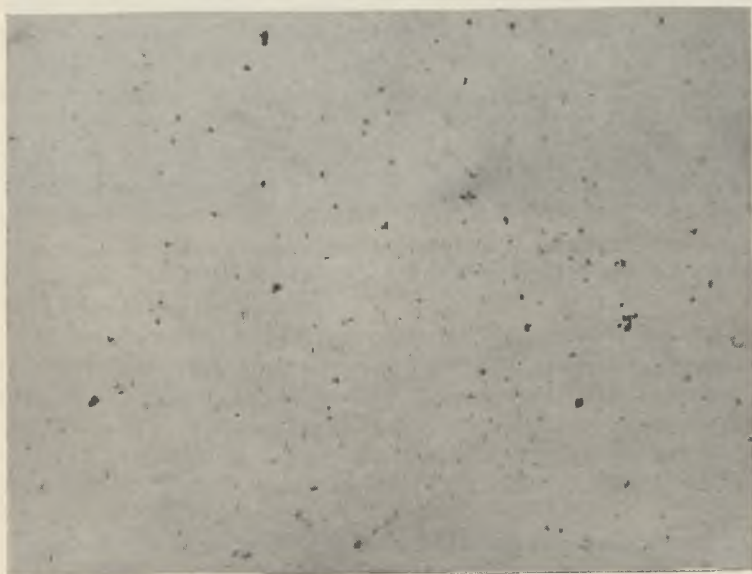


FIG. 3.—Same as Fig. 2 but Reheated to 950° C. and Slowly Cooled to 300° C. and Quenched. × 1000.

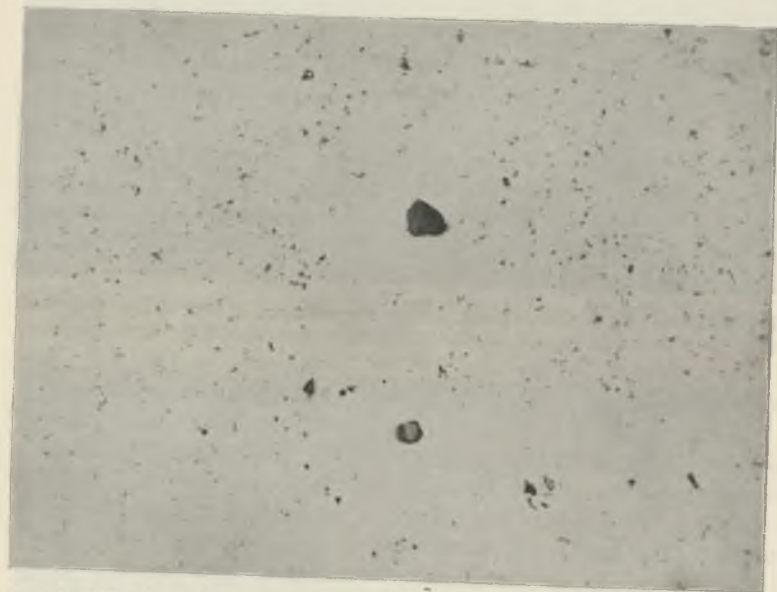


FIG. 4.—Wire L46, Containing Added Sulphur, Annealed at 950° C. and Slowly Cooled to 300° C. and Quenched. $\times 1000$.

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(e) In view of the marked effect of alterations in chemical composition, it is possible that increase in solubility of some commonly-occurring elements with increase in temperature may be the cause of the differences noted. Quenching would retain these elements in solution, while slow cooling would bring about their precipitation. The influence of oxygen would be of importance in counteracting the effect of these elements. Many sections of wires were examined in an effort to correlate resistance differences with variations in microstructure. In only two sets of samples were variations detected, namely in L44 and 45 containing added selenium, and L46 and 47 containing added sulphur. After quenching these wires from 950°C ., the field was clear (see Fig. 2, Plate I), but after slow cooling from that temperature very small inclusions were present (see Figs. 3 and 4, Plates I and II) and repeated polishing and etching proved that they were part of the structure. Whilst L44 and 45 contained very few large inclusions, L46 and 47 contained a number of relatively large sulphide and oxide particles after all treatments, no difference being noted either in their number or in their distribution with variations in cooling rate. There was, too, another distinction between L44-45 and L46-47, namely, that whereas after slow cooling from 950°C . the small inclusions in L44-45 were evenly distributed throughout the field, in L46-47 they were not generally visible in the immediate neighbourhood of the large particles. This point is illustrated to some extent in Fig. 4 (Plate II).

Rhines and Mathewson² have shown that when copper of a high degree of purity, but containing oxygen, is quenched from about 1000°C . and then reheated at 400°C ., precipitation of a constituent—presumably copper oxide—occurs. It is possible that the variation in solubility of copper oxide is partly responsible for the differences in resistance, but that it is not the major influence is indicated by the fact that the differences are reduced by increases in oxygen content. No precipitation of fine particles could be detected in any wire-bar sample used in the present experiments.

(f) In the various wires described in this paper the influence of grain-size on resistance appeared to be slight, but so far an exhaustive examination of this side of the subject has not been made. While, naturally, the grain-size after annealing at 500°C . was smaller than after annealing at 950°C ., no variations in size were noticed on varying the cooling rate from 950°C . The effect on grain-size of variations in drawing methods has not yet been examined.

Although a sample of wire may be annealed in such a way that large variations in grain-size may exist with practically no variation in resistance, the precise effect of grain-size must remain in abeyance until

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the various factors responsible for resistance differences are better understood.

ACKNOWLEDGMENTS.

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REFERENCES.

- ¹ P. Röntgen and F. Möller, *Metallwirtschaft*, 1934, **13**, 81-83, 97-100.
- ² F. N. Rhines and C. H. Mathewson, *Trans. Inst. Metals Div., Amer. Inst. Min. Met. Eng.*, 1934, **III**, 337-353.

MEETINGS OF OTHER SOCIETIES

THURSDAY, NOVEMBER 21.

INSTITUTE OF MARINE ENGINEERS, JUNIOR SECTION.—R. S. Kennedy: "Modern Methods of Welding." (L.C.C. School of Engineering and Navigation, High St., Poplar, E.14, at 7 p.m.)

FRIDAY, NOVEMBER 22.

INSTITUTE OF BRITISH FOUNDRYMEN, LANCA-SHIRE BRANCH, JUNIOR SECTION.—J. Sherwood: "Practical Foundry Experiences." (College of Technology, Sackville St., Manchester, at 7.30 p.m.)

INSTITUTION OF HEATING AND VENTILATING ENGINEERS, LONDON AND DISTRICT BRANCH.—W. L. Kilburn: "The Bronze Welding of Copper Piping." (Borough Polytechnic, Borough Road, Southwark, London, S.E.1, at 7 p.m.)

SATURDAY, NOVEMBER 23.

INSTITUTE OF BRITISH FOUNDRYMEN, NEW-CASTLE-UPON-TYNE AND DISTRICT BRANCH.—W. E. Mordecai: "The Properties of Foundry Coke." Joint Meeting with the Coke Oven Managers' Association. (Neville Hall, Westgate Rd., Newcastle-upon-Tyne, at 6.15 p.m.)
INSTITUTE OF BRITISH FOUNDRYMEN, SCOTTISH BRANCH.—H. Lowe: "Locomotive Castings." (Heriot-Watt College, Chambers St., Edinburgh, at 4 p.m.)

MONDAY, NOVEMBER 25.

COMPANY OF ARMOURERS AND BRASERS IN THE CITY OF LONDON.—V. E. Pullin: "Non-Destructive Testing of Materials." First of Three Lectures. (Royal School of Mines, Prince Consort Road, South Kensington, London, S.W.7, at 8 p.m.)

WEDNESDAY, NOVEMBER 27.

INSTITUTE OF BRITISH FOUNDRYMEN, LANCA-SHIRE BRANCH, PRESTON SECTION.—W. D. Knagg: "Insight into Modern Sand Testing." (Technical College, Corporation St., Preston, at 7.30 p.m.)

INSTITUTE OF WELDING, NORTH-WESTERN BRANCH.—J. A. Ashworth: "Welding Jigs and Fixtures." (College of Technology, Sackville Street, Manchester, at 7.15 p.m.)

SATURDAY, NOVEMBER 30.

INSTITUTE OF BRITISH FOUNDRYMEN, EAST MIDLANDS BRANCH.—F. Hudson: "Some Properties of Mould and Core Materials at High Temperatures." (Technical College, Derby, at 6 p.m.)

MONDAY, DECEMBER 2.

COMPANY OF ARMOURERS AND BRASERS IN THE CITY OF LONDON.—V. E. Pullin: "Non-Destructive Testing of Materials." Second of Three Lectures. (Royal School of Mines, Prince Consort Road, South Kensington, London, S.W.7, at 8 p.m.)

TUESDAY, DECEMBER 3.

ELECTRODEPOSITORS' TECHNICAL SOCIETY.—J. Binns: "Methods of Heating Solutions in Electrodeposition." (James Watt Memorial Institute, Gt. Charles St., Birmingham, 3, at 7.30 p.m.)

FRIDAY, DECEMBER 6.

INSTITUTE OF BRITISH FOUNDRYMEN, BIRMINGHAM, COVENTRY & WEST MIDLANDS BRANCH.—T. W. Trayherne: "The Moulding of Light Castings by Means of Strickles." (James Watt Memorial Institute, Gt. Charles St., Birmingham, 3, at 7.30 p.m.)

INSTITUTION OF STRUCTURAL ENGINEERS, WESTERN COUNTIES BRANCH.—W. H. Dearden, M.Sc.: "Some Aspects of the Theory of Corrosion." (Merchant Venturers' Technical College, Unity St., College Green, Bristol, at 7.15 p.m.)

SATURDAY, DECEMBER 7.

INSTITUTE OF BRITISH FOUNDRYMEN, LANCA-SHIRE BRANCH.—V. C. Faulkner and J. N. Burns: "The Dagenham Factory of the Ford Motor Co., Ltd." (Engineers' Club, Albert Sq., Manchester, at 4 p.m.)

INSTITUTE OF BRITISH FOUNDRYMEN, SCOTTISH BRANCH, FALKIRK SECTION.—H. Cowan: "Metal Finishes on Cast Iron." (Temperance Café, Lint Riggs, Falkirk, at 6 p.m.)

MONDAY, DECEMBER 9.

COMPANY OF ARMOURERS AND BRASERS IN THE CITY OF LONDON.—V. E. Pullin: "Non-Destructive Testing of Materials." Last of Three Lectures. (Royal School of Mines, Prince Consort Road, South Kensington, S.W.7, at 8 p.m.)

WEDNESDAY, DECEMBER 11.

INSTITUTION OF HEATING AND VENTILATING ENGINEERS, BIRMINGHAM AND DISTRICT BRANCH.—W. C. Freman: "Welding of Lead and Copper." (Chamber of Commerce, 95 New Street, Birmingham, at 6.45 p.m.)

THURSDAY, DECEMBER 12.

INSTITUTE OF VITREOUS ENAMELLERS, SOUTHERN SECTION.—J. Ferdinand Kayser: "Heat-Resisting Alloys." (British Industries House, Marble Arch, London, W.1, at 8 p.m.)

SATURDAY, DECEMBER 14.

INSTITUTE OF BRITISH FOUNDRYMEN, NEW-CASTLE-UPON-TYNE AND DISTRICT BRANCH.—H. Fabre and H. Dubois: Discussion on "Strickle Moulding of Large Castings." (Neville Hall, Westgate Rd., Newcastle-upon-Tyne, at 6.15 p.m.)

INSTITUTE OF BRITISH FOUNDRYMEN, SCOTTISH BRANCH.—W. E. Ballard: "Metal Spraying." (Royal Technical College, George St., Glasgow, at 4 p.m.; Evening: Annual Dinner.)

MONDAY, DECEMBER 16.

INSTITUTION OF ENGINEERS AND SHIPBUILDERS IN SCOTLAND.—J. E. Hurst: "The Addition of Non-Ferrous Metals to Cast Iron." (The Institution, 39 Elmbank Crescent, Glasgow, C.2, at 7.30 p.m.)

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METALLURGICAL ABSTRACTS

(GENERAL AND NON-FERROUS)

Volume 2

NOVEMBER 1935

Part 11

I.—PROPERTIES OF METALS

(Continued from pp. 453-461.)

***Distillation of Aluminium.** Yohei Yamaguchi and Haruo Nakazawa (*J. Electrochem. Assoc. Japan*, 1935, 3, 92-95; *C. Abs.*, 1935, 29, 5791).—[In Japanese.] Aluminium in a crucible of pure powdered corundum and fine aluminium powder (5 : 1) was distilled *in vacuo* in an electric arc. The distilled metal has a metallic lustre or takes the form of crystalline scales or black powder.—S. G.

Refined Aluminium. R. Gadeau (*Schweiz. Arch. angew. Wiss. Tech.*, 1935, 1, 145-148; *Aluminium*, 1935, 17, 513).—Cf. *Met. Abs.*, this vol., p. 365. The Cie-Alais, Froges et Camargue, prepare 99.99% aluminium by a modification of the Hoopes' process using a 33% copper-aluminium anode and an electrolyte of aluminium and sodium fluorides with barium chloride. The metal obtained is remarkably soft and resistant to corrosion; in the form of foil it is used for packing cheese and other foodstuffs, for making electric condensers, and for heat-insulating purposes.—A. R. P.

***A Revision of the Atomic Weight of Arsenic. I.—The Analysis of Arsenic Tribromide. II.—The Analysis of Arsenic Trichloride.** Gregory P. Baxter, William E. Shaeffer, Merrill J. Dorcas, and Edward W. Scripture, Jr. (*J. Amer. Chem. Soc.*, 1933, 55, 1054-1066).—The value obtained was 74.91.—L. A. O.

***A Revision of the Atomic Weight of Arsenic. The Comparison of Arsenic Trichloride with Iodine Pentoxide.** Gregory Paul Baxter and William Ernest Shaeffer (*J. Amer. Chem. Soc.*, 1933, 55, 1957-1963).—Confirms previous results. See preceding abstract.—L. A. O.

***Changes in the Thermal and Electrical Conductivity of a Single Crystal of Bismuth in a Magnetic Field.** H. Reddemann (*Ann. Physik*, 1934, [v], 20, 441-448).—v. G.

Properties of Sublimed Calcium. Paul Bastien (*14me. Congrès chim. ind., Paris*, 1934, 21 pp.).—Cf. *Met. Abs.*, 1934, 1, 226, and this vol., p. 413. A mere complete description of the investigations.—S. G.

***The Hardness of Electrolytic Chromium and the Influence of Hydrogen Dissolved in the Metal.** S. P. Marakiwka and N. D. Biriukow (*Z. Elektrochem.*, 1935, 41, 623-631).—The evolution of hydrogen from electrolytic chromium between 20° and 650° C. was investigated. The hardness of the metal is not dependent on the hydrogen content. When the metal is heated to 200° C. with the removal of 30% of the hydrogen content, the hardness increases, due to the transformation of the hexagonal lattice of soft chromium at high temperature to the cubic (face-centred) lattice of hard chromium. On increasing the temperature to about 575° C., 98% of the hydrogen is removed, and the hardness remains at the higher value. At $575^{\circ} \pm 20^{\circ}$ C., after the removal of all the hydrogen, a marked softening occurs, this being a critical temperature at which the disappearance of internal elastic strain in the lattice and the recrystallization of the metal occurs, analogous to the annealing of cold-worked metal.—J. H. W.

***Revision of the Atomic Weight of Niobium [Columbium]. Analysis of Niobium Pentachloride.** O. Honigschmid and K. Wintersberger (*Z. anorg. Chem.*, 1934, 219, 161-177).—Analysis of highly purified NbCl_5 gave a value of 92.91 as the atomic weight of columbium.—A. R. P.

* Denotes a paper describing the results of original research.

† Denotes a first-class critical review.

M M

***Passivity of Gold.** W. J. Müller and E. Löw (*Trans. Faraday Soc.*, 1935, **31**, 1291-1298).—Passivation of gold in 5*N*-hydrochloric acid occurs according to the laws of passivation by surface layers and chemical passivation. Gold exposed to air becomes coated with an oxide layer, which is removed during passivation in concentrated acid but is re-formed when the metal is again exposed to the air. Anodic passivation in dilute hydrochloric acid does not destroy the natural oxide layer but remains limited to its pores, the relation between initial current and time of passivation being given by the expression: $(i - i_0)t = \text{constant}$. The difference in the behaviour of protected and of freely suspended electrodes are of a qualitative nature only; in the first case passivity is obtained sooner or later even with a very small current density, and in the second case the time of passivation is greater and there is a minimum current density below which passivation does not occur at all owing to the dissolved metal being removed by convection. This is in agreement with the fact that the limiting current is greater the more vigorous the stirring. The nature of the oxide layer produced by exposure of gold to the air appears to be different from that of the secondary layer produced by electrolysis since the former is more stable and is removed only by concentrated hydrochloric acid, whereas the latter disappears rapidly even in dilute acids when the current is switched off. In 5*N*-hydrochloric acid the secondary oxide layer which causes passivation dissolves to a certain extent even while the current is on, and its alternate formation and dissolution leads to long period oscillations in the current density; in *N*- and in 0.05*N*-acid no dissolution of the passive layer occurs during passage of the current and the time of passivation of a re-activated electrode is shorter than in more concentrated acid.—A. R. P.

***A Revision of the Atomic Weight of Indium.** Gregory P. Baxter and Chester M. Alter (*J. Amer. Chem. Soc.*, 1933, **55**, 1943-1946).—The value obtained was 114.76.—L. A. O.

†Lead and Its Alloys. Arthur Burkhardt (*Metallwirtschaft*, 1935, **14**, 445-449, 525-531, 581-587, 625-630).—A complete and detailed summary of the literature on the physical, chemical, and mechanical properties of lead and its alloys and on their various uses is given, with special reference to bearing metals, cable-sheathing, type metal, accumulator plates, and solders. The endurance strength under rotational bending is: lead, 0.2; 0.5% antimonial lead, 0.64; 1% antimonial lead, 0.90; and 0.05% tellurium lead, 0.6 kg./mm.². The influence of mercury, tellurium, cadmium, lithium, sodium, bismuth, silver, antimony, tin, copper, and calcium on the strength, elongation, and resistance to vibration of lead is discussed, and the influence of small quantities of impurities on the dressing of lead is reviewed. Antimony up to 0.1% increases, whereas more than 0.5% has no effect on, dress formation.—v. G.

***On the Internal Friction of Molten Metals and Alloys. VI.—The Internal Friction of Lead, Cadmium, Zinc, Silver, Tin, Potassium, and Sodium and the Problem of the Structure Viscosity of Amalgams.** K. Gering and F. Sauerwald (*Z. anorg. Chem.*, 1935, **223**, 204-208).—Values obtained for the viscosity of the above metals at temperatures between their melting points and 200°-300° C. higher are tabulated, and the pressure viscosimeter used in the work is described. The dependence of the viscosity of amalgams on the pressure, when this is low, is ascribed to the presence of small crystals of the metal or of a solid amalgam of the metal in the mercury. Pure mercury itself exhibits this phenomenon at very low pressures, but this is probably due to the effect of surface tension.—A. R. P.

***The Atomic Weight of Lead from Katanga Pitchblende.** Gregory P. Baxter and Chester M. Alter (*J. Amer. Chem. Soc.*, 1933, **55**, 2785-2792).—Experimental results yielded the following values for different varieties of lead: common, 207.21; Bedford cyrtolite, 205.94; Katanga pitchblende, 206.00; Katanga pitchblende extract, 205.97.—L. A. O.

The Standard Electrode Potential of Lithium in Methyl Alcohol. Angus MacFarlane and (Sir) Harold Hartley (*Phil. Mag.*, 1935, [vii], 20, 611–616).—The standard electrode potential of lithium in methyl alcohol is found to be -3.095 v.—J. S. G. T.

Purification of Magnesium by Sublimation. J. Hérenghuel and G. Chaudron (*14me. Congrès chim. ind., Paris, 1934*, 5 pp.; *C. Abs.*, 1935, 29, 6188).—Cf. *Met. Abs.*, 1934, 1, 478, and this vol., p. 202. The sublimation method yields a very pure magnesium (99.99%). Remelting under argon can yield pure alloys without the use of a chemical fluxing agent. The results obtained by filtration show that the fluxes used in the refining of magnesium have a purely physical action consisting in the removal of inclusions suspended in the molten metal. The same technique is applicable to calcium, but the purification of the commercial metal must be carried out in two stages. The metal is first heated to about 800° C. under a pressure of a few cm. of argon to remove sodium, excessive loss of calcium being avoided by carrying out distillation with two or three trays; this is followed by sublimation at 800° C. under a pressure of 0.05–0.02 mm.—S. G.

***On the Scaling of Iron and Other Metals [Manganese].** Kurt Fischbeck and Franz Salzer (*Metallwirtschaft*, 1935, 14, 733–739, 753–758).—The rate of oxidation of manganese changes suddenly at the $\alpha \rightarrow \beta$ transformation temperature.—v. G.

***The Dependence of the Resistance of Nickel at the Curie Point on the Temperature.** Boerje Svenson (*Ann. Physik*, 1935, [v], 22, 97–100).—v. G.

***On the Adsorption of Dyes by Nickel Wires in the Transition of the Nickel Wires from the Hard to the Soft State.** G. Tammann (*Z. anorg. Chem.*, 1935, 223, 222–224).—When hard-drawn nickel wires are heated, a rapid decrease in their absorptive power for dyes occurs in the range 500° – 600° C., in which the metal recovers its original physical and magnetic properties and the first signs of recrystallization are visible.—A. R. P.

***Optical X-Ray Investigations on Thin Films of Nickel.** Rudolf Riedmiller (*Ann. Physik*, 1934, [v], 20, 377–403).—The density, electrical conductivity, and index of refraction for X-rays of nickel films, 400–1750 Å. thick, prepared by vacuum sublimation, were determined.—v. G.

***On Palladium-Hydrogen.** William Krause and Louis Kahlenberg (*Electrochem. Soc. Preprint*, 1935, Oct., 35–55).—The isothermal absorption of hydrogen by palladium was studied from 0° to 138° C. The curves show the same general characteristics as the isotherms determined by previous investigations, i.e. a preliminary rise, a central horizontal portion followed by an almost vertical rise on saturation of the palladium with hydrogen. The curves do not show definite evidence of formation of a compound between palladium and hydrogen. The rates of absorption were studied for the same temperature range as the isotherms. The amount of hydrogen taken up by palladium decreases with increased temperature and the decrease is a linear function of the temperature from 0° to 82° C., while above 82° C. the amount of hydrogen taken up diminishes rapidly. The shrinkage of the palladium foil affected the rate of absorption below 56° C., but had no effect at higher temperatures. The change in dimensions of palladium foil with continued hydrogenation was studied extensively. There was increase in chemical activity with deformation of the palladium until, after 90 hydrogenations, the hydrogen in palladium-hydrogen united with oxygen with explosive violence. There was no temperature increase when the metal was put in a vacuum or in an atmosphere of nitrogen. When the metal was put in air or oxygen water was formed on the sides of the tube.—S. G.

On the Theory of Passivity Phenomena. XXVII.—On the Time Phenomena in the Anodic Polarization of Smooth Platinum in 2N-Sulphuric Acid. Wolf Johannes Müller and O. Hering (*Monatsh.*, 1935, 66, 35–56).—The current-

time and potential-time curves are similar for potentials of 1.8-3.5 v., but the ratio between the initial current and the final current after 20 minutes is a function of the applied potential although the amount of current passing in the period of initial rapid increase of current is practically constant. The main process occurring in the anodic polarization of platinum with potentials up to 2 v. is the dissolution of the metal from the pores, but with higher potentials it is the evolution of oxygen.—A. R. P.

***A Revision of the Atomic Weight of Potassium.** Gregory Paul Baxter and William Marshall MacNevin (*J. Amer. Chem. Soc.*, 1933, **55**, 3185-3190).—Using silver as standard of comparison, a value of 39.096 was found, confirming the results of Richards and Staehler and of Richards and Mueller.—L. A. O.

***The Atomic Weight of Less Volatile Potassium Prepared by Hevesy.** Gregory Paul Baxter and Chester M. Alter (*J. Amer. Chem. Soc.*, 1933, **55**, 3270-3271).—The atomic weights of common potassium and heavy potassium concentrated by ideal distillation by Hevesy and Lögstrup were found to be 39.096 and 39.109, respectively.—L. A. O.

***The Solution of Silver in Alkaline Cyanide Solutions.** A. Simon and H. Deckert (*Z. Elektrochem.*, 1935, **41**, 737-738).—The solubility of silver in 1% cyanide solutions was determined and compared with that of gold. The addition of hydrogen peroxide at first accelerates and then strongly reduces the solubility. Iron, copper, and manganese solutions reduce the rate of solution.—J. H. W.

***Reflection of Light by Silver Mirrors, and the Transformation from the Amorphous to the Crystalline State at Low Temperatures.** R. Suhrmann and G. Barth (*Z. tech. Physik*, 1934, **15**, 547-549).—See *Met. Abs.*, this vol., p. 140.
—J. S. G. T.

***Revision of the Atomic Weight of Tantalum. Analysis of Tantalum Pentabromide.** O. Hönigschmid and R. Schlee (*Z. anorg. Chem.*, 1934, **221**, 129-141).—The value obtained with carefully purified materials was 180.88.

—A. R. P.

***Revision of the Atomic Weight of Tellurium. III.—Analysis of Tellurium Tetrachloride.** O. Hönigschmid and H. Baudrexler (*Z. anorg. Chem.*, 1935, **223**, 91-100).—The value obtained was 127.63.—A. R. P.

***A Revision of the Atomic Weight of Thallium. The Analysis of Thallous Chloride.** Gregory Paul Baxter and Joseph Smith Thomas (*J. Amer. Chem. Soc.*, 1933, **55**, 2384-2387).—The value obtained, 204.40, confirms very closely the work of Hönigschmid, Birkenbach and Kothe, and Hönigschmid and Striebel, as well as that of Aston.—L. A. O.

***Magnetic Behaviour of Supraconducting Tin Spheres.** K. Mendelssohn and J. D. Babbitt (*Proc. Roy. Soc.*, 1935, [A], **151**, 316-333).—The magnetic field in the neighbourhood of a supraconducting tin sphere was investigated. The induction in the spheres is zero only when the sphere is cooled in zero magnetic field and the threshold value is not surpassed in any part of the sphere. In all cases where supraconductivity sets in while an external magnetic field is established, part of the magnetic flux remains in the specimen and the total induction never becomes zero. This "freezing-in" of part of the flux gives rise to a magnetic hysteresis phenomenon which may be related to the hysteresis observed in conductivity. The proportion of "frozen-in" flux is greater in a hollow than in a solid sphere.—J. S. G. T.

***On the Question of the Allotropy of White Tin, and the Equilibrium Diagram of the System Cadmium-Tin.** Yosiharu Matuyama (*Rikwagaku-Kenkyū-jo Iho* (*Bull. Inst. Phys. Chem. Res.*), 1931, **10**, 639-660).—[In Japanese.] See *Met. Abs.* (*J. Inst. Metals*), 1932, **50**, 213.—S. G.

The Contact Potential Difference Between Clean and Oxygenated Tungsten. A. L. Reimann (*Phil. Mag.*, 1935, [vii], **20**, 594-607).—The contact p.d. at room temperature between slightly electronegatively-contaminated tungsten

and tungsten having an oxygen coating which is apparently most effective in increasing the work-function of the metal is found to be 1.70 v. The contact p.d. at 1500° K. between perfectly clean tungsten and slightly less oxygen-coated tungsten, calculated from thermionic data, is found to be 1.75 v. Of the various degrees of oxygen coating that are stable in a vacuum, the most effective in increasing the work-function is the most complete coating.—J. T.

***The Photoelectric Threshold of Uranium, Calcium, and Thorium Treated with Limited Amounts of Oxygen.** H. C. Rentschler and D. E. Henry (*Phys. Rev.*, 1935, [ii], 47, 807).—Abstract of a paper read before the American Physical Society. At a meeting of the Optical Society (Feb. 23, 1935), R. and H. reported a shift in the photoelectric threshold toward the longer wave-length when a surface of pure thorium is allowed to react with a small amount of oxygen. Uranium and calcium are found to possess this same property. The photoelectric work-functions for these oxygen-treated surfaces agree remarkably well with the thermionic work-functions obtained by Dushman (*J. Inst. Metals*, 1923, 30, 542) for activated tungsten filaments containing oxides of these same metals. The amount of oxygen required for best results depends on the area and thickness of the active coating. The threshold shift is definitely obtained before the interaction with the oxygen is complete. Excessive amounts of oxygen again completely destroy the photoelectric activity in all cases.—S. G.

***The Preparation of Thin Wires by Freezing Streams of Molten Metal.** G. Tamman and G. Moritz (*Z. Metallkunde*, 1935, 27, 114–115; and (translation) *Light Metals Research*, 1935, 4, 4–6).—Thin wires of tin, bismuth, cadmium, lead, zinc, and aluminium may be prepared by forcing the liquid metal at 20°–40° C. above the melting point through fine glass jets under a pressure of 3–5 atmospheres (compressed air). If the temperature is too near the melting point or the pressure is too low the wires, which, under the best conditions, consist of a series of long single crystals, are interrupted by small beads consisting of aggregates of 10–50 crystallites.—A. R. P.

Strengthening of Metals by Cold-Stretching. W. Fuller (*Umschau*, 1934, 38, 528–530).—The mechanism of the hardening of metals by cold-work is briefly discussed with reference to recent investigations on lattice distortion, slip, and crystal recovery.—A. R. P.

***Mechanical Properties of Metals at Low Temperatures [—I, —II].** A. P. Tulyakov (*Khim. Mashinostroenie*, 1935, (1), 4–9, (2), 9–18; *C. Abs.*, 1935, 29, 6187).—[In Russian.] (I.—) A review of the literature. (II.—) Experimental. Two samples of carbon steel, and samples of chromium–nickel and stainless steel, of copper, brass, aluminium, bronze, and Duralumin were cooled to +15°, –40°, –80°, and –180° C., and tested at these temperatures for mechanical properties such as strength, elasticity, malleability, plasticity, and pliability. The results are in good agreement with those found in the literature.—S. G.

***On the Power of Readily Fusible Metals to Wet Metals with a High Melting Point.** G. Tamman and Ad. Rührenbeck (*Z. anorg. Chem.*, 1935, 223, 192–196).—Iron is not wetted by molten tin, lead, and bismuth in a hydrogen atmosphere at 400° C., but wetting starts at 600° C. in about 30 minutes; liquid bismuth does not wet β -iron between 800° and 900° C., and silver wets γ -iron at 1000° C. only with difficulty. Tin and lead do not wet ferromagnetic nickel, but wetting commences at the transformation temperature (340°–358° C.); bismuth, however, wets nickel at 310° C. and at higher temperatures rapidly penetrates it with the formation of brittle compounds. Polished plates of tungsten, molybdenum, and tantalum are wetted by tin at 941°, 651°, and 761° C., respectively. Bismuth and lead begin to wet copper at about 400° C., whereas tin wets it at 250° C. in about 3 hrs.—A. R. P.

***A Study of Certain Finely-Divided Metals and a Method for Their Preparation.** E. G. Insley (*J. Physical Chem.*, 1935, **39**, 623).—The adsorption of hydrogen, ethylene, and ethane on metallic catalysts, *viz.* copper, nickel, iron, and cobalt, prepared from the oxides and amalgams was investigated. The rate of hydrogenation of ethylene was similarly studied. The catalytic activities of the metals prepared from amalgams are comparable with those of the metals prepared from the oxides. Only a very small part of the total adsorption of hydrogen on nickel is attributable to "physical adsorption."—J. S. G. T.

***On the Vapour Pressure of High Boiling Metals. I.—Determinations by the Boiling Method [Lead, Silver].** Joseph Fischer (*Z. anorg. Chem.*, 1934, **219**, 1-16).—The boiling point of lead is $1750^{\circ} \pm 10^{\circ}$ C., and that of silver $2150^{\circ} \pm 20^{\circ}$ C. The experimental value of the vapour pressure of lead is in close agreement with the theoretical, and the value of the Trouton constant is normal.
—A. R. P.

***On the Vapour Pressure of High Boiling Metals. II.—Determinations by Ruff's Spring Balance Method [Zinc, Cadmium, Silver].** Joseph Fischer (*Z. anorg. Chem.*, 1934, **219**, 367-375).—Ruff's method has been modified and the vapour pressures of zinc, cadmium, and silver determined by the new technique.
—A. R. P.

***New Researches on the Chlorination and Chloridizing Volatilization of Metals and Alloys.** Heinz Borchers (*Metallwirtschaft*, 1935, **14**, 713-719).—The formation and volatilization of chlorides when the molten metal or alloy is treated with chlorine is investigated in the following cases: cobalt, iron, gold, silver, mercury, copper, and copper-silver and silver-gold alloys.—v. G.

Optical Properties of Solids. A. H. Wilson (*Proc. Roy. Soc.*, 1935, [A], **151**, 274-295).—The present position of the theory of the optical constants of metals is briefly reviewed. There appears to be no really consistent theory; the theory so far as it relates to the visible and ultra-violet regions of the spectrum is critically discussed. The Kramers-Heisenberg dispersion formula is derived, and the dispersion formula for metals, with special reference to silver, is discussed.—J. S. G. T.

A Simple Theory of the Anomaly of Electrical Resistance of Ferromagnetic Substances. Tokutaro Hirone (*Rikwagaku-Kenkyū-jo Iho (Bull. Inst. Phys. Chem. Res.)*, 1935, **14**, 1-4).—[In Japanese.] The anomaly of the electrical resistance of a ferromagnetic substance is explained by the fact that the mean free path of the conduction electron is affected by the rotational vibration of the molecular magnet. It is also to be noted that an equation of corresponding state exists between the resistance and the temperature of the ferromagnetic substance. This conjecture has been confirmed by results of measurements on iron, cobalt, and nickel.—S. G.

On the Change in Resistance of Metals in a Magnetic Field. Serban Țițeica (*Ann. Physik*, 1935, [v], **22**, 129-161).—A theoretical discussion.—v. G.

†**Recent Investigations Relating to Superconduction.** W. Meissner (*Z. tech. Physik*, 1934, **15**, 507-514).—See *Met. Abs.*, this vol., p. 144.—J. S. G. T.

***The Thermal Behaviour of Metals at Extremely Low Temperatures.** W. H. Keesom (*Z. tech. Physik*, 1934, **15**, 515-520).—See *Met. Abs.*, this vol., p. 144.
—J. S. G. T.

***Thermodynamics of the Superconducting State.** C. J. Gorter and H. Casimir (*Z. tech. Physik*, 1934, **15**, 539-542).—See *Met. Abs.*, this vol., p. 144.
—J. S. G. T.

***Electron Theory of Superconduction.** R. Schachenmeier (*Z. tech. Physik*, 1934, **15**, 542-545).—See *Met. Abs.*, this vol., p. 144.—J. S. G. T.

Electron- and Lattice-Conduction in the Case of Heat-Flow in Metals. E. Grüneisen and H. Reddemann (*Z. tech. Physik*, 1934, **15**, 535-539; and *Ann. Physik*, 1934, [v], **20**, 843-877).—See *Met. Abs.*, this vol., p. 144.—J. G. S. T.

II.—PROPERTIES OF ALLOYS

(Continued from pp. 461–466.)

†Development and Technical Importance of Duralumin. G. Sachs (*Metallwirtschaft*, 1935, 14, 691–693).—A review.—v. G.

*The Variations in the Mechanical Properties Observed for an Aluminium-Magnesium Alloy as a Function of Its State of Purity. H. Fournier (*Light Metals Research*, 1935, 4, 79–81).—Translated from *Compt. rend.*, 1935, 200, 1398–1400; see *Met. Abs.*, this vol., p. 280.—J. C. C.

*The Influence of Small Quantities of Excess Magnesium or Zinc on the Hardening of Alloys of Aluminium with $MgZn_2$. R. Schmitt (*Z. Metallkunde*, 1935, 27, 121–125; and (abstract) *Light Metals Research*, 1935, 4, 9–10).—The hardness of cast aluminium alloys containing 2.6–14% of $MgZn_2$ after quenching from 475° C. and ageing for various times at different temperatures are shown graphically. The maximum Brinell hardness obtainable by ageing is 106 with the alloy containing 6% of $MgZn_2$, and this maximum increases sharply to 150 with increase in the $MgZn_2$ content to 9%; further additions tend to produce brittleness without materially improving the hardness. Addition of up to 6% of either zinc or magnesium to the $MgZn_2$ -aluminium alloys has little effect on the hardening phenomena.—A. R. P.

*On the System Aluminium-Zinc. E. Schmid and G. Wassermann (*Mitt. Material., Sonderheft* 26, 1935, 115–120).—See *Met. Abs.*, this vol., p. 147.

—B. Bl.

*Structure of Cadmium-Base Antifriction Alloys. L. Losana and C. Gorla (*Chimica e industria (Italy)*, 1935, 17, 159–163; *C. Abs.*, 1935, 29, 5055).—The alloys of cadmium containing high amounts of copper and silver have been studied by means of cooling curves, as well as micrographically, to determine the region giving alloys useful as antifriction alloys. The best results are obtained in the restricted region with silver 0.2–0.3 and copper 1.3–1.8%. Increasing the amount of silver or decreasing that of copper gives no improvement.—S. G.

*The Solubility of Carbon in Iron-Chromium-Silicon Alloys. Otto Lucas and Hanns Wentrup (*Z. anorg. Chem.*, 1934, 220, 329–333).—The solubility of carbon in iron-chromium alloys with 40–80% Cr decreases rapidly as the iron is replaced by silicon; thus at 1550° C. the carbon content is 9.64% in the 60% chromium alloy free from silicon and 3.47% in the alloy with 20% silicon. In alloys with 40% chromium and 40% silicon the carbon content is about 1% at 1700° C. The bearing of these results on the manufacture of carbon-free ferro-chromium is briefly discussed.—A. R. P.

*Decomposition of Cobalt Amalgam. J. H. Hogarth (*J. Proc. Roy. Soc. New South Wales*, 1935, 68, 153; *C. Abs.*, 1935, 29, 5370).—Cobalt amalgam, on exposure to air, forms almost quantitatively a solid suboxide of cobalt, which is insoluble in mercury. The solid reacts with dilute hydrochloric acid and dilute sulphuric acid to form hydrogen and the usual pink cobalt solution, and with hydrogen to form neutral water and grey metallic cobalt. No chlorine was evolved with hydrochloric acid. Decomposition of the amalgam is retarded by dilute sulphuric acid, and inhibited by hydrogen.—S. G.

*The Equilibrium Diagram of the System Copper-Gallium. Friedrich Weibke (*Z. anorg. Chem.*, 1934, 220, 293–311).—This system has been investigated similarly to the copper-indium system and contains the same number of phases (see following abstract). The α -solid solution contains 21.5% gallium at 20° C., 20.8% at 620° C., and 15.7% at 908° C. The β -phase (Cu_3Ga) undergoes a eutectoidal decomposition at 620° C., but can be retained by quenching. The γ -phase is homogeneous at temperatures above 589° (31.3% gallium)–639° C. (38.1% gallium), being converted into δ at lower

temperatures. The δ -phase is cubic ($a = 8.710$ A.) and appears to be Cu_3Ga_4 ; it is homogeneous between 32.8 and 40% gallium. The ε' phase exists in a narrow range round 45% gallium at 465° – 478° C., below which temperature it is converted into ε which is not stable below 249° C. and partly melts again during cooling. The ϕ -phase has a narrow range of composition round 57.5% gallium, and forms a eutectic with gallium at 29° C., 99.5% gallium. The solid solubility of copper in gallium appears to be very small.—A. R. P.

***The Equilibrium Diagram of the System Copper-Indium.** Friedrich Weibke and Hans Eggers (*Z. anorg. Chem.*, 1934, **220**, 273–292).—The system was examined by thermal, micrographic, and X-ray methods using very pure metals and making the alloys by melting the constituents in porcelain tubes in a current of hydrogen. There are 7 intermediate phases, 3 being stable only at high temperatures. The α -solid solution contains 6.5% indium at 20° C., 7.8% at 400° C., 19.2% at 574° C., and 16% at 715° C. At 715° C., in alloys with 16–32.2% indium, a peritectic reaction between liquid and α leads to the formation of β ; this phase has a body-centred cubic structure of the β -brass type and appears to be the compound Cu_4In . The range of pure β is a triangle bounded by lines joining the points: 715° , 28.7%; 679° , 36.0%; and 574° , 31.7% indium; below 574° C. it undergoes a eutectoidal transformation into $\alpha + \delta$, the eutectoidal line extending from 19.2 to 42.3% indium, and at 679° C., 38.5% indium it forms a eutectic with the γ -phase. The range of existence of γ is small being about 3% around 43% indium; the phase appears to be a compound since the liquidus reaches a maximum at 685° C. (42.5% indium), but it cannot be quenched without decomposing into δ or $\alpha + \delta$. The δ -phase contains 42.3–44.5% indium and has a γ -brass structure, being probably Cu_9In_4 . The ε -phase has a narrow range of existence at 45% indium, but decomposes into $\delta + \eta'$ eutectoid at 615° C. The η and η' phases have a transition point at 389° C., and exist over the range 46.7–53.2% indium; they are probably the compound Cu_2In . The ϕ phase contains 55.3–55.9% indium, and is formed by a peritectic reaction between liquid and η at 310° C.; it forms a eutectic with indium at 153° C. and 99.1% indium.—A. R. P.

***Search for New High-Grade Alloys with a Copper or Aluminium Base.** F. A. Borin and J. P. Velichko (*Zvetnye Metally (Non-Ferrous Metals)*, 1935, (2), 103–106; *C. Abs.*, 1935, **29**, 5400).—[In Russian.] A series of pseudo-binary alloys with aluminium or copper as a base and Mg_2Si , Ni_3Si , MgZn_2 , &c., as addition compounds was prepared, heat-treated, and tested for Brinell hardness. Heat-treatment of the aluminium alloys consisted in quenching at 500° – 510° C. in cold water and annealing at 150° – 160° C. for 36 hrs.; in the case of the copper alloys it consisted in heating to 850° C. and annealing at 400° – 450° C. for 3 hrs. In every case the effect of additions to the aluminium or copper was an increase in hardness of the heat-treated samples. Copper alloys containing Ni_3Si , Mn_3P_2 , or Al_3Ti , and aluminium alloys containing MgZn_2 , Cu_3Si , Cu_3Sn , or Cu_2Sb are worth further study.—S. G.

***[Contribution] to the Knowledge of the Iron-Nickel-Copper Alloys.** O. Dahl, J. Pfaffenberger, and N. Schwartz (*Metallwirtschaft*, 1935, **14**, 665–670).—The boundaries of the miscibility gap between the iron- and copper-rich solid solutions at various temperatures were determined by measurements of the hardness and electrical resistance of the alloys after various heat-treatments. Since the limits vary considerably with the temperature a large range of these alloys can be precipitation-hardened and thereby given special magnetic properties. According to the composition and the heat-treatment there are 3 types of alloys, *viz.* alloys of high permeability, alloys of constant permeability (independent of the field strength), and alloys of specially high coercivity. The last-named type have been closely investigated and the properties correlated with the structure.—v. G.

***On Magnetically Hard Iron-Nickel-Copper Alloys.** H. Neumann (*Metallwirtschaft*, 1935, 14, 778-779).—The results of Dahl and others (see preceding abstract) are confirmed and amplified.—v. G.

***Microscopic Detection of the Course of Precipitation in Copper-Silver Alloys.** H. Bumm (*Metallwirtschaft*, 1935, 14, 429-431).—The precipitation of silver on annealing a quenched alloy of copper with 7-10% silver has been followed by planimetric measurement of the surface area which darkens during the process.—v. G.

***Dilatometric Investigations on Cast Copper-Rich Bronzes.** Denzo Uno, Saburo Katori, and Masamichi Fuji (*Bull. Chem. Soc. Japan*, 1935, 10, 397-407).—[In German.] Copper-tin bronzes containing 4-16.5% tin were cast in sand and chill moulds to give a wide range of rates of solidification. All therefore showed segregation to a greater or less extent. The specimens obtained were then annealed at both constant and varying temperatures and the changes taking place were followed by dilatometer measurements and examination of the microstructure.—C. E. H.

***Heat-Treatment and Hardening of Some Special Bronzes.** M. Hansen (*Metallwirtschaft*, 1935, 14, 693-696).—The tensile properties of extruded bronzes containing (a) aluminium 11.5, iron 5.5%, and (b) nickel 13.1, aluminium 2-17, manganese 0.96, iron 0.46% were investigated after various heat-treatments; both alloys can be improved by suitable heat-treatment. The first has a tensile strength of 100 kg./mm.², a yield-point of 56 kg./mm.², and an elongation of 9% after quenching from 650° C., and the second a tensile strength of 85 kg./mm.², a yield-point of 60 kg./mm.², and an elongation of 12% after quenching from 900° C. and re-heating at 550°-600° C.—v. G.

***Effect of Beryllium on Special Bronzes.** A. P. Smiriagin (*Zvetnyye Metally (Non-Ferrous Metals)*, 1935, (1), 92-103; *C. Abs.*, 1935, 29, 5399).—[In Russian.] Various bronzes containing 0.5-1.5% beryllium were prepared and analyzed chemically and micrographically. The physical and mechanical properties were investigated, and the results are tabulated so as to show the possible uses of these bronzes in the machine construction industry.—S. G.

***A Study of Lead-Bronzes with Special Reference to Manganese as an Alloying Element.** J. Wecker and H. Nipper (*Z. Metallkunde*, 1935, 27, 149-156).—Tin and manganese have similar hardening effects on copper, but, whereas in lead-bronzes containing 30% lead segregation commences with 5% tin, more than 7% of manganese is necessary before liquation of the lead occurs. Addition of 2% nickel to the 30% lead-7% manganese-copper alloy produces cleaner melts and better castings, but for large castings it is better to keep the manganese at about 5%. The hardness of the alloys may be slightly increased by addition of a little arsenic, but phosphorus acts only as a deoxidizer and not as a hardener. The advantages of nickel-manganese-lead bearing bronzes over other bearing bronzes and white metals are discussed.—A. R. P.

***Application of X-Ray Analysis to the Study of Season-Cracking in Brasses.** V. I. Iveronova (*Zvetnyye Metally (Non-Ferrous Metals)*, 1935, (1), 107-112; *C. Abs.*, 1935, 29, 5399).—[In Russian.] Two examples were investigated; the compositions of the samples were: (1) copper 62.53, lead 0.036, iron 0.05, arsenic 0.004, antimony 0.004, tin 0.02%, and phosphorus a trace; (2) copper 60, lead 0.1, iron 0.15, phosphorus 0.01, arsenic 0.01, antimony 0.05, bismuth 0.03, and tin 0.15%. Cracking was found to be due to seasonal changes of temperature. To obviate cracking, brass (1) should be tempered at 350° C. for 1 hr., and brass (2) at 400° C. for 40 minutes. Higher tempering temperatures can also be used, and in that case the tempering period can be shortened.—S. G.

***Obtaining High-Grade Aluminium-Bronzes and Brasses.** A. A. Bocharov and N. Laktionova (*Zvetnyye Metally (Non-Ferrous Metals)*, 1935, (1), 104-106; *C. Abs.*, 1935, 29, 5399).—[In Russian.] A study was made of the effect of

additions of aluminium, nickel, and iron on the hardness of copper-zinc alloys. The compositions of the alloys varied between the following limits: copper 55.0-75.0, zinc 20.0-32.0, aluminium 0.5-5.0, nickel 2.0-12.0, iron 0-5.0%. Hardness measurements were carried out on castings, before heat-treatment, after hardening at 900° C. in water, and after annealing for 2 hrs. at 450°-500° C. The maximum hardness was obtained with the following samples, annealed at 450°-500° C. for 2 hrs.: (1) copper 67, zinc 28, aluminium 2, and nickel 3%; (2) copper 69, zinc 25, aluminium 2, and nickel 4%; (3) copper 70, zinc 25, aluminium 2, and nickel 3%; (4) copper 65, zinc 25, aluminium 2, and nickel 8%; (5) copper 68.5, zinc 25, aluminium 2, nickel 4, and iron 0.5%; (6) copper 69.5, zinc 25, aluminium 2, nickel 3, and iron 0.5%. The Brinell hardness of these samples was 212, 227, 212, 227, 212, and 227, respectively.—S. G.

***The Influence of Third Metals on the Constitution of Brass Alloys. VI.—The Influence of Iron. A Contribution to the Knowledge of the Ternary System Copper-Zinc-Iron.** O. Bauer and M. Hansen (*Mitt. Material., Sonderheft 26, 1935, 99-107*).—See *Met. Abs.*, 1934, 1, 490.—B. Bl.

***Materials for Screw Propellers.** Yoshiro Fujii (*Tetsu-to-Hagane (J. Iron Steel Inst. Japan)*, 1935, 21, 305-314; *C. Abs.*, 1935, 29, 5791).—[In Japanese.] Measurements were made on 36 kinds of non-ferrous alloys for freezing points, single potentials and corrosion-fatigue limits in sea-water, and microscopical, mechanical, and corrosion tests were carried out. A new, superior alloy for screw propellers was found, the composition of which is aluminium 2-3, nickel 3-4, silicon 1-2, zinc 22-25%, remainder copper. The corrosion-fatigue limit and corrosion-resistance in sea-water were three times and twice those of ordinary manganese-bronze, respectively.—S. G.

***The System Germanium-Tellurium.** Wilhelm Klemm and Georg Frischmuth (*Z. anorg. Chem.*, 1934, 218, 249-251).—The system contains one compound GeTe which melts incongruently at $725^{\circ} \pm 3^{\circ}$ C., and has a density of 6.20 ± 0.02 at 25° C. The eutectic composition is about 15 atomic-% germanium, 450° C.—A. R. P.

***On Gold-Calcium Alloys.** Fr. Weibke and W. Bartels (*Z. anorg. Chem.*, 1934, 218, 241-248).—The system contains 6 compounds: Au₄Ca (melting point 880° C.), Au₂Ca (melting point 864° C.), Au₉Ca₁₀ (melting point about 1015° C.), Au₃Ca formed by a peritectic reaction at 853° C., Au₅Ca₄ formed by a peritectic reaction at 849° C., and AuCa₂ formed by a peritectic reaction at 798° C. Eutectics occur at 804° C., 13.2 atomic-% calcium; 764° C., 30.3 atomic-% calcium; 807° C., 38.9 atomic-% calcium; and 658° C., 87.5 atomic-% calcium. Au₂Ca undergoes a transformation at 700° C., and Au₉Ca₁₀ one at 844°-886° C. according to whether it contains excess of gold or of calcium in solid solution. Calcium appears to be practically insoluble in solid gold, but at room temperature it dissolves 4-5 atomic-% gold. Another range of solid solutions exists between 49 and 56 atomic-% calcium.—A. R. P.

***Some Effects of Soldering and Other Heat-Treatment on Orthodontic Alloys.** R. L. Coleman (*Internat. J. Orthodontia*, 1933, 19, 1238-1253; *C. Abs.*, 1935, 29, 6559).—The following 4 alloys were investigated (compositions in weight-%): (1) gold 63, silver 12, copper 20, lead 2, zinc 3; (2) gold 62, silver 8.5, copper 11, platinum 11.5, palladium 5.5, zinc 1.5; (3) silver 39.1, copper 16.7, palladium 44.2; (4) gold 55, silver 7, copper 11, platinum 18, palladium 7.5, zinc 1.5. The hardening produced by heating alloys (1) and (2) to various temperatures (300°-1300° F.) is shown in a diagram; two other diagrams show the effect of heating to relatively high temperatures on the tensile strength and ductility of alloys (3) and (4). For alloy (1) the maximum hardness was obtained at 600° F., for alloy (2) at 800° F. Different alloys, therefore, should be heated to different temperatures, a fact of importance when two or more alloys are used in one construction. The structure of the different alloys after mechanical and heat-treatment is illustrated by photomicrographs.

From a consideration of the micrography of different alloys from practice, it is shown how the relation between structure, mechanical properties, and previous heat-treatment can be used for the recognition of sources of error in cases of unknown or uncontrolled heat-treatment. Photomicrographs are given of soldered joints which were made with a point soldering apparatus. This apparatus has the advantage of local heating only on the spot to be soldered, leaving the rest of the wire cold.—S. G.

†**Lead and Its Alloys.** (Burkhardt.) See p. 498.

***Tensile Tests on Antimonial-Lead Tubes.** H. Sieglerschmidt and G. Fiek (*Mitt. Material., Sonderheft 26*, 1935, 157-159).—See *Met. Abs.*, this vol., p. 215.—B. Bl.

***The Arsenic-Lead Alloys.** O. Bauer and W. Tonn (*Z. Metallkunde*, 1935, 27, 183-187).—At ordinary pressure alloys containing only up to 35% arsenic can be prepared by melting the constituents together. The system contains no compound and only a very limited range of solid solutions at the lead end. The eutectic contains 2.6% arsenic and melts at 290° C. The solid solubility of arsenic in lead is 0.05% at the eutectic temperature and about 0.01% at room temperature. The primary crystallites in hypereutectic alloys consist of pure arsenic, and hence lead appears to be insoluble in arsenic. Hypoeutectic alloys show little tendency to segregate, but arsenic in excess of the eutectic amount tends to rise to the surface during solidification of the alloy. Quenched alloys containing more than 0.05% arsenic are harder than pure lead, but the hardness decreases on storage at room temperature owing to the separation of arsenic from the supersaturated solid solution. Addition of arsenic to lead has no effect on its resistance to corrosion in water.—A. R. P.

***Some Physical and Metallurgical Properties of Lead-Calcium Alloys for Storage Cell Grids and Plates.** Earle E. Schumacher and G. S. Phipps (*Electrochem. Soc. Preprint*, 1935, Oct., 165-162).—The most important mechanical property of an alloy for storage-cell grids is probably the tensile strength; by addition of calcium to lead the strength of alloys which have been aged at 20° C. for 1 week and then heat-treated at 100° C. for 18 hrs. is increased almost linearly to a maximum of about 8000 lb./in.² with 0.1% calcium (the limit of solid solubility at the peritectic temperature). This value is approximately the same as that of ordinary cast antimonial lead, but whereas these alloys consist of dendrites of lead-rich solid solution interspersed with eutectic, the calcium-lead alloys have a structure resembling that of a pure metal, the Pb₃Ca being in a highly dispersed, sub-microscopic condition; the calcium alloys are, therefore, superior in corrosion-resistance. A further advantage of the calcium alloys is their ability to be cold-rolled; the 0.04% calcium alloy is the best in this respect, a strength of 6600 lb./in.² being attainable with a 95% reduction after the above-described heat-treatment. The tensile strength of hardened calcium-lead remains constant or slightly increases with prolonged storage probably owing to the slow rate of diffusion of the large Pb₃Ca molecule; their electrical conductivity is about 20% greater than that of 9% antimonial lead.—A. R. P.

Lead-Base Bearing Metals. W. Kroll. R. T. Rolfe (*Met. Ind. (Lond.)*, 1935, 47, 371).—Letters to the Editor. K. puts forward claims for barium-free lead alloys, said to have been ignored by R. (*Met. Abs.*, this vol., p. 464). R. justifies his criticism of alkaline earth metal-hardened lead alloys.—J. H. W.

***Replacing the Tin in Cable-Sheath Alloys by Tellurium.** E. Kröner (*Elekt. Nach.-Tech.*, 1935, 12, 113-119; *C. Abs.*, 1935, 29, 5795).—Pure lead and lead alloys with 1% and 3% tin were compared with a lead alloy containing 0.05% tellurium. For the same tensile strength the tellurium alloy has a higher % elongation and is much more resistant to recrystallization. It is fine-grained and very resistant to vibrations. The extrusion pressure for the tellurium

alloy is about the same as that for the 3% tin alloy; therefore thinner sheaths can be extruded.—S. G.

***Specific Heat of a Supraconducting Alloy [PbTl₂].** K. Mendelssohn and J. R. Moore (*Proc. Roy. Soc.*, 1935, [A], **151**, 334–341).—The specific heats of the lead–thallium alloy, PbTl₂, have been determined over the temperature range 3°–6° abs. A discontinuity in the value of the specific heat, to be anticipated in accordance with Rutgers' formula at about 4° abs., was not found. Conclusions as to the constitution of a supraconducting alloy are reached from the results.—J. S. G. T.

***The Alloys of Lithium with Mercury and Indium.** G. Grube and W. Wolf (*Z. Elektrochem.*, 1935, **41**, 675–681).—The complete lithium–mercury equilibrium diagram was determined by thermal analysis. The compounds Li₆Hg, Li₃Hg, Li₂Hg, LiHg, LiHg₂, and LiHg₃ were detected, and of these, only Li₃Hg (melting point 375° C.) and LiHg (melting point 590° C.) can be melted unaltered. The remaining compounds are formed by peritectic reactions and their upper temperature limits are: Li₆Hg 164° C., Li₂Hg 375° C., LiHg₂ 340° C., and LiHg₃ 235° C. In the lithium–indium system, only the compound LiIn, remaining unaltered at its melting point, 625° C., exists. This compound forms an unbroken range of solid solutions with lithium, but only a limited range with indium.—J. H. W.

***Creep Tests on Supersaturated Magnesium Solid Solutions [Elektron].** W. Schmidt and H. Vosskühler (*Z. Metallkunde*, 1935, **27**, 179–181).—The creep of Elektron (containing aluminium 8, zinc 0.5, and manganese 0.2%) after various heat and mechanical treatments was determined at 140° C. Creep of the cast alloy and that of the homogeneous solid solution is relatively small, whereas the creep of the decomposed solid solution alloy and of the forged and recrystallized alloy is relatively high.—A. R. P.

***Equilibrium Diagram of the Magnesium-Rich Magnesium–Aluminium–Silicon Ternary System.** Hachie Sawamoto (*Suiyokwai-Shi (Trans. Min. Met. Alumni Assoc.)*, 1935, **8**, 713–727; *C. Abs.*, 1935, **29**, 5003).—[In Japanese.] The equilibrium diagram of the system magnesium–aluminium–silicon was determined by thermal and microscopic methods. The ternary eutectic temperature coincided with a eutectic temperature of the magnesium–aluminium binary system at 437° C., composition aluminium 32.7 and magnesium 67.3%.—S. G.

***Ultra-Light Magnesium Alloys. The Ternary System Mg–Ca–Zn.** P. Mondain-Monval and René Paris (*14me. Congrès chim. ind., Paris*, 1934, 5 pp.; *C. Abs.*, 1935, **29**, 6553).—See also *Met. Abs.*, this vol., p. 215. The system was studied from the point of view of the preparation of ultra-light alloys (magnesium *d* 1.74, calcium *d* 1.6) for aeronautical equipment in which mechanical properties are not of primary importance. The alloys were obtained in hermetically-sealed iron crucibles in an atmosphere of their own vapours. The diagrams of the liquidus and the distribution of the solid phases were established from the thermal analysis and micrography of 215 alloys, which were well distributed throughout the various zones of magnesium–zinc–calcium concentrations. A special study was made of the mechanical properties of the very rich magnesium alloys, which, though not exceptionally interesting, are probably suitable for certain applications.—S. G.

***Contribution to the Knowledge of the Transformations in Irreversible Iron–Manganese Alloys.** Erich Scheil (*Arch. Eisenhüttenwesen*, 1935–1936, **9**, 115–116).—Iron–manganese alloys containing more than 7% manganese undergo a transformation on heating to about 250° C., which is shown to be due to the conversion of the ϵ -constituent into the γ . The reverse change occurs on cooling at about 80° C. in the alloy with 20% manganese.—A. R. P.

***Thermal Analysis of the System Rubidium–Mercury. A Review of the Mercurides of the Alkali Metals.** Wilhelm Biltz, Friedrich Weibke, and Hans

Eggers (*Z. anorg. Chem.*, 1934, **219**, 119–128).—The rubidium–mercury system contains the following compounds (melting points in parentheses): Rb_3Hg_4 (170° C.), RbHg_2 (256° C.), Rb_2Hg_7 (197° C.), $\text{Rb}_5\text{Hg}_{18}$ (194° C.), Rb_2Hg_9 (162° C.), RbHg_6 (132° C.), RbHg_9 (67° C.), and Rb_7Hg_8 (formed by a peritectic reaction at 157° C.). Eutectics are formed at 3·8 atomic-% mercury, 25° C. (rubidium– Rb_7Hg_8); 74·6 atomic-% mercury, 186·5° C. (RbHg_2 – Rb_2Hg_9); and at 99·3 atomic-% mercury, –46° C. (RbHg_9 –mercury). Comparison of these results with those for binary systems of mercury with the other alkali metals shows that the affinity for mercury increases as the atomic weight of the alkali metal increases, and the nature of the compounds formed becomes more complex.—A. R. P.

*On the Internal Friction of Molten Metals and Alloys. VI.—The Internal Friction of Lead, Cadmium, Zinc, Silver, Tin, Potassium, and Sodium, and the Problem of the Structure Viscosity of Amalgams. (Gering and Sauerwald.) See p. 498.

Electrical Resistance Alloys; Why Nickel–Chromium so Successfully Serves as Heating Element Material. Fred P. Peters (*Electrochem. Soc. Preprint*, 1935, Oct., 351–362).—To be suitable for resistance heating elements, a metal or alloy must have a conveniently high resistivity, a low temperature coeff. of resistivity which is approximately constant from room to operating temperatures, a high resistance to oxidation and scaling up to 1150° C., a high melting point and narrow melting range, sufficient strength at high temperatures combined with absence of grain growth and of permanent increase in length, and a reasonable cost. The properties of 10 commercial alloys from the point of view of these criteria are tabulated and briefly discussed, and it is shown that the 80 : 20 nickel–chromium alloy is the only one which fulfils all the conditions satisfactorily.—A. R. P.

Nickel–Chromium Heat-Resisting Alloys. A. M. C. Murphy (*Met. Ind. (Lond.)*, 1935, **47**, 387–390, 402).—The structure, physical properties, production, technique, forging practice, wire-drawing, and heat-treatment of these heat-resisting alloys, with and without iron, are described.—J. H. W.

*On the Properties of the Ferromagnetic Alloys of the Ternary System Iron–Nickel–Vanadium. Heinrich Kühlewein (*Z. anorg. Chem.*, 1934, **218**, 65–88).—The ternary system was investigated up to 40% vanadium at the iron corner and 20% vanadium at the nickel corner by X-ray, electrical, and magnetic methods. Addition of vanadium to the α -alloys of the iron–nickel system results in transition to a body-centred cubic phase of greater parameter at 15–20% vanadium, and above 20% vanadium to a new phase of, as yet, undetermined structure. With increasing nickel content the structure gradually reverts to the face-centred cubic nickel lattice, but there is a more or less broad range of duplex ($\alpha + \gamma$) structure. In the γ -range the magnetic transformation point is lowered by about 40° C. for every 1% addition of vanadium. Numerous curves are given showing the variation of the different magnetic properties with the composition.—A. R. P.

*On the Lower Sulphides of Palladium. The Equilibrium Diagram of the System Palladium–Palladium Sulphide. Friedrich Weibke and Joachim Laar [in part with Karl Meisel] (*Z. anorg. Chem.*, 1935, **224**, 49–61).—The system was examined by thermal, micrographic, and X-ray methods. Addition of PdS to palladium rapidly reduces the liquidus temperature to 761° C., at which point a peritectic reaction occurs with the formation of Pd_4S (7% sulphur). PdS melts at 970° C. and forms an unstable β -phase with Pd_4S at about 72 at.-% palladium; this phase undergoes a eutectoidal transformation at 554° C. PdS is insoluble in solid palladium, and alloys with less than 69·5 at.-% palladium separate into two layers on solidification.—A. R. P.

*On the Alloys of Platinum with Chromium. V. A. Nemilov (*Z. anorg. Chem.*, 1934, **218**, 33–44).—See *Met. Abs.*, 1934, **1**, 571.—A. R. P.

*Contributions to the Systematic Science of Affinity. LXIV.—On the Combining Power of Platinum and Phosphorus. Wilhelm Biltz, Friedrich Weibke, and Ernst May (*Z. anorg. Chem.*, 1935, 223, 129-143).—Platinum and phosphorus form two compounds—PtP₂ which has a lustre like chromium, is hard and brittle and decomposes above 683° C., and Pt₂₀P₇ which is somewhat malleable and has a colour resembling that of nickel. On heating above 588° C. Pt₂₀P₇ gradually loses phosphorus and is converted into the eutectic which melts at 588° C. and contains 3.8% phosphorus. The formation of this eutectic when platinum vessels are heated with phosphatic materials in the presence of reducing agents accounts for the breakdown of the vessel.—A. R. P.

The Effect of Rhodium in Strengthening Platinum Gauze. I. E. Adadurov (*Ukrainskii Khimichnii Zhurnal (J. Chim. Ukraine)*, 1935, 10, 106-117; *C. Abs.*, 1935, 29, 6372).—[In Russian.] Addition of 5% rhodium to platinum used in the preparation of gauze for the ammonia oxidation process increases considerably the resistance of the gauze to corrosion, owing to the fact that the alloy absorbs less hydrogen than pure platinum.—S. G.

*Contributions to the Systematic Study of Affinity. LXIII.—The System Rhenium-Phosphorus. Haakon Haraldsen (*Z. anorg. Chem.*, 1935, 221, 397-417).—Rhenium reacts with phosphorus above 750°-800° C. to form the compounds ReP₃, ReP₂, ReP, and Re₂P.—A. R. P.

*New Researches on the Chlorination and Chloridizing Volatilization of Metals and Alloys [Copper-Silver, Silver-Gold]. (Borchers.) See p. 502.

*The Penetration of Molten White Metals into Stressed Steels. W. E. Goodrich (*Iron Steel Inst. Advance Copy*, 1935, Sept., 1-22).—A number of carbon alloy steels have been tested for yield load, maximum load, maximum deflection, and time to fracture at 250° and 350° C., with and without solder and bearing metal. Premature fracture only occurred when specimens were stressed in tension in the presence of molten white metal, and resistance to penetration decreased with rise in temperature and slower rates of loading. The tensile properties in the presence of molten white metal afforded no reliable indication of the resistance of the steels to interpenetration. The addition of nickel up to 1.2% to carbon steels was deleterious, and that of molybdenum to nickel-chromium steels appeared to confer no advantage. The microstructure of the material constituted the main factor influencing the resistance to interpenetration. The effect of grain-size was very marked, small grain being beneficial. Temper-brittleness appeared to have no effect on the resistance to interpenetration.—J. H. W.

*Impact Abrasion Hardness of Moulded Boron Carbide and of Cemented Tungsten and Tantalum Carbide. Lowell H. Milligan and Raymond R. Ridgway (*Electrochem. Soc. Preprint*, 1935, Oct., 453-458).—Abrasive blast tests on different grades of some cemented tungsten and tantalum carbide alloy materials gave widely varying relative abrasion hardness values covering a range of more than 8-fold. The hardest product of this kind studied had a hole depth of 20×10^{-4} in. (0.051 mm.) after the test, corresponding to an "impact abrasion" number of 1500.—S. G.

†New Methods for Investigating the Constitution [of Alloy Systems]. G. Grube (*Z. Metallkunde*, 1935, 27, 194-195).—Magnetic methods are described briefly with especial reference to methods and apparatus for determining the magnetic susceptibility at high temperatures.—A. R. P.

*Phase Equilibria of the Third Order. E. Justi and M. v. Laue (*Z. tech. Physik*, 1934, 15, 521-528).—See *Met. Abs.*, this vol., p. 155.—J. S. G. T.

Discussion on the Paper by G. Borelius: "On the Theory of Transformations of Metallic Solid Solutions." U. Dehlinger. G. Borelius (*Ann. Physik*, 1934, [v], 20, 646-649, 650-652).—See *Met. Abs.*, this vol., p. 422.

—v. G.

III.—STRUCTURE

(Metallography; Macrography; Crystal Structure.)

(Continued from pp. 467-470.)

Recent Progress in Metallography. G. Guzzoni (*Industria meccanica*, 1935, 17, 387-395; *C. Abs.*, 1935, 29, 5392).—The use of X-rays and γ -rays, the electron microscope, and photography with mesothorium and in polarized light are described, their principles explained, and their application described with examples.—S. G.

***Diffusion Research as a Means for the Simple Micrographic Detection of Compound Formation Between Alloy Constituents in Ternary and Polynary Systems.** M. Bosshard (*Aluminium*, 1935, 17, 477-481).—The method consists in making a conical drilling in one alloy, e.g. a 5-10% iron-aluminium alloy, and inserting therein a closely fitting cone of the other alloy, e.g. a 10-20% silicon-aluminium alloy; the combination is then heated for several days at a temperature just below the solidus, after which it is sectioned through the drilling and examined micrographically. If combination has taken place between the two alloying constituents this is readily seen by changes in the structure or etching properties (or both) of the phases. In this way the formation of a ternary compound, probably $Al_6Fe_2Si_3$ in the above case, has been confirmed. When manganese- or chromium-aluminium alloys are used instead of the iron alloy the formation of MnSi and CrSi can be detected. The method has also confirmed the existence of the ternary compounds, Al_2Cu_2Fe , Al_3NiCu_2 , and Al_6Mg_4Cu .—A. R. P.

***A Contribution to the Study of the Crystallization of Binary Eutectic Systems.** E. Raub (*Z. Metallkunde*, 1935, 27, 77-83).—When binary alloys containing a eutectic solidify, a grain structure is produced similar to that of a pure metal; this structure can be developed usually only with great difficulty. The nature and size of the individual crystal grains is determined chiefly by the composition of the alloy, the preponderating constituent being the determining factor; but other factors which modify the type and size of crystals of pure metals also have similar effects in the case of eutectic alloys. From investigations on copper-silver alloys it is concluded that the crystal structure of the alloys has little influence on the mechanical properties, but has a great effect on the working properties when the mechanical properties of the two constituents are approximately equal; the distribution of the phases plays only an unimportant part in determining the workability of these alloys. After cold-working the crystal grains behave similarly to those of pure metals and solid solution alloys; on annealing the new alloy grains formed by recrystallization start from the new grains of the preponderating constituent. Recrystallization leads to a characteristic anisotropy in rolled sheets which is attributed to the setting up of an ordered recrystallization position of the constituent which produces the recrystallization.—A. R. P.

***On the Mechanism of Eutectic Crystallization.** A. A. Botchvar (*Z. anorg. Chem.*, 1934, 220, 334-336).—The subject was studied by the aid of two organic compounds of different colours (see *Met. Abs.*, this vol., p. 470).—A. R. P.

Recrystallization and Crystal-Growth in Aluminium. A. von Zeerleder (*Schweiz. Arch. angew. Wiss. Tech.*, 1935, 1, 148-151; *Aluminium*, 1935, 17, 513).—The primary crystallization, recrystallization, and crystal-growth of aluminium are discussed from a theoretical point of view. The cold-worked metal begins to recover on heating to a temperature between 100°-200° C., the yield-point, tensile strength, and hardness decreasing and the elongation increasing. At slightly higher temperatures depending on the degree of cold-working and the time of annealing, a visible change in the structure denotes the

start of recrystallization. A furnace for the preparation of single crystals is described.—A. R. P.

***Recrystallization of Aluminium in the Cast State.** H. Röhrig (*Z. Metallkunde*, 1935, 27, 175-178).—Fuller details are given of work the results of which were published in *Aluminium*, 1935, 17, 411 (*Met. Abs.*, this vol., p. 454).

—A. R. P.

***X-Ray Analysis of the Recrystallization of Complex Alloys.** E. F. Bachmetew (*Zavodskaya Lab. (Works' Laboratory)*, 1932, (3), 34-43; *C. Abs.*, 1935, 29, 6552).—[In Russian.] Cf. *Met. Abs. (J. Inst. Metals)*, 1933, 43, 16, 50. X-ray investigations of the recrystallization of alloys of the Duralumin type showed the possibility of the existence of different structures in the completely recrystallized alloy, in which there was a relation between the recrystallization texture and the degree of cold-rolling prior to heating. The possibility of determining the condition of the Duralumin after the various types of thermal treatment on the basis of the presence of CuAl_2 on the röntgenogram was established.—S. G.

***On the Arrangement of the Micro-Crystals in Lead Deposited by Electrolysis.** Hideki Hirata, Yoshio Tanaka, and Hisaji Komatsubara (*Bull. Chem. Soc. Japan*, 1935, 10, 391-396).—[In English.] The arrangement of the micro-crystals in deposits formed in acetic acid solutions was determined by means of X-rays, using the so-called "transmission method." By examination of the diffraction patterns, it was found that the micro-crystals tend to be deposited in a fibrous form, with one of the normals to their (211) faces arranged parallel to a definite common direction. The direction of growth of the mass of deposited lead as a whole was found, however, to coincide approximately with one of the [211] axes, which are inclined at angles of 0° , $33^\circ 34'$, $48^\circ 12'$, and $80^\circ 24'$, respectively, to the common axis of the micro-crystals.—C. E. H.

***Solid Solution Formation in Single- and Multi-Crystalline Material.** E. Schmid and G. Siebel (*Mitt. Material., Sonderheft* 26, 1935, 1-20).—See *Met. Abs.*, 1934, 1, 497.—B. Bl.

***On the Mechanism of the Precipitation of CuAl_2 in a Hardenable Copper-Aluminium Alloy.** G. Wassermann and J. Weerts (*Metallwirtschaft*, 1935, 14, 605-609).—On annealing at 200°C . a quenched aluminium alloy with 5% copper, the X-ray structure shows lines of a hitherto unknown tetragonal phase with $a = 8.2$, $c = 11.6\text{ A.}$; this is apparently an intermediate state of the CuAl_2 phase.—v. G.

***On the Transformations in β -"Aluminium-Bronze."** G. Wassermann (*Mitt. Material., Sonderheft* 26, 1935, 49-55).—See *Met. Abs.*, 1934, 1, 238.

—B. Bl.

***X-Ray Determination of the [Crystal] Structure of FeAl_3 .** E. Bachmetew (*Trans. Research Inst. Aircraft Materials (U.S.S.R.)*, 1935, (35), 1-38).—[In Russian.] See *Met. Abs.*, this vol., p. 423.—S. G.

***X-Ray Investigation of Iron-Nickel Alloys.** F. Marschak and D. Stepanow (*Z. Elektrochem.*, 1935, 41, 599-602).—Electrodeposited iron-nickel alloys were examined by X-rays, using a Debye camera and a Preston camera. The alloys form solid solutions with a marked range of heterogeneity between 30% and 50% of nickel, in which range the lattice constant increases to 3.58 Å. The results of Iwasé and Nasu (*Bull. Chem. Soc. Japan*, 1932, 7, 305) were not confirmed. The high lattice constant at 30% nickel corresponds to the existence of a galvanic or perhaps a chemical resistance limit at this composition.—J. H. W.

***Crystal Structure and Composition of Intermediate Phases Present in Iron-Tungsten and Iron-Molybdenum Alloys.** Harry Arnfelt and A. Westgren (*Jernkontorets Ann.*, 1935, 119, 184-196 (with English summary); *C. Abs.*, 1935, 29, 6194).—From the X-ray data of Arnfelt (*J. Inst. Metals*, 1929, 42, 516), the crystal structure of the intermediate phases present in the iron-

tungsten and iron-molybdenum systems was determined. The unit cell of the hexagonal phase Fe_3W has the dimensions $a = 4.727 \text{ \AA}$.; $c = 7.704 \text{ \AA}$. The phases usually denoted by the formulæ Fe_3W_2 and Fe_3Mo_2 are rhombohedral, the edges being, respectively, 9.02 \AA . and 8.97 \AA ., and the angles $30^\circ 30.5'$ and $30^\circ 38.6'$. In both cases the unit cell consists of 13 atoms, hence the above formulæ are incorrect. If the two kinds of atoms are not statistically distributed on the lattice points, the only possible divisions falling within the homogeneity ranges are represented by Fe_7W_6 and Fe_7Mo_6 . Determination of the atomic grouping verifies this conclusion. Fe_7W_6 is not stable at low temperatures but has a low rate of decomposition, but the Fe_7Mo_6 phase is stable for at least 1 month at $500^\circ\text{--}700^\circ \text{ C}$.—S. G.

Magnesium Crystals. G. Boky (*Mém. soc. russe minérale*, 1933, 62, 430-431; *C. Abs.*, 1935, 29, 5716).—Hexagonal crystals of magnesium are described.—S. G.

***X-Ray Analysis of the Structure of the Homogeneous Phases in the Magnesium-Nickel System. Preliminary Note.** E. F. Bachmetew (*Acta Physico-chem. U.R.S.S.*, 1935, 2, 567-570).—[In German.] Large hexagonal plates found in a pipe in a large casting of a 45 : 55 nickel-magnesium alloy proved to be a new compound Mg_3Ni having an hexagonal lattice $a = 5.26$, $c = 13.3 \text{ \AA}$., the unit cell containing 4 molecules. The known compound MgNi_2 was also found to be hexagonal with $a = 4.87$, $c = 16 \text{ \AA}$., and 8 molecules in the unit cell.—A. R. P.

***The Crystal Structure of MgNi_2 , and Its Relation to the MgCu_2 , and MgZn_2 , Types.** F. Laves and H. Witte (*Metallwirtschaft*, 1935, 14, 645-649).— MgNi_2 has an hexagonal structure with $a = 4.805$, $c = 15.77 \text{ \AA}$., $c/a = 3.28$, the unit cell containing 8 molecules. The distribution of the atoms at the lattice points is described.—v. G.

†**Investigation of the Fine Structure of Non-Ferrous Metals by X-Rays.** W. E. Schmid (*Z. Metallkunde*, 1935, 27, 49-62).—The use of X-rays in the study of metal systems, in the detection of lattice distortion caused by cold-work and by precipitation of new phases, and in the study of corrosion is reviewed, and modern types of apparatus for carrying out this work are described; a bibliography of 57 references to recent literature is given.—A. R. P.

Modern Investigations of Metals. J. D. Bernal (*Ergebn. tech. Röntgenkunde*, 1931, 2, 200-239; *Chem. Zentr.*, 1934, 105, I, 183-184; *C. Abs.*, 1935, 29, 5047).—A review. Includes (1) methods of investigation; (2) metallic types, structures, and properties; (3) characterization of metallic types by the nature of the binding force; (4) theory of the metallic state, and (5) theory of conduction. Extensive tables include (1) lattice types; (2) structure and properties of metallic elements and compounds; (3) survey of the metallic elements (periodic system); and (4) the most important binary intermetallic systems investigated by means of X-rays.—S. G.

Crystal Structure Investigations for 1930-1932. E. Schiebold (*Ergebn. tech. Röntgenkunde*, 1933, 3, 202-205; *C. Abs.*, 1935, 29, 4987).—A brief review of the more important recent work.—S. G.

***Photometric Measurements of the Number of Crystals Oriented in Metal Wires.** J. García de la Cueva (*Anales soc. españ. fis. quim.*, 1935, 33, 433-437; *C. Abs.*, 1935, 29, 6484).—By use of the Moll apparatus and method, it was found that the number of non-oriented crystals diminishes with diameter of wire up to a certain limit, after which it remains about 20% of the total number of crystals. This 20% corresponds to exterior surface, and its disorientation is due to rubbing against the die. The effect of size of the bundle of X-rays is pointed out.—S. G.

***On the Influence of the Method of Working on the Orientation of Crystals of Wire.** G. von Vargha and G. Wassermann (*Mitt. Material., Sonderheft* 26, 1935, 33-35).—See *Met. Abs.*, this vol., p. 16.—B. Bl.



X-Ray Examination of Metals by the Absorption Method. — Quevron, — Oudine, and R. Sancier (*Recherches et Inventions*, 1934, 15, 221-229, 295-301; *C. Abs.*, 1935, 29, 5014).—The physical principles of radiography, and typical examples of their applications are discussed.—S. G.

Recent Methods of Crystal Structure Investigation. E. Schiebold (*Ergebn. tech. Röntgenkunde*, 1931, 2, 64-107; *Chem. Zentr.*, 1934, 105, I, 9; *C. Abs.*, 1935, 29, 5344).—The relation of the reciprocal lattice to the space-lattice and to X-ray interference and functions, and goals of crystal structure analyses (value of methods for the determination of symmetry to functional structure analyses) are discussed.—S. G.

***X-Ray Investigation of the Mechanism of the Transformation from Face-Centred Cubic Lattice to Body-Centred Cubic.** Zenji Nishiyama (*Sci. Rep. Tôhoku Imp. Univ.*, 1934, [i], 23, 637-664).—[In English.] See *Met. Abs.*, this vol., p. 101.—S. G.

***Application of J. Leonhardt's Method Relating to the Orientation of Laue Diagrams in the Case of Unknown Crystal Orientation, to the Investigation of the Deposition of Phosphor-Nickel Iron in Kamacite.** W. Borchert and J. Ehlers (*Z. Krist.*, 1934, 89, 553-559).—[In German.] Leonhardt's method of determining crystal orientation (*Neues Jahrb. Mineral., Geol. Paläont.*, 58A, 192; *Fortschr. Min.*, 1927, (12), 52) is briefly described. Investigations carried out on meteoric iron derived from the San Martin and Cerros del Buei meteorites show that the laminar deposits of phosphor-nickel-iron contained in Kamacite lie along the planes {221}.—J. S. G. T.

IV.—CORROSION

(Continued from pp. 470-472.)

***Influence of Heat-Treatment on the Corrosion-Resistance of Plated Duralumin.** P. Brenner (*Z. Metallkunde*, 1935, 27, 169-173; discussion, 173-174; and (summary) *Light Metals Research*, 1935, 4, 100-101).—The effect of various annealing procedures on the corrosion-resistance of Duralumin coated on both sides with pure aluminium was determined. With sheets 0.5 mm. thick having 0.03 mm. of aluminium on each side, annealing at 500° C. for more than 10 minutes results in diffusion of copper from the Duralumin to the surface of the pure aluminium and consequent serious reduction in the corrosion-resistance; sheets 1.5 mm. thick with 0.05 mm. of aluminium on each side can, however, be heated for more than 3 hrs. at 500° C. without serious deterioration in their corrosion-resistance. With correct heat-treatment strong sheets of Duralplat can be obtained which have an extraordinarily high resistance to corrosion by sea-water.

—A. R. P.

***On the Endurance Strength of Light Metals with Especial Reference to Duralumin.** J. Krystof (*Metallwirtschaft*, 1935, 14, 701-702).—A review of recent work, with especial reference to that of Gerard and Sutton (*J. Inst. Metals*, 1935, 56, 29-45). Some results of K.'s own work on the endurance strength of Duralumin under corrosion and load are given.—v. G.

†**Resistance to Corrosion of Strong-Worked Light Metal Alloys.** Erich K. O. Schmidt (*Metallwirtschaft*, 1935, 14, 699-701).—The nature of the corrosive attack on Duralumin and its protection by anodic oxidation and by plating (Duralplat) are briefly reviewed.—v. G.

***Corrosion Tests with Duralplat in Norderney.** W. Stenzel (*Metallwirtschaft*, 1935, 14, 696-699).—Tests have been carried out over a period of 4 years on the corrosion in sea-water of Duralumin plated with alloys free from, or containing only small amounts of, copper. In the first case no decrease in strength of 1 mm. sheets occurred after 2 years, but the strength of 0.5 mm. sheets began

to decrease in 1-1½ years. By increasing the thickness of the plating at 20% the strength of the sheets was decreased by 4 kg./mm.², but such sheets remained unattacked after 4 years in sea-water. By plating with a 1% copper-aluminium alloy the loss in strength is very slight and the corrosion-protection sufficient for most purposes although not so good as when pure aluminium is used for the plating.—v. G.

***Studies on the Oxidation of Metals. II.—Copper, Brass, Aluminium—Brass, Aluminium—Bronze, Magnesium, and some Magnesium Alloys.** G. D. Preston and L. L. Bircumshaw (*Phil. Mag.*, 1935, [vii], 20, 706-720).—See also *Met. Abs.*, this vol., p. 59. The oxide film formed on copper at room temperature, at 100° C. in air, and at 183° C. in oxygen at atmospheric pressure consists of cuprous oxide with the usual cubic structure of this oxide. The oxide is oriented with the (111) plane parallel to the polished surface of the metal. Brass (zinc 30, copper 70%) oxidized at temperatures up to 183° C. is covered with a film of cuprous oxide; at 400° C. the oxide film is zinc oxide. Aluminium-brasses (zinc 22, aluminium 2%) show the presence of cuprous oxide after oxidation at 183° C. for 10 minutes; at 400° C. zinc oxide is present with another phase not identified; the absence of any trace of alumina is attributed to the amorphous nature of this oxide. Magnesium and magnesium alloys (the latter containing manganese; zinc and manganese; cadmium; copper and aluminium, respectively), oxidized at 400° C. are covered with a film of cubic magnesia. The films of oxide on polished surfaces are generally oriented; the plane in the oxide having the highest density of metal atoms per unit area tends to lie on the polished surface.—J. S. G. T.

***The Behaviour of Copper, Nickel, and Copper-Nickel Alloys Towards Attack by Washing and Bleaching Agents.** O. Bauer and H. Arndt (*Mitt. Material., Sonderheft* 26, 1935, 57-61).—See *Met. Abs.*, 1934, 1, 582.—B. Bl.

The Drinking Water Supplies of the Island of Heligoland and the Occurrence of Lead Therein. Karl Höll (*Arch. Hyg. Bakt.*, 1935, 113, 283-295; *C. Abs.*, 1935, 29, 5556).—The inhabitants of the island are dependent on private cisterns for their water supplies. The water is brought to the houses in lead pipes. The water is heavily contaminated by sea-water carried inland as spray, dust, bird excrement, and other material which collects on the roofs.

—S. G.

***The Factors which Play a Rôle in the Solution of Lead by Water.** Karl Höll (*Gesundheits-Ing.*, 1935, 58, 323-328; *C. Abs.*, 1935, 29, 5959).—Natural waters to which had been added known amounts of various salts were allowed to stand for varying periods of time (3-12 hrs. or several days) in a length of lead pipe at the pressure of the Hanover city mains, and the water was then analyzed for dissolved lead. Chlorides, as either potassium or sodium salts in amounts less than 500 mg./litre chlorine had no effect on the lead-dissolving action of the water; only when the chlorine concentration reaches 1000 mg./litre is the amount of lead dissolved appreciably influenced, the increase of lead concentration amounting to 10-50% (50% in the case of a soft water containing 5000 mg./litre chlorine). Waters of such high chlorine content are no longer potable in any case, owing to their taste. These results are in contradiction to those obtained by other investigators using distilled water, in which case the amount of lead dissolved decreased with increase in chlorine concentration. Thus, the effect of the chlorine concentration is influenced by other ions present in the water. Except in the case of hard waters of p_H above 7.5, the presence of a nitrate concentration of 50 mg./litre N_2O_3 increased the amount of lead dissolved by the natural water appreciably, the effect being greater the softer and more acid the water. This concentration of nitrate increased the amount of lead dissolved by 20% in a water of p_H under 7. The effect of 100 mg./litre is noticeable even in hard waters of p_H over 7.5. The nitrate content is of no significance in effecting the solubility of lead in potable waters, as the effect is

first noticed at a concentration of 200 mg./litre N_2O_5 , a concentration greatly exceeding that found in natural waters used as sources of potable water. Potassium and sodium sulphates increased the amount of lead dissolved by natural waters only when present in concentrations exceeding 200 mg./litre (the amount of lead dissolved increased from 1.8 to 1.9 when the SO_4^{--} concentration was increased from 25 to 300 mg.). However, gypsum had a more marked effect; increasing the content of this salt from 25 to 250 mg./litre SO_4^{--} increased the amount of lead dissolved approximately 10%. Thus, waters high in gypsum hardness are corrosive to lead. Grounding a radio antenna on the lead pipe was without influence on the amount of lead dissolved.—S. G.

***Antimonial Lead for Water Pipes.** O. Bauer and G. Schikorr (*Metallwirtschaft*, 1935, 14, 463-470).—The loss in weight of lead containing up to 1.5% antimony was determined in various corrosive waters and salt solutions. Carbon dioxide-free pure water attacks soft lead severely, but with increasing antimony content the attack rapidly decreases. With increase in the carbon dioxide content of the water the attack on pure lead decreases owing to the formation of a protective film. Waters containing humic acid corrode antimonial lead more severely than pure lead, whereas 3% sodium chloride solution and artificial North Sea water corrode pure lead somewhat more severely than antimonial lead. In 0.045*N*-lime water soft lead is much more readily attacked than antimonial lead, a well-defined minimum in the corrosion curve being obtained with 0.8% antimony; on the other hand moist lime mortar has a more severe action on antimonial lead than on soft lead, but in any case it is dangerous to embed any sort of lead pipe in lime mortar, especially if the mortar is frequently allowed to become moist.—v. G.

Corrosion of Lead in the Manufacture of Sulphuric Acid. V. Pershké (*14me. Congrès chim. ind., Paris, 1934*, 13 pp.).—See *Met. Abs.*, this vol., p. 382.—S. G.

***On the Oxidation of Nickel.** Gabriel Valinski (*Compt. rend.*, 1935, 201, 523-524).—As a result of micro-examination and X-ray investigation of the oxidation of nickel, in addition to the usual experiments, the conclusions of Pilling and Bedworth (*J. Inst. Metals*, 1923, 29, 529) were confirmed. The threshold temperature of the alteration of pure nickel in oxygen is about 550° C., and depends but little on the nature of the surface. It is lowered by the presence of water vapour and impurities (475° C. for 98.7% nickel). It becomes 680° C. if the metal is preheated *in vacuo*. Above 950° C., the powdered metal becomes saturated with oxygen, and the resulting product contains more than the normal amount of oxygen, equivalent to the formula $NiO_{1.04}$. Arrhenius' equation was also confirmed. If T is the absolute temperature, t the time in hrs., the number of grams of oxygen fixed per $cm.^2$, $n = 11.46 \frac{11210}{T} \sqrt{t}$.—J. H. W.

Corroding Effects of Asbestos on Nickel and Its Alloys. E. Schürmann and W. Esch (*Mitt. Material., Sonderheft 26*, 1935, 109-114).—See *Met. Abs.*, 1934, 1, 583.—B. Bl.

***The Solution of the Electrodeposit of Iron-Nickel Alloys.** D. Stepanow, F. Marschak, N. Balaschowa, and W. Kabanowa (*Z. Elektrochem.*, 1935, 41, 597-599).—See Marschak, Stepanow, and Lewius, *Met. Abs.*, this vol., p. 526. The solution of electrodeposited iron-nickel alloys in tap-water, sea-water, caustic soda solution, sulphuric acid, and lactic acid was determined. The specimens were immersed for 7 hours daily for 3 days in the solutions. The anodic behaviour of the deposits was also determined.—J. H. W.

***The Atmospheric Corrosion and Tarnishing of Tin.** L. Kenworthy (*Trans. Faraday Soc.*, 1935, 31, 1331-1345).—The corrosion of pure tin (99.985%), tin alloyed with 0.2% copper, and tin alloyed with 2.2% antimony was determined by weight increments (or loss) and by tensile tests on specimens exposed to an indoor and to an outdoor (both shielded and unshielded) atmosphere. In an

indoor atmosphere all the tin specimens behaved better than comparison specimens of copper, zinc, or cadmium, pure tin being slightly superior to the alloyed tin; the weight-increment of tin was found to be a linear function of the time of exposure, showing that the film formed is of a granular, non-protective nature, but after 750 days the gain in weight was only 3 mg./dm.². In the Stevenson screen all the tin specimens behaved similarly and all were superior to nickel, but slightly inferior to copper, and in conditions of complete exposure the tin specimens were superior to any of the comparison metals as regards loss in weight by corrosion. The effect of outdoor exposure on mechanical properties is somewhat greater for tin than for copper, but definitely less than for cadmium; the corrosion penetration of tin, however, was only of the order of 0.0004 in. per year.—A. R. P.

Corrosion of Tinplate and the Food-Preserving Industry. H. Cheftel (*Etablissements J.-J. Carnaud, Forges Basse-Indre, Lab. Recherches Biol. Bull.* No. 5, 1935, 77 pp.; *C. Abs.*, 1935, 29, 5195).—Discusses in detail the various effects brought about by corrosion in tin cans; the theoretical aspects, especially the electrochemical phenomena; and practical remedies. *A bibliography* of 33 references is given.—S. G.

***Corrosion-Resistance of Metals in Corn Processing.** F. L. LaQue (*Canning Age*, 1935, 16, 315-317, 332).—Specimens of nickel, tin, copper, zinc, Monel metal, bronze containing 5% each of tin, zinc, and lead, 50:50 tin-lead solder, 2 and 1 brass, and 18% nickel silver were exposed at various points of an actual working plant for processing and canning corn. The specimens were thus exposed to boiling brine, air, steam, and contact with the corn, and the test was carried out for 8-10 hrs. Tests were also made of the effects of small quantities (2-80 p.p.m.) of chromium, copper, nickel, tin, and zinc in solution on the colour and flavour of canned corn.—C. E. H.

***Corrosion-Resistance Tests of Metals Used in Tomato Products Processing.** F. L. LaQue (*Canning Age*, 1935, 16, 363-366).—Specimens of copper; bronze containing 5% each of tin, zinc, and lead; tin; nickel; aluminium, and Monel metal were exposed in the tomato scalding tank, catsup boiling kettle, and catsup finisher of a working tomato processing plant. The tests were supplemented by an examination of the effects of small amounts (1-80 p.p.m.) of aluminium, chromium, copper, nickel, tin, and zinc on the colour and flavour of tomato juice.—C. E. H.

***On the Corrosion of Electrolytic Zinc and Refined Zinc.** O. Bauer and G. Schikorr (*Mitt. Material., Sonderheft* 26, 1934, 63-70).—See *Mct. Abs.*, 1934, 1, 424.—B. Bl.

***The Effect of Milk upon Metals and Metals upon Milk.** Benjamin H. Whitfield, H. P. Davis, and P. A. Downs (*Milk Dealer*, 1934, 24, (2), 34-35; (3), 40-42; (4), 42-44; *C. Abs.*, 1935, 29, 5528).—Corrosion studies were carried out with copper, nickel, Inconel, Allegheny metal, and Aluminium 3 S. Nickel and copper were the only materials that corroded. In general, nickel corroded more than copper, as judged by losses in weight of the test strips exposed to milk at 60° F. (16° C.) and at 144° F. (62° C.). Exposure of the metals at 144° F. caused greater corrosion than at 60° F. At 144° F. an atmosphere of oxygen over the milk caused greatest corrosion, air next, and carbon dioxide least. At 60° F. the corrosion of copper by milk was practically the same under the 3 atmospheres, with possibly greater loss in weight of the strip in milk under air. For nickel at 60° F. the strips in milk under an atmosphere of carbon dioxide showed the greatest loss in weight, while there were no significant losses under air or oxygen. Losses in weight of nickel and copper were greater as the times of exposure increased, but corrosion rates determined from short periods of exposure were greater than when determined for long periods. Copper was brightened and nickel was darkened by exposure to milk. The intensity of the discoloration was increased by an atmosphere of oxygen over

the milk and by longer periods of exposure. Copper always affected the flavour of the milk, causing a tallowy flavour within 18 to 24 hrs. after exposure to the metal. The intensity of the off-flavour varied with time of exposure and length of storage period after exposure; it was increased by an oxygen atmosphere, and decreased by one of carbon dioxide. Nickel produced an off-flavour only occasionally, and then only when corrosion was great. Inconel, Aluminium 3 S, and Allegheny metal produced no detectable flavour defects. Milk under a carbon dioxide atmosphere developed a high acid flavour. No change in acidity or p_H value of the milk could be attributed to contact with the metals. Milk under a carbon dioxide atmosphere increased in acidity and p_H value. Copper dissolved in the milk more than did nickel. The greenish colour produced in milk at 144° F. by these metals was intensified by long exposures and by the pressure of oxygen. Holding the milk at 55°-60° F. for 15 hrs. after milking had no effect on the corrosion rate of nickel at 144° F. under an atmosphere of air.—S. G.

The Action of Water on Materials for Service Pipes. F. Wellington Gilreas (*J. New England Water Works Assoc.*, 1935, 49, 170-175; *C. Abs.*, 1935, 29, 6339).—Water quality should determine the metal best suited for service pipes. The advantages and disadvantages of lead, zinc, brass, iron, and copper are cited, and the values of pipe linings and water treatment are discussed.—S. G.

***The Effect of Excess Lime Hydrate upon Corrosive Soft Water.** Frank E. Hale (*Water Works Eng.*, 1935, 88, 569-573, 624-628; *C. Abs.*, 1935, 29, 5960).—Laboratory experiments were carried out to test the corrosive effect of a water treated with calcium hydroxide on galvanized and black wrought iron, copper, and brass pipes in the cold and at 150° C. Less clogging occurred in the black wrought iron, galvanized iron, and copper pipes if 10 p.p.m. excess calcium hydroxide were used. The experiments indicated that a moderate excess of calcium hydroxide is beneficial in preventing corrosion and in building up a protective calcium carbonate deposit in the pipes. Numerous tables and graphs are given.—S. G.

Corrosion : Its Nature and Effect on Selection of [Oil] Production Equipment. W. H. M. E. Crake (*Oil and Gas J.*, 1935, 33, (49), 18, 20, 85-86).—S. G.

Should Petrol Containers be Protected from Corrosion? K. R. Dietrich (*Oel u. Kohle*, 1935, 11, 703-705).—D. attributes the corrosion of tank containers to impurities, especially water, in added alcohol. Corrosion, other than a negligible amount due to atmospheric influences, is eliminated if the purity of the alcohol is safeguarded. Atmospheric corrosion is important in the case of drums, the frequent emptying and filling of which exposes them to attack, whilst the oxide coating is liable to become detached when the drums are moved. Tinning the interior of petrol drums and cans is therefore recommended.—P. M. C. R.

†Knowledge and Research Results in the Field of Corrosion Protection of Tubes. Walther Schneider (*Korrosion IV. Bericht über die IV Korrosions-tagung, Berlin, 1934*, 73-76; and (abstract) *Chem. Fabrik*, 1935, 8, 191-192).—Recent theories of the nature of corrosion are reviewed and their application to practice indicated.—A. R. P.

Diseases of Steels and Other Metals and Their Prevention. Robert S. Williams (*Proc. Amer. Assoc. Textile Chem. Colorists*, 1935, 235-239; and *Amer. Dyestuff Reporter*, 1935, 24, 369-373).—A review.—S. G.

Errors in Corrosion Research. R. B. Mears and H. E. Daniels (*Electrochem. Soc. Preprint*, 1935, (Oct.), 233-242).—The probable errors for the corrosion experiments made by Evans and his collaborators at Cambridge under thermostatic conditions have been computed statistically. The errors are considered to be the resultant of two components, one being inaccuracies in measurement and the other due to variations in the material tested; the accuracy of the determinations of losses less than 3 mg. is chiefly affected by experimental errors and

can be improved only by improved measuring technique. A statistical analysis of Borgmann and Evans' measurements on the corrosion rates of rolled zinc sheet half-immersed in potassium chloride solutions indicates that the rate of corrosion-concentration of the solution curve continues to rise up to the highest concentration tested.—A. R. P.

Topochemical Points of View. H. Stager (*Korrosion u. Metallschutz*, 1935, 11, 73-88).—Various aspects of corrosion phenomena are discussed from a topochemical point of view. The following are of non-ferrous metal interest: the corrosion of nickel and cadmium plate by volatile varnish acids, the corrosion of brass in 10% hydrochloric acid and in 5% sodium chloride, and the corrosion of copper wires by electric glow discharges.—A. R. P.

Theory of Corrosion. Mária Andauer (*Magyar Chemiai Polyóirat*, 1935, 41, 37-47; *C. Abs.*, 1935, 29, 6195).—A general summary of present theories. Protection against corrosion consists in (1) use of absolutely pure metals; (2) coating of the surfaces (by oxidation, plating, painting, &c.); (3) alloying with metals that promote passivity, e.g. 2.5% manganese added to magnesium; and (4) increase of overpotential by a connection with a less noble metal.

—S. G.

Use of Inhibitors in Preventing Corrosion by Acids.—II. V. A. Wardell (*Chem. Eng. Min. Rev.*, 1935, 27, 321-323).—The scope of inhibiting effects, the mechanism of inhibiting action, and the localization of corrosion by inhibitors are described. A bibliography of 25 references is appended.

—J. H. W.

V.—PROTECTION

(Continued from pp. 472-473.)

The Surface Treatment of Aluminium and Its Alloys. H. Krause (*Illust. Zeit. Blechindustrie*, 1935, 64, 936-937, 968-969).—For a variety of purposes, effectively protected aluminium or light alloy die-castings may safely be substituted for copper or nickel parts. A necessary preliminary to almost all forms of surface-treatment is the roughening of the surface by pickling; methods recommended by Ballay and by Canac and Tassily are summarized. A method is described for the deposition of brass as a basis for nickel or chromium plating, and the M.B.V., Eloxal, and Jirotko oxidation processes are reviewed, certain modifications of the latter introduced by K. being described.

—P. M. C. R.

Conditions Governing the Formation of Highly Insulating Anodic Layers on Aluminium. J. E. Lilienfeld, J. K. Nieh, and S. Goldman (*Electrochem. Soc. Preprint*, 1935, (Oct.), 67-80).—When a fixed voltage is applied across the terminals of a cell containing an aluminium anode in a "forming" electrolyte the initial current density at the anode either remains substantially constant or decreases rapidly to a steady value; in the first case the initial current density is smaller than a definite value, i_m , and in the second it is larger, but rapidly decreases to i_m , which may be called the maximum leakage current or the minimum formation current. i_m is a function of the composition of the electrolyte and for a given electrolyte is independent of the fixed voltage applied across the cell; in pure ammonium, sodium, and potassium hydroxide solutions i_m is directly proportional to the hydroxyl ion concentration and decreases rapidly as increasing amounts of a weak acid are added to the solution, the decrease being more rapid the stronger the acid. A theory is developed to account for the existence of i_m based on the fact that there is a constant potential drop which moves hydroxyl ions in a thin layer separating the surface of the aluminium anode from the dielectric layer. In this thin embryonic layer new strata of the dielectric layer are formed and it is assumed that the latter consists of a form of alumina permeable only to hydroxyl ions. The

modifying effect of other ions on i_m is attributed to their action in shielding the hydroxyl ions from the field and in changing the viscosity of the electrolyte.

—A. R. P.

Characteristics of Anodized Aluminium. R. E. Pettit (*Machinist (Eur. Edn.)*, 1935, 79, 552-553E).—The Alumilite process for surface-treating aluminium is explained and the characteristics of the resulting coating are briefly described.—J. H. W.

†**Aluminium Plating.** H. G. Heine (*Aluminium*, 1935, 17, 467-476).—A critical review of the development and present position of materials of the type of Duralplat is given under the headings: diffusion, technical properties, manufacture; 44 references to periodical and patent literature are included.

—A. R. P.

†**Aluminium Coating of Iron by Hot-Dipping.** A. von Zeerleder (*Aluminium*, 1935, 17, 483-487).—The chemical resistivity of aluminium renders it a desirable substitute for zinc for coating iron, especially for domestic utensils and culinary apparatus, where the poisonous nature of zinc is objectionable. Application of the usual galvanizing methods to aluminium, however, fails to yield a satisfactorily adherent and regular coating of aluminium on iron; until recently such a coating has been obtained only by the use of a spray pistol and by heating the iron in a mixture of alumina and aluminium powder, but some success has lately been obtained by rolling aluminium sheet on to iron at high temperatures. These 3 methods are critically discussed, and recent patent literature is reviewed.—A. R. P.

†**Corrosion at Metal-to-Metal Joints and Its Prevention.** Erich K. O. Schmidt (*Metallwirtschaft*, 1935, 14, 409-412).—Metals and alloys can be protected from corrosion by joining less noble metals to them, the protective action not being dependent on an uninterrupted surface film, e.g. galvanized iron or materials of the type of Duralplat. If several metals are to be used in combination the ever-present danger of electrochemical corrosion may be avoided by coating all the metals with the same protective metal or insulating the different metals with the same less noble metal, e.g. cadmium foil between iron and aluminium joints.—v. G.

Examination of Steel Wires Coated with Cadmium and Cadmium-Zinc. G. Montelucci (*Atti soc. ital. progresso sci.*, 1935, 23, II, 545; *C. Abs.*, 1935, 29, 5403).—The samples are plunged for several minutes in a solution containing stannic chloride 10, ammonium chloride 15, and tartaric acid 0.5 gm.-%, and weighed before and after the treatment.—S. G.

The Hot-Tinning of Grey Cast-Iron. — (*Galvano*, 1935, (37), 29-31; (38), 26-28).—A fairly detailed account of average practice, comprising the following series of operations: preliminary pickling, sand-blasting, final pickling, coppering, immersion in flux, rough-tinning in a bath at 300°-325° C., fine-tinning in a second bath at about 240° C., cooling, and cleaning.

—C. E. H.

***Striations in Tin Coatings on Copper.** Bruce Chalmers and W. D. Jones (*Trans. Faraday Soc.*, 1935, 31, 1299-1303).—When a piece of cathode copper is tinned by hot-dipping a characteristic "eutectic pattern," consisting of a smooth normally reflecting surface crossed by wavy bands which scatter or diffuse the light which falls on them, is obtained; the striations appears at right angles to the direction of crystallization and with non-uniform crystallization may produce a concentric pattern radiating from the nucleus of crystallization. Examination of specimens exhibiting these markings by optical and metallographic methods indicate that they are related to the crystallization of the tin-copper eutectic.—A. R. P.

***Examination of the Surface of Tinplate by an Optical Method.** W. E. Hoare and Bruce Chalmers (*Iron Steel Inst. Advance Copy*, 1935, Sept., 1-8; and *Tech. Publ. Internat. Tin Res. Develop. Council, Series A*, 1935, (21), 1-8).—

The surface of tinplate was examined by an optical method involving the formation of interference fringes between an optical flat and the tin surface. This method enables a distinction to be made between hollows and relief in the surface. The depth can be determined by counting the fringes under visual observation. It is suggested that the method should be applicable to the study of the surface contours of hot-dipped, electrodeposited, and other coatings, and possibly of some of the intrinsic properties of metals.—J. H. W.

***On the Occurrence of a High Crystallizing Power in the Formation of Iron-Zinc Alloys [in Galvanizing].** E. Scheil (*Z. Metallkunde*, 1935, 27, 76-77).—In the hot-dip galvanizing of some varieties of steel, very rapid growth of a hard layer of FeZn, occurs at 450°-480° C. The force of crystallization of this layer is much greater than that of any substance for which it has yet been measured, reaching more than 6 kg./mm.² at 450° C. Galvanized steels on which this layer is formed cannot be bent without fracture of the layer and consequent deterioration of the coating.—A. R. P.

The Semi-Mechanical Galvanizing of Tubes. A. Forny (*Galvano*, 1935, (39), 22-23).—A description of the process, with details of a typical installation. Figures are given for the consumption of fuel, zinc, acid, and flux, for the output per shift, and for the amount of dross produced. By means of comparative figures for hand galvanizing, it is shown that the semi-mechanical process offers a saving of cost of about 40%.—C. E. H.

The Mechanical Galvanizing of Tubes. A. Forny (*Galvano*, 1935, (40), 22-23).—A plant of this type, working in Greece, is described with a plan, and details of costs are given. For comparison, similar details for the hand process and semi-mechanical processes are included, and it is shown that although the mechanical process is much cheaper than hand-dipping, yet it is not quite so economical as the semi-mechanical process.—C. E. H.

The Mechanical Galvanizing of Strip [-I, -II]. A. Forny (*Galvano*, 1935, (38), 28-30; (39), 21).—(I.—) A practical description of the process, with average figures for production, consumption of materials, and labour required. The thickness of zinc applied is less than that obtained in the hand-dipping of sheets, being about 0.03 mm. (II.—) Two new developments are described. One process being used in America consists in passing the galvanized strip through a furnace immediately after its emergence from the zinc-bath, in order to reduce porosity, whilst in Poland, cold-rolled strip, annealed in a neutral atmosphere, is being galvanized without intermediate pickling.

—C. E. H.

The Mechanical Galvanizing of Wire. A. Forny (*Galvano*, 1935, (41), 25-28).—A general account of the operation. Particular stress is laid on the point that the wire, in its passage through the galvanizing bath, must reach the temperature of the molten zinc. Thus the length of the bath and speed of travel of the wire must be adjusted carefully to the gauge of the wire. The effect of various factors on the quality of the coating is discussed, and a new process recently patented in America is described.—C. E. H.

***Detection of Unsoundness in Zinc Coatings on Steel.** Georg Garre (*Arch. Eisenhüttenwesen*, 1935-1936, 9, 91-94; discussion, 94).—The ordinary ferroxyl test does not give satisfactory results in testing galvanized iron for porosity. Of various simple immersion tests which have been tried the following give satisfactory results: (a) immersion in a solution of potassium ferricyanide containing oxalic acid and hydrogen peroxide produces a blue colour in 20-30 minutes on spots where the iron is exposed; (b) immersion in 0.001-0.004N-potassium permanganate solutions results in blackening of the exposed iron. A quicker test comprises making the specimen the anode in a solution containing potassium ferrocyanide 40, and magnesium sulphate 2 grm./litre using the current from a 4-v. accumulator; the exposed iron

immediately becomes blue. This procedure will detect pores which are revealed only after subsection of the specimen for 24 hrs. to the salt-spray.

—A. R. P.

Tests of Galvanized Steel Wires. A. R. Matthis (*14me. Congrès chim. ind., Paris, 1934, 25 pp.*; *C. Abs., 1935, 29, 6550*).—The principles and processes of galvanizing are described, together with tests to which galvanized steel wires are usually subjected. The causes of the divergencies in the results obtained by the Preece test for controlling the regularity of the zinc coating are discussed, as also are the fairly numerous causes of error, which are confirmed by comparative tests. A plea is made for the development of a commercial method of control which would eliminate, so far as possible, the personal factor and make it possible to obtain concordant results in different laboratories. A number of experiments carried out to this end are described, though they gave negative results.—S. G.

Enamel as Protection for Galvanized Iron. L. Vielhaber (*Emaillerie, 1933, 1, (10), 14-16*; *Emaillwaren-Ind., 1935, 12, (9), 73*).—S. G.

***Metallic Cementation. VI.—Cementation [of Iron, Nickel, and Copper] by Means of Silicon Powder.** Tsutomu Kase (*Kinzoku no Kenkyu, 1935, 12, 397-410*).—[In Japanese.] The cementation of iron, nickel, and copper by powdered commercial silicon was studied between 500° and 1200° C. The depth of penetration was measured, microscopic and chemical analyses were carried out, and a study was made of oxidation at high temperatures and corrosion by some acids. Silicon diffuses into iron, nickel, and copper at about 500° C., and the rate of diffusion increases as the temperature increases; the rate of diffusion of silicon into iron increases, however, almost abruptly at the A_3 point (906° C.). The relation between the increase in weight of the specimen (ΔW), or the depth of penetration (P), and the absolute temperature of cementation (T) is given by an exponential function ΔW (or P) = $ae^{-b/T}$, as in a former case studied by K. The relation between ΔW or P and the length of time for cementation (θ) is given by a similar function ΔW (or P) = $ae^{b\theta}$, where a and b are different constants in each case. Though the cemented surfaces of iron and nickel are brittle, they are resistant to atmospheric oxidation at high temperatures. The surfaces of iron and nickel cemented by silicon are not easily attacked by dilute sulphuric acid. The surfaces of copper cemented by silicon tend to become porous, and decrease the weight of the specimens.—S. G.

Protective Metallic Coatings by the Wire Spraying Process. W. E. Ballard (*Trans. Manchester Assoc. Eng., 1934-1935, 113-146*; also (abstracts) *Mech. World, 1935, 97, 103-104*; and *Machinist (Eur. Edn.), 1934, 78, 704-705E*).—A brief description is given of the construction and operation of a metal spray pistol, the characteristics of sprayed coatings are discussed, and a number of applications described. The sprayed structure consists of saucer-shaped particles, each enveloped with a very thin oxide skin, and held together by mechanical interlocking and instantaneous partial fusing. Oxidation is very slight; magnesium can be sprayed without firing, and zinc only loses about 0.2%. For protection at high temperatures against oxidizing and sulphurous atmospheres, aluminizing, or spraying with aluminium and heating, is widely used. Above 970° C., however, protection may cease owing to diffusion of the aluminium into the underlying metal. Examples quoted of corrosion protection include spray zinc on window frames (0.002 in. thick), pylons (0.004 in.), and water and petrol tanks. Aluminium is used for spraying food vessels and, combined with a zinc layer, for gasholders. An aluminium coating on petrol engine combustion heads increases flame speed. Thick coats (0.010 in. thick) of tin are used in food factories and of nickel in paper and silk equipment.—J. C. C.

Metallizing or the Spraying of Molten Metal. E. F. Bespalow (*Ice and Refrigeration, 1935, 89, 42*).—S. G.

Coating of Aluminium and Its Alloys. H. Röhrig and W. Nicolini (*Maschinenbau: Der Betrieb*, 1934, 13, 293–294; *C. Abs.*, 1935, 29, 6779).—Protection of aluminium surfaces by paints or other coatings is necessary only in special cases owing to the tenacious oxide film present. Because of the smooth surfaces of rolled and pressed objects, preliminary treatment prior to painting, &c., to increase the adhesion of the coating applied, is indispensable. Mechanical roughening destroys the oxide film and reduces the hardness of thin objects. Etching makes careful washing necessary. Treatment by the MBV or Eloxal processes is recommended as increasing the adhesion of the coating applied and rendering the metal surface passive. Removal of oils or fat by organic solvents is necessary when no preliminary treatment is used and sometimes after such treatment. Of the basic coatings, red lead is not useful against the action of sea-water. A thinly-applied asphalt base (with the addition of stearol pitch) is good, but nicks through readily. Aluminium-bronzes and special base lacquers for light metals can be recommended. Cellulose films adhere to smooth rolled surfaces. Surface coatings must adhere well, be non-porous, and adapt themselves to the high thermal expansion of aluminium. Pigmentation increases the protection. Stand oil and wood oil should be added only sparingly to linseed-oil varnishes. Oil films are flexible, but not very hard. Asphalt and tar films resist sea-water, but shrivel and crack in summer sun. This difficulty is eliminated by the addition of aluminium-bronze powder. Nitro lacquers, which are hard and only slightly elastic, can be sprayed on, but are dangerously inflammable. Nitro oil lacquers have sufficient hardness and are pliable and highly resistant to corrosion. Baked lacquers can be used for aluminium alloys only at temperatures below 120° C. Aluminium-bronze, because of its light weight, and high covering and reflecting properties, is most suitable as a pigment. Errors in applying such coatings are briefly discussed.—S. G.

The Formation of Paint Films and Their Protection of Metal. Hans Wolff (*Paint Varnish Production Manager*, 1935, 13, (Aug.), 7–8, 10; *C. Abs.*, 1935, 29, 6439).—The p_H of varnish films increases very slowly even at temperatures up to 30° C.; this indicates that the active acidity of a film depends on the conditions which prevail during drying and much less on the conditions encountered after drying. In pigmented films, the basic pigments gave p_H values higher than in the straight varnish films in like drying conditions, but zinc oxide was the only one giving a p_H higher than 5. High acidity may cause a reaction between the film and the metal surfaces, or may affect the properties of the film by a colloid-chemical mechanism. Adhesion may depend wholly or in part on the active acidity of the film.—S. G.

Corrosion-Preventing Paints. I. V. Vinogradova (*Novosti Tekhniki Seriya Gorno-Rudnaya Promishlennosti*, 1935, (15), 4–6; *C. Abs.*, 1935, 29, 6439).—[In Russian.] Formulæ are given for paints for agricultural machinery, tractors, aircraft, milk containers, bicycles, oxygen containers, thermos bottles, copper, aluminium, and brass goods, automobile lights, metal gauze, heavy metal goods, containers for petrol and kerosene, and electrical illuminating appliances.—S. G.

Aluminium Paints and the Protection of Iron. J. Roux (*Recherches et Inventions*, 1935, 16, 228–229; *C. Abs.*, 1935, 29, 5286).—A brief discussion of the protection of structural iron and steel by means of aluminium paints, showing in particular the exceptionally efficient protection afforded by aluminium coal-tar pitch paints (see also *Met. Abs.*, this vol., p. 234).—S. G.

The Problem of Corrosion. Paints and Corrosion-Resisting Coatings. G. Genin (*Industrie chimique*, 1934, 21, 898–901; 1935, 22, 93–97, 250–255, 402–404, 488–489).—A general discussion of the subject.—C. E. H.

VI.—ELECTRODEPOSITION

(Continued from pp. 473-475.)

***Electroplating of Aluminium on Metals [from a Fused Salt-Bath].** Naoto Kameyama, Shikao Sato, Tatsuo Inoue, Hiroshi Iida, and Yasuji Torii (*J. Electrochem. Assoc. (Japan)*, 1935, 3, 127-141; *C. Abs.*, 1935, 29, 5749).—The best results were obtained when the electrolysis was carried out at 110°-130° C. at a current density of less than 1 amp./dm.². The fused salt was aluminium bromide plus 16-18% potassium bromide. The anode was aluminium, and the cathode most easily plated was lead; other metals plated with lead can be used as cathode. Copper, zinc, brass, tin, cadmium, iron, magnesium, and aluminium cathodes are also suitable. Superposing a.c. on d.c. gives good results. The fused salt-bath must be free from iron.—S. G.

Our Experience in Cadmium Plating in a Barrel. Austin F. Fletcher (*Monthly Rev. Amer. Electroplaters' Soc.*, 1935, 22, (9), 32-38).—A record of the work done by F.'s firm over a period of several years.—A. R. P.

Electrodeposition of Cadmium. — (*Met. Ind. (Lond.)*, 1935, 47, 92-93).—Discussion of a paper by H. Marston read before the Electrodepositors' Technical Society, and M.'s reply (see *Met. Abs.*, this vol., p. 165).—J. H. W.

***Influence of Sulphate on Chromium Hardness.** R. J. Piersol (*Metal Cleaning and Finishing*, 1935, 7, 219-222, 230; *C. Abs.*, 1935, 29, 5357).—The ratio of the CrO₃ to the sulphate radical (sulphate ratio) is of importance for the quality of the chromium plate and governs the cathode efficiency. The latter has its maximum at a ratio of about 100 : 1, with a bath containing 250 gm. CrO₃ per litre, operated at a current density of 50-100 amp./ft.² and between 33° and 45° C. For a given sulphate ratio, the current efficiency increases with increasing current density and decreases with increasing temperature. At low temperatures a higher concentration of sulphate is required in order to obtain the maximum throwing power. At over 25° C. the maximum throwing power was obtained at a sulphate ratio of about 115 : 1, whereas at 45°-60° C. the ratio was about 150 : 1. The usual sulphate concentration of 2.5 gm./litre (sulphate ratio 100 : 1) as well as a concentration of 1.25 gm./litre (ratio 200 : 1) gave deposits of maximum hardness at a current density corresponding to a rate of deposition of approximately 1.2 mils chromium per hr. The maximum hardness value for the 100 : 1 ratio was about 25% higher than that for the 200 : 1 ratio. At rates of deposition of about 1.5 mils chromium per hr. the hardness values were about the same, whereas at higher rates of deposition the lower sulphate content (high sulphate ratio) produced a harder plate up to a rate of about 6 mils chromium per hr., at which point the hardness resulting from the two sulphate concentrations again approached the same value. At 68° C. the customary sulphate ratio of 100 : 1 produced a slightly harder plate than a ratio of 125 : 1 at rates of deposition up to 12 mils per hr. In the conditions described, any sulphate ratio greatly below the normal value rapidly decreases the throwing power and current efficiency and, especially at high temperatures, produces an inferior quality of chromium plate.—S. G.

***Determining the Thickness and Throwing Power in Nickel- and Chromium-Plating Practice.** A. Portevin and M. Cymboliste (*14me. Congrès chim. ind., Paris*, 17 pp.; *C. Abs.*, 1935, 29, 6510).—A complete account is given of the investigation which is incompletely and improperly reported by Onitchenko (*Met. Abs. (J. Inst. Metals)*, 1933, 53, 709). Owing to practical difficulties of construction and manipulation in carrying out the throwing power tests with the right-angled cathode, this type of cathode has now been abandoned for one consisting of 2 coaxial spirals having the same surface, one of 5 mm. diameter and the other of 20 mm. diameter.—S. G.

***Concentrated Copper Cyanide Plating Baths.** L. C. Pan (*Electrochem. Soc. Preprint*, 1935, Oct., 243–253).—Cf. *Met. Abs.*, 1934, 1, 596, and this vol., p. 63. A study was made of the effect of variations in the free cyanide and sodium carbonate content of *N*-copper cyanide plating baths on their operating characteristics. The data obtained show that the best results are given by a bath containing copper cyanide 89.6, sodium cyanide 106.2 (free cyanide 8.2), and sodium carbonate 78.0 gm./litre. The bath is operated at 20°–25° C. with a current density of 2.0 amp./dm.², the anode current efficiency is 75.5%, the cathode current efficiency 95%, the anode polarization 1.55 v., the cathode polarization 0.85 v., the resistivity 7 ohms/cm.², and the throwing power (by the Blum–Haring method) 47.4%. Hence the bath plates twice as rapidly as the acid copper bath and has a much better throwing power; it should be of considerable value, therefore, in plating iron and steel, since the whole of the deposit can be made from it, instead of using the customary cyanide “strike” and following with building up the deposit in the acid bath.—A. R. P.

***The Electrolysis of Lead in Perchloric Acid.** Robert Weiner (*Z. Elektrochem.*, 1935, 41, 631–635).—Good deposits of lead are obtained from an electrolyte containing lead perchlorate 50 gm. and perchloric acid 10 gm. in 1 litre of water, using a current density of 0.25–0.50 amp./dm.². Better deposits are obtained by agitating the bath and adding 0.2–0.4 gm./litre of peptone, and higher current densities can then be used.—J. H. W.

***On the Arrangement of the Micro-Crystals in Lead Deposited by Electrolysis.** (Hirata, Tanaka, and Komatsubara.) See p. 512.

Defects in Nickel Plating. André Darlay (*Galvano*, 1935, (34), 17–18; (36), 17–19; (37), 20–21; (38), 21–25; (39), 15–17; (40), 19–22).—The mode of appearance and probable causes of nickel-plating defects, together with possible remedies, are discussed in considerable detail under the headings: (1) defects of the bath (acidity, alkalinity, crystallization, turbidity, bad colour, gelatinous matter in suspension); (2) defects in the deposit itself (uniform dark colour, black streaks, blackening at the point of contact with the supporting wire, black and pitted deposits, grouped and isolated pits, burnt streaks, irregular burnt patches, flaked and laminated exfoliation, brittle deposits exfoliating in hard laminations, dull spots, thin and rough deposits).

—C. E. H.

***Inorganic Addition Salts in the Nickel Plating Solution.** Russel Harr (*Electrochem. Soc. Preprint*, 1935, Oct., 289–308).—The Krombolz metal distribution test, in which the metal deposited on 10 equal sections of a wire cathode arranged horizontally in the bath with one end close to a vertical cathode is determined, gives a better indication of the distribution of electro-deposited metal than does the Haring–Blum throwing power test. The distribution curves obtained in standard nickel-plating baths are unaffected by changes in p_H between 2.0 and 6.3, and by small additions (0.25*N*) of sodium, magnesium, or aluminium sulphates to the high p_H bath; aluminium sulphate also has no effect on the plating from low p_H baths, but the other two sulphates are harmful. When the bath is made 1.5*N* with respect to the addition salt and plating is done at 1.9 amp./dm.² at 60° C. sodium sulphate is most effective in improving metal distribution at both low and high p_H , magnesium sulphate causes a slight improvement at high, and a deterioration at low p_H and aluminium sulphate is harmful at all p_H . Increase in current density to 3.8 amp./dm.² has a serious detrimental effect in all baths. Critical current density tests indicate that nickel may be satisfactorily deposited from low p_H solutions at higher current densities than from high p_H solutions, that boric acid is necessary and ammonium sulphate harmful in low p_H solutions, and that ammonium sulphate is beneficial in high p_H solutions. Magnesium and sodium sulphates decrease the critical current density to an extent which

is greater the greater is their concentration, but small additions of aluminium sulphate decrease, and large additions increase, the critical current density. The so-called "burning" of nickel deposited at too high a current density is shown to be due to the formation of an alkaline film of solution around the cathode. Previous statements that deposits obtained from solutions containing magnesium sulphate consist of a magnesium-nickel alloy are shown by chemical and spectrographic analysis to be erroneous.—A. R. P.

*The Electrolysis of Solutions of Chlorides of Nickel and Cobalt in a Mixture of Water and Ethyl Alcohol. Claude Charmetant (*Compt. rend.*, 1935, 201, 43-45).—The method of investigation of the electrolysis of nickel and cobalt chloride solutions was similar to that for zinc chloride (cf. *Compt. rend.*, 1935, 200, 380). The solutions contained 80 gm./litre of the salt, the electrodes being platinum, and the current density 1, 2, and 4 amp./dm.². The anodic phenomena were the same as in the case of zinc: for low alcohol content, a little of the chlorine evolved escaped into the air, and the rest reacted with the solvent to form hydrochloric acid and to oxidize the alcohol to aldehyde; at higher concentrations (150 gm./litre) the conversion of the acid is virtually complete. In the case of nickel, there is at the cathode no metallic deposit, but a deposit of a hydrated oxide of nickel and a strong evolution of hydrogen. In solutions of low alcoholic content, as in water, this deposit is black, and in stronger solutions lighter. After drying, this deposit was found to contain 50-55% of nickel. As the electrolysis is continued, the acid formed at the anode dissolves the cathodic deposit, and metallic nickel is deposited. The effects of the alcohol content, the current density, and the time on this nickel deposit are recorded. In the case of cobalt, the results at the cathode are the opposite. In a neutral solution there is always a very pure deposit of cobalt and an evolution of hydrogen, the yield decreasing with the time, with an increase of the current density, and with increase of alcohol content up to 100 gm./litre, after which it increases. As with nickel, but differing from zinc, the theoretical yield in hydrogen calculated by difference is never attained.

—J. H. W.

*Electrodeposition of Iron-Nickel Alloys.—II. F. Marschak, D. Stepanow, and L. Lewius (*Z. Elektrochem.*, 1935, 41, 596-597).—Cf. *Met. Abs.*, 1934, 1, 430. The influence of the temperature, total concentration of Fe²⁺ and Ni²⁺ and current density on the composition of the deposit obtained in the electrodeposition of iron and nickel from a mixture of the solutions of the simple salts was determined.—J. H. W.

*The Solution of the Electrodeposit of Iron-Nickel Alloys. (Stepanow, Marschak, Balaschowa, and Kabanowa.) See p. 516.

*The Electrodeposition of Tin and Its Alloys. I.—The Effect of Addition Agents on the Deposition of Tin from Alkaline Stannate Baths. Lawrence E. Stout and August Erspamer (*Electrochem. Soc. Preprint*, 1935, (Oct.), 57-65).—Lactic acid appears to be the best addition agent in the plating of tin from alkaline stannate baths. A concentration of 0.6 gm./litre gives the best deposit. Malic acid, ethylene, glycol, and tartaric acid also worked well, although they did not give quite as good deposits as did lactic acid. Other additions studied were sodium perborate, sodium baborate, casein, glucose, aloin, starch, triethanolamine, and glycerine. Increasing the alkalinity of the bath reduces the weight of the deposit. Varying the concentration of the addition agent has an effect on the weight of the deposit. With some addition agents a certain concentration of the agent causes a maximum weight of deposit to form, while with others a deposit of minimum weight forms.

—S. G.

Tin Plating of Pistons is Held under Close Control. F. B. Jacobs (*Steel*, 1935, 96, (11), 50, 52).—A short description of the electrodeposition of tin on

cast-iron automobile pistons. The thickness of the coating, which is applied to facilitate running-in, is 0.001 in.—C. E. H.

Dropping Tests for Determining the Local Thickness of Electrodeposited Zinc and Cadmium Coatings. R. O. Hull and P. W. C. Strausser (*Cadalyte Service Bull.*, 1935, 3, (1), 5-12; and *Met. Ind. (N. Y.)*, 1935, 33, 133-134).—See *Met. Abs.*, this vol., p. 237.—A. R. P.

The Thickness of Electrodeposits and Its Determination. O. Macchia and V. P. Sacchi (*Industria meccanica*, 1934, 12, 957-960; 1935, 13, 13-16, 109-113, 216-219, 319-323, 416-419; *C. Abs.*, 1935, 29, 5357).—The protective value of electrolytic deposits as a function of thickness is investigated, factors which influence uniformity of the deposit are discussed, and means to determine the thickness described. The paper deals exhaustively with the various metals deposited on different metallic bases, curves give the required thickness for protection from corrosion, and tables give solutions for the removal of deposits used in measuring the thickness. The chemical method for thickness determination is considered to be the most precise, as a definite area can be selected from which the deposit is removed without destroying the remainder; the deposit can easily be restored, without leaving a trace, and, especially, the method can be applied to objects of irregular shape. A *bibliography* of 49 references is given.—S. G.

***Throwing Power. I.—The Method for Its Determination and Definition.** Yoshiki Ogawa and Eiichi Nishikata (*J. Electrochem. Assoc. (Japan)*, 1935, 3, 149-152; *C. Abs.*, 1935, 29, 5750).—The throwing power of copper sulphate-sulphuric acid solutions with varying concentrations was determined at 30° C. and a current density of 1 amp./dm.² in a cell with diaphragm. In general, the throwing power increases with increase in sulphuric acid concentration. Complicated relations were found when the copper sulphate concentration was varied and the sulphuric acid concentration kept constant. The neutral solution shows a negative throwing power irrespective of the copper sulphate concentration. In a 0.5*N* sulphuric acid solution, the throwing power decreases with increasing copper sulphate concentration. With 2*N* sulphuric acid there is a rapid decrease of the throwing power with increase in copper sulphate concentration up to 1*N*, and then a gradual increase.—S. G.

Discussion on Cyanide Baths. M. Vaudroz (*Galvano*, 1935, (39), 17-20).—The fact that an excess of cyanide in a copper bath prevents the copper depositing, whilst it has no such effect on a silver bath, is explained by reference to the structures of the complexes formed in the two cases.—C. E. H.

The Mode of Operation of Modern Conveyor Vats for the Production of Electrodeposited Metallic Coatings. — (*Elektrotech. Anzeiger*, 1934, 51, 712-714).—A description of the main features of the different varieties of baths of this type, with a discussion of their advantages as regards quality of finish and output. The control of the bath, preparation of the work, and methods of circulating and filtering the electrolyte are also discussed.—C. E. H.

Further Principles of Electrochemistry Applied to Electrodeposition. VIII.—Buffering the Plating Solution. Samuel Field (*Met. Ind. (Lond.)*, 1935, 47, 378-379).—J. H. W.

The Specification of Electrodeposited Coatings. S. Wernick (*Indust. Chemist*, 1935, 11, 155-156, 233-234, 239, 275-276, 315-317).—Cf. *Met. Abs.*, this vol., p. 168. The characteristics and methods of producing electrodeposits of cadmium, zinc, nickel, and chromium are discussed from the point of view of the formulation of definite specifications for quality and methods of testing. Specifications for both anodic and cathodic deposits are advocated, and a specification for a nickel-chromium finish, which has been successfully employed for several years, is reproduced.—C. E. H.

Modern Methods of Electroplating. — (*Indust. Chemist*, 1935, 11, 343-352).—A detailed, illustrated account of the nickel and chromium plating

of automobile radiator shells, hub-caps, &c., at the Osberton Works of Morris Motors, Ltd. Continuous automatic operation is employed for cleaning and nickel plating, and batch operation for chromium plating.—C. E. H.

Electroplating Methods. W. A. Koehler (*Metal Cleaning and Finishing*, 1935, 7, 227-230; *C. Abs.*, 1935, 29, 5024).—The procedures employed in the electrodeposition of cadmium, aluminium, antimony, arsenic, chromium, and tungsten are described. Bath compositions are given.—S. G.

British Standard Specifications for Cyanides (Classes A and B) Suitable for Electroplating. — (*Brit. Stand. Inst.*, 1935, (622), 19 pp.).—S. G.

VII.—ELECTROMETALLURGY AND ELECTROCHEMISTRY

(Other than Electrodeposition.)

(Continued from p. 475.)

***The Electrochemical Behaviour of Lead, Lead-Antimony, and Lead-Calcium Alloys in Storage Cells.** H. E. Haring and U. B. Thomas (*Electrochem. Soc. Preprint*, 1935, Oct., 163-177).—Electrochemical theory indicates that for the manufacture of grids and plates for storage cells the lead used should be alloyed with a metal which is electronegative to lead and that the required physical properties should be secured by the addition of small quantities of uniformly distributed alloying constituents which have little tendency to diffuse or segregate. In both these respects calcium-lead alloys are superior to antimonial lead. Plates of the former take 10 times as long to sulphate as plates of the latter under a static discharge and they behave both anodically and cathodically like pure lead. Storage batteries made up with calcium-lead alloy plates retain their charges for a much longer time than do ordinary batteries with antimonial lead plates and have a higher efficiency; in addition the plates are much less prone to corrosion. Anode potential-time curves for lead, calcium-lead, and antimonial lead with current densities of 0.001-0.1 amp./dm.² are given to show the superiority of the calcium alloys in dynamic conditions.—A. R. P.

***On the Potential of Metals in Solution of Foreign Ions.** O. Essin and M. Lozmanova (*Zhurnal Obshchei Khimii (J. General Chem.)*, 1934, [A], 4/66, (8), 1138-1146).—[In Russian.] See *Met. Abs.*, 1934, 1, 432.—M. Z.

***The Theory of Passivity.—XXVIII.** W. J. Müller (*Z. Elektrochem.*, 1935, 41, 641-653).—*Cf. Met. Abs.*, this vol., p. 230. Continues the exposition of M.'s theory of passivity, including the anodic behaviour of iron in sodium chloride and hydrochloric acid solutions.—J. H. W.

IX.—ANALYSIS

(Continued from pp. 475-479.)

Bibliography of Microchemical Work Appearing During the Year 1934, with Supplementary Data Concerning 1932 and 1933. — (*Beiheft zu Mikrochemie*, 1935, 17, 80 pp.).—S. G.

***On the Spectrographic Detection of Tin in Copper.** J. E. R. Winkler (*Z. anorg. Chem.*, 1934, 218, 45-48).—Homologous line-pairs are given for use in the spectrographic determination of up to 14% Sn in bronzes.—A. R. P.

Methods for the Chemical Analysis of Elektron. N. F. Guseva and R. S. Molchanova (*Zavodskaya Lab. (Works' Laboratory)*, 1932, (3), 31-34; *C. Abs.*, 1935, 29, 6525).—[In Russian.] The first method depends on the different solubilities of Cu and Cd in CH₃COOH. To about 1 grm. of the metal covered with 5 c.c. H₂O is added dropwise 20-25 c.c. 80% CH₃COOH. Then 50 c.c. of

H₂O is added and the whole boiled no longer than 10–15 minutes. After filtering, the Cd in the cold filtrate is precipitated with H₂S. After 2–3 hrs. the precipitate is filtered off, washed until free from H₂S, and dissolved on the filter with hot HCl (1 : 3). The solution is evaporated in a weighed porcelain crucible with 2 drops H₂SO₄ to remove the HCl, then heated at 300°–400° C. in an electric furnace or on a sand-bath, and the Cd weighed as CdSO₄. The precipitate containing the Cu (insoluble in CH₃COOH above) is dissolved in HNO₃, diluted with H₂O, and the Cu determined electrolytically. To determine Al : after dissolving 1 grm. of the metal in HCl and precipitating the Cu and Cd hot (40°–45° C.) with H₂S, the Al in the filtrate is precipitated by the addition of NH₄OH and NH₄NO₃ or NH₄Cl, the precipitated Al(OH)₃ ignited and weighed as Al₂O₃. Mn is determined by the persulphate method. According to the second scheme, the Cu and Cd are separated from the other metals as sulphides. The Cu is then precipitated electrolytically in HNO₃ solution and the Cd, which remains in solution, determined as sulphide. Si is determined in the usual manner by oxidation with HNO₃, evaporation with HCl, and subsequent treatment of the precipitate with HF. When Zn is present it is determined in the filtrate as ZnS or as Zn₃P₂O₇ after the removal of the Al.

—S. G.

Analysis of Nickel-Aluminium-Iron Alloys. Ernest C. Pigott (*Indust. Chemist*, 1935, 11, 273–274).—Fe and Cu are precipitated with cupferron, and the Cu washed out of the residue after filtration by means of NH₄OH. The residue is then ignited to Fe₂O₃ and weighed. The filtrate from the cupferron precipitation is treated with NH₄OH in order to precipitate Al, and when the latter has been filtered off, Ni is determined in the filtrate by the glyoxime method. A table of the reactions of all the probable constituents of these alloys is appended.—C. E. H.

***The Behaviour of Copper on Fusion with Soda and Sulphur.** Robert Høltje and Walter Kahmen (*Z. anorg. Chem.*, 1935, 223, 234–240).—Fusion of materials containing Cu with S and Na₂CO₃ for the separation of As, Sb, and Sn from Cu results in appreciable amounts of Cu passing into the aqueous solution of the melt; the Cu can be precipitated partly by addition of NaOH, Na₂S, or Na₂SO₃ to the solution, but a small amount of Cu, depending on the nature and amount of the accompanying metal, still remains in solution. A repetition of the whole process is necessary when much As, Sb, or Sn is present, but even then 0.5–1 mg. of Cu may fail to be recovered.—A. R. P.

***On the Separation of Tin with Nitric Acid [in the Analysis of Alloys] and the Contamination of the Tin Dioxide with Other Metals.** Woldemar Tilk and Robert Høltje (*Z. anorg. Chem.*, 1934, 218, 314–320).—The quantities of Cu, Pb, Zn, Ni, and Fe retained by the SnO₂ precipitate when Sn alloys are dissolved in HNO₃ and the solution evaporated to dryness have been determined. Retention of impurities is least when concentrated HNO₃ is used for the decomposition of the alloy.—A. R. P.

***On the Electrolytic Deposition of Metals from their Pyrophosphate Solutions.** Shiro Koyanagi (*Bull. Chem. Soc. Japan*, 1935, 10, 355–356).—[In English.] A study of the electrodeposition of Ni, Fe, Co, Cu, Cd, and Zn from their complex pyrophosphate solutions with Classen's electrode, to determine the value of this method in quantitative analysis. Fe was not completely deposited, but with the other metals very trustworthy results were obtained. Working details are given.—C. E. H.

The Rapid Determination of Alkali Metals in Metallic Aluminium and Magnesium, and Their Alloys. N. I. Chervyakov (*Zavodskaya Lab. (Works' Laboratory)*, 1932, (4), 29; *C. Abs.*, 1935, 29, 6526).—[In Russian.] 10 grm. Hg and 2–3 grm. Pb (the latter is added in order to obtain a readily fusible amalgam) are added to the sample of metal and the whole is heated with a Teclu burner. The amalgam obtained is decomposed with water, when the

alkali metals dissolve to give hydroxides, which are converted into carbonates by bubbling CO_2 through the solution. After filtering off the residue, the carbonate is determined by titration.—S. G.

***Precipitation of Aluminium with Hydrogen Ammonium Carbonate.** Toshio Kozu (*Bull. Chem. Soc. Japan*, 1935, **10**, 356-359).—[In English.] A method for the determination of Al is worked out, in which the Al is precipitated as a basic carbonate by means of a solution of $(\text{NH}_4)_2\text{CO}_3$ saturated with CO_2 . The solution is then heated to expel CO_2 and NH_3 , and the precipitate is filtered off, ignited, and weighed as oxide.—C. E. H.

Methods for the Determination of Small Quantities of Antimony in Variegated Metal Alloys. V. F. Vetoshkin (*Zavodskaya Lab. (Works' Laboratory)*, 1932, (3), 31-34; *C. Abs.*, 1935, **29**, 6526).—[In Russian.] A simplified combined method for the determination of Sb in Cu, Ni, Pt, Zn, and their alloys according to Blumenthal, Evans, and Clark is described.—S. G.

The Determination of Small Quantities of Arsenic in Metals and Ores by Precipitation with Sodium Hypophosphite. S. Yu. Fainberg and L. B. Gintzburg (*Zavodskaya Lab. (Works' Laboratory)*, 1932, (7), 23-29; *C. Abs.*, 1935, **29**, 6526).—[In Russian.] Detailed instructions are given for a method very similar to that of Evans (*J. Inst. Metals*, 1929, **42**, 534). The determination of As in non-ferrous metals (Cu, Ni, Cd, Bi, Pb, Sn, and Sb), in alloys (brass, bronze, and bearing alloys containing Sn and Pb), and in ores is described.—S. G.

***On the Analysis of Bismuth by Means of Selenious Acid.** Otozo Funakoshi (*Bull. Chem. Soc. Japan*, 1935, **10**, 359-362).—[In English.] An investigation of the possibility of determining Bi quantitatively, by precipitation with H_2SeO_3 as bismuth selenite. The metals Cu, Cd, Fe^{++} , Al, Co, Mn, Zn, Ca, Li, Na, and K were found not to be precipitated by H_2SeO_3 , but Hg, Pb, Sn^{++} , Sb, Ag, Ba, Sr, Mg, Ti, and Th are precipitated at certain concentrations and make the determination somewhat uncertain. The precipitation should be carried out in HNO_3 solution below 0.5*N*, and it is found that more accurate results are obtained by igniting the precipitate to oxide, than by weighing it as selenite.—C. E. H.

***The Use of a New Reagent for the Gravimetric Determination of Some Metals. II.—Macro- and Micro-Determination of Cadmium.** G. Spacu and M. Kuraš (*Z. anal. Chem.*, 1935, **102**, 108-110).—In ammoniacal solution Cd is precipitated quantitatively by alcoholic mercaptobenzthiazole as a white crystalline diamino-complex which on drying at $110^\circ\text{-}120^\circ$ loses NH_3 and is converted into $[\text{C}_6\text{H}_4(\text{S})\text{N}(\text{CS})_2\text{Cd}$ (25.3% Cd).—A. R. P.

***The Use of a New Reagent for the Gravimetric Determination of Some Metals. I.—Determination of Copper.** G. Spacu and M. Kuraš (*Z. anal. Chem.*, 1935, **102**, 24-28).—An alcoholic solution of mercaptobenzthiazole precipitates Cu completely from neutral or $\text{CH}_3\text{-CO}_2\text{H}$ solutions as an orange yellow flocculent compound which must be ignited to CuO for weighing. The method separates Cu from Co, Ni, Zn, Cd, Mn, and Mg, but not from Pb, Bi, Hg, Ag, Au, and Tl which are precipitated in similar conditions.—A. R. P.

***A New Gravimetric Method for the Determination of Lead as Lead Salicylaldoxime and Its Solubility Measurement by Using ThB as Radioactive Indicator.** Masayoshi Ishibashi and Haruo Kishi (*Bull. Chem. Soc. Japan*, 1935, **10**, 362-368).—[In English.] Pb may be quantitatively precipitated as a salicylaldoxime compound in an ammoniacal solution of p_{H} somewhat above 6.5. The compound is filtered off, washed with alcohol, dried at 105°C ., and weighed. It contains 60.81% lead, and its solubility in water at 25°C . is 1.37×10^{-3} gm./litre. Pb may be determined by this method in the presence of Cu.—C. E. H.

***The Electrolytic Determination of Lead as Dioxide and Its Conversion into Lead Monoxide by Ignition.** A. J. Lindsey (*Analyst*, 1935, **60**, 598-599).—It is well known that the anodic deposition of PbO_2 does not afford a deposit

of sufficiently constant composition for weighing. Attempts to convert the deposit into pure PbO by heating in an electric furnace at 700° C. invariably gave low results probably owing to loss by volatilization.—A. R. P.

***Volumetric Determination of Manganese by the Use of Induced Oxidation from Manganous Salt to Manganimetaphosphoric Acid.** Rudolf Lang (*Z. anal. Chem.*, 1935, 102, 8-16).—The cold nitrate or sulphate solution containing 5-40 c.c. of free acid in a volume of 180 c.c. is treated with 5-10 gm. of HPO_3 , 0.1 c.c. of a 1% solution of diphenylamine in HPO_3 , 50-60 c.c. of $\text{K}_2\text{Cr}_2\text{O}_7$ solution (15 gm./litre), and 50-60 c.c. of As_2O_3 solution (15 gm./litre of 1.5% Na_2CO_3 solution). The resulting deep-red solution of manganimetaphosphoric acid is titrated with 0.1N- FeSO_4 solution until the colour changes through violet and blue to a sharp green end-point. The method gives rapid and accurate results for Mn in alloys containing Cu, Fe, Ni, Cr, or Co.—A. R. P.

***A Rapid Photometric Method for the Determination of Silicon in Light Alloys.** Hans Pinsl (*Z. Metallkunde*, 1935, 27, 107-114; and (summary) *Light Metals Research*, 1935, 4, 1-3).—Al alloys (0.1 gm.) are dissolved in 10 c.c. of 15% NaOH solution containing 10 drops of 3% H_2O_2 in a Ni dish covered with a Ni lid. After 10 minutes the solution is poured into 11 c.c. of 1:1 HCl and the mixture warmed until a clear solution is obtained; a few drops of KMnO_4 solution are added to colour the liquid pink, and the colour is discharged by the cautious addition of $\text{H}_2\text{C}_2\text{O}_4$. After cooling, 5 c.c. of 20% $(\text{NH}_4)_2\text{MoO}_4$ solution are added, the solution is shaken, and the yellow colour is compared with that of a freshly prepared standard after 3 minutes using a Pulfrich photocolourimeter. Mg alloys (0.1 gm.) are dissolved in a mixture of 8 c.c. of HNO_3 (*d* 1.11), 20 c.c. of H_2O and 10 drops of 3% H_2O_2 , 1 c.c. of HCl is added, and the KMnO_4 , $\text{H}_2\text{C}_2\text{O}_4$, and $(\text{NH}_4)_2\text{MoO}_4$ treatments are carried out as for Al alloys.—A. R. P.

Pure Titanium Oxide as a Standard in the Volumetric Estimation of Titanium. W. W. Plechner and J. M. Jarmus (*Indust. and Eng. Chem. (Analyt. Edn.)*, 1934, 6, 447-448).—A method for preparing pure TiO_2 by hydrolysis of fractionally distilled TiCl_4 in dilute $\text{H}_2\text{C}_2\text{O}_4$ solution is described.—A. R. P.

***The Electrolytic Deposition of Zinc from Acid Solutions.** Hisashi Kiyota (*Bull. Chem. Soc. Japan*, 1935, 10, 353-354).—[In English.] The object of the investigation was to develop an electrolytic deposition method for the analytical determination of Zn. This had previously presented difficulties owing to the unsuitable type of deposit obtained. It was found that the best deposits were obtained with an acetic acid solution containing CH_3COONa , and in this way accurate quantitative results could be obtained. Full experimental details are given, together with the effects of various salts on the nature of the deposit.—C. E. H.

X.—LABORATORY APPARATUS, INSTRUMENTS, &c.

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

(Continued from p. 479.)

An Outfit for Photomicrography. H. Wrighton (*J. Roy. Microscop. Soc.*, 1935, 55, 79-82).—A new apparatus, providing critical illumination for examining metal specimens over the range 4-2500 magnifications, is described. A special feature is the use of short-focus micro-anastigmat lenses, working without an eye-piece, for photography at low magnifications. These have a sufficiently long free-working distance to permit the use of a glass slip reflector between lens and object. Critical vertical illumination is thus obtained.

—J. C. C.

Principles of Phototechnics Applied to Metallography. R. Servant (*Métaux*, 1935, 10, 115-130).—The theory of light as required for metallographic photography, photographic plates, light filters, printing papers, and practical observations on the taking of metallographic photographs are discussed.

—J. H. W.

Laboratory Electric Furnaces for Very High Temperatures. Henri George (*J. Four élect.*, 1935, 44, 285-289).—The construction of compensated helicoidal resistor furnaces for obtaining temperatures up to 2000° C. is described.

—J. H. W.

A Practical Apparatus for the Determination of the Gas Content of Metals. — (*Giesserei-Praxis*, 1935, 56, 412-413).—A description is given of the Straube-Pfeiffer apparatus for determining the gas content of metals. The fluid metal is placed under a bell-jar connected to a high-vacuum pump, and the evolution of gas during solidification under atmospheric pressure or any desired degree of vacuum can be observed.—J. H. W.

***A Method for Casting Molybdenum Buttons in Brass, for Water-Cooled Targets in X-Ray Tubes.** F. H. Trimble (*Rev. Sci. Instruments*, 1935, 6, 216).—A simple electric arc furnace, assembled from simple laboratory apparatus, is described.—J. S. G. T.

***An Illuminator for Printing Laue (X-Ray Crystal) Photographs.** C. H. Dwight and H. Kersten (*Rev. Sci. Instruments*, 1935, 6, 287).—When Laue photographs are made with a small distance between crystal and film the central portion of the photograph is usually over-exposed. A device for illuminating the photograph when making prints from it so that nearly as much detail can be seen on the positive as was visible on the original negative when viewed by transmitted light, is described.—J. S. G. T.

***A Technique for X-Ray Studies of Substances under High Pressures.** Ludo K. Frevel (*Rev. Sci. Instruments*, 1935, 6, 214-215).—Laboratory apparatus, utilizing the pressure produced in heated toluene or the tension produced in the same air-free liquid when cooled, and suitable for determining linear coefficients of compressibility of crystalline solids and the X-ray study of substance under tension is briefly described.—J. S. G. T.

†Magnetic Methods for Attaining Extremely Low Temperatures. P. Debye (*Z. tech. Physik*, 1934, 15, 499-504).—See *Met. Abs.*, this vol., p. 173.—J. T.

New Method for the Dry Purification of Mercury. — Ziener (*Glas u. Apparat*, 1934, 15, 187-189; *C. Abs.*, 1935, 29, 4975).—Pass a current of cotton-filtered air at atmospheric temperature through the mercury for 4-5 hrs.; cool the air as it leaves the mercury and pass through a tower of activated bone charcoal containing iodine which completely absorbs any entrained mercury. This gives a technically pure product suitable for gauges, &c. To obtain a product suitable for thermometers (at least 99.6% mercury), continue passing air and gradually increase the temperature to 105° C. in 2 hrs., keep at this temperature for at least 15 minutes and filter repeatedly through paper cones perforated with a fine hole. Pure mercury has a brilliant surface; when 100 c.c. is shaken for 15 minutes in a white 1-litre flask the surface must not be covered with a dull film. The method is economical, simple, and free from danger, and the mercury retained by the charcoal or the impurities can be recovered easily.—S. G.

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

(Continued from pp. 479-480.)

***The Use of the Hele-Shaw Apparatus in the Investigation of the Flow of Metals.** A. M. Herbert and F. C. Thompson (*Iron Steel Inst. Advance Copy*, 1935, Sept., 1-8).—The Hele-Shaw apparatus used for the study of stream-

line flow of fluids has been applied to the study of the flow of metals in hot- and cold-working. Typical drop forgings, tubes, and, particularly, wire were investigated, and the degree of agreement with actual work is good. The extent to which quantitative as well as qualitative information can be obtained is indicated, and some of the limitations of the method are pointed out.—J. H. W.

Some New Fatigue Testing Machines. J. S. G. Primrose (*Trans. Manchester Assoc. Eng.*, 1934–1935, 147–152).—Reference is made to the trend towards the testing of fabricated structures, wires, and ropes instead of machined specimens in fatigue machines. Brief descriptions are given of the Pulsator, which applies 250–700 load impulses per minute to the test-piece under load in any hydraulic testing machine, and a torsion testing machine which applies repeated stresses in one direction or in alternate directions, as required.—J. C. C.

Relations Between Cohesion and Plasticity (On the Tensile Effect of Stretched and Compressed Specimens). W. Kuntze (*Mitt. Material., Sonderheft 26*, 1935, 121–122).—See *Met. Abs.*, this vol., p. 175.—B. Bl.

Bending Tests and Resiliency Tests of Metals. F. Figari (*Industria meccanica*, 1935, 17, 501–506; *C. Abs.*, 1935, 29, 5790).—Views which consider a resiliency test sufficient for determining the structure are reviewed. Without a bending test no certain results can be derived. There may even occur reversals owing to temperature, *i.e.* a metal which proved to be superior to another at 15° C. may be inferior to it at –20° C. The bending test is considered to be by far the better test. (See also following abstract).—S. G.

Further Considerations on Bending and Resiliency Tests. St. Menghi (*Industria meccanica*, 1935, 17, 507–509; *C. Abs.*, 1935, 29, 5790).—See also preceding abstract. The views expressed formerly that the resiliency test can give valuable information regarding the structure of a material are defended; limitations and procedures are discussed briefly.—S. G.

Analysis of Tensile Tests. I. Oding (*Tech. Physics (U.S.S.R.)*, 1934, 1, 101–107).—[In Russian.] Mathematical.—S. G.

RADIOLOGY.

X-Ray Measurement of Elastic Stresses. R. Glocker (*Z. Metallkunde*, 1935, 27, 196–198).—The mathematical principles underlying the determination of internal stress in metals are explained, and the formulæ derived are confirmed by tests on steel tubes and rods.—A. R. P.

XII.—TEMPERATURE MEASUREMENT AND CONTROL

(Continued from p. 481.)

†**Errors in the Measurement of Temperatures with Thermocouples (Hints for the Practical Use of Thermocouples and Protection Tubes).** Hans Euler and Kurt Guthmann (*Arch. Eisenhüttenwesen*, 1935–1936, 9, 73–90).—The composition, range of usefulness, thermo-electric power, and electrical conductivity of, and effects of temperature and gas atmospheres on the elements of numerous base and precious metal thermocouples are tabulated and discussed and means for overcoming the effect of errors introduced by the resistance of the wires, ageing phenomena, and variations in the temperature of the cold-junction are described. The composition, properties, and use of metallic and ceramic protection tubes are also tabulated and discussed. A bibliography containing more than 40 references to books and periodical and trade literature is appended.—A. R. P.

XIII.—FOUNDRY PRACTICE AND APPLIANCES

(Continued from pp. 481-482.)

***The Shrinkage of Castings and Its Effects.** E. Scheuer (*Metallwirtschaft*, 1935, 14, 337-344, 365-367; and (translation in summary) *Light Metals Research*, 1935, 3, 402-409).—The causes and prevention of pores and pipes produced in castings by shrinkage in the volume of the metal in the solidification range and in the solid state are discussed at length. The direction of the temperature gradient in the casting determines whether the pipe is open, penetrates deep into the metal, or is totally enclosed. Alloys which have a solidification range may have many small cavities in the casting, the shape of which depends on the nature of the alloy; these pores are difficult to distinguish from those produced by a gas content in the metal. Shrinkage cracks and the effect of various types of cavities on the mechanical properties of the metal are also discussed as well as the bearing of the theoretical aspects on the practical side.—v. G.

The Casting Properties, Mould Capacity, and Fluidity of Cast Metals and Alloys. H. Obermüller (*Giesserei-Praxis*, 1935, 56, 413).—The effect on the melting of metals and alloys of the specific heat, heat of fusion, melting point, tendency to gas absorption in overheating, shrinkage, and solidification behaviour is discussed.—J. H. W.

†**Deoxidation and Degasification of Metals. Developments in Refining Methods.** Henry Lepp (*Met. Ind. (Lond.)*, 1935, 47, 315-318, 341-345).—Theoretical considerations regarding metal-gas systems, the nature of these systems, the solubility of gases in alloys and their effect on the solidified metal are discussed. Deoxidation by magnesium, aluminium, calcium, &c., and by means of slags, methods of refining, selective oxidation, the influence of oxidation products, and the elimination of sulphur are described. A bibliography of 103 references is appended.—J. H. W.

Some Hints for Aluminium Foundries. H. Nipper (*Light Metals Rev.*, 1935, 2, 76-78).—Translation in summary from *Giesserei*, 1935, 22, 287-289. See *Met. Abs.*, this vol., p. 393.—L. A. O.

***On the Action of Chloride Fluxes on Oxides Contained in Aluminium.** Takayasu Harada (*Bull. Chem. Soc. Japan*, 1935, 10, 379-390).—[In English.] Melts of aluminium were treated with the following chlorides: Na, K, NH₄, Li, Ca, Mg, Ba, Ni, Mn, Zn, Al, Fe(II), Cu(II), Sn(II), Si, Ti, and C. The melts after treatment were cast and subjected to analysis and micrographic examination, whilst the gases evolved were absorbed by silver nitrate solution in order to determine their chlorine content. Comparative experiments were carried out to determine the extent of decomposition of the various chlorides when heated to the same temperature out of contact with aluminium. None of the ingots contained chlorine after treatment. All the chlorides had some cleaning action on the oxides in the metal, and it is concluded from the results that this is due to the chlorine evolved when they decompose under the action of heat. Chlorine alone passed into the melt was very effective, and of the chlorides, the most easily decomposed had the greatest effect. It was found that iron, silicon, copper, and zinc had higher ignition temperatures than aluminium in a chlorine atmosphere, so that a loss of these constituents when treating an alloy is improbable. Nitrogen also has a good cleaning effect, and it is suggested that the action of all the fluxes and gases investigated is a purely mechanical one. Thus any gas or any flux which evolves a gas on heating, and imparts no harmful constituent to the aluminium could be used.—C. E. H.

†**The Casting of Ingots of Aluminium Alloys for Rolling, with Special Reference to the Mould Question.** A. v. Zeerleder (*Metallwirtschaft*, 1935, 14, 545-548).—To obtain smooth castings the mould should be made of pearlitic

cast-iron and should have been annealed for some hours at 800°–900° C. before use; its surface should not be too highly polished. Pure aluminium should be cast at 700° C. into moulds preheated to 400°–500° C., copper-aluminium alloys into moulds heated to 100° C., and aluminium–Mg₂Si alloys into moulds heated to 250° C. The moulds are first inclined at 20° and slowly brought upright during the casting; a smooth pour is obtained with the Zublin mould or by using a graphite pouring head. The weight of the moulds must be great enough to prevent their temperature rising by more than 100° C. so that the metal is cooled sufficiently rapidly to obtain a fine-grained structure.

—v. G.

What Has the Foundryman to Consider in the Manufacture of Aluminium Chill Castings? M. Schied (*Giesserei-Praxis*, 1935, 56, 343–348, 362–366).—The composition, physical and mechanical properties, and applications of a large number of aluminium casting alloys, the composition and construction of the moulds and their preparation (preheating and dressing), and difficulties likely to be encountered in casting the alloys are discussed.—J. H. W.

A New Type of Mould Design for Thin-Walled and Complicated Castings. F. Paschke (*Giesserei-Praxis*, 1935, 56, 387–390).—The design and manufacture of moulds suitable for the casting of automobile engine parts in light alloys are described.—J. H. W.

Methods of Removing the Casting Skin from Rolling Bars of Brass and Copper. Karl Scherzer (*Metallwirtschaft*, 1935, 14, 563–565).—A description of various planing machines.—v. G.

Metallurgy of Lead-Bronze. László Jakoby (*Bányász. Kohász. Lapok*, 1935, 68, 177–183; *C. Abs.*, 1935, 29, 6194).—Precipitation of lead can be prevented by the addition to the bronze of nickel, tin, sodium, or even lithium. Increase of lead content considerably diminishes wear, but more than 30% lead causes casting difficulties.—S. G.

***Refining Silicon-Bronzes and -Brasses.** A. P. Smiriagin (*Zvetnye Metally (Non-Ferrous Metals)*, 1934, (2), 87–103; *C. Abs.*, 1935, 29, 6554).—[In Russian.] Since Fe–Si is used in the preparation of silicon-bronzes and -brasses, the iron must be eliminated from these alloys and also some objectionable impurities such as aluminium, arsenic, tin, and antimony. The following fluxes recommended in the literature were tested: S + K₂SO₄, Na₂SO₄, CaSO₄, SiO₂ + Na₂CO₃ and SiO₂ + CuO. The first three fluxes removed aluminium and some iron, but increased the sulphur, which could not be removed by a subsequent treatment with Na₂CO₃. The other fluxes did not remove the iron. The method of refining by blowing air through the molten alloys was unsatisfactory because the silicon was also removed by this operation. In view of these failures, the coalescence method was developed. This method is based on the fact that when zinc is added to the system copper-silicon-iron, the melting point of the alloy (*e.g.* consisting of silicon 5, iron 5, zinc 15, copper 75%) is decreased and a solid phase, rich in iron, separates from the liquid within a few minutes and rises to the surface. Successful coagulation of the iron depends mainly on temperature control: below 1000° C. the separation is too slow, above 1100° C. the coagulated mass disintegrates. The optimum temperature is 1055°–1065° C. By this method about 70% of the iron can be removed. It is difficult, however, to decrease the iron content below 0.8%. Numerous tables and photomicrographs are included, and a *bibliography* of 51 references is given.—S. G.

***Casting Tests with Commercial Spelter.** Josef Klarding (*Z. Metallkunde*, 1935, 27, 93–94).—The best ingots for rolling into sheet are obtained by casting commercial zinc at just above the melting point, *e.g.* at 430° C. into moulds preheated to 300°–350° C.; in this way a large number of crystallization nuclei are present when the metal enters the mould and the structure is consequently fine-grained and homogeneous. The low casting temperature

also keeps the impurities well distributed throughout the mass. With higher casting temperatures and lower mould temperatures the ingots have a coarse-grained columnar structure which leads to cracking during rolling.—A. R. P.

†**Centrifugal Casting of Non-Ferrous Metals.** Ad. H. Ludwig (*Giesserei*, 1935, 22, 428-434).—The development of the process is reviewed and a description is given of modern machines for, and processes of, producing centrifugal castings. The effect of speed of rotation on the quality of the castings is considered and the properties of centrifugally cast metals are compared with those of chill- and sand-cast.—A. R. P.

Die-Casting of Copper Alloys. K. V. Peredel'skii (*Zvetnye Metally (Non-Ferrous Metals)*, 1935, (2), 96-102).—[In Russian.] A review.—S. G.

Die-Casting with Machines of Simple Design (—I). — (*Machinery (Lond.)*, 1935, 46, 717-720).—See *Met. Abs.*, this vol., p. 441.—J. C. C.

Die-Casting with Machines of Simple Design (—II). Charles O. Herb (*Machinery (N. Y.)*, 1935, 41, 721-725).—See also *Met. Abs.*, this vol., p. 441. Dies for casting 3 pieces at a time, for a lead battery nut with internal thread, and for casting 2 lead terminals on the ends of insulated wire cable are described and illustrated in detail.—J. C. C.

Adjustable Die-Casting Dies. — (*Machinery (Lond.)*, 1935, 46, 565-567).—See *Met. Abs.*, this vol., p. 394.—J. C. C.

***Effect of Chemical Composition of Colloids on the Cohesion of Dried Moulding Sands.** A. Glazunov and V. Petak (*14me. Congrès chim. ind., Paris, 1934*, 5 pp.; *C. Abs.*, 1935, 29, 6187).—A study was made of the cohesion of pure silica sand; clay was used as binder and drying was at 110° C. The tests were carried out with the Dietert tester. On increasing the proportion of clay, the cohesion increases to a maximum and then slowly decreases. Micro-examination showed that so long as the proportion of binder did not exceed the amount required entirely to cover the surface of the sand grains, cohesion increased; but when a larger amount of binder was used the excess formed a sponge or powder between the sand grains and produced a decrease in cohesion. Addition of colloidal Fe₂O₃ to the clay increases cohesion, and addition of silica decreases it. Preliminary experiments appear to indicate that the chemical composition of the sand influences cohesion.—S. G.

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

(Continued from p. 482.)

Tinplate Scrap (Recovery) in Italy. Salvatore Alonzo (*Ann. merceol. siciliana*, 1934, 2, 215-260; *C. Abs.*, 1935, 29, 5390).—The manufacture of tinplate and the methods for recovery of tin from tinplate scrap are reviewed.

—S. G.

Experiences in the Recovery of Tin from Tinplate. Salvatore Alonzo (*Ann. merceol. siciliana*, 1934, 2, 261-281; *C. Abs.*, 1935, 29, 5390).—The action of mixtures of hydrochloric acid and nitric acid at various concentrations is studied. Other mixtures of hydrochloric acid with oxidants (e.g. HCl-KClO₄) are useless.—S. G.

XV.—FURNACES AND FUELS

(Continued from pp. 482-483.)

Atmospheric Control in Radiant Tube Furnaces. W. M. Hepburn and H. C. Weller (*Metal Progress*, 1935, 28, (2), 41-45, 66).—A summary is given of the atmospheric conditions which normally prevail in gas-fired, electric, muffle, and "radiant tube" furnaces. The heating element of the latter is a tube of

the "immersion" type, heated in a gas of special composition; combustion proceeds under reduced pressure. The heating element may surround a thin metal hood. The complete control of furnace atmosphere renders the process especially applicable to the bright-annealing of ferrous and non-ferrous materials; suitable plant for both purposes is described.—P. M. C. R.

Combustion Research with Gas Burners of Different Mixing Characteristics.

—IV. M. H. Mawhinney (*Indust. Heating*, 1935, 2, 192–193).—See *Met. Abs.*, this vol., p. 73. A summary of the conclusions of a paper by R. Pistor (*Mitt. Wärmestelle Vereins deut. Eisenhüttenleute*, No. 151). (1) In the combustion of coke-oven gas the maximum content of carbon monoxide in the flue gases is found when the air supply is half of the theoretical amount of air for perfect combustion; (2) the quantity of hydrogen in the flame and waste gases is usually equal to or greater than the amount of carbon monoxide. The hydrogen, then, does not burn suddenly; (3) the more intimate the mixing of gas and air and the greater the excess of air, the shorter the flame; (4) the wall temperature has no effect on the flame length required for complete combustion. Kalkhof does not confirm all these results.—W. A. C. N.

†**Producer Gas for Furnace Heating.** — (*Fuel Economist*, 1935, 10, 982–984, 1007–1009).—Modern methods for using producer gas efficiently for furnace heating are discussed. Among the subjects referred to are: advantages of the multi-flame system; circular cell furnaces; pressure burners; recuperators and regenerators.—J. S. G. T.

Advances in Electric Furnace Design. Rene Leonhardt (*Chem. Eng. Min. Rev.*, 1935, 27, 254–255).—A modern German high-frequency induction furnace of 8-ton capacity for melting metals and alloys is described.—J. H. W.

Electrically Heated Heat-Treatment Furnaces for Light Metals. H. Farsky (*Aluminium*, 1935, 17, 481–483).—Two sizes of electrically-heated salt-bath furnaces for the heat-treatment of Duralumin rivets are described with reference to diagrams.—A. R. P.

Ceramic Heating Elements for Electric Furnaces. L. Litinsky (*Ceram. verrerie emaille*, 1934, 2, 523–525).—A review.—S. G.

FUELS.

Heating Values of Fuels. J. S. Doolittle (*Combustion*, 1935, 6, (11), 14–15).—S. G.

Combustion of Coal Dust. Renato San Nicolò (*Politecnico*, 1934, 82, 394–406, 454–466; *Chim. et Ind.*, 1935, 33, 1104; *C. Abs.*, 1935, 29, 5250).—Time of combustion depends above all on the fineness of the coal, and in practice it can be calculated from the exponential formula $T = kd^n$, where T is the time of combustion in seconds, d the diameter of the particles, and k a constant which depends on operating conditions (temperature, speed of air of combustion, amount of excess air, &c.); the value of the exponent n varies from 1.2 to 2 according to different authors. The optimum excess of air is a function of the volatile constituents of the coal, but on the average it corresponds to about 40% of the theoretical amount of air. The shape and size of the combustion chamber have a considerable effect on the transmission of heat; the number of calories produced per m.³ per hr. is calculated differently according as the chamber has a uniform cross-section, is prismatic or conical.—S. G.

XVI.—REFRACTORIES AND FURNACE MATERIALS

(Continued from p. 483.)

***Variations in the Pyrometric Cone Equivalent of Refractories after Reheating at Elevated Temperatures.** D. A. Dickens, S. S. Cole, and M. E. Holmes (*Bull. Amer. Ceram. Soc.*, 1935, 14, 135–138; *C. Abs.*, 1935, 29, 5240).—Samples

of 20 fireclays and 20 fire-bricks were tested "as received" and after reheating for 5-50 hrs. at 1350°-1550° C. Reheating decreased the values 1-3 cones, or in many instances increased the value 1 cone. The greatest variations were found after reheating at 1450°-1550° C. for 25 hrs. Results show that the cone equivalent after reheating to high temperatures will not necessarily be the same as the original value.—S. G.

A Quick Method for Determining Porosity of Refractory Materials. A. I. Sharfshtein and E. I. Kheifetz (*Ogneuporui*, 2, (10), 24-27; and *Zavodskaya Lab.*, 1934, 3, 732-735; *C. Abs.*, 1935, 29, 5239).—[In Russian.] The dried sample is heated for 20-30 minutes at 110°-115° C. and then boiled for 30-40 minutes in water, cooled, wiped with a moist towel, and weighed. The Sager volumometer is not sufficiently accurate. A simple device based on the hydrostatic law of Archimedes gives accurate results. It consists of a balance, one scale of which is immersed in water. The sample is put on this scale and weighed with an accuracy of 0.01 gm. The volume in c.c. is $V = P_1 - P_2 + K$, in which $P_1 - P_2$ is the loss in weight in water and K is a correction coeff. dependent on the temperature of the water.—S. G.

Characteristics of Some Special Refractory Products.—IV. Marcel Lépingle (*Rev. mat. trav. publ.*, 1933, (282), 51-54B; *Ceram. Abs.*, 1933, 12, 266).—See also *Met. Abs.* (*J. Inst. Metals*), 1933, 53, 578. Discusses data regarding German, American, French, and Swedish refractories. Among special refractories, corundum, silicon carbide, zirconium, and chromite bricks are discussed, and their characteristics are given.—S. G.

XVII.—HEAT-TREATMENT

(Continued from p. 445.)

***On the Testing of the Nitre Melt in Heat-Treatment Baths.** B. Pretsch (*Metallwirtschaft*, 1935, 14, 703-704).—The nitrite, chloride, and hydroxide content should be determined once a month and the sludge which settles to the bottom should be removed weekly.—v. G.

The Hardening of Cast Aluminium Alloys. E. Söhnchen (*Giesserei-Praxis*, 1935, 56, 306-308, 326-327).—Examples of the age-hardening of a number of aluminium alloys are given, and details of heat-treatment are described.

—J. H. W.

XVIII.—WORKING

(Continued from pp. 483-484.)

†**Researches on the Plastic Deformation of Metals.** Friedrich Körber (*Naturwiss.*, 1934, 22, 565-569).—A review of recent work on the mechanism of rolling and drawing, with special reference to rolling mild steel.—A. R. P.

Pressing Small Tinplate Containers. A. G. Arend (*Tin Printer and Box Maker*, 1935, 11, (127), 5-6).—A practical account, with notes of precautions necessary to avoid fracture of the tinplate. This method of manufacture is considerably cheaper for small containers than that in which the sides and base are made separately and soldered together.—C. E. H.

Metal Extrusion. P. Roux (*Métaux*, 1935, 10, 139-154).—The history, principles, and applications of extrusion are briefly reviewed, and details of the construction of horizontal and vertical presses are described.—J. H. W.

Metallurgical and Metallographic Principles Involved in the Production of Rolls from White Metal. V. N. Svechnikov (*Domez*, 1935, (3), 23-33).—[In Russian.] A review.—S. G.

Gold Leaf. Th. Wolff (*Metallwaren-Ind. u. Galvanotechnik*, 1934, 32, 451-453; *C. Abs.*, 1935, 29, 433).—Preparation, properties, and uses are described.

—L. A. O.

XIX.—CLEANING AND FINISHING

(Continued from pp. 484-485.)

Metal Cleaning by Tumbling and Burnishing. N. Ransohoff (*Metal Progress*, 1935, 28, (3), 57-60, 76).—A distinction is emphasized between ordinary cleaning, which aims at the removal of dirt, and tumbling, which involves some further alteration of the surface condition of the material, e.g. the removal of scale. Gentle agitation in a continuous cleaning plant suffices for the former operation, whilst tumbling is a more vigorous process, frequently assisted by the presence of hard metal "stars" which remove deposits from re-entrants. The scope of the process, and types of plant required are discussed and illustrated. Burnishing is carried out by a modification of the tumbling process; precleaning is a necessary part of the treatment, which is described.—P. R.

The Acid Pickling of Non-Ferrous Metals. P. Mabb (*Machinery (Lond.)*, 1935, 46, 661-663).—Recommendations are given for pickling baths suitable for cleaning parts of copper, nickel, aluminium, magnesium, and zinc alloys preparatory to finishing by painting or plating.—J. C. C.

An Electrolytic Method for Colouring the Oxide Films on Aluminium. Akira Miyata and Ichiro Ebihara (*J. Electrochem. Assoc. (Japan)*, 1935, 3, 60-62; *C. Abs.*, 1935, 29, 5751).—When aluminium is previously coated with a thick and porous anodic film in an oxalic acid bath, and then re-electrolyzed in an aqueous solution of 2% potassium permanganate and 0.1% sulphuric acid at 10 milliamp./cm.², manganese oxides are precipitated in the structure of the aluminium oxide film, thus giving it a fast dark green colour. A subsequent lacquer treatment greatly increases the corrosion-resistance of the film. The consumption of potassium permanganate is 0.923 gm./amp. hr.; good colouring is obtained until the potassium permanganate concentration has decreased to about 1.5%. The comparatively high energy consumption and the need for cooling are the weak points in this colouring method. Treatment with a.c. gives unsatisfactory results.—S. G.

Metal Polishes. C. A. Tyler (*Glass Packer*, 1934, 13, 777-779; *C. Abs.*, 1935, 29, 6326).—The compositions, uses, and manufacture of several types of metal polishes are reviewed.—S. G.

XX.—JOINING

(Continued from pp. 485-486.)

Solder. — (*Bull. Internat. Tin Res. Develop. Council*, 1935, (2), 54 pp.).—The publication gives a comprehensive account of tin solders, their properties, applications, and methods of use. It is divided into the following sections: (1) *Historical Note*. (2) *Methods of Soft Soldering*: An account of the constitution and properties of soft solders and a description of the different types of soldering operations. Fluxes, cored and paste solders, and the size and shape of solder sticks are discussed. (3) *Soldering Machines for Cans and Boxes*. (4) *Solder in the Development and Manufacture of the Internal Combustion Engine Radiator*: The history of the development of radiators is discussed and the types at present in use are described. An illustrated account of the manufacture of the different varieties is given. (5) *Soldered Joints in Automatic Telephone Exchanges*. (6) *General Uses of Solder*: The use of solders in plumbing, refrigerators, air-conditioning, dairy equipment, automobile body manufacture, and general sheet metal work is dealt with. (7) *Bibliography*: A classified list of 80 references.—C. E. H.

The Production of Welded and Soldered Joints in Light Metals. R. Schulze (*Elektrotech. Anzeiger*, 1935, 52, 940-944).—A general description is given of

the various modifications of electric welding, gas welding, hard soldering, and soft soldering as applied to aluminium alloys. The advantages and disadvantages, and the fields of application of the different processes are discussed.—C. E. H.

The Reaction Soldering of Aluminium. E. Herrmann (*Neue Zürcher Zeit.*, 1935, (1206); *Aluminium*, 1935, 17, 510).—Aluminium parts may be joined together by a kind of soldering operation involving coating the parts with a paste of mixed chlorides of tin, zinc, cadmium, and lead, and heating the joint until reaction of the paste with the aluminium causes an alloy of the metals of the paste to be formed which acts as a solder. The chloride paste also acts as a flux for the superficial oxide film on the aluminium and the joint is made stronger by allowing time for the alloy to diffuse into the aluminium.—A. R. P.

The Hard Soldering of Metal Sheet by Means of Silver Solder. R. J. Snelling (*Illust. Zeit. Blechindustrie*, 1935, 64, 973-974, 995-996).—By the use of silver solder an excessive temperature can be avoided, whilst the difference between the melting-points of the original and the added material is much less than when ordinary solders are used. An account, with a table of compositions and melting-points, is given of the silver solders; the special precautions demanded by their use are indicated, and the effect of certain added elements is described. Cadmium may be advantageously substituted for some of the zinc, but the proportions of copper and silver must not be decreased. Tin causes an undesirable lowering of the melting-point, and any admixture of iron or lead is harmful. Directions and compositions of the solders are given for the soldering of brass, bronze, nickel, Monel metal, Neusilber and special steel.—P. M. C. R.

Metals are Brazed in Controlled Atmosphere Electric Furnaces. H. M. Webber (*Steel*, 1935, 97, (7), 30-33; (9), 36-38, 50).—Describes the application of copper brazing to refrigerator, cash register, and other steel parts. Steel is especially easy to braze, since copper is sufficiently soluble in it for alloying to occur, but not soluble enough to diffuse into it very far. Alloys with lower melting points than copper are used for brazing non-ferrous alloys. The strength of certain brazed cash-register parts is 50-280% greater than that of corresponding parts joined by riveting. The furnace atmosphere is usually produced by partial combustion of coal-gas or natural gas, and parts are conveyed through it mechanically.—C. E. H.

Brazing for Plumbers. Horace Jenkinson (*Plumbing Trade J.*, 1935, 15, 72-73).—A brief account of the brazing of copper pipes and gun-metal fittings, with some practical details. Particular reference is made to the use of brazing solders containing silver, the melting points of which are lower than those of the older brazing solders.—C. E. H.

Welding Bronze to Steel. Charles H. Jennings (*Electric J.*, 1935, 32, 317-318).—The welding procedure for coating steel with bronze by using a metallic arc and allowing the bronze to flow about $\frac{1}{4}$ in. ahead of the arc, is described. The use of copper dams to prevent the bronze running over edges or the sides of previous layers is discussed.—J. C. C.

The Autogenous Welding of Nickel and Its Alloys. P. Modro (*Métaux et Machines*, 1935, 19, 279-280).—Improved methods of production have facilitated the welding of nickel by reducing its sulphur content. The presence of magnesium or titanium in the basis metal and of silicon in the added material appears desirable. A description is given of the welding of Monel metal.—P. M. C. R.

Distortion Control Technique. David Boyd and Gordon Cape (*Symposium on the Welding of Iron and Steel, Advance Copy (Iron Steel Inst.), Group 2*, 1935, 69-79; and *Welding Eng.*, 1935, 20, (7), 19-23).—The reduction of distortion and residual stress in large steel fabricated structures is obtained

by assembling them from smaller welded units. Preheating of the material before and during welding is carried out by means of steam coils. A careful distinction should be made between weld stresses and plate stresses, the latter being minimized at the expense of increasing the former, by using small electrodes. The use of large electrodes with high current tends to balance the two stresses.—H. W. G. H.

Safety Rules and Precautions in the Use and Handling of Oxy-Acetylene Equipment and Gases. — (*Welding Eng.*, 1935, 20, (7), 31–33).—A comprehensive list.—H. W. G. H.

XXI.—INDUSTRIAL USES AND APPLICATIONS

(Continued from pp. 486–488.)

The Progress of the Aluminium Industry, with a Particular View to New Uses for Aluminium in Recent Times. S. Kloumann (*Teknisk Ukeblad*, 1935, 82, 76–78).—A review.—S. G.

The Applications of German Light Metals at the Present Time. M. W. Nolden (*Metallwirtschaft*, 1935, 14, 704–706).—A review of the various fields in which light metals can be used.—v. G.

[German] Native Materials in Household Use. G. Ehlers (*Illust. Zeit. Blechindustrie*, 1935, 64, 965–968).—Aluminium or light alloy parts, especially when provided with an oxide coating, may be substituted for copper or brass fittings for many household purposes. For certain lighting parts difficulty in soldering renders successful substitution unlikely, but good results have been obtained with gas and air inlet pipes; aluminium, Pantal, and Anticorodal have proved satisfactory in hot-water installations, especially after protection by the Eloxal process. Owing to the varied action of different natural waters, light alloys cannot be unreservedly recommended for water piping, but good results have been obtained in the U.S.A. with washing vessels of aluminium, especially of the smaller type. Various fittings (taps, finger-plates, door and window latches, towel-rails, reflectors) are described and illustrated.—P. R.

The Standardization of Aluminium, DIN 1712, and Aluminium Alloys, DIN 1713. Wilhelm Wunder (*Aluminium*, 1935, 17, 494–496).—A critical review of the proposed German standard specifications for aluminium and some of its alloys.—A. R. P.

The Uses of Aluminium in Sewage-Disposal Plants. R. C. Wilson (*Proc. 16th Texas Water Works Short School*, 1934, 99–102; *C. Abs.*, 1935, 29, 6679).—A general review of installations in which aluminium has been applied successfully as corrosion-resistant lining in cast-iron diffuser-plate containers, cast link-bars in screens, rotary distributors for dosing trickling filter beds, &c.—S. G.

†Aluminium Cables and Insulated Aluminium Conductors. — (*Aluminium*, 1935, 17, 488–491).—A short review of the physical properties of aluminium is followed by a critical review of modern methods for joining aluminium cables and conductors. Loading tables are given for high voltage lead-covered aluminium and copper cables.—A. R. P.

Conditions of Delivery for Aldrey Wires and Conductors. — (*Metallwirtschaft*, 1935, 14, 344–345).—v. G.

Cast [Aluminium Alloy] Rotor Conductors. E. C. Wadlow (*Met. Ind. (Lond.)*, 1935, 47, 363–367).—The properties and use of cast aluminium alloys suitable for the manufacture of small squirrel cage induction motors are described. 14 references are given.—J. H. W.

Aluminium Alloy Rods for Locomotives. Brian Reed (*Met. Ind. (Lond.)*, 1935, 47, 339–340).—Continental and American experiences are reviewed.

—J. H. W.

Aluminium in Architecture. E. Herrmann (*Light Metals Rev.*, 1935, 2, 31-32).—Summarized from *Aluminium*, 1935, 17, 20-28, 322-341; see *Met. Abs.*, this vol., pp. 123, 402.—L. A. O.

Aluminium Wool as a Packing for Joints. M. H. (*Aluminium*, 1935, 17, 492-493).—Aluminium wool is a good substitute for lead wool for packing into joints, especially of pipes which are to be laid underground since it is inert towards humic acid and other soil acids.—A. R. P.

Military Bridges of Steel and Aluminium. J. P. Growden and T. Jenkins (*Military Engineer*, 1934, 26, 349-356; *Aluminium*, 1935, 17, 511).—A trestle bridge with a roadway 2.8 m. wide and a span of 15 m., made of an aluminium alloy with a breaking strength of 42 kg./mm.² and an elongation of 12%, weighs only 1.4 tons or about $\frac{1}{10}$ the weight of a similar wooden bridge. Bridges of this type have been made for the military authorities of the United States which will carry a field-gun and 10-ton tractor as well as a living load of 24 tons plus 25% for vibration.—A. R. P.

***Test of Aluminium Foil Insulation.** Haruhisa Inokuty, Teisuke Nagano, Zyunikiti Nagaoka, and Eizi Nomura (*Rikvagakū-Kenkyū-jo Iho (Bull. Inst. Phys. Chem. Res.)*, 1935, 14, 5-19).—[In Japanese.] The heat conductivity of aluminium foil (6.65 and 8.33 μ . thick) was investigated over the range 400° C. to -20° C.; it can be expressed by $\lambda = 0.042 + 0.00011t_m$. In order to study the effect of corrosion on the heat conductivity of aluminium foil, numerous small holes were made in the foil, which resulted in an increase of about 20% in heat conductivity. Aluminium foil and very thin asbestos paper were piled alternately to prevent heat conduction caused by contact of foil and corrosion resulting from electro-chemical action by moisture; the result was a decrease of heat conductivity of 10% as compared with aluminium foil only.—S. G.

***A Comprehensive Test of Aluminium Priming [on Wood].** Robert I. Wray and Junius D. Edwards (*Paint, Oil, & Chem. Rev.*, 1935, 97, (15), 11-12, 14, 16; *C. Abs.*, 1935, 29, 6774).—S. G.

Houses Built of Copper Resist Deterioration. — (*Eng. and Min. J.*, 1935, 136, 479-480).—Walls, roof and roofing accessories, in addition to plumbing and heating lines, hardware, &c., of a house in Washington were made of copper or copper alloys, the framework being of structural steel.

—R. Gr.

Heat Transfer and Pressure Drop Data for an Oil in a Copper Tube. J. F. Downie Smith (*Amer. Inst. Chem. Eng. Advance Copy*, 1934, (Nov.), 28 pp.).—Data have been obtained and mathematical expressions derived for determining the heat transfer by forced convection to a fluid within a horizontal copper tube.—A. R. P.

The Use of Nickel Utensils in the Dairy. W. Schreiber (*Molkerei-Zeit. (Hildesheim)*, 1935, 49, 231-233, 263-265; *C. Abs.*, 1935, 29, 6656).—A review of the literature, with 68 references.—S. G.

Nickel Alloys in the Paper-Making Industry. A. B. Everest (*Paper Maker and Brit. Paper Trade J.*, 1935, 89, TS 54-59).—See *Met. Abs.*, this vol., p. 451.—S. G.

***The Influence of Different Wrapping Materials [Tin Foil, Aluminium Foil] on the Keeping Quality of Butter.** F. Kieferle and A. Seuss (*Deut. Molkerei-Zeit.*, 1935, 56, 1115-1118; *C. Abs.*, 1935, 29, 6659).—The use of different wrapping materials was accompanied by decomposition in butter, decreasing in the following order: uncovered, Pergament paper, Cellophane and Ulrament paper, and tin or aluminium foil.—S. G.

The Use of Titanium in Alloying. G. F. Comstock (*Metallurgist (Suppt. to Engineer)*, 1935, 10, 47-48).—A summary of an article by C. in *Metal Progress*, 1935, 27, (1), 36-41; see *Met. Abs.*, this vol., p. 126.—R. G.

Vanadium in Industry. F. Ravier (*Chimie et Industrie*, 1935, **33**, 817-822).—Deals with the history, uses, and manufacture of vanadium and its salts. A bibliography of 42 references is given.—S. G.

New Markets and Uses for Zinc. Russell B. Paul (*Amer. Metal Market*, 1935, **42**, (186), 5).—Summary of a paper presented at the Metal Mining Convention, American Mining Congress, Chicago, in September, 1935.—L. A. O.

†**Metals and Alloys in the Pulp and Paper Industry.** J. D. Miller (*Metals and Alloys*, 1934, **5**, 263-267).—The pulp digesters and most of the fittings on the side handling hot acid liquors in the paper industry are made of some form of stainless steel or iron, but nothing superior to phosphor-bronze for the wire screens of the Fourdrinier paper machine has yet been found.—A. R. P.

Poisonous Metals in Foodstuffs. T. McLachlan and D. M. Matthews (*Food Manufacture*, 1935, **10**, 325-327).—A brief discussion of the contamination of foods by tin, lead, copper, zinc, aluminium, arsenic, and antimony, with special reference to the requirements of sanitary authorities.—C. E. H.

Smooth Metallic Screens of Any Metal, Mesh, Size, or Thickness. — (*Eng. and Min. J.*, 1935, **136**, 480-481).—Electrolytically deposited screens of copper, nickel, brass, &c., with smooth surfaces are produced by "controlled ionic migration." The screens are designed for use in photo-engraving work and in certain high-grade telephone and broadcast transmitters. Screens of 400 holes per in. and finer can be produced.—R. Gr.

Strong and Fine Metals Used on the "Normandie." Marjorie Rud Hyslop (*Metal Progress*, 1935, **28**, (3), 41-44).—An account is given of the constitution and properties of metallic materials employed in the construction and fitting of the liner "Normandie."—P. M. C. R.

The Progress of Automobile Engineering. (Sir) Henry Fowler (*Proc. Inst. Civil Eng.*, 1935, **238**, 477-502).—James Forrest lecture. Reference is made to the improvements in materials available for automobile construction. The non-ferrous metals dealt with are the light alloys including those of aluminium and magnesium, and the use of lead-bronzes for bearings.

—J. W. D.

XXII.—MISCELLANEOUS

(Continued from pp. 488-489.)

On the History of the Kaiser Wilhelm-Institut für Metallforschung. P. Rosbaud (*Metallwirtschaft*, 1935, **14**, 484-488).—v. G.

The Development of the Dürener Metallwerke A.-G. from 1885 to 1935. P. Rosbaud (*Metallwirtschaft*, 1935, **14**, 686-690).—A description of the works. —v. G.

†**Examples of Applied Metallurgy.** Werner Köster (*Metallwirtschaft*, 1935, **14**, 492-496).—v. G.

Chemistry and Metallurgy in Their Scientific Unity. G. J. Painvin (*14me. Congrès chim. ind., Paris*, 1934, 9 pp.).—An address.—S. G.

The Light Alloy Castings Industry in 1934. W. C. Devereux (*Found. Trade J.*, 1935, **52**, 21-22; and (abstract) *Light Metals Rev.*, 1935, **1**, 316-317).—The increasing use of aluminium castings during 1934 is commented upon and their applications are discussed. Although very few new applications of magnesium alloys appeared during the year, there has been a very considerable growth in their use in the automobile industry.—J. H. W.

Electrolytic Zinc Plant "Electrozinc" at Ordjonikidze (formerly Vladikavkaz). S. A. Titov (*Zvetnye Metally (Non-Ferrous Metals)*, 1935, (1), 79-91).—A description.—S. G.

Powder Metallurgy and Its Application in the Production of Hard Metal. Karl Bonthron (*Teknisk Tidsskrift Uppl. C., Bergsvetenskap* **65**, 1935, 41-47, 52-56; *C. Abs.*, 1935, **29**, 6187).—A description is given of methods for

producing filaments for incandescent lamps and hard alloys for tools by cementation of metal powders, particularly tungsten. The mechanical properties and the economic advantages of cemented hard metals are discussed.—S. G.

Gold, Silver, and "Aluminium-Bronze" Powders. Otto A. Both (*Indust. Finishing*, 1935, 11, (9), 9-11, 46-49; *C. Abs.*, 1935, 29, 6442).—The manufacture of bronze powders is briefly described. Methods for testing their quality for various purposes, the vehicles to be used, the preservation of their lustre, the colours that may be produced, and the effects obtained when mixed into coloured enamels are discussed.—S. G.

A New Metallurgical Method: Fritting. Applications: Extra-Hard Alloys; Extra-Soft Alloys. M. Oswald (*14me. Congrès chim. ind., Paris*, 1934, 14 pp.; *C. Abs.*, 1935, 29, 6545).—A review, with 20 references.—S. G.

Industry versus Dermatitis. Frank J. Oliver (*Factory Management and Maintenance*, 1935, 93, 233-234; *C. Abs.*, 1935, 29, 5197).—The causes of dermatitis are enumerated in various chemical categories, and methods for sterilizing are given for vegetable and mineral oils.—S. G.

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XXIV.—BOOK REVIEWS

(Continued from pp. 492-496.)

An Introduction to the Study of Physical Metallurgy. By Walter Rosenhain. Third Edition, revised and partly re-written by John L. Haughton. Demy 8vo. Pp. xvi + 368, with 159 illustrations. 1935. London: Constable and Co., Ltd. (20s. net.)

Dr. Rosenhain, just before his death, had proposed to publish a new edition of his "Introduction" and, in view of the rapid progress made in the subject in recent years, doubtless the book would have been completely reconstructed. The task of revision has fallen to Dr. Haughton, who has "attempted to keep intact as far as possible the character of the earlier editions" and to alter only obsolete and inaccurate parts of the book. This edition, in consequence, unlike the earlier editions, far from expresses an up-to-date presentation of a rapidly growing subject. In the chapter on mechanical testing, for example, we notice that the principal alterations have been the introduction of some 25 lines descriptive of the Erichsen and Vickers hardness testing machines and of Meyer's work, the rewriting of a comparatively small section on fatigue testing, the substitution of a description of the Haigh machine for that of an older type, and the omission of some three pages. The chapter on the effect of strain on metals remains unchanged except for the introduction of a short paragraph advising the student to read Gough's book. This and another book are given in the list of references at the end of the chapter, but, with these exceptions, the latest reference in this list is to a paper published in 1914. We believe that this chapter would have received very different treatment at Dr. Rosenhain's own hands. There would at least have been some discussion on the energy retained by a metal when it is cold-worked, a subject in which Dr. Rosenhain himself was interested and, perhaps elsewhere in the book, a more detailed account of the production of single crystals and a précis of the mass of information which the X-ray method has given about the changes which take place in a metal when it is worked and annealed.

Four chapters on the thermal analysis and microstructure of alloys, however, have been considerably changed, and a new chapter has been added. These chapters are of the quality which we should expect from Dr. Haughton, who has made the subject of which they treat very much his own. There are, for example, clear descriptions of the gradient furnace and the plotting chronograph, and the sections on the constitution and physical properties of alloys are good. The choice of typical equilibrium diagrams has perhaps been a little unfortunate. For example, the original lead-tin diagram of Rosenhain and Tucker has been allowed to remain and the selected aluminium-zinc diagram cannot be said to be "generally accepted as being substantially correct," while the ternary aluminium-copper-zinc diagrams are perhaps too overwhelming to have a place in an Introduction. About half of the new chapter is devoted to a description of the examination of the constitution of alloys by X-rays. This section has been written by Mr. G. D. Preston. We find it quite excellent, but rather too short.

The new edition is more handsome than the old, though most of the photomicrographs are old friends.—D. STOCKDALE.

The Principles of Physical Metallurgy. By Gilbert E. Doan. Med. 8vo. Pp. ix + 332, with 240 illustrations. 1935. New York: McGraw-Hill Book Co., Inc. (\$3.00); London: McGraw-Hill Publishing Co., Ltd. (18s. net).

This volume is a reprint of Dr. Doan's section of Liddell and Doan's book "The Principles of Metallurgy" (for review see *Met. Abs.*, 1934, 1, 158), with some re-grouping, revision, and slight expansion. The book is divided into three parts, The Physics of Metals, Metallography, and Metal Technology, and is essentially Part III of the larger work with the substitution of a chapter on commercial alloys for that on slags and matte. This new chapter is of less value than the old one. The approach to the subject is stated by the author to be that of classical physics and chemistry, beginning with the states of aggregation, and the object to be put before the reader the principles of metallic behaviour and not the particular properties of individual alloys or the details of processes.

The quality of the work is curiously mixed and the standard unbalanced. There is a very clear and detailed account of the types of equilibrium diagram (but with no mention of Roozeboom), but one hesitates to advise elementary students to use the book because it contains a considerable number of statements which should not be accepted without discussion. On the other hand the sections on X-rays and deformation are adequate for intermediate students and there is an instructive chapter on the shaping of metals. The author's outlook has been greatly influenced by the books of Sauerwald and Tammann, and their diagrams have been borrowed to a considerable extent. Indeed, we notice that of the 14 diagrams in the chapter on the properties of alloys, six are to be found in the 1925 (English) edition of Tammann's "Text-Book of Metallography." Certain aspects of physical chemistry are treated in somewhat naive fashion, and, in spite of the method of approach, there is mention of the electron gas theories, the exclusion principle, and the Fermi statistical method, but only, as the author hastens to add, as "fragmentary indications of the progress being made."

The information given is sometimes not quite up-to-date. There is a brief notice of Hume-Rothery's views on electron sharing in metallic crystals, but no mention of the Valency Rules. The Bellby surface layer theory is discussed and discarded, but with no mention of recent work or of the results which have been obtained by the electron diffraction method, or even of the method itself. The Fahrenheit and Centigrade scales of temperature are both used, sometimes indiscriminately, and when photomicrographs are reproduced, the magnifications are too often omitted.

On the whole, however, the merits of this book outweigh its faults. The range of information to be found within its covers is enormous, and necessarily the treatment of certain subjects must be somewhat sketchy. It is profusely illustrated, few of the diagrams being redundant and most of them being graphic. There is a full table giving the principal physical properties of the metals, and the list of books at the end of every chapter is useful, although there are no references to original papers.—D. STOCKDALE.

The Alloys of Iron and Copper. By J. L. Gregg and B. N. Daniloff. (Alloys of Iron Research Monograph Series.) Med. 8vo. Pp. xii + 454, with 182 illustrations. 1934. New York: McGraw-Hill Book Co., Inc. (\$4.00); London: McGraw-Hill Publishing Co., Ltd. (30s. net).

This book, like the others in this series, is remarkable for the thoroughness with which it deals with the subject-matter. One hardly realises, until pursuing the work of these authors, that so much research work has been conducted on the alloys of iron and copper.

In the chapter on the constitution of iron-copper alloys, the authors review in a very thorough manner the various equilibrium diagrams proposed for the binary system. This chapter, whilst it impresses the reader as being a complete account of all the researches that have been carried out, leaves the impression that the iron-copper equilibrium diagram has not, as yet, been worked out in every detail, and that further work is necessary before an accurate and complete diagram is arrived at.

The chapters dealing with the iron-copper-carbon alloys, copper-irons and -steels, the effect of copper on the structures and properties of steels, both cast and wrought, are extraordinarily complete. A prominent and useful feature of this work is that it is not only an account of data published, but is to a certain extent discursive, the authors from time to time giving their own views of the published data. The data pertaining to copper cast-iron and copper alloy steels is accurately detailed. Naturally, a large part of the work relating to the effect of copper on steels deals with its effect on the corrosion-resistance properties, and here again, one is forced to realise that copper as an anti-corrosive element in steels, has not, as yet, been completely proved.

At the end of each chapter the authors give a summary which in each case is an admirable synopsis of the matter dealt with in each respective chapter, and a summary as given by these authors would be an exceedingly useful addition to any treatise on a subject such as this.

The book is exceedingly well arranged, the printing of the photomicrographs leaves nothing to be desired, whilst the literary style is in every way excellent. The authors are to be congratulated on publishing such a treatise, which could only be possible after an exhaustive perusal of all the literature dealing with the subject. One notable feature is that English work receives as much attention as work published in other countries.—J. H. ANDREW.

Gates and Risers for Castings. Function and Application of Gates and Risers in the Production of Castings of Grey Iron, Brass, Bronze, Aluminium, Steel, and Malleable Iron. By Pat Dwyer. Med. 8vo. Pp. 364, with 244 illustrations. 1935. Cleveland, O.: The Penton Publishing Co. (\$3.15 post free); London: The Penton Publishing Co. (13s. 6d. post-free).

To those not directly concerned with the production of castings, it may appear remarkable that a book of 364 pages should be devoted exclusively to the consideration of gates and risers for castings. In a great many cases the successful production of sound castings is so intimately bound up with the correct design and disposition of heads and risers, that this aspect of foundry practice is worthy of the closest study. No hard and fast rules can be laid down for any alloy, or even for any particular design, and opinions vary widely among foundrymen as to the most suitable procedure to follow, even on similar types of castings.

The present work is intended "primarily for the benefit of foundrymen who, for any of various reasons, have not had a full opportunity of studying the subject in its almost infinite ramifications," and in a very practical manner the author draws upon his 40 years of experience and shrewd observation to review almost every conceivable type of gate and riser and its application to ferrous and non-ferrous castings.

The book is divided into five sections, with a separate complete index for each under the headings of Grey Iron, Brass and Bronze, Aluminium, Steel, and Malleable Iron. For ready reference to the special problems relating to a particular alloy, this enhances the value of the book (which would be still further increased by the numbering of the contents list), but the foundryman who desires to gain the fullest knowledge of his craft will find inspiration in plenty, if he extends his study to the methods described in the other sections of the book.

On the whole the volume is well planned, but there are instances—particularly in the section dealing with brass and bronze—where disconnected references to the same topic appear in several chapters.

This is the first comprehensive treatise to be published on this subject, and the foundryman will find sympathetic treatment of the problems which he encounters in his daily work. These are clearly explained in terms familiar to him, with the help of numerous diagrams and sketches. The price is very reasonable and the book is well bound, but the paper and printing are not of the same standard.—J. E. NEWSON.

Practical Electric Cable Jointing. By W. Maskery. Pp. viii + 120, with 37 illustrations. 1935. London: The Technical Press Ltd. (5s. net.)

Written by one who appears to have spent his life as a cable jointer, this little book describes at some length the operation of making wiped joints in cable-sheath, and also gives an account of the methods used in joining and insulating the conductors of power cables. It may be found of interest as presenting the point of view of a craftsman, proud of his work, and often observant. It is marred, however, by an inaccuracy—at times dangerously misleading—in those sections which attempt to retail theoretical matters. The lines drawn on squared paper and supposed to relate to the melting points of the solders are particularly regrettable, and should never have passed the publisher's reader. The book can thus scarcely be recommended as a manual for the apprentice.—J. C. CHASTON.



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