Contains papers to be printed in the half-yearly volume:
Journal of the Institute of Metals, 1934.
Vol. LIV.

Vol. 1. **Part 1.**

The Monthly Journal of the INSTITUTE OF METALS

and

METALLURGICAL ABSTRACTS

JANUARY, 1934

THE "MONTHLY JOURNAL" NOW CONTAINS ADVANCE COPIES OF PAPERS TO BE PRESENTED AT THE GENERAL MEETINGS OF THE INSTITUTE.

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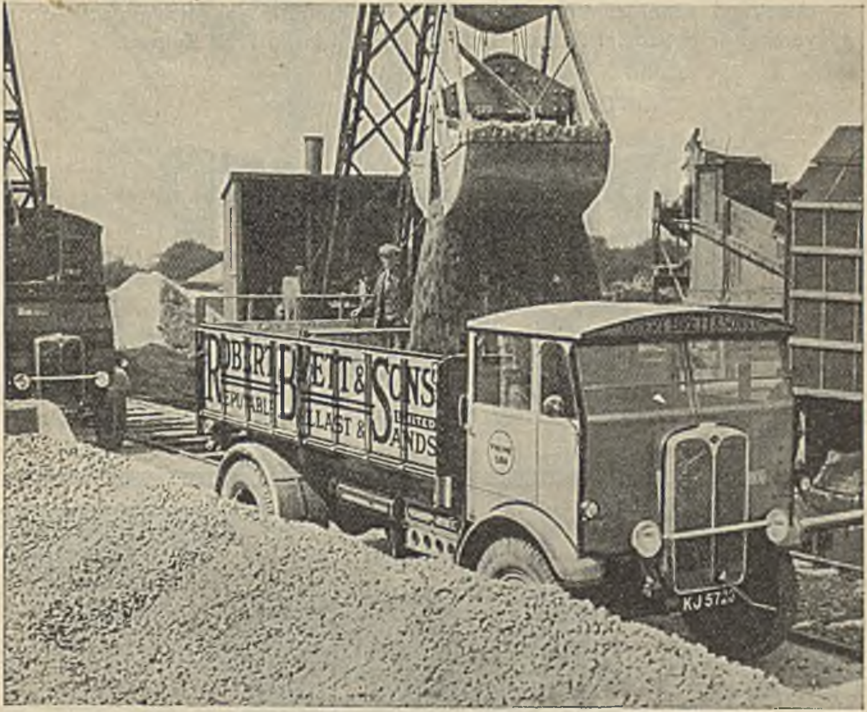
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UNIVERSITY COLLEGE OF SWANSEA.

(A Constituent College of the University of Wales.)

PRINCIPAL: C. A. EDWARDS, D.Sc., F.R.S.

APPLIED SCIENCE DEPARTMENTS.

METALLURGY.

Professor	C. A. EDWARDS, D.Sc. (Manchester), F.R.S.
Assistant Professor	L. TAVERNER, A.R.S.M., D.I.C., M.I.M.M.
Lecturers	R. HIGGINS, Ph.D. (Glasgow). R. GRIFFITHS, M.Sc. (Wales).
Assistant Lecturer	A. E. W. SMITH, Ph.D. (Birmingham).

ENGINEERING.

Professor	FREDERIC BACON, M.A. (Cantab.), A.M.Inst.C.E., M.I.Mech.E., M.I.E.E.
Lecturer in Electrical Engineering	R. G. ISAACS, M.Sc. (Bristol), B.Sc. (Lond.), A.M.I.E.E.
Lecturer in Civil Engineering	A. A. FORDHAM, B.Sc. (Lond.), A.M.Inst.C.E., M.I.Struct.E.
Lecturer	J. SELWYN CASWELL, M.Sc. (Wales), A.M.I.Mech.E.

The College offers a number of exceptional advantages to students who aim at entering upon professional careers in Metallurgy or in Engineering. It is situated in the heart of an industrial area which includes a large number of works of very varied character, and presents an unrivalled variety of metallurgical practice. The Manufacturers of the district, who contribute largely to the support of the College, give the Staff and Students of the Applied Science Departments every access to the Works, and the Managers, Engineers, and Technical Officials co-operate with the Staff of the College in making visits to Works of practical educational value to the Students.

Courses of Study are provided (1) for the B.Sc. degree of the University of Wales in (*a*) Metallurgy; (*b*) Civil Engineering; (*c*) Mechanical Engineering; (*d*) Electrical Engineering; and (2) for Diplomas of the College in (*a*) Metallurgy; (*b*) Civil Engineering; (*c*) Mechanical Engineering; (*d*) Electrical Engineering.

Persons who are not desirous of studying for Degrees or Diplomas may attend selected College classes provided they satisfy the authorities of the College that they are qualified to benefit by such classes.

Entrance Scholarships will be offered for competition in April, 1934.

Particulars concerning admission to the College, and of the Entrance Scholarships, may be obtained from the undersigned.

Singleton Park, Swansea. EDWIN DREW, *Registrar.*

APPOINTMENTS REQUIRED

By Members of the Institute of Metals.

Enquiries in connection with these advertisements should be addressed to the Box numbers given, Institute of Metals, 36 Victoria Street, London S.W.1.

EXPERIENCED CHEMIST-METALLURGIST desires post. Particulars of education and references available. Would consider post as laboratory attendant, where knowledge and experience would be useful. Opportunity for study and further experience desired. (Box No. 12.)

METALLURGICAL CHEMIST, aged 27, open for engagement. Wide experience in analysis of all metals and alloys. Specialist in non-ferrous metals, particularly Aluminium and its Alloys. Also experienced in corrosion testing, microscopic examination, and research. (Box No. 14.)

SPACE in this section of the Monthly Journal *will in future be made available to members of the Institute for the purpose of setting forth details of posts which they have to offer, or particulars of their training and qualifications with a view to securing suitable appointments.*

For particulars of rates apply to:

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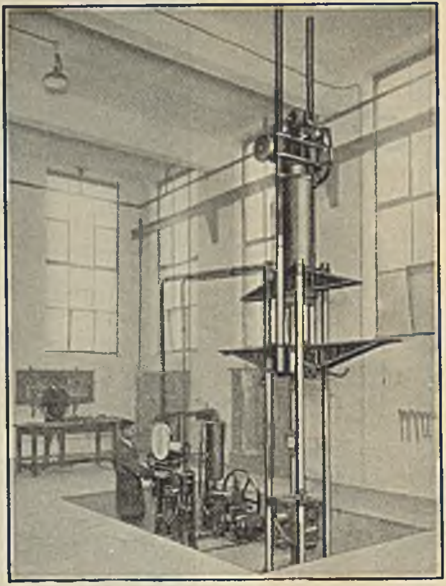

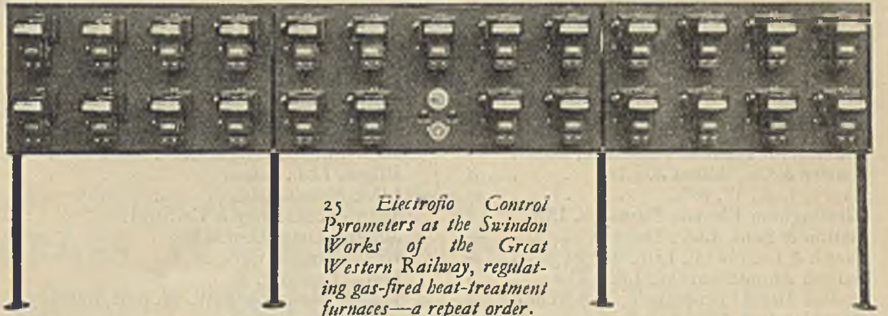

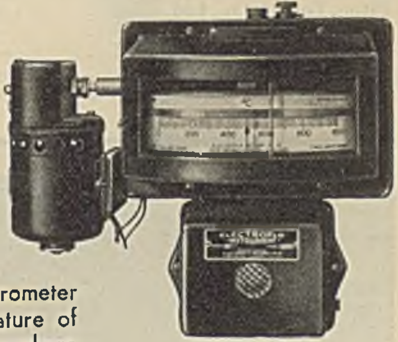

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JANUARY, 1934


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G. SHAW SCOTT,
M.Sc., F.C.I.S.

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S. C. GUILLAN.

Volume 1 JANUARY, 1934 **Part 1**

CONTENTS

Metallurgical Abstracts may be cut up for card indexes, as members will receive early in 1935 the year's abstracts in bound form. Papers will be reprinted with discussion, if any, in the bound half-yearly *Journal.*

INSTITUTE NEWS AND ANNOUNCEMENTS

THE INSTITUTE'S PUBLICATIONS.

Changes of Title and Volume Numbering.

Since the introduction of the monthly *Journal* and the issue of our "Metallurgical Abstracts and Index" as a separate annual volume, the title "Journal of the Institute of Metals" has been applied to each of these three main publications of the Institute.

In order to avoid inconvenience which may be caused by the adoption of this system of nomenclature it has been decided that the following modified titles will be used as from January, 1934:—

(1) **"Journal of the Institute of Metals."**—Two half-yearly volumes per annum, containing the papers in permanent form, together with the discussions and other matter, the numbering of the volumes being continuous with the previous volumes of the *Journal.* Vol. LIV will be issued in June, 1934.

(2) **"Monthly Journal of the Institute of Metals."**—The present issue begins the new series, being January, 1934, Vol. 1, No. 1.

(3) **"Metallurgical Abstracts."**—Vol. 1 will appear early in 1935 and will contain, in bound form, the abstracts printed in the *Monthly Journal* throughout the year 1934, with complete index to these abstracts. This publication, hitherto bound in the *Journal* series, will in future be considered and bound as an entirely separate publication.

Attention should be given to the notices appearing on the cover of this issue and at the foot of the first page of each paper which it contains, to avoid any difficulty or confusion in quoting references to papers, &c., appearing in the Institute's publications.

ANNUAL GENERAL MEETING, LONDON

MARCH 7–8, 1934.

The Twenty-Sixth Annual General Meeting will be held in the Hall of the Institution of Mechanical Engineers, Storey's Gate, Westminster, S.W.1 (by kind permission of the Council of the Institution), on March 7 and 8. The following is a time-table of the Meeting:—

Wednesday, March 7.

10 a.m.–12.30 p.m.	*General Meeting.* The Report of the Council and the Report of the Honorary Treasurer will be presented. The results of the election of the Council for the year 1934–1935 and of new members will be declared. The new President will be inducted into the Chair and will read his Presidential Address. Papers will be read and discussed.
12.45 p.m.	Members who so desire will lunch together at St. Ermin's Restaurant (table d'hôte meal, 2*s.* 6*d.*).
2 p.m.–4 p.m.	Papers will be read and discussed.
7 p.m. for 7.15 p.m.	Annual Dinner and Dance at the Trocadero Restaurant, Piccadilly Circus, W.1.

Thursday, March 8.

10 a.m.–12.30 p.m.	Papers will be read and discussed.
3 p.m.–4.30 p.m.	A visit will be made to the Post Office Engineering Research Station, Dollis Hill, London, N.W.2.

Institute News and Announcements

Certain of the papers that have been accepted for presentation at the Meeting have already been published in the *Monthly Journal* (beginning with the November issue). In the next issue of the *Monthly Journal* other papers will be given, together with a complete list of the papers to be presented. There will be circulated to members, in due course, a form which may be used to apply for tickets for the Annual Dinner and Dance.

Annual Dinner and Dance.

The Annual Dinner will be followed by a Dance, which will be continued until 1 a.m.: Pilbeam's Band has again been engaged. The price of tickets for the Dinner and Dance—exclusive of wines—is 15*s*. Application for tickets may be made now by members who desire to reserve seats or tables for the Dinner. Members who have paid for tickets and, later, find that they are unable to use them, may obtain refunds if their applications for such refunds are in the Secretary's hands not later than first post on Monday, March 5.

Election of Council.

As only sufficient nominations to fill the vacancies announced at the last General Meeting have been made, no ballot will be necessary, and the following members, who have been nominated for election on the Council, will be declared duly elected at the Annual General Meeting:

President:

H. MOORE, C.B.E., D.Sc., Ph.D.

Vice-Presidents:

A. G. C. GWYER, Ph.D.	Warrington.
PROFESSOR D. HANSON, D.Sc.	Birmingham.
H. C. LANCASTER	London.
E. L. MORCOM, M.A.	Birmingham.

Treasurer:

JOHN FRY	London.

Members of Council:

PROFESSOR J. H. ANDREW, D.Sc.	Sheffield.
ENGINEER VICE-ADMIRAL H. A. BROWN, C.B.	London.
H. W. BROWNSDON, M.Sc., Ph.D.	Birmingham.
H. H. A. GREER	Glasgow.
J. L. HAUGHTON, D.Sc.	Teddington.
PROFESSOR R. S. HUTTON, D.Sc., M.A.	Cambridge.
KENNETH GRAY	Sheffield.

May Lecture.

Professor E. K. RIDEAL, F.R.S., has accepted the Council's invitation to give the next May Lecture. This will be delivered in the Hall of the Institution of Mechanical Engineers, Storey's Gate, Westminster, on Wednesday, May 9, at 8 p.m., when Professor Rideal will lecture on Metals and Gases.

Membership.

Forms of application for membership (one of which will be found attached to the Secretary's circular letter dated January 1, 1934) received by the Secretary by noon on January 18 will be considered by the Council on that day, and the election of members approved by the Council will be completed before the Annual General Meeting on March 7. Candidates so elected will have the privilege of membership for the extended period ending June 30, 1935, instead of for the usual twelve months, an arrangement that applies also to candidates whose forms are received before next month's Council Meeting on February 15, and who are subsequently elected. Members are invited to acquaint friends who are qualified for membership of this concession.

Newly Elected Members.

The following persons were duly elected on December 14, 1933:—

As Members.

Name.	Town.
Ayckbourn, Philip John, B.Sc.	New Plymouth, New Zealand.
Ball, Arthur Cyril	Nottingham.
Eatwell, Henry Thomas	London.
Grant, Ivan Stanley	Port Talbot.
Hartigan, Thomas Joseph	Sydney, N.S.W., Australia.
Kamienski, Erwin, Dr.-phil.	Olowno k/Lowicza, Poland.
Melvin, Sir Martin J., Bart., J.P.	Olton.
Nagao, Major Takeo	London.
Nicosia, Captain Beniamino	Milano, Italy.
Priestman, Robert Thomas	Birmingham.
Rao, Mannigay Umanath, M.Sc.	Jodhpur (Rajputana), India.
Simpson, Joseph Gordon	London.
Williams, Leslie Ballesat, B.A., B.E.	Matlock.

As Student Members.

Booth, Leonard T.	Birmingham.
Colman, Geoffrey William	Birmingham.
Cowley, Charles Leonard Marshall, B.Sc.	Birmingham.
Mace, Cyril William	Napier, New Zealand.
Robinson, John Herbert	Sydney, N.S.W., Australia.
Thomas, Ivor Henry, B.Sc.	Bankyfelin.

Original Members of the Institute.

On December 31, 1933, which year marked the twenty-fifth anniversary of the foundation of the Institute, the names of the following 122 Original Members of the Institute remained on the list of subscribers, who had numbered 355 on December 31, 1908.

Adams, George, Leytonstone.
Allan, Jas. McN., Sheffield.
Andrew, J. H., Sheffield.
Baker, T., Rotherham.
Bamford, C. C., Birmingham.
Bannister, C. O., Liverpool.
Barclay, W. R., London.
Barnard, G. W., Birmingham.
Bawden, F., Liverpool.
Beare, Sir T. H., Edinburgh.
Bell, Sir T., Clydebank.
Bengough, G. D., Teddington.
Bibby, J. H., Liverpool.
Bill-Gozzard, G., Birmingham.
Billington, C., Stoke-on-Trent.
Bolton, T., London.
Braby, C., London.
Bridges, F. W., London.
Brownsdon, H. W., Birmingham.
Canning, T. R., Birmingham.
Carpenter, Sir H. C. H., London.
Clamer, G. H., Philadelphia.
Clark, Henry, Sunderland.
Cookson, Clive, Newcastle-on-Tyne.
Corfield, R. W. G., Swansea.
Corse, W. M., Washington.
Davies, Peter, Liverpool.
Desch, C. H., Teddington.
Dingwall, F. W., Liverpool.
Dobbs, E. W., Birmingham.
Drury, H. J. H., Sydney, N.S.W.
Dugard, H. R., Birmingham.
Eccles, E. E., London.
Echevarri, J. T. W., London.
Edmiston, J. A. C., Hamilton, Lanark.
Edwards, C. A., Swansea.
Evans, S., Hornchurch, Essex.
Farley, D. H., Sheffield.
Féron, A., Brussels.
Fraser, K., Leeds.
Gardner, H., London.
Garfield, A. S., Paris.
Garnham, F. M., London.
Gibbins, W. W., Brockworth, Glos.
Goodwin, Sir G., Havant.

Greenwood, H. W., London.
Greenwood, T., London.
Greer, H. H. A., Glasgow.
Gulliver, G. H., London.
Gwyer, A. G. C., Warrington.
Hadfield, Sir R., London.
Harbord, F. W., London.
Harlow, B. S., Stockport.
Hartley, R. F., London.
Highton, D. C., London.
Hirst, T. G., Leigh, Lancs.
Holt, H., Bury.
Hudson, O. F., London.
Hughes, J., Birmingham.
Humphreys, T. C., Birmingham.
Hunter, Summers, Stocksfield-on-Tyne.
Hurren, F. H., Coventry.
Hutton, R. S., Cambridge.
Johnson, F., Birmingham.
Jude, A. A., Birmingham.
Kamps, H. H., Tervueren.
Kemp, J. F., Birmingham.
King, E. G., London.
Klein, C. A., Enfield.
Lancaster, H. C., Woking.
Lang, C. R., Glasgow.
Langdon, P. H., New York.
Lantsberry, F. C. A. H., New York.
Law, E. F., London.
Lord, F. A. B., London.
McKechnie, A. M., Widnes.
Merrett, W. H., Wallington.
Millington, E., Derby.
Morcom, E. L., Birmingham.
Morrison, W. M., London.
Nisbett, G. H., Prescot.
Oram, Sir H. J., Hale, Sussex.
Parker, W. B., Rugby.
Petavel, Sir J. E., Teddington.
Preston, Sir F., Salisbury.
Primrose, H. S., Pershore, Worcs.
Primrose, J. S. G., Manchester.
Radley, W. A., London.
Reid, A. T., Glasgow.
Rhead, E. L., Manchester.
Ridge, H. M., London.
Rigby, R., Birmingham.
Robertson, W. H. A., Bedford.
Rogers, H., Birmingham.
Rosenhain, W., London.
Russell, C. A., Birmingham.
Scott, A. A. H., London.
Seligman, R., London.
Silvester, H., Birmingham.
Smith, E. A., Sheffield.
Smith, H. D., Newcastle.
Smith, P. W., London.
Spittle, A., Smethwick.
Stanley, G. H., Johannesburg.
Stansfield, A., Montreal.
Steven, J., Glasgow.
Sulman, H. L., London.
Sumner, L., Manchester.
Tawara, K., Tokyo.
Teed, H. R., London.
Thorne, E. I., London.
Titley, A., Birmingham.
Tomlinson, F., Manchester.
Turner, T., Leatherhead.
Webb, A. J., London.
Webster, W. R., Bridgeport.
Weeks, H. B., London.
Weir, the Rt. Hon. Lord, Cathcart.
Williams, H. W., Salop.
Willott, F. J., Swansea.
Wilson, J. H., Smethwick.
Wright, R., Simla.

Papers for Autumn Meeting.

Members are invited to offer papers for the Autumn Meeting.

In accordance with the new scheme for printing advance copies of papers in the *Monthly Journal*, it will be possible to begin the publication of the Autumn Meeting papers in the May issue.

Manuscripts should be submitted in duplicate. Drawings for reproduction must be submitted in india ink on Bristol board, tracing or good drawing paper. All lettering must be in pencil to enable the Institute's draughtsman to add this to conform to the style adopted throughout the *Journal*.

Photomicrographs must be trimmed to one of the following sizes, preferably the former: 2 in. × 2¼ in.; 3 in. × 2¼ in.; 3 in. × 4 in. Magnifications should be given in all cases.

A brief synopsis should be given at the head of each paper submitted, and the MS. should be accompanied by a declaration of originality, the form for which may be obtained from the Secretary.

The Editor should be advised as soon as possible by intending authors of papers when their MSS. may be expected.

LETTERS TO THE EDITOR

Educational Tours.

Readers of the *Monthly Journal* will remember that in the issue for April, 1933, a letter appeared from Mr. Roosevelt Griffiths suggesting that the Institute should organize educational tours to foreign countries, for Student and other members of the Institute.

This suggestion is one of many which has already received the close attention of the Meetings and Papers Committee, and it was decided to recommend its adoption.

I am glad to be able to announce that the Council has now approved of the scheme, and has appointed a small committee—of which I am Chairman—to organize the first Education Tour of the Institute of Metals, if possible during the forthcoming Easter vacation.

The Committee has already got to work, and hopes to be able to make a detailed announcement shortly.

In the meantime, it can be stated that the tour is not to be confined to Student Members, but is to be open to all junior members of the Institute who think that they would benefit thereby.

Expenses are to be kept to the lowest possible limit to suit the class of member to which it is hoped the opportunity will appeal. The duration of the tour is to be approximately one week.

The Committee hopes that those responsible for the training of metallurgical students will direct the attention of junior members and potential members to the proposed tour, and will suggest to those who are interested that they send in their names at once, either to the Secretary or to me, so that detailed information can be sent to them direct as soon as this is available.

Richard Seligman.

Lincoln House, Parkside,
Wimbledon Common,
London, S.W.19.

Centenary of the Pattinson Process.

Previous to Pattinson's invention, silver present in lead was recovered by the wasteful process of cupelling the entire lead. This had been the practice of the ancient Greeks and Burmese, who left thousands of tons of litharge (oxide of lead) in dumps, which have been worked up in recent times.

Mr. Hugh Lee Pattinson of Alston, Cumberland, a lead-assayer, discovered by accident that the liquid portion from a partly solidified mass contained notably more silver, and in 1833 obtained a patent, which he himself worked. His process became universal. Silver of quite low content was concentrated by a series of crystallizations up to 500 oz. per ton, and was then cupelled. Luce and Rozan improved the process, using steam for stirring, and Tredinnick in the United States made further advances, although the principle remained the same.

Although the Pattinson process is now almost entirely superseded by the Parkes zinc process, in which both the purity of the lead and recovery of silver are much greater, the immense advance which it represented and the important part which it played for so many years in the desilverization of lead bullion establish it as an outstanding metallurgical achievement.

Pattinson's process is one of those cases in which practice anticipated theory by many years. It was not until 1884 that Guthrie (the centenary of whose birth was celebrated last year), in the course of his studies of alloys of low freezing points, recognized in those having the lowest freezing points in certain series the analogues of the "cryohydrates" of salt solutions to which he had given much attention. He proposed the name "eutectic" for such alloys, and he recognized the significance of his work in relation to the Pattinson process, and the limit to which this operation can be carried before cupellation of the enriched lead becomes necessary.

The subsequent work of Heycock and Neville (1897), Friedrich (1906), and Petrenko (1907) established the freezing-point curve for the alloys of lead and silver, from which it is seen that the eutectic point lies very near to the end of the curve corresponding with pure lead, the actual position being at 2·25 per cent. of silver by weight. This composition is the theoretical maximum to which concentration of silver could be effective by the Pattinson process, the actual figure to which the concentration can be taken in practice being, of course, much less.

The practical use which was made by Pattinson of what in present-day metallurgical parlance would be called the separation of the "first-formed lead primaries" should be of considerable interest to students of metallurgy. The fact that these "primaries" are discrete and free-moving crystallites is not without significance in regard to the various explanations which have been put forward from time to time to explain the mechanism of segregation during solidification, and the resulting inequalities of distribution of the constituents which are found not only in lead alloys containing silver and gold, but in many others of similar constitution.

HARRY C. LANCASTER.
S. W. SMITH.

London.

Council and Committee Meetings.

The following meetings have been held during the past quarter :—

Council :
October 26
December 14.

Publication Committee :
October 26.
November 23.
December 21.

Membership Committee :
October 26.
December 14.

Meetings and Papers Committee :
November 23.

Journal Printing Costs Committee :
November 28.

Autumn Meetings Committee :
November 28.

Finance and General Purposes Committee :
December 7.

"ACHEMA" ANNUAL, 1931–1934.

There will be issued in connection with the forthcoming Exhibition of Chemical Apparatus and Plant, to be held in Cologne on May 18–27, 1934, an "Achema" Annual. This publication, to appear early this year, will contain advance information with regard to the Cologne Exhibition; also particulars concerning the present position and development of chemical apparatus and plant. Members interested may obtain gratis, upon payment of postage (two international prepaid postal coupons), a copy of the above publication, the ordinary price of which is M. 10. Applications should be addressed to :—Dechema, Achema-Geschäftsstelle, Seelze-bei-Hannover, Germany.

PERSONAL NOTES

The Editor requests that his attention be directed to items of interest to members that might be included under the "Personal Notes" heading. All contributions for the February issue of the Monthly Journal *should reach the Editor not later than January* 25.

Mr. Norman P. Allen, M.Met., received the degree of D.Sc., at the December Congregation of the University of Birmingham.

Miss S. Ball, Assistant to Mr. Shaw Scott, completed twenty-five years' service with the Institute on January 14. She was the first to be appointed to a staff that now numbers nine keen and hard-working members, to whose loyalty and enthusiasm the Secretary and Editor is glad to be able to pay this slight public tribute.

Professor Kotaro Honda, President of the Tohoku Imperial University and Director of the Research Institute for Iron and Steel and other Metals, Sendai, has been made a honorary doctor of the Mathematical–Natural Science Faculty of the University of Göttingen.

Dr. Arthur Dehon Little, on the occasion of his 70th birthday, on December 15, was presented by his staff with a specially bound and inscribed volume of the Morse Collection of Japanese Potteries. The presentation was made by Mr. Roger C. Griffin, Director of Tests, and a member of the Board of Directors of Arthur D. Little, Inc. Mr. Griffin is a son of Mr. Roger B. Griffin, Dr. Little's original partner when the organization was formed as Griffin & Little in 1886.

Dr. Carlo Sonnino has left the Tonolli Metallurgical works of Milan to open an Office of Metallurgical Engineering (aluminium, lead, tin, copper, and residues) in Milan—Corso Italia 68.

Mr. E. V. Walker, B.Sc., A.R.S.M., has joined the staff of the Post Office Engineering Research Station at Dollis Hill, London.

Lord Weir was appointed a G.C.B. in the New Year's Honours List.

Obituary.

Mr. John Bright Hoblyn died suddenly on December 24, 1933, in the Bute Nursing Home, Luton, Bedfordshire. He was metallurgist to Messrs. Vauxhall Motors Limited, and joined the Institute in 1918. He had read papers before Local Sections of the Institute and was keenly interested in the Institute's work.

During December *The Times* published the following obituary notices of two former members who took a prominent part in the activities of the Institute prior to their retirement from active professional work.

Mr. Elliott Cumberland died on December 8 at Coombe Hill Golf Club, Kingston Hill, Surrey, after a long illness, at the age of 61. He had held the lease of the club since 1918 and lived there. After cremation at Woking, the ashes were scattered beneath the silver birch trees near the ninth green at Coombe Hill, always a favourite spot with him. Mr. Cumberland, who was born in Melbourne, invented an electrolytic system of preventing the corrosion of ships' boilers and condensers, which proved successful and was widely adopted. At the Coombe Hill Golf Course he made a Japanese garden reputed to have cost £5,000. He was an excellent shot, and bred pedigree setters, golden retrievers, and Cairn terriers.

Dr. T. J. Milton, an engineering authority in his day and for several years chief surveyor to Lloyd's Register, died in his sleep at his house at Emsworth, Hants, on December 13 a few hours before the funeral at Emsworth of his brother, Rear-Admiral William Milton. Dr. Milton was 83, and was a prominent speaker at societies such as the Institute of Naval Engineers. His wife died some years ago, and he leaves three sons, two of whom are in the medical profession, and three daughters. Both brothers were natives of Portsmouth. Rear-Admiral Milton was one of the few remaining survivors of the Samoa hurricane of 1889. He was aboard the *Calliope*, which steamed out of harbour in the teeth of the storm.

LOCAL SECTIONS NEWS

SYNOPSES OF PAPERS TO BE READ IN FEBRUARY.*

Birmingham Section.

Electric Welding. By C. A. Hadley. (*Jan.* 16.)

The following will be dealt with : the basic principles of resistance welding ; characteristics of various metals under welding condition ; comparison of methods employed ; types of resistance welding machines ; automatic welding ; recent developments, and examples of welded work.

Open Discussion on " The Metallurgical Inspection of Engineering Materials." (*Feb.* 1.)

Age-Hardening Copper Alloys. By Maurice Cook, Ph.D., M.Sc. (*Feb.* 13.)

The principles underlying age-hardening are briefly reviewed as an introduction to the paper and reference is made to the various copper-rich alloys in which hardening occurs on reheating after quenching from high temperatures.

A few selected alloys, notably copper alloys containing additions of nickel and aluminium, copper alloys containing nickel silicide and copper–beryllium alloys, are treated in greater detail and the changes in properties resulting from suitable thermal treatment are described.

Possible applications of such alloys are discussed, and a short comparison is made between their properties and those of existing commercial copper alloys.

London Section.

Electric Annealing and Heat-Treatment Furnaces. By A. G. Lobley, M.Sc. (*Feb.* 8.)

A general review of the present position of electric furnaces in relation to the industrial heat-treatment of metals, with examples of a number of modern installations. Reasons are given for the rapidly growing interest in electric heat-treatment, and the following are described : mechanically-operated furnaces of various types ; continuous wire and strip annealing ; improvements in furnaces for low-temperature processes, such as the tempering of steel ; treatment of aluminium alloys, and the annealing of various metals and alloys.

Batch-type and continuous furnaces for the bright-annealing of metals, with special reference to recent installations are discussed.

North-East Coast Section.

Chairman's Address. By J. E. Newson, M.Met. (*Feb.* 13.)

The Address will deal with the effect of aluminium on the 60 : 40 and 70 : 30 brasses.

It is proposed to review the previous work on melting and casting, and to consider the effects of varying amounts of aluminium on the mechanical properties, the hot- and cold-working properties, and the microstructure. Brief reference will also be made to the influence of aluminium in conjunction with the other hardening elements usually found in the high-tensile manganese-brasses.

Under the heading of theoretical considerations may be included some notes on the volume changes in these alloys and the relationship between physical properties and constitution.

N.B.—Mr. C. E. Pearson's paper on " The Flow of Metals in the Extrusion Process," originally announced to be read on February 13, will be delivered instead on March 13 when the Chairman's Address—now to be given on February 13—had been expected.

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* For places and times of meetings the green folder programme, as already issued to all Local Section members, should be consulted.

Local Sections News

Scottish Section.

Combustion Efficiency. By J. A. C. Edmiston. (*Feb.* 12.)

The paper affords an opportunity to study the principles of combustion which are sometimes not thoroughly understood by practical boiler-firemen and furnacemen.

A few tables are given to indicate clearly the main points to be observed, if truly economical results are desired, together with certain practical results, which illustrate the author's argument.

Sheffield Section.

Recovery and Refining of the Precious Metals. By H. G. Dale. (*Feb.* 9.)

Sources of precious metals. Sampling and assay of materials containing precious metals. Smelting and concentration of precious metals into lead. Refining of lead ingots up to 99 per cent. precious metal. Separation of precious metals by (1) electrolytic treatment; (2) acid treatment. Preparation of very pure silver. Treatment of electrolytic slimes. Preparation of pure platinum, palladium, iridium, ruthenium, rhodium, osmium. By-products: copper sulphate and refined lead. Collection of fume. Treatment of furnace slags. Preparation of fine silver ingots and sheet. Preparation of standard silver ingots and sheet. Preparation of gold alloys. White gold. Preparation of platinum ingots and sheet. Preparation of platinum alloys.

Swansea Section.

Cracking and Fracture of Metals, with Special Reference to Service Breakages. By Professor F. Bacon, M.A. (*Feb.* 20.)

Failures of machine parts in service are mostly of " fatigue " type in which cracks gradually spread inwards, leaving conchoidal markings which register successive contours. It is of importance to decipher from these markings all that can be reliably inferred regarding the causes of failure. In laboratory fatigue tests, however, the fractured faces of the broken specimens are rarely regarded as of any interest, largely because they are battered and featureless.

The author has evolved a technique whereby the salient features of service fractures *can* be faithfully reproduced in the laboratory. Consequently, the analysis of conspicuous objective evidence available in post-mortem examinations need no longer remain unverified conjecture, because it can now be made the subject of systematic experimental study. Progress already made along this line of inquiry is reviewed.

The paper includes observations on the problem of deciding whether or not conjoint corrosive action has stimulated fatigue. Finally, reference is made to failures brought about by the conjoint action of cyclic stress and surface abrasion, for which the term, *erosion-fatigue* is suggested.

REPORTS OF DECEMBER MEETINGS

North-East Coast Local Section.*

The Addition of Non-Ferrous Metals to Cast Iron. By J. E. Hurst. (*Dec.* 12.)

In introducing his paper, the author directed attention to the great development which had taken place since 1926 in the application of those materials known as alloy cast irons to industry, where they are now firmly established. They fall into several main groups: (*a*) high-duty irons. The most important added element in this class is nickel, the specific effect of which is the elimination of chill, grain-refinement, and the production of uniform machining properties. When present to the extent of 1·5 per cent., with 0·5 per cent. chromium, nickel gives good strength and heat resistance. A recent development is the

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* Joint Meeting with the Newcastle Branch of the Institute of British Foundrymen.

production of irons with tensile strength in the cast condition of 30 tons in.², by the addition of nickel and silicon to a base iron which itself normally casts white. Chromium alone is of service in stabilizing carbides, and irons containing 0·25–0·75 per cent. have found application in motor cylinder work. In greater amounts chromium confers important heat-resisting qualities, for which purpose molybdenum, titanium, and vanadium are often also added; (*b*) irons capable of undergoing hardening and tempering. The importance of these is that they may be machined in the soft condition and hardened subsequently for service. They are frequently air-hardening, and contain 3–6 per cent. nickel and 1·5–2 per cent. chromium; (*c*) irons which have a martensitic structure in the cast condition for use where hard-wearing surfaces are required. These usually contain 5–6 per cent. nickel; (*d*) irons suitable for nitriding. In the presence of small amounts of aluminium and chromium, very satisfactory surface hardening can be obtained by treatment in ammonia gas at 500° C.; (*e*) austenitic irons. A number of combinations serve to preserve the austenitic structure, typical examples of which are found in Niresist (nickel, 13; copper, 6; chromium 2·5–5 per cent.); Nomag (nickel, 10; manganese, 5 per cent.); Nicrosilal (nickel, 18; silicon, 5–6; chromium, 1·5–5 per cent.). In the production of austenitic alloys, copper is now frequently used to replace part of the more expensive nickel, the effect of which it resembles to some extent.

Scottish Section.

The Use of Fluxes and Slags in Non-Ferrous Foundry Practice. By T. Tyrie. (*Dec.* 11.)

In the course of the discussion it was pointed out that the adoption of the proper flux treatment had not only resulted in the use of a very much larger percentage of scrap metal, but had also ensured an improved quality of castings. It should now be possible and profitable to use much scrap material which hitherto had gone direct to metal refiners.

An analogy was drawn between the ordinary processes of solution and precipitation which take place in the laboratory and the precipitation of impurities by the correct addition of suitable fluxes.

Mr. Tyrie referred to the deleterious effect of phosphorus on both ordinary brass and on gun-metal, porous castings being a possible result in the one case, and reduced mechanical properties in the other.

One drawback to the use of slags was the cutting action which they had on the crucible, this necessitating a gradual reduction in the amount of metal melted in order to obtain a good life of the crucible.

The successful application of fluxes did not depend on a large quantity of chemical additions, but entirely on the attainment of the correct equilibrium between the slag, the temperature, and the composition of the metal.

At a fairly rough estimate, the cost of fluxing is about 12*s*. to 13*s*. per ton of metal melted, the amount of flux used being approximately between 3 and 4 per cent. of the weight of the metal.

Local Sections' Papers in Archives.

The following Local Section papers, as read during the past quarter, have been deposited in the Institute's archives. They can be borrowed from the Library by members under the usual conditions attaching to Library loans:

Aldridge, D. W.	"The Copper Refinery of Prescot."
Annan, R.	"Gold: Sources and Production."
Ballard, W. E.	"Metal Spraying."
Batley, G. L.	"Deoxidizers and Fluxes."
Handforth, J. R.	"A Metallurgist's Outlook on Modern Foundry Productions."
Hurst, J. E.	"The Addition of Non-Ferrous Metals to Cast Iron."
Tyrie, Thos.	"The Use of Fluxes and Slags in Non-Ferrous Melting Practice."

PAPER No. 655. This paper is not to be reprinted, wholly or in part, until presented (and then only with due acknowledgment) at a meeting to be held on March 7–8, 1934, in the Hall of the Institution of Mechanical Engineers, Storey's Gate, Westminster, London, S.W.1. The Institute as a body is not responsible for the statements or opinions expressed in this paper, on which written discussion may be sent to the Secretary not later than March 19, 1934.

This paper will not be reissued in the form of a separate "Advance Copy," a method of publication which has been discontinued.

TRANSFORMATIONS IN THE COPPER–PALLADIUM ALLOYS.[*]

By R. TAYLOR,[†] B.A., B.Sc., MEMBER.

SYNOPSIS.

Copper–palladium alloys up to 55 atomic per cent. of palladium have been examined by thermal, micrographic, and electrical resistance methods. The determination of the electrical resistance–temperature curves has been carried out with a much slower change of temperature than had previously been used. The occurrence of two transformations at 10–30 atomic per cent. and 35–50 atomic per cent., respectively, and associated with different types of electrical resistance curve has been confirmed. The results are compared with those of earlier workers and the mechanism of the transformations is discussed.

INTRODUCTION.

THE transformations which occur in the copper–palladium alloys have been previously examined by many methods.[1–8] The X-ray work of Holgersson and Sedström[2] and of Johansson and Linde[3,4] makes it clear that at high temperatures alloys of all compositions possess a face-centred cubic lattice, but no regular arrangement of the two kinds of atoms has as yet been detected. On cooling to lower temperatures, alloys containing between 10 and 30 and between 38 and 50 per cent.[‡] of palladium undergo transformations. The lattice in the former range is unchanged, but the atoms take up a regular distribution based on the ratio 3 Cu : 1 Pd, with the palladium atoms occupying the cube corners, and the copper atoms the centres, of the faces. According to Borelius, Johansson, and Linde,[5] the super-lattice lines in the X-ray photographs, which indicate the regular atomic distribution, are strongest at about 17 per cent. In the range 38–50 per cent. at low temperatures there is a change to a body-centred cubic lattice, with a regular arrangement of the atoms based on the 1 : 1 ratio, each component being at the points of a simple cubic lattice, as in CsCl.

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[*] Manuscript received October 13, 1933.

[†] Downing College, Cambridge.

[‡] Compositions are throughout expressed in atomic percentages and alloys are referred to by their nominal palladium content.

Note to Abstractors and Other Readers.—This paper will be published, in permanent form, in the *Journal of the Institute of Metals*, Vol. LIV, 1934. Reference should accordingly be as follows—*J. Inst. Metals*, 1934, **54** (Advance copy).

The electrical resistance measurements carried out at room temperature by Sedström,[1] Johansson and Linde,[3, 4] and Svensson[6] show that a low value of the specific resistance is associated with the ordered arrangement of the atoms. The minimum values in the two ranges are displaced from the simple atomic ratios, occurring respectively at 16–18 per cent. and at 47 per cent. The values of the specific resistance for alloys with an irregular distribution of atoms lie on a comparatively smooth curve and attain a maximum at about 60 per cent. of palladium.

EXPERIMENTAL.

Preparation of Alloys.

The alloys were prepared from electrolytic copper (the only impurity found was 0·002 per cent. iron) and palladium sponge of approximately the same purity. They were made up at 5 per cent. intervals from 5 to 55 per cent. of palladium, except that, for the micrographic and electrical resistance work, additional alloys were prepared near 40 per cent.

TABLE I.—*Composition of Alloys.*

Nominal Atomic Per Cent. Palladium.	Weight Per Cent. by Analysis.		Atomic Per Cent. Palladium.
	Pd.	Cu.	
5	8·05	91·95	4·96
10	15·65	84·35	9·95
15	23·10	76·90	15·18
20	29·50	70·50	19·95
25	36·08	63·92	25·17
30	41·96	58·04	30·11
35	47·74	52·26	35·26
38·5	52·50 *	47·65	39·62
40	52·57	47·43	39·77
41	54·69 *	45·45	41·75
42·5	56·59 *	43·49	43·67
45	58·21	41·79	45·36
48	62·01 *	38·08	49·24
50	63·02	36·98	50·38
55	67·49	32·51	55·31

Atomic weights : Palladium . . . 106·7
Copper . . . 63·57

* By analysis (in other cases only copper was estimated).

The alloys were made in high *vacuo*, using a high-frequency induction furnace, and were twice remelted before the final cooling. The crucibles used were made from Alundum tube and the ingots obtained were cylindrical, 1–1·5 cm. long and 0·8 cm. in diameter, and weighed about 12 grm. These ingots were used directly for the thermal investigation after holes had been bored in them to take the necessary thermocouples, with the exception of the 25 per cent. alloy, which had to be softened by quenching before it could be drilled. The same ingots were afterwards used in the micrographic investigation. Specimens similarly prepared were drawn down, first through Widia dies and then through diamond dies, to suitable wires for the electrical resistance work.

The compositions of the alloy wires are given in Table I. Samples from different parts of each wire were analysed and the results were in close agreement.

Thermal Investigation.

The specimens were heated in an electrical resistance tube furnace controlled by a thermo-electric thermostat, in an atmosphere of hydrogen or nitrogen. In taking heating curves a steady current was maintained through the furnace of such magnitude as to give a change of temperature of 1·5°–3° C. per minute over the critical range. Cooling curves were, in general, taken with no current passing, and the rate of cooling was therefore greater the higher the temperature; over the critical ranges it varied from 2° C. to 4° C. per minute.

It was found necessary to use a differential method in order to detect the evolution or absorption of heat accompanying the changes in the alloys. The neutral was a short piece of pure copper rod of the same size as the specimen. A Chromel–Alumel differential couple was used in conjunction with a "water-dropper." The short wire of this couple was of Alumel, which had periodically to be renewed, as it was embrittled by nitrogen in the absence of oxygen. The temperature of the alloy specimen was measured with a platinum/platinum–rhodium thermocouple and a millivoltmeter.

In tracing the temperature difference–time curves on the screen, the time was calibrated by marking the position of the spot of light every 2 minutes: the millivoltmeter was read every 4 minutes. The temperature difference–temperature curves could then be constructed if desired, although in most cases the temperature of a change was determined directly from the experimental tracings.

The specimens were usually given a preliminary anneal between 600° and 700° C. for some hours before cooling and heating curves were taken. Reproducible results could then be continuously obtained without further annealing.

Micrographic Analysis.

The specimens were annealed in an atmosphere of nitrogen in the furnace used for the heating and cooling curves, with the exception that, towards the end of the investigation, a triple furnace[9] with hydrogen was employed. A thread recorder was used to detect any irregularity in the temperature control. Two sets of very slowly cooled specimens were obtained by using an aluminium block furnace heated by gas, the flow of which was controlled by a crude form of thermostat. Cooling from 500° to 300° C., at which temperature one set was quenched, was spread over 23 days, and the further cooling to room temperature took 16 days. In this experiment the specimens were sealed in evacuated Pyrex tubes.

The initial heat-treatment of nearly all the specimens was an anneal for at least 2 hrs. in the neighbourhood of 800° C. The temperature was then lowered to that required, and was maintained for several hours before the specimen was removed and quenched in cold water.

A 1 per cent. solution of bromine in alcohol proved to be a satisfactory etching reagent for the alloys with more than 30 per cent. of palladium. A more dilute solution was used for the other alloys, which were rather easily stained and pitted. On the advice of Mr. E. M. Wise,* a mixture of equal volumes of 10 per cent. solutions of ammonium persulphate and potassium cyanide was tried. This was somewhat slower in action, and produced the same result on the higher palladium alloys as the bromine reagent.

Electrical Resistance Measurements.

In order that several alloys might be examined together, a large tube furnace was constructed. This furnace was wound in five sections with Nichrome tape, and, by arranging external resistances in parallel with the inner sections, a length of 15 cm. was obtained in which the temperature variation was less than 3° C. The furnace was fitted with a triple Chromel–Alumel couple for the thermostat control.

The alloys were examined *in vacuo* by the following arrangement: copper wires, about 33 cm. in length, were joined to the ends of about 45 cm. of alloy wire by means of small beads of silver. Tungsten wires, 7–8 cm. long, were brazed to the free ends of the copper wires, and copper leads were similarly joined to them. The tungsten wires were cleaned, oxidized slightly in a flame, and coated with a film of Pyrex glass. The alloy wire was wound, in the form of a spiral, round narrow Pyrex tubing, one lead passing up the inside of the tube. The specimen was then placed in a wider Pyrex tube, one end of which was sealed by pinching the hot glass round the tungsten wires. After the other end had been drawn down, the tube was evacuated and sealed off. For each

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* Private communication. See also E. M. Wise and J. T. Eash, "The Rôle of the Platinum Metals in Dental Alloys.—III," *Trans. Amer. Inst. Min. Met. Eng.*, 1933, 104, *Inst. Metals Div.*, p. 303.

alloy a similar specimen was prepared, but with only 5–10 cm. of alloy wire. By this means it was possible to eliminate the resistances of the leads.

It was possible to get twelve of these tubes in the furnace together, and six alloys could thus be examined at one time. The tubes were placed so that the whole of each alloy was within the range of constant temperature; the inside copper–tungsten junctions were then near the end of the furnace and the seal was just outside it.

The resistances of the specimens were measured by a potentiometric method. A lead accumulator and a 200-ohm coil were connected in series with a standardized Manganin coil and with a specimen. The fall of potential across the specimen was compared with that across the Manganin coil using a Pye potentiometer. The current through the specimen was then reversed and the readings were re-taken. The average value was used. The examination of a specimen was followed immediately by that of the corresponding subsidiary specimen. Measurements were made at various temperatures, the furnace being kept at each temperature until the resistances ceased to change. Outside the range of transformations, 3–6 hrs. was sufficient for this, but about 24 hrs. was given when a transformation was in progress. The result of longer annealing is considered on p. 25. The temperature was changed in steps of 30°–50° C. at low temperatures and 8°–15° C. through the transformation ranges. A Foster quadruple strip recorder was used to follow the changes in the temperature and in the resistances of three of the alloys. This gave an indication of the approach to equilibrium. The recorder was also used in two series of experiments to determine the temperatures of the transformations during continuous heating and cooling. The chart was calibrated for temperature by taking readings of the millivoltmeter at intervals, and the transformations were indicated by marked changes in direction on the resistance curves.

RESULTS.

(a) 0–30 *Per Cent. of Palladium.*

Satisfactory evidence of a transformation in this range was obtained in only three of the six alloys which were examined by the thermal method. For the alloys containing 15, 20, and 25 per cent. palladium, curves were obtained similar to those shown for that containing 15 per cent. (Fig. 1 (I, II)). These curves have been derived from the experimental tracings by changing the time ordinate to a temperature ordinate (p. 13), and the scale of the alloy/neutral temperature difference has been reduced to one-third in reproduction. (Curves III, IV have been obtained similarly.) It should be noted that the alloys containing 20 and 25 per cent. palladium gave no indication of the smaller change point shown in the heating curve for that containing 15 per cent., nor did this point appear on cooling curves of that alloy. The curves for the alloy containing 5 per cent. palladium showed no transformation, whilst evidence with those containing 10 and 30 per cent. was indefinite. The effect of the gas in contact with the specimens was examined with the 20 and 25 per cent. palladium alloys. With the temperature of the furnace steady, a curve was traced while nitrogen was removed from the tube

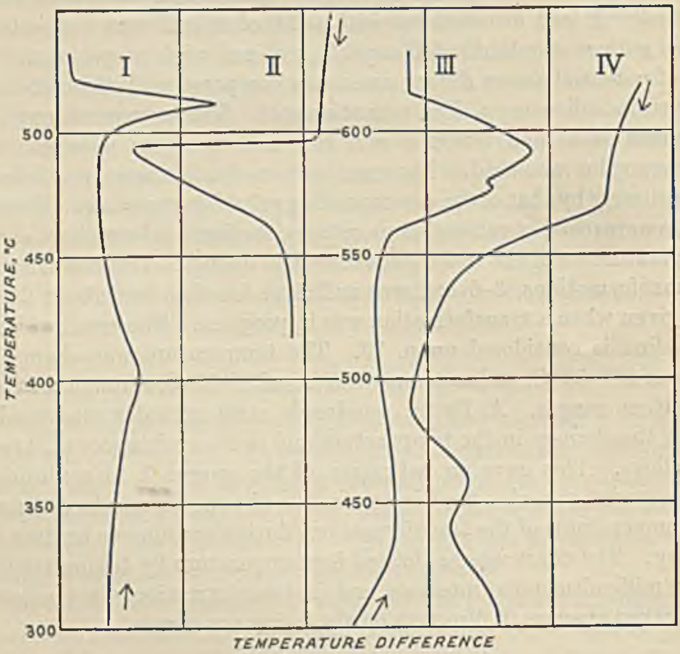

Fig. 1.—Thermal Curves.

and hydrogen was admitted. No indication of any heat change was obtained; further, results obtained in hydrogen were in good agreement with those in nitrogen.

The temperatures at which the transformations commenced and where the temperature difference was greatest are given in Table II. Where only one value is given, two or more experiments gave results to ± 3° C. The temperature–composition curves are irregular, and will be considered with the results of the work on electrical resistance.

A micrographic examination of these alloys yielded no results. Both the slowly cooled specimens and those quenched from 580° C. showed the typical polygonal grains of a solid solution. The alloy containing 25 per cent. palladium was examined at intervals of 20° C. from 520° to 460° C., and no indications of a duplex structure were obtained.

Examples of the electrical resistance–temperature curves are shown in Fig. 2 (I, II). The typical curve for this range is made up of three

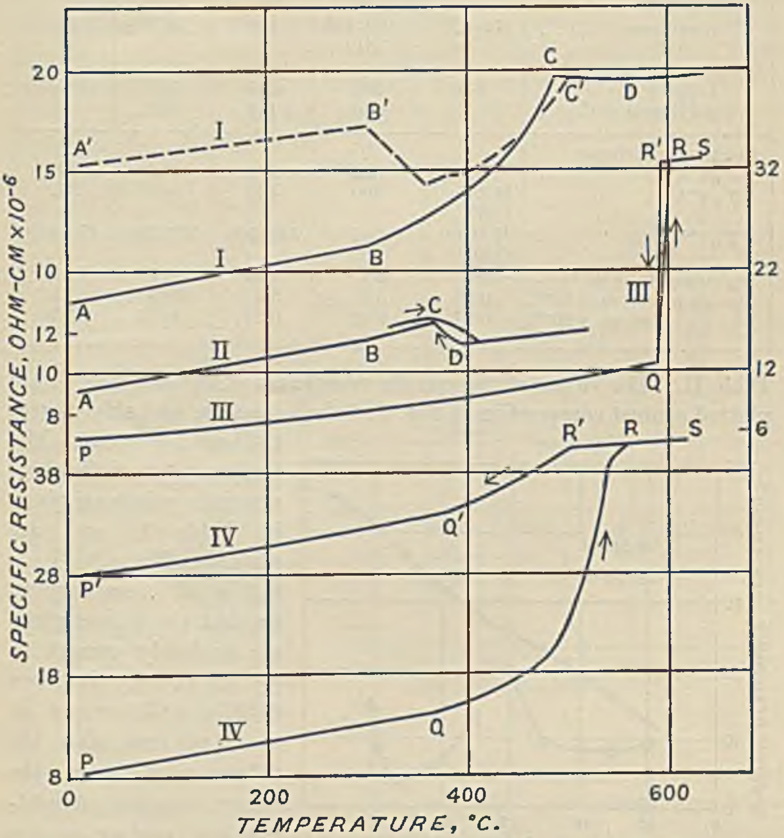

FIG. 2.—Electrical Resistance Curves. I, 20 per cent. Palladium; II, 10 per cent. Palladium; III, 41 per cent. Palladium; IV, 48 per cent. Palladium.

parts: (*a*) a linear increase of resistance with temperature to about 300° C. (*AB*); (*b*) a more rapid increase, with a continually increasing temperature coefficient, over a range of 100°–200° C. up to a sharp peak (*C*); (*c*) a small but definite decrease in resistance to a flat minimum (*D*), followed by a slow but steady increase. The changes in specific resistance between *B* and *C* and *C* and *D*, respectively, are given in

TABLE II.

	10% Pd.	15% Pd.	20% Pd.	25% Pd.	30% Pd.
Thermal investigation :					
Change on heating :					
began (° C.)	300–340	i 336–365 ii 488	455–475	440	336
maximum (° C.)	400–420	i 400–440 ii 512	488	477	410
Change on cooling :					
began (° C.)	480	504	505	518	460–470
maximum (° C.)	...	490	474	443	...
Electrical resistance :					
T_B (° C.)	300	312	300	312	278
T_C (° C.)	H 357 C 372	500	490	460	382
T_D (° C.)	H 430 C 397	507	540–560	530–540	470–480
ρ_{20} (ohm-cm. $\times 10^{-6}$)	9·2	8·1	8·64	9·7	19·9
$\rho_C - \rho_B$ (ohm-cm. $\times 10^{-6}$)	0·76	5·3	8·3	10·8	2·9
$\rho_C - \rho_D$ (ohm-cm. $\times 10^{-6}$)	0·81	0·18	0·21	0·22	0·10

Table II. The values of the specific resistances at 20° and 600° C. are plotted against composition in Fig. 3 : * the values are probably correct to about 2 per cent. The temperatures of the characteristic points are given in Table II and are plotted in Fig. 4.* T_B is not in all cases easy to fix, but the values given are probably correct to ± 10° C. T_C is more definite and, except in the 10 per cent. alloy, the difference between the values obtained on heating and cooling is less than ± 3° C. In the alloys containing 20–30 per cent. palladium the minimum extends over a considerable range of temperature, the upper limit of which is plotted in the figure. There is no discontinuity of any kind on the curve for the alloy containing 5 per cent. palladium and whilst the heating curve for that containing 10 per cent. (Fig. 2, II) seems to indicate a departure from the typical

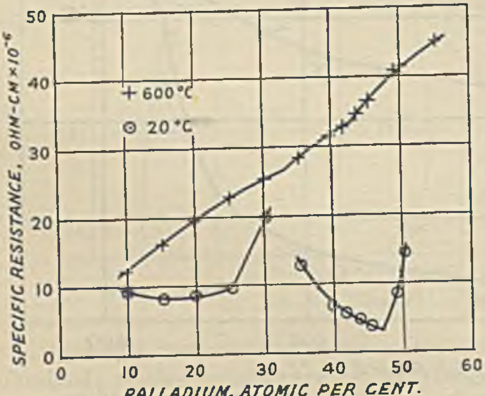

Fig. 3.

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* In order to save space, the results for all the alloys are shown in these figures.

curve described above, the cooling curve conforms. The comparatively sharp rise from the minimum to the peak occurs again in the 15 per cent. palladium alloy.

The specimens were usually annealed for at least one day at 400°–500° C. and then cooled slowly in the furnace before an investigation was commenced, but one group of specimens was examined from the start, the results in this case for the 20 per cent. alloy being indicated in Fig. 2, I. The resistance was comparatively high at the start (*A′*) and increased along the broken line until the temperature reached 300° C. (*B′*). There was then a fall, probably due to the removal of the work-hardness introduced in preparing the wires, followed by a rise to the peak *C′* at 500° C. From this point to the end of the examination, which included (*a*) heating to 630° C. and cooling to room temperature, (*b*) determining T_C with the recorder, and (*c*) heating from 330° to 616° C. and cooling to room temperature, all the readings for which the heat-treatment had been sufficient (nearly 50) lay very close to the curve *ABCD*.

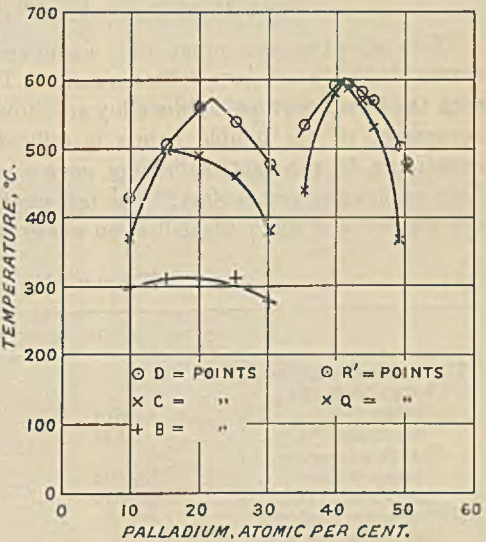

FIG. 4.

The decrease of resistance from the peak on cooling was found to be a comparatively slow process; for example, in the curve obtained with the recorder for a rate of cooling of 0·25° C. per minute there was a depression of 6° C. in the value of T_C for the 15 and 20 per cent. palladium alloys. The resistance of the 20 per cent. palladium alloy wire at room temperature was 0·544 ohm and 0·516 ohm, respectively, after the treatments (*a*) and (*c*) above. The difference was even greater in the alloy containing 25 per cent. palladium. As the only difference in the treatments was that the furnace had cooled freely from 350° C. in (*a*) and from 210° C. in (*c*), it seems probable that the more rapid cooling from the higher temperature had some quenching effect.

The results of the thermal investigation do not bear a very close relation to those of the work on electrical resistance. It will be seen from Table II that in the heating curves the absorption of heat commences between the *B* and *C* points and the maximum deflections correspond satisfactorily with the *C* points if allowance be made for slight superheating. The changes as shown by the cooling curves start between the *D* and *C* points, and the maximum deflections occur 10°–20° C. below the *C* points. As this may be entirely due to the rate of cooling employed, it is reasonable to conclude that the greatest change of energy occurs at about the *C* point, whilst both the *B–C* and *D–C* changes of electrical resistance are accompanied by small energy changes.

(b) 35–55 *Per Cent. of Palladium.*

Five alloys in this range were examined by heating and cooling curves, and only two gave definite results. The types of curve obtained with the 45 per cent. palladium alloy are shown in Fig. 1 (III, IV). The occurrence of the double points is difficult to explain. The alloy containing 40 per cent. palladium gave a very large and sharp peak both on heating and cooling. The temperatures at which the changes commenced and where the deflection was greatest are given in Table III.

TABLE III.

	35% Pd.	40% Pd.	42·5% Pd.	45% Pd.	50% Pd.	55% Pd.
Thermal investigation :						
Change on heating :						
began (° C.) .	...	618	...	538	...	...
maximum (° C.) .	...	642	...	592	...	...
Change on cooling :						
began (° C.) .	...	592	...	576	...	...
maximum (° C.) .	...	579	...	492	...	...
Micrographic analysis :						
Limits of upper phase boundary (° C.) .	540–550	604–613	604–613	594	572–575	521–537

The results of the micrographic examination can be divided into two parts, dealing respectively with the determination of the upper phase boundary and with the changes at lower temperatures. Except where one phase was present in only a small quantity, it was often difficult to distinguish between the phases under the microscope.

In the alloys containing 35, 50, and 55 per cent. palladium the separation of the second phase in the grain boundaries could be detected readily and the temperature of its appearance was obtained within satisfactory limits, which are given in Table III. Fig. 12 (Plate II) shows the separation of the second phase in the 50 per cent. alloy about 20° C. below the boundary, where it has begun to appear in the grains

FIG. 5.—40 per cent. Palladium. Quenched from 600° C. × 150.

FIG. 6.—40 per cent. Palladium. Quenched from 594° C. × 150.

FIG. 7.—42·5 per cent. Palladium. Quenched from 594° C. × 75.

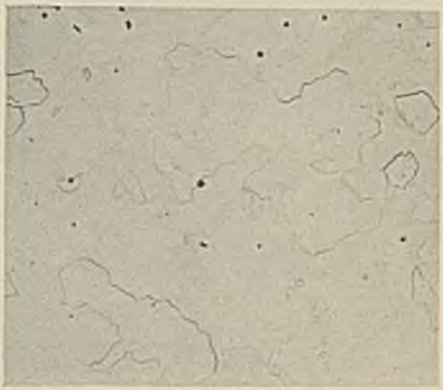

FIG. 8.—42·5 per cent. Palladium. Quenched from 590° C. × 75.

FIG. 9.—45 per cent. Palladium. Quenched from 599° C. × 150.

FIG. 10.—45 per cent. Palladium. Quenched from 598° C. × 50.

PLATE III.

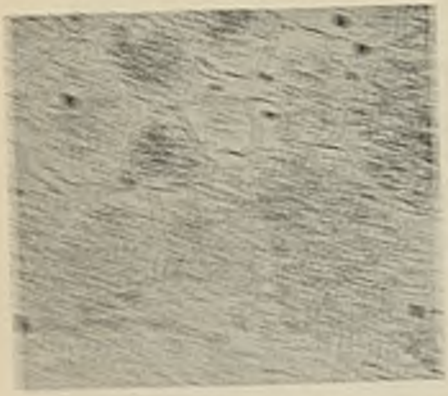

FIG. 11.—45 per cent. Palladium. Quenched from 384° C. × 150.

FIG. 12.—50 per cent. Palladium. Quenched from 555° C. × 75.

FIG. 13.—35 per cent. Palladium. Quenched from 500° C. × 150.

FIG. 14.—40 per cent. Palladium. Quenched from 500° C. × 75.

FIG. 15.—45 per cent. Palladium. Quenched from 300° C. × 150.

FIG. 16.—50 per cent. Palladium. Quenched from 300° C. × 150.

as well as along the grain boundaries. Early experiments placed the boundary between the one-phase and two-phase areas at 598°–602° C. for both the 40 and 45 per cent. palladium alloys; Fig. 10 (Plate I) shows the presence of the second phase at 598° C. in the alloy containing 45 per cent. palladium and Fig. 11 (Plate II) the marked increase in quantity at only 4° C. lower. A 42·5 per cent. palladium alloy was therefore prepared to determine the course of the curve between 40 and 45 per cent. palladium, specimens of all three compositions being annealed and quenched together. Considerable difficulty was experienced in interpreting the structures shown by the specimens quenched from the neighbourhood of 600° C. and, discrepant results being obtained, the following experiment was carried out: nine specimens, three of each composition, after being annealed for 18 hrs. at 870° C., were heated to 900° C., quenched in cold water, and then hammered. The specimens, in sets of three, were then annealed in the triple furnace at 604°, 600°, and 594° C., respectively, for 43 hrs., and quenched. The specimens of the alloys containing 40 and 42·5 per cent. palladium showed two phases at all temperatures, the quantity of separating phase being greater the lower the temperature and, at a given temperature, being greater in the 42·5 per cent. palladium specimen. The effect of temperature is shown in Figs. 5, 6 (Plate I), and of composition in Figs. 6, 7 (Plate I); in the latter case, the predominant phase is believed to be that separating with fall of temperature. Fig 8. (Plate I) shows this at a later stage of development. Two of the specimens containing 45 per cent. palladium were uniform (Fig. 9, Plate I) and that quenched from 594° C. showed only traces of a second phase. The limits given in Table III are based on the above results.

In order to determine what happens when the alloys are cooled to lower temperatures, specimens were quenched from 521°, 400°, and 300° C., and one set was slowly cooled to room temperature, the two last being treated in the aluminium block furnace. Figs. 13–16 (Plate II) show the structures of the 35, 40, 45, and 50 per cent. palladium alloys quenched from 300° C. Fig. 13 shows the largest quantity of second phase seen in any 35 per cent. palladium alloy, and even here there are only traces of it. Only the 40 per cent. palladium alloy showed a uniform structure at low temperatures. In the alloys containing 45, 50, and 55 per cent. palladium the quantity of the second phase seemed to increase and then to decrease as the temperature was lowered. The greatest amount observed for each composition was at 550°, 521°, and 400° C., respectively.

The type of electrical resistance–temperature curve obtained in this range differs from that in the copper-rich alloys (Fig. 2). Curve III was obtained for the 41 per cent. palladium alloy and curve IV for the 48 per cent. palladium alloy. The characteristics of these curves are : (*a*) a steady increase of resistance over a considerable range of temperature (*PQ*); (*b*) a large increase of resistance over a comparatively short range of temperature (*QR*); (*c*) a further steady increase with a very small temperature coefficient (*RS*). The curve is not completely reversible on cooling. The retardation, *RR′*, varied from 6° to 50° C. in the alloys examined, and while in some alloys the resistance then fell to, and continued along, the line *QP* (curve III), in others it fell only a fraction of its rise, and then smoothed out to a curve *Q′P′* almost parallel to *QP* (curve IV). The temperatures of the *Q*, *R*, *R′*, *Q′* points and the changes in resistance between these points are given in Table IV, together with the specific resistances at 20° C. before and after the experiments. The lower values at 20° C. and the values at 600° C. are plotted in Fig. 3, and the *Q*, *R′* points in Fig. 4.

TABLE IV.

	35% Pd.	38·5% Pd.	40% Pd.	41% Pd.	42·5% Pd.	45% Pd.	48% Pd.	50% Pd.	55% Pd.
Temperatures (° C.) :									
T_Q . . .	440	582	596	588	570	531	368	472	...
T_R . . .	570	598	606	600	596	598	542	528	...
T_R' . . .	535	592	591	594	584	570	504	480	...
T_Q' . . .	440	580	585	588	550	490	380	408	...
Specific resistance (ohm-cm. $\times 10^{-6}$) :									
ρ_{20} before . .	12·7	6·7	6·7	5·6	5·0	4·0	8·3	14·4	43·5
ρ_{20} after . .	22·9	6·7	6·7	5.6	4·8	3·7	28·2	36·1	43·8
$\rho_R - \rho_Q$ . .	11·5	18·4	18·4	20·2	21·2	24·0	26·3	17·0	...
$\rho_R' - \rho_Q'$ . .	2·5	18·5	18·6	20·2	22·4	25·8	6·2	1·5	...

The effect of continuous heating and cooling on the temperatures of the transformations was examined with the 40 and 45 per cent. palladium alloys. The results are collected in Table V, and comparison with

TABLE V.

Alloy Palladium Per Cent.	Rate of Change of Temperature ° C. per Minute.		Transformation	
			Began ° C.	Ended ° C.
40	Heating	0·3	596	607
		0·23	596	606
	Cooling	1·0	586	577
		0·03	591	585
45	Heating	0·4	557	598
	Cooling	0·4	518	...
		0·06	546	below 480

Table IV shows that the method of long-time annealing is almost essential for obtaining stable equilibrium during a transformation, especially in alloys away from 40 per cent. palladium. During the transformation of a 50 per cent. palladium alloy wire, its resistance increased from 1·033 to 1·260 ohms in the first 24 hrs. and to 1·290 ohms after a further 20 hrs., the temperature being kept constant. Annealing for only 24 hrs. thus yields a result about 3 per cent. too low, which has the effect of extending the temperature range of the transformation. Owing to the steepness of the curves in these experiments, it is unlikely that errors greater than 3° C. have been introduced as the result of insufficient annealing.

The resistance of the 55 per cent. palladium alloy increased by 1·5 per cent. on heating from room temperature to 250° C., and then remained constant to ± 0·5 per cent. up to 620° C. On cooling, the resistance was constant down to 200° C., and then decreased by 1·5 per cent. to the value at room temperature.

The low resistances of the 35, 48, and 50 per cent. palladium alloys after the preliminary anneal, in contrast to the high values after cooling slowly from above the transformation range, led to an investigation of the effects of quenching and rolling the wires. The resistances of the " as received " wires were respectively 7, 29, and 3 per cent. higher than the resistances of the slowly cooled wires given in Table IV (ρ_{20} after) for these compositions.

(a) *Rolling.*—35 and 50 per cent. palladium alloy wires in the slowly-cooled state were reduced by about a third, and their resistances were examined as before at various temperatures. There was little sign of a decrease in resistance due to the removal of the work-hardness, and the increases due to the transformation were only 14 and 5 per cent., respectively, of the increases obtained with the annealed alloys.

(b) *Quenching.*—35, 48, and 50 per cent. palladium alloy wires in the slowly-cooled state were heated to 620° C. for 1½ hrs. and quenched in cold water. The resistances were then 2–3 per cent. higher than in the " as received " condition. After treatment similar to the preliminary anneal, the resistances had decreased by amounts equal to 12, 14, and 3 per cent., respectively, of the corresponding decreases with the " as received " wires.

(c) *Quenching and Rolling.*—A length of the 48 per cent. palladium alloy wire was annealed at 615° C. for 1½ hrs., quenched, and then rolled to a 66 per cent. reduction in thickness. On annealing, the resistance fell 49 per cent., compared with 77 per cent. for the " as received " wire. It appears, therefore, that to produce a wire of low resistance requires both quenching and cold-work. It is probable that in the preparation of the alloys the cooling was comparatively fast and that the cold-work in preparing the wires was considerable, but since this treatment may not have been the ideal, it is possible that still lower values for the resistance of these alloys in the ordered arrangement may be obtained, in which case the transformations will commence at a lower temperature.

DISCUSSION OF RESULTS.

The general form of the electrical resistance–temperature curves is in agreement with the work of Borelius, Johansson, and Linde,[5] who used a rate of change of temperature of 50°–100° C. per hr., a rate which the present work has shown to be much too great for the maintenance of equilibrium conditions. As a result, they found the *B* points in the copper-rich range indefinite with T_B about 50° C. above the values given here, and the resistances below the *B* points considerably too high. Similarly in the 35–50 per cent. range the temperatures of the changes on heating were much higher than those given here. In this connection it is to be noted that the results of the present thermal investigation, obtained with a greater rate than the above, are, with one exception, in good agreement with the present electrical resistance work. Borelius, Johansson, and Linde obtained a considerably sharper transformation, but the hysteresis was much more pronounced. The resistance of their 49·8 per cent. palladium alloy decreased from the high value right down to the values on the heating curve at low temperatures, whilst in the present work only partial falls were obtained with both the 48 (by analysis 49·24) and 50 per cent. palladium alloys. Svensson [6] states that he was unable to obtain the regular arrangement of the atoms in a 49 per cent. alloy in spite of annealing it for several weeks between 700° C. and 300° C., and he considers that the 49·8 per cent. alloy, which Sedström and Johansson and Linde obtained in the ordered condition, was not completely homogeneous. The experiments with quenched and rolled wires suggest that the previous treatment may also have played a part.

The specific resistances (Fig. 3) corresponding with the ordered arrangement at 20° C. are all lower than values previously obtained, due, no doubt, to the treatment employed. In the copper-rich range the differences are not appreciable except at 30 per cent., and the present results are not in disagreement with the occurrence of the minimum specific resistance at 16–18 per cent. of palladium. Low values of the specific resistance have been obtained over a wider range of composition than before in the range 35–50 per cent. palladium, but the position of the minimum is in agreement with the work of Svensson. The specific resistance–composition curve at 600° C. shows two breaks at 32·5 and

42 per cent. of palladium, respectively, differing from the smooth curve up to 50 per cent. given by Borelius, Johansson, and Linde, and from Svensson's curve for quenched alloys, which has a point of inflection between 30 and 35 per cent. of palladium.

In the temperature–composition diagram (Fig. 4) the curve of the *D* points differs essentially from that of Borelius, Johansson, and Linde in placing the maximum at 22 per cent. instead of at the simple atomic ratio 3 Cu : 1 Pd. The course of the curve for the *B* points is tentative. In the range 35–50 per cent. palladium, only the beginnings of the transformations on heating and cooling are plotted (*Q*, *R*′ points), representing the upper limit of existence of the pure body-centred cubic phase and the lower limit of the pure face-centred cubic phase, respectively, when the previous treatment of an alloy has ensured that the stable phase is alone present. The maximum near 40 per cent. palladium and the *R*′ points above the *Q* points are in marked contrast to the earlier results, and emphasize the deficiencies of the method.

The composition limits of the two transformations cannot be accurately fixed by the present work. The copper-rich transformation probably begins very little below 10 per cent. and ends above 30 per cent. palladium. There is probably a region with no transformation between 30 and 35 per cent. palladium although there is at present no experimental proof available. The upper limit of the second transformation is very close to, but definitely above, 50 per cent. palladium. This indicates, as has been noted previously,[4] that the palladium atoms are unable to replace the copper atoms in the ideal body-centred cubic lattice of the CsCl type to any appreciable extent.

Theoretical Considerations.

The occurrence at 17 per cent. of palladium of the minimum specific resistance and the maximum intensity of the super-lattice lines in the X-ray photographs of slowly-cooled alloys was explained by Borelius, Johansson, and Linde in terms of the splitting up of the crystallites into small zones during the ordering of the atoms. So far as the electrical resistance is concerned, there is another explanation for the displacement of the minimum away from 25 per cent. Two opposing factors combine to determine the value of the specific resistance: the regularity of the atomic arrangement favours a low resistance; the dilation of the copper lattice by the addition of palladium atoms produces an increase of resistance. As the 600° C. isotherm (Fig 3) shows, this latter effect is very considerable—atom for atom, palladium is nearly twice as effective as gold in increasing the resistance of copper. As a result, the first factor is outweighed by the second, and, while the decrease of resistance due to the ordering of the atoms ($\rho_C-\rho_B$, Table II) is greatest at 25 per cent., the minimum resistance is displaced to the copper-rich side.

The temperature–composition diagram for the copper-rich alloys does not have the same significance as the usual equilibrium diagram, since it represents stages in a uniphase rearrangement of atoms which, even at the composition of the simple atomic ratio, takes place over a considerable range of temperature. An interpretation of the resistance–temperature curves is necessary to determine the stages associated with the *B*, *C*, and *D* points. From the X-ray work, the structure of the alloys at low temperatures is considered to be ordered in terms of the Cu_3Pd structure (p. 11). Thus the 25 per cent. palladium alloy should have the ideal arrangement; in alloys richer in copper, the excess atoms should occupy cube corners; on the other side, the excess of palladium atoms should go to the centres of the cube faces. The high-temperature arrangement is an irregular distribution of the atoms on the points of a face-centred cubic lattice. The following suggestions are based mainly on the results for the 15–25 per cent. palladium alloys. From *A* to *B* (Fig. 2, I) the resistance increases steadily with temperature as in a pure metal, due to the normal expansion of the space-lattice. At *B* the change of slope is taken to indicate that the ordered arrangement of the atoms has begun to be upset. If it be assumed that, away from the 25 per cent. palladium alloy, the ordered arrangement of the atoms consists of small groups with the Cu_3Pd structure distributed throughout the whole, then in the production of the uniform irregular distribution the local change of composition is less at 25 per cent. palladium than on the copper-rich side. The transformation should therefore be completed there more readily, *i.e.* at a lower temperature. The *C* point may thus correspond with the conclusion of the atomic redistribution. It is suggested that this process produces a distortion of the lattice, the rectification of which, taking place between *C* and *D*, causes the observed small decrease in resistance. The values of $\rho_C-\rho_D$ for the 15–25 per cent. palladium alloys indicate that the greatest distortion is at 25 per cent., and the range of temperature of the change supports this. Above *D* the normal increase of resistance is resumed.

In the case of the 10 per cent. palladium alloy, where only 40 per cent. of the atoms need be concerned in the ordering, it is conceivable that the resistance when these atoms are arranged statistically among themselves in groups is greater than when the palladium atoms are distributed uniformly at random. There is thus the possibility of a two-stage process, which would also account for the lag on cooling.

On the palladium side of the simple ratio, the conditions differ, in that the excess atoms are the larger (atomic radii :—copper 1·28 A., palladium 1·38 A.). In the ordered state, these larger atoms must go to the centre of a cube face, and thus be closer to a neighbouring palladium atom than on the copper-rich side. With the lattice spacing larger, the palladium atoms may conceivably be able to move more freely, and the change begin and end at a lower temperature: the distortion too would be correspondingly reduced.

The temperature–composition diagram may now be construed. (i) The *D* line marks the lower limit of the undistorted face-centred cubic lattice with the atoms irregularly arranged; (ii) between the *C* and *D* lines the lattice is distorted, with an irregular arrangement of atoms; (iii) between the *B* and *C* lines the diffusion of the atoms from the ordered to the irregular arrangement is taking place, accompanied by a distortion of the lattice; (iv) the *B* line marks the upper limit of the ordered face-centred cubic structure.

The hysteresis obtained in the resistance–temperature curves of the range 35–50 per cent. palladium seems to be a definite characteristic of these alloys. The loop is small in the alloys near 40 per cent. of palladium, and it is only some 50° C. wide at the limiting compositions. It is therefore possible that a modified form of under-cooling is responsible for its occurrence. The thermal and electrical resistance results with alloys near the limiting compositions indicate that the difference in energy content of alloys in the two states is small. Thus quite small factors should be able to retard the change.

SUMMARY.

1. In the range 10–30 per cent. of palladium, the electrical resistance–temperature curves for the transformation from an irregular to a regular distribution of the atoms on the points of a face-centred cubic lattice are explained on the assumption that a lattice distortion, which produces a small increase in resistance, is followed by the ordering of the atoms which causes a large diminution in resistance.

2. The highest temperature for the commencement of the first stage is about 570° C. at a composition near 22 per cent. of palladium. The corresponding figures for the second stage are 500° C. and 15 per cent.

3. The minimum specific resistance in the ordered state is $8{\cdot}1 \times 10^{-6}$ ohm-cm. at 20° C. in the 15 per cent. palladium alloy. The increase due to the transformation is greatest at 25 per cent. palladium.

4. In the range 35–55 per cent. palladium, the transformation from a face-centred cubic lattice with the atoms arranged irregularly to a body-centred cubic lattice with an ordered distribution of the atoms takes place completely near 40 per cent., but only partly on cooling in alloys near the limiting compositions. The change in the latter case

can be made more complete by quenching from 600° C., cold-rolling, and then annealing at 450° C.

5. In no case has the transformation been found to take place at constant temperature, the range being smallest and the temperature highest at 40 per cent. palladium.

6. The specific resistance in the ordered state is a minimum at 47 per cent. of palladium ($3{\cdot}1 \times 10^{-6}$ ohm-cm. at 20° C.).

7. There are two breaks in the specific resistance–composition curve for the irregular arrangement of the atoms, at 32·5 and 42 per cent. palladium, respectively.

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PAPER No. 656. This paper is not to be reprinted, wholly or in part, until presented (and then only with due acknowledgment) at a meeting to be held on March 7–8, 1934, in the Hall of the Institution of Mechanical Engineers, Storey's Gate, Westminster, London, S.W.1. The Institute as a body is not responsible for the statements or opinions expressed in this paper, on which written discussion may be sent to the Secretary not later than March 19, 1934.

This paper will not be reissued in the form of a separate "Advance Copy," a method of publication which has been discontinued.

ALLOYS OF SILVER AND BERYLLIUM.*

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SYNOPSIS.

The constitution of the whole range of alloys in the silver–beryllium system has been redetermined by thermal and micrographic analyses, and the results are recorded. Modifications and amplifications of Oesterheld's original constitutional diagram are proposed.

A description is given of new tarnish-resisting silver alloys obtained by the addition to silver and to some "standard" silvers of very small quantities of beryllium.

INTRODUCTION.

AN investigation of the effects of the addition of beryllium to silver and its alloys was undertaken in the Metallurgy Department of the National Physical Laboratory as part of the work on beryllium and its alloys which has been carried out for the Minor Metals Committee of the Metallurgy Research Board, Department of Scientific and Industrial Research. The investigation was to include the addition of beryllium to high- and low-grade silver alloys, particularly those containing copper.

The results of the work on high-grade alloys are described in Part II of the present paper.

In the case of low-grade silver alloys containing copper, no advantages were found by the introduction of beryllium, but it was observed that within certain ranges of composition separation into two liquid layers occurred. This immiscibility disappeared on the addition of nickel.

These observations, which are collected in Table I, led to an investigation of the constitution of the silver–beryllium system, the results being described in Part I of the present paper.

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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. LIV, 1934. Reference should accordingly be as follows—*J. Inst. Metals*, 1934, 54 (Advance copy).

TABLE I.

Number of Alloy.	Composition, by Weight.				Colour.
	Ag.*	Cu.	Be.	Ni.	
ABC1 . . .	50·07	48·91	0·98	...	Yellow
ABC2 . . .	49·83	48·62	1·50	...	Light yellow
†ABC3 Top layer .	33·03	64·50	2·51	...	Yellow (about same as ABC1)
†ABC3 Bottom layer	61·20	37·91	0·92	...	Pale yellow
†ABC4 Top layer .	19·63	75·00	5·33	...	Dark yellow
†ABC4 Bottom layer	76·52	22·81	0·72	...	Very pale yellow
ABCN4 . . .	49·63	42·42	1·66	6·29	,, ,,
ABCN7 . . .	49·88	41·28	2·57	6·31	,, ,,

* All alloys were made up to contain approximately 50 per cent. by weight silver.

† In ABC3 the volumes of the two layers were approximately equal. In ABC4 the volume of the top layer was approximately twice that of the bottom layer.

Various attempts were made to obtain homogeneous castings from ABC3 and ABC4, but without success. The sharpness of demarcation between the two layers is illustrated in Fig. 4 (Plate I), which shows a typical "meniscus."

PART I.—*The Constitution of the Silver–Beryllium System.*

The unexpected immiscibility found in the case of certain of the ternary alloys of silver, copper, and beryllium led to a critical examination of the constitutions of the three binary systems, silver–copper, copper–beryllium, and silver–beryllium. The following question naturally presented itself. Does this immiscibility occur in one or other of the binary systems, or is it confined to a range of compositions in the ternary series?

The constitution of the silver–copper system has been investigated and confirmed by many workers, whilst Masing and Dahl [1] have recently re-determined the constitution of the copper–beryllium series, particularly in the copper-rich range. Their proposed equilibrium diagram differs from that given by Oesterheld,[2] but the evidence is undoubtedly in favour of the later work of Masing and Dahl.

With regard to the silver–beryllium system, it will be noticed that, in the ternary alloys shown in Table I which exhibited immiscibility, the beryllium content in the silver-rich layers was always very small, suggesting that a peculiarity might exist in the silver–beryllium series. The only available information about this system was contained in the paper by Oesterheld, referred to above, whose work was carried out in 1916 on very small specimens, owing to the scarcity of beryllium at that time. Oesterheld's diagram is reproduced in Fig. 1.

In the region 40–70 atomic per cent. beryllium, the liquidus is comparatively flat. It appeared possible that in this region the true liquidus might be as suggested in Fig. 2, indicating immiscibility in the liquid state, which might persist in the presence of a third metal. Moreover, a more accurate knowledge of the silver-rich alloys of the

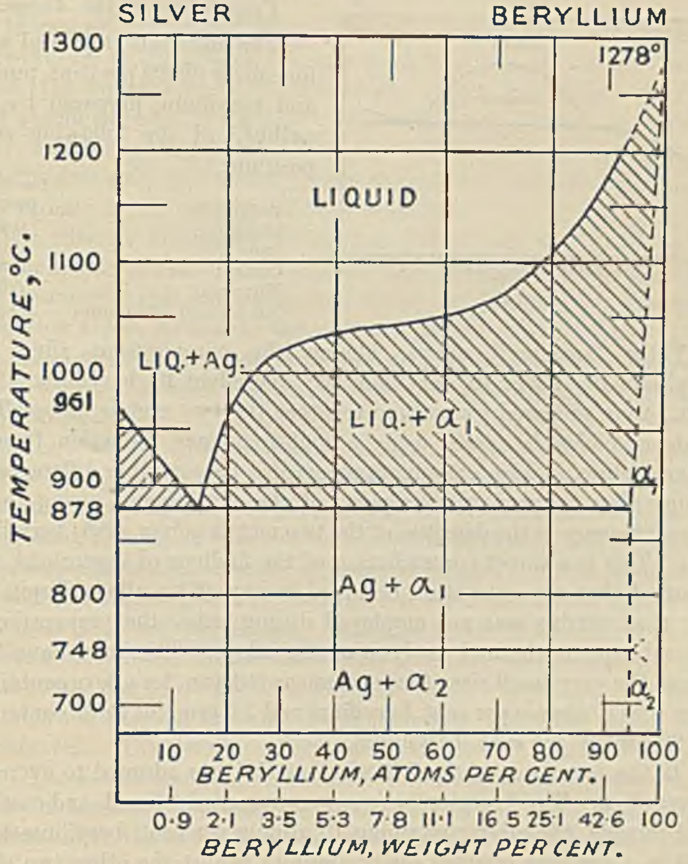


Fig. 1.

series was desirable in view of the investigation described in Part II of the present paper.

The constitution of the whole system was accordingly investigated by thermal and micrographic analyses. Owing to the enormous difference in the atomic weights of the two metals (silver, 108; beryllium, 9), all percentages are given as atomic, as these give a much clearer idea of the true composition of a particular alloy than do the weight percentages. The following formulæ are included to facilitate conversion of one to the other.

$$x = \frac{y}{12 - 0{\cdot}11y}; \quad y = \frac{12x}{1 + 0{\cdot}11x} \quad \begin{array}{l}\text{where } y = \text{atomic per cent. beryllium.}\\ \text{and } x = \text{weight per cent. beryllium.}\end{array}$$

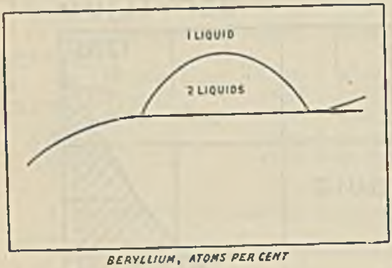


FIG. 2.

Preparation of the Alloys.

The materials employed were fine silver (99·99 per cent. purity) and beryllium, prepared by the author,[3] of the following composition:

	Per Cent.
Beryllium . . .	99·7
Oxygen . . .	0·2
Iron	0·01
Carbon . . .	0·05
Nitrogen . . .	0·005
Silicon and aluminium .	trace

Three "master" alloys, having the compositions silver 90, beryllium 10; silver 40, beryllium 60; and silver 10, beryllium 90 per cent., were prepared by melting together the two metals in beryllium oxide crucibles *in vacuo*, using a high-frequency induction furnace. After cooling, *in situ*, examination revealed considerable differences in composition between various parts of the same ingot, owing to the large difference in the densities of the two metals (silver, 10·5; beryllium, 1·8). This is a direct contradiction of the findings of Oesterheld, who reported that no segregation occurred in any of his alloys despite the fact that stirring was not employed during either the preparation or the subsequent thermal analysis of the alloys. This may have been due to the very small size of his specimens (10 grm. for alloys containing from 0 to 70 atomic per cent. beryllium and 2·5 grm. for those containing 70–90 atomic per cent. beryllium).

In the present case, the following method was adopted to overcome segregation. The "master" alloys were remelted, stirred, and cast into cold moulds, the alloy containing 10 atomic per cent. beryllium being held in a graphite crucible under graphite, whilst the other two alloys were contained in beryllia crucibles under a sodium fluoride–beryllium fluoride flux. The difficulty was, in this way, almost completely overcome, chemical analysis revealing only negligible differences in composition in different parts of individual castings.

The above procedure was adopted for the preparation from the "master" alloys of a series covering the whole composition range, the silver-rich alloys being melted in graphite crucibles under graphite, whilst beryllia crucibles and the flux were employed for those rich in beryllium. The alloys were cast in the form of cylinders about 2 cm. in diameter and 2 cm. in height, the weights varying from about 80 grm. (silver-rich) to about 10 grm. (beryllium-rich).

Thermal Analysis of Alloys.

In general, the relationships in the system are simple. The addition of beryllium to silver causes a very marked depression of the freezing point, the liquidus curve falling steeply until a beryllium content of 10·4 atomic per cent. is reached. This is the composition of the eutectic alloy, and its melting point is 881° C. With increasing beryllium, the liquidus first rises very sharply, then flattens out, and afterwards again rises rapidly to the melting point of beryllium.

The eutectic horizontal (solidus) at 881° C. can be traced on the beryllium side to about 85 atomic per cent. beryllium, where the arrest becomes very feeble and occurs at a lower temperature. It disappears altogether above 90 atomic per cent. beryllium. On the silver side, it was followed down to a beryllium content of about 3 atomic per cent., below which the arrest becomes ill-defined and occurs at a higher temperature.

An interesting observation noted by Oesterheld was confirmed. This is the occurrence in the beryllium-rich alloys of an arrest point at a temperature of 750° C. As one proceeds towards the silver end of the system, this point becomes more and more feeble, and cannot be found experimentally, in spite of many attempts, in alloys containing less than 50 atomic per cent. beryllium (Oesterheld traced it down to 65 atomic per cent. beryllium). In alloys in the range 92–98 atomic per cent. beryllium, this arrest occurs at lower temperatures. It is undoubtedly due to a solid transformation, and will be discussed later.

Attention may be directed to the practical difficulties which were encountered. These were entirely due to the serious effects of segregation. The actual analyses were carried out *in vacuo*, and in most cases it was impossible to obtain consistent results for the liquidus temperatures after the alloys had been twice melted. A very sharp arrest was always given by the first heating curve, and a somewhat diffuse one by the first cooling and second heating curves. By this time segregation had had sufficient opportunity to occur, and the results of the second cooling curve were quite inconsistent. Usually two arrests merging into each other occurred, which corresponded more or less with the true liquidus points of two alloys the compositions of which were one on each side of the particular alloy under consideration. The liquidus temperatures were therefore based on the results given by the first heating and cooling curves. In most cases confirmation was

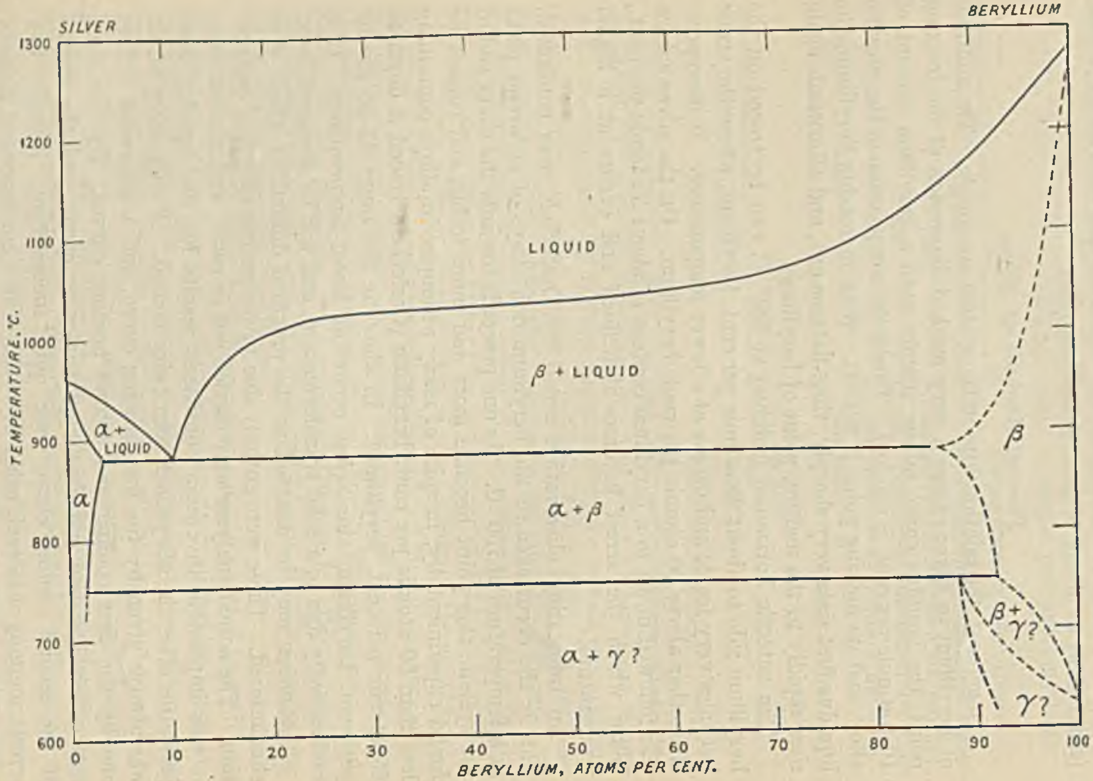

SILVER
BERYLLIUM
1300
1200
1100
1000
900
800
700
600
TEMPERATURE, °C.
0
10
20
30
40
50
60
70
80
90
100
BERYLLIUM, ATOMS PER CENT.
LIQUID
β + LIQUID
α + LIQUID
α
α + β
β
α + γ ?
β + γ?
γ?

Fig. 3.

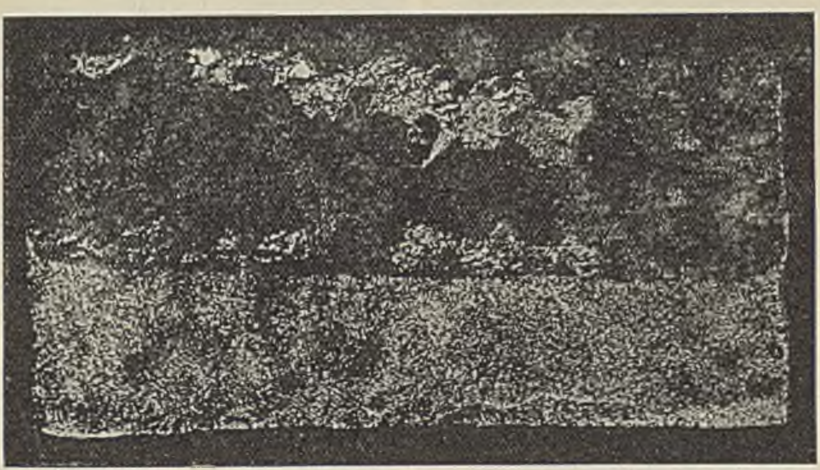


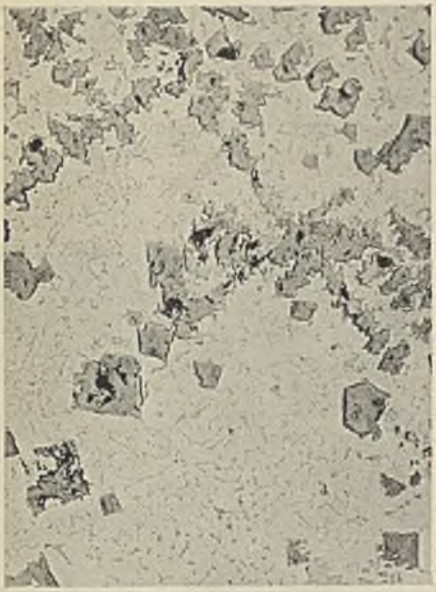
FIG. 4.

FIG. 6.—AB 3 (2·43 atomic-% Be). × 100.

FIG. 7.—AB 5 (3·44 atomic-% Be). × 100.

FIG. 8.—AB 10 (10·40 atomic-% Be). × 50.

FIG. 9.—AB 10 (10·40 atomic-% Be). × 75



[FIG. 10.—AB 13 (19·80 atomic-% Be). × 75.

FIG. 11.—AB 19 (65·78 atomic-% Be). × 75.

FIG. 12.—AB 21 (75·10 atomic-% Be). × 75.

FIG. 13.—AB 24 (86·83 atomic-% Be). × 75.

FIG. 14.—AB 27 (93·39 atomic-% Be). × 75.

FIG. 15.—AB 3 (2·43 atomic-% Be). Annealed at 810° C. Quenched. × 100.

obtained by using other specimens of the same composition with which thermal analysis had not up to that time been carried out.

In order to ensure that the incipient segregation, which occurs even on once melting, should not stultify the subsequent chemical analyses, the specimens were sectioned vertically through the centre, and millings were taken from the whole surface thus exposed.

Table II gives the compositions of the alloys investigated, together with the temperatures at which thermal arrests occur. Fig. 3 shows the proposed constitutional diagram.

Micrographic Analysis in the Solid State.

The silver-rich alloys containing less than 10 atomic per cent. beryllium were examined in order to determine the limit of solid solu-

TABLE II.

Number of Alloy.	Percentage, by Weight.		Atomic Percentage Be.	Temperature of		
	Ag.	Be.		Primary Solidification, °C.	Eutectic Solidification, °C.	Solid Transformation, °C.
AB 1	100·00	0·00	0·00	961	...	...
2	99·83	0·13	1·50	955	...	...
3	99·76	0·21	2·43	948	...	...
4	99·72	0·24	2·77	946	890	...
5	99·68	0·30	3·44	941	882	...
6	99·43	0·54	6·05	922	883	...
7	99·32	0·63	6·99	914	881	...
8	99·20	0·77	8·42	900	881	...
9	99·04	0·93	10·01	886	882 *	...
10	98·99	0·97	10·40	...	881	...
11	98·96	1·02	10·89	899	882	...
12	98·47	1·49	15·20	971	881	...
13	97·93	2·04	19·80	1003	880	...
14	97·39	2·59	24·20	1017	881	...
15	95·90	4·07	33·46	1025	881	...
16	94·34	5·65	41·52	1028	883	...
17	92·06	7·91	50·74	1033	881	750
18	88·94	11·03	59·51	1040	880	750
19	86·03	13·95	65·78	1050	880	751
20	83·21	16·76	70·47	1061	882	750
21	79·68	20·28	75·10	1076	880	752
22	78·60	21·37	76·31	1081	881	750
23	68·51	31·47	84·64	1128	880	750
24	64·52	35·46	86·83	1145	878	751
25	60·71	39·26	88·58	1160	873	750
26	51·97	48·00	91·72	1189	...	750
27	45·92	54·06	93·39	1206	...	736
28	26·95	73·03	97·01	1246	...	696
29	24·18	75·80	97·41	1251	...	690
30	0·00	100·00	100·00	1282	...	...

* This point was somewhat vague, overlapping with the initial thermal arrest.

bility of beryllium in silver at various temperatures. The specimens were held at 875° C. for 24 hrs. The temperature was then altered to that required, and maintained for 24 or 48 hrs., after which the specimens were quenched. The maximum solid solubility was then established by micrographic analysis to be 3·5 atomic per cent. beryllium at the temperature of the freezing point of the eutectic. The solubility decreases slowly with decreasing temperature, which was confirmed by slight age-hardening which could be obtained by suitable heat-treatment of these alloys. Investigation of the limit of solubility was not carried out at temperatures below 750° C.

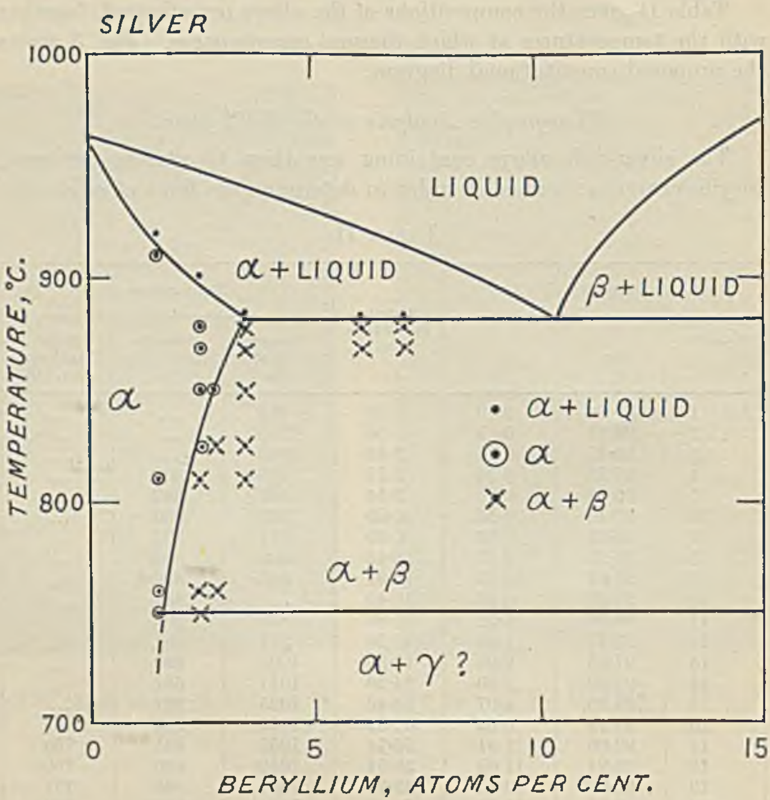


Fig. 5.

Fig. 5 shows this portion of the diagram on a larger scale, whilst Table III gives the results on which Fig. 5 is based. The α-phase is a saturated solid solution of beryllium in silver and the β-phase is a corresponding solution of silver in beryllium.

At the beryllium end of the series, the relationships in the solid state were not so exhaustively investigated, as it was considered that such alloys were unlikely to possess other than a purely academic interest. It was found, however, that in alloys containing more than 90 atomic per cent. beryllium, heat-treatment at temperatures up to 900° C. followed by quenching led to the production of a single-phase alloy (β), and in the absence of other evidence it is suggested that the solidus curve in this portion of the constitutional diagram is as indicated by the dotted line in Fig. 3.

There still remains, however, the consideration of the arrest point found at 750° C. during the thermal analysis of certain alloys in the series. In spite of several attempts, no micrographic, X-ray, or other evidence could be found to confirm or disprove its existence. The author is forced to conclude, with Oesterheld, that it is due to a polymorphic change in the β-phase, and since the thermal effect of the heat of transformation is small, it cannot be detected in the silver-rich alloys of the series containing this phase.

If this explanation be accepted, the logical consequence is that pure beryllium itself must possess a change point occurring at a temperature below 750° C. (In view of the fact that the thermal arrests occur below 750° C. in the range 92–98 atomic per cent. beryllium, it is reasonable to suppose that the transformation temperature in pure beryllium is below

TABLE III.

Number of Alloy.	Structure after Heat-Treating and Quenching from										
	750° C.	760° C.	810° C.	825° C.	850° C.	868° C.	878° C.	883° C.	901° C.	910° C.	920° C.
AB 2	α (traces of β)	α	α	...	...	...	...	...	...	α (traces of liquid)	α + liq.
3	$\alpha + \beta$	$\alpha + \beta$	$\alpha + \beta$	α (traces of β)	α	α	α	...	α + liq.	...	...
4	...	$\alpha + \beta$	...	$\alpha + \beta$	α (traces of β)	...	...	...	...	...	...
5	...	...	$\alpha + \beta$	$\alpha + \beta$	$\alpha + \beta$	$\alpha + \beta$	$\alpha + \beta$	α + liq.	...	...	...
6	...	...	...	...	...	$\alpha + \beta$	$\alpha + \beta$	α + liq.	...	...	...
7	...	...	...	...	...	$\alpha + \beta$	$\alpha + \beta$	α + liq.	...	...	...

and not above 750° C.) This consideration again raises the question of allotropy in pure beryllium, a question which has already been discussed in a previous publication,[4] in which it was pointed out that although the author and other investigators had found considerable evidence in favour of the existence of allotropy in beryllium, no confirmation could be obtained over the temperature range in question by the use of the most sensitive form of thermal analysis of the pure metal, using a differential thermo-couple. It was stated that "an allotropic change might be more readily found in beryllium-rich alloys than in the pure metal." The present investigation strongly suggests that allotropy does exist in beryllium, but that it is of the type which is largely inhibited in the pure metal, and can thus be detected only by methods which are more sensitive than thermal analysis, and that it is only in the presence of another metal that the transformation proceeds to completion and permits of its ready detection.

The simplest constitution which accords with the ascertained facts is shown in Fig. 3 by the dotted lines which continue at both ends of the horizontal continuous line at 750° C. Allotropy in beryllium is accepted. This is supported by the most recent work of Jaeger,[5] who gives the transition temperature as between 600° and 700° C.

Structure of Alloys.

Except for special purposes, the microstructures of the alloys are quite clearly visible without etching. Figs. 6–14 illustrate the structure of alloys representative of the whole series. The eutectic alloy, Figs. 8 and 9 (Plate II) is of interest, as it contains only 10·4 atomic per cent. beryllium, and its structure is typical of eutectics with a large preponderance of one metal over the other.

Figs. 6 (Plate II) and 15 (Plate IV) are typical of the structures obtained during the determination of the limit of solid solubility of beryllium in silver.

On the beryllium side of the eutectic, it will be seen (Fig. 12, Plate III) that the ground mass consists largely, not of the eutectic, but of the pure α-phase. This impoverishment of the eutectic of one of its components is not uncommon. Again, the primary beryllium solid solution (β-phase) is quite different in appearance, depending on the temperature of initial solidification and on the solidification range. In Fig. 10 (Plate III), which shows the structure of the alloy in which solidification begins at 1003° C., the crystal boundaries are straight-lined polyhedra. At higher temperatures the surfaces begin to round off as shown in Fig. 11, whilst Fig. 12 illustrates the complete rounding.

The hardness of the alloys increases with the beryllium content, whilst the colour ranges from the white of pure silver to the steel grey of beryllium.

CONCLUSIONS.

In the liquid state, all the alloys of the series are completely miscible, so that the immiscibility noted in the introduction above in certain ternary silver–copper–beryllium alloys cannot be definitely accounted for by peculiarities in any one of the three binary systems involved. It appears probable, however, that the almost horizontal central portion of the liquidus curve in the silver–beryllium series is an indication that, in these alloys, the maximum temperature at which liquid immiscibility can exist is only slightly lower than the temperature at which they become solid; that is to say, were it possible to supercool them, liquid immiscibility would occur. This cannot be achieved directly, but its effects can be obtained by the addition of a third metal which lowers the solidification temperature to an extent such that they remain liquid below the maximum temperature at which immiscibility can exist; thus the addition of copper leads to the phenomenon noted above. Similar reasoning explains why the addition of a fourth metal, nickel, which raises the solidification temperature again, results in the reappearance of homogeneous alloys.*

In general, the constitutional diagram proposed by Oesterheld was confirmed and amplified except in the following particulars:

(*a*) There is a definite solid solubility of beryllium in silver, which reaches a maximum of 3·5 atomic per cent. at the temperature of the freezing point of the eutectic alloy.

(*b*) The composition of the eutectic alloy is 10·4 atomic per cent. and not 15·3 atomic per cent. beryllium.

(*c*) The freezing point of the eutectic alloy is 881° C., and not 878° C.

The latter two differences may be accounted for by the use in the present work of purer materials and larger specimens.

The constitutional diagram has been completed except for the alloys containing more than 90 atomic per cent. beryllium, on which further work is desirable in order to determine the exact shape of the solidus curve and transformation in this region.

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* A case analogous to the above is cited by Roozeboom: "Die heterogenen Gleichgewichte," Vol. 3, Part 2, pp. 6 and 12, in connection with the components, water–phenol–acetone. Below 68° C. water and phenol are only partly miscible. Above 68° C. they are miscible in all proportions. The systems acetone–phenol and acetone–water are completely miscible at all temperatures. In the ternary system, however, immiscibility occurs at temperatures well above 68° C.

PART 2.—*Tarnish-Resisting Silver–Beryllium Alloys.**

The tarnish-resisting properties of beryllium which are due to the formation of a very tenacious self-healing surface oxide film had already led some previous workers to consider the possibility of its application to silver and its alloys in order to render them stainless. The available data were, however, very contradictory. Jordan and his collaborators,[6] who investigated the effects of the additions of various metals to silver, stated that beryllium actually seems to decrease the tarnish resistance of silver. Ray and Baker [7] found that " beryllium made silver alloys containing more than 90 per cent. by weight of silver hard and brittle, and decreased the tarnish resistance." Cooper,[8] on the contrary, found that alloys containing more than 90 per cent. by weight of silver and from 3 to 5 per cent. by weight of beryllium were immune to the action of sulphur and its compounds. Such alloys were said to be brittle in the chill-cast state, but, by suitable heat-treatment, could be rendered almost as ductile as silver itself.

The chief application of tarnish-resisting silver alloys is to the silver-ware industry, in which at present the alloy chiefly in use is standard or " hall-marked " silver containing 92·5 per cent. by weight silver and 7·5 per cent. by weight copper. Investigation was accordingly confined to those alloys which contain 90–100 per cent. by weight silver, and particularly to those containing 92·5 per cent. by weight silver. The chief considerations which had to be borne in mind were that if tarnish-resisting alloys could be produced by the introduction of beryllium, such alloys should differ as little as possible in melting and casting temperatures, in working properties, and in appearance, from the materials already in use and for which a well-established technique has arisen.

Preliminary examination of the alloys advocated by Cooper confirmed his results, but the alloys were unsatisfactory owing to the comparatively high beryllium content. They were not only brittle, but were also very different from pure or " standard " silver in appearance. Reference to Fig. 3 will show that in these alloys the primary constituent is a hard beryllium solid solution. If the surface of such an alloy be polished, this hard primary stands in relief and gives the surface an almost macro-etched structure, which is very undesirable in most polished silver-ware. This is true not only in the binary silver–beryllium alloys, but also in ternary alloys containing more than 90 per cent. by weight silver, 3–5 per cent. by weight beryllium, the remainder being copper, in which the limit of solid solubility of the beryllium and

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* The alloys described below form the subject of British Patent, No. 399,261, 1933.

the percentage above which beryllium or a beryllium-rich solid solution begins to separate as a primary constituent are not materially different from the values found in the binary system silver–beryllium. Moreover, these alloys have a very long solidification range, which leads to serious inhomogeneity and to a coarse structure.

These considerations imposed a further limitation to the useful range which could be investigated, and the beryllium content was accordingly kept below 1·2 per cent. by weight throughout. It soon became apparent that considerably less than the 3 per cent. by weight beryllium advocated by Cooper was required to produce immunity to the action of sulphur compounds.

The first alloy prepared had an approximate composition silver 92·5, copper 6·5, and beryllium 1·0 per cent. A comparison was made between the effect of sulphur compounds on this alloy and on " standard " silver. A very remarkable difference was found. Whereas the " standard " silver specimen became coated with a dark violet tarnish film, the new alloy was practically unchanged in colour.

The actual test used throughout this work was as follows: The specimens were rolled and cut to a standard size, 1 in. square and 0·02 in. thick. After being annealed, they were polished, weighed, and suspended, for periods up to 72 hrs., in an air thermostat maintained at 25° C., in an atmosphere of purified air containing a constant concentration of hydrogen sulphide and moisture. In different experiments the hydrogen sulphide content and humidity of the atmosphere could be varied within wide limits. The increases in weight of the specimens were noted together with the colours of the tarnish films.

A series of alloys ranging in composition from 90 to 100 per cent. silver, 0 to 1·2 per cent. beryllium, and 0 to 10 per cent. copper was then subjected to this test. Examination of the results revealed that two opposing factors were in operation. Increase in the beryllium content led to more complete immunity, whilst decreasing the silver or, rather, increasing the copper, led to less complete protection. In all cases the maximum immunity was obtained when the beryllium content had reached about 0·4 per cent. by weight. Further additions of beryllium seemed to have very little effect. It is to be noted that the solid solubility of beryllium in alloys of this type is approximately 0·4 per cent. by weight, and it appears that once the alloy is saturated with beryllium in the form of a solid solution, that is to say, once the beryllium is uniformly and finely dispersed throughout the whole mass, any excess, present either in the eutectic ground mass or as a primary constituent, has no further influence on the tarnish-resisting properties of the alloy.

Three alloys of the series were finally selected for more exhaustive tests. Their compositions are given in Table IV, and a comparison of their behaviours under the above test conditions, in Table V. Values for "standard" silver specimens are also included.

Table IV.

Number of Alloy.	Percentage, by Weight.		
	Silver.	Copper.	Beryllium.
SAB 1	94·41	5·05	0·52
,, 2	92·52	6·56	0·90
,, 3	92·46	7·10	0·41
"Standard" silver SS 1	92·5	7·5	0·0
"Standard" silver SS 2	92·5	7·5	0·0

It will be seen that under the conditions of the experiments these alloys are practically completely immune to the tarnishing effects of sulphur compounds.

A point of some interest is raised by a consideration of the increases in weight of the various specimens. It will be seen from the figures that the increase in weight is somewhat larger than might be expected to correspond with the very small colour changes associated with the films. It is suggested that the increases in weight are largely due to the formation of a colourless beryllium oxide film which protects the whole surface from sulphur tarnish.

The alloys were then subjected to the action of vinegar, fruit juices, and vegetable liquors. Whilst not completely resistant, the new alloys withstood these conditions more satisfactorily than did specimens of "standard" silver.

In appearance and colour, the new alloys are almost indistinguishable from pure or from "standard" silver. In melting temperature, casting, and general working properties they resemble "standard" silver very closely. Small age-hardening effects can be obtained by suitable heat-treatments. Moreover, control of composition, at any rate on the scale of the present experiments, presents no additional difficulties, whilst scrap metal can be readily remelted.

A suggested method of preparation is as follows. A beryllium-copper alloy containing the correct proportions as required in the final ternary alloy is prepared directly by electrolytic deposition of beryllium on to a molten copper cathode. This alloy is then melted with the correct weight of silver. It has been found that graphite crucibles and graphite protection for the surface of the melt are satisfactory for the production of sound castings. This method does not necessitate

TABLE V.

Atmosphere.	Period of Exposure, Hours.	Number of Alloy.	Weight Increments, Mg.		Appearance after Exposure.
			Expt. 1.	Expt. 2.	
0·005% Hydrogen Sulphide. 40% Relative humidity temperature 25° C.	24	SAB 1	0·004	0·004	Practically unaltered.
		2	0·017	0·022	" "
		3	0·022	0·018	" "
		SS 1	0·101	0·109	Steel-blue film with purple edge about 2 mm. wide.
		2	0·095	0·123	" " " "
	72	SAB 1	0·028	...	Practically unaltered—pale yellow edge about 3 mm. wide.
		2	0·039	...	Pale yellow film extending nearly halfway from edge to centre.
		3	0·046	...	Pale yellow film.
		SS 1	0·133	...	Purple film.
		2	0·143	...	" "
0·005% Hydrogen Sulphide. 75% Relative humidity temperature 25° C.	24	SAB 1	0·020	0·019	Practically unaltered—slight yellow edge about 1 mm. wide.
		2	0·022	0·026	" " " "
		3	0·036	0·030	Pale yellow film extending nearly half-way from edge to centre.
		SS 1	0·112	0·111	Purple film with steel-blue centre.
		2	0·111	0·113	" " " "

increasing the temperature of the silver very much above its own melting point, as the binary copper–beryllium alloys which are used have comparatively low melting points (between 950° and 1000° C.).[9] This greatly facilitates control of composition and prevents loss of silver by volatilization.

Very little trouble due to gassing is experienced, owing to the deoxidizing action of the beryllium. The beryllium oxide so formed rises to the surface. From the point of view of control of composition, it is desirable that as little oxygen as possible should come in contact with, or be contained in, the molten alloys, in order to avoid loss of a portion of the beryllium as oxide.

The question of inhomogeneity in different portions of a casting was examined, and it was found that, provided the melt was stirred just before pouring, segregation was negligible under the best conditions. The following analyses of the top and bottom of a small casting 1 in. square by 6 in. high are typical :

	Top, Per Cent.	Bottom, Per Cent.
Silver	92·25	92·27
Copper	6·82	6·80
Beryllium . . .	0·90	0·89

It is hoped that, at this stage of their development, these alloys may be investigated under production conditions, so as to bring to light difficulties which, so far, have not been found, but which may occur in their manipulation on a large scale.

ACKNOWLEDGMENTS.

The work described above was commenced under the direction of Dr. W. Rosenhain, F.Inst.Met., F.R.S., until 1931 Superintendent of the Metallurgy Department of the National Physical Laboratory, and completed under that of Dr. C. H. Desch, F.R.S., the present Superintendent of the Department.

The author wishes particularly to thank Dr. W. H. J. Vernon, of the Chemical Research Laboratory, who carried out the tarnish tests, and Mr. W. H. Withey, B.A., of the Metallurgy Department of the National Physical Laboratory, who carried out many of the chemical analyses. Thanks are also due to Mr. W. E. Carrington for his valuable help as assistant throughout.

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[9] Masing and Dahl, *loc. cit.*

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THE DIFFUSION OF ZINC AND IRON AT TEMPERATURES BELOW THE MELTING POINT OF ZINC.*

By GILBERT RIGG,† Member.

Synopsis.

When clean rolled zinc sheet is heated in close contact with clean iron diffusion commences at below 300° C. and is fairly rapid at above 380° C.; it proceeds by the formation of cones of diffusion products which spread out from isolated points where the contact between the metals is most perfect, and gradually penetrate into the zinc and across its surface. The progress of the diffusion is governed to a large extent by the nature and smoothness of the iron surface, and does not seem to be dependent on the vapour pressure of the zinc. Two well-defined layers of diffusion products are formed, a thin layer of constant thickness (about 0·08 mm.) containing about 17 per cent. iron being next to the iron, and a thicker layer containing 0–11 per cent. iron outside this. On continued heating, the thin layer moves towards the zinc, being continuously converted into the zinc-rich layer; this would seem to indicate that the principal diffusing constituent is the iron. The rate of penetration depends on time and temperature, and is independent of the grade of zinc, but the thickness of the zinc-rich layer is less with electrolytic than with pure zinc. The mechanism of the diffusion process is discussed.

Some preliminary experiments carried out about eighteen years ago showed that when pieces of zinc and low carbon steel with smooth surfaces were clamped together and heated to a temperature somewhat below the melting point of zinc for about 48 hrs., the two metals became strongly adherent to one another. During the last twelve months the present author has studied the matter in considerable detail in order to elucidate this action, the object of the present investigation being to study the diffusion of zinc and iron at such temperatures with special reference to the structure and composition of the product of diffusion.

In all these experiments the surfaces of the two metals, more or less polished, were brought together cold, and, with few exceptions, were kept in contact with a clamp. The heating was carried out in

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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. LIV, 1934. Reference should accordingly be as follows—*J. Inst. Metals*, 1934, **54** (Advance copy).

an electrically-heated oven, the temperature of which was controlled to ± 10° C. The temperatures used varied from 390° to 300° C. At the latter temperature, which is 119° C. below the melting point of zinc, the diffusion was small in amount and slow, but quite recognizable.

The zinc used was mostly in the form of rolled sheet. With cast zinc the action was usually, but not invariably, imperfect, and soon stopped, the same being true of electrolytic zinc cathode, although rolled electrolytic zinc worked well. The thickness of the zinc sheet varied from 0·01 to 0·1 in., and the area from 1 to 1·5 in.^{2}. The steel generally used had a carbon content of not more than 0·04 per cent.

Various degrees of polishing were tried on the steel, ranging from grinding wet with emery (0·01 in. diameter grains) to a metallographic polish. The degree of smoothness had a marked effect on the structure of the layer of diffusion product. In general, a surface obtained by grinding wet with fine emery (Wellington knife polish) gave good results. The zinc was cleaned by rubbing with whitening and water. The surface acquired during rolling was smooth enough for the purpose.

In order to obtain adhesion it is essential that the metals should be in perfect contact with one another, either over the entire surface or else at points sufficiently close together to start an action which can spread laterally and so become confluent.

When adhesion starts from a number of isolated points, cones of diffusion product begin to form at each centre from which growth continues from the steel into the zinc and radially along the surface of the steel. Fig. 1 (Plate I), taken from a specimen in which the action has just begun, shows a large number of small rough cones of diffusion product. The background is the surface of the steel plate which was ground with fine emery and water. The scratches due to grinding and general roughness of the surface are easily seen in the photograph. It will be noticed that the cones have a tendency to develop along scratches in the steel. As these scratches would be raised at the edges, the contact with the zinc would be good. The zinc surface showed pits corresponding with the cones on the steel.

Fig. 2 shows the result of an experiment in which the development of the cones has progressed considerably further. In this case a Belgian common spelter, rolled to 0·025 in., was used. The steel was of the same quality as used in the preceding experiment, and the surface of the metals was prepared in the same way. The zinc plate was sandwiched between two steel plates and the whole placed in a clamp and heated at an average temperature of 388° C. for 24 hrs. A corner was sawn off by two cuts at right angles and the sawn surface polished and etched with 5 per cent. concentrated nitric acid in water.

PLATE I.

FIG. 1.—Steel Plate Heated for a Short Time at 380° C. in Contact with Zinc. Zinc Plate Removed. × 28, Oblique Illumination.

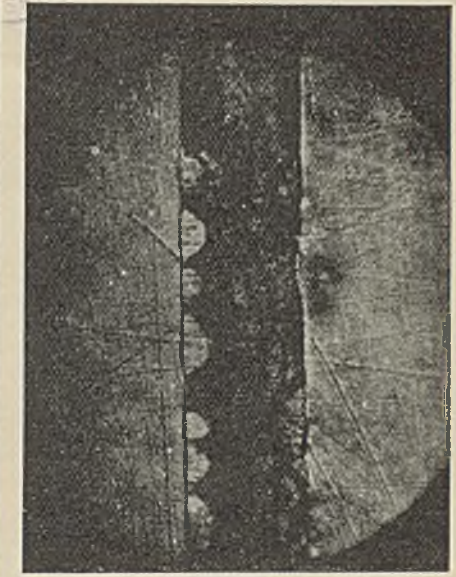

FIG. 2.—Rolled Zinc. Belgian Common Spelter, Heated for 24 hrs. at 388° C., between Steel Plates. × 30, Vertical Illumination. Etched with 5% HNO_3 in Water.

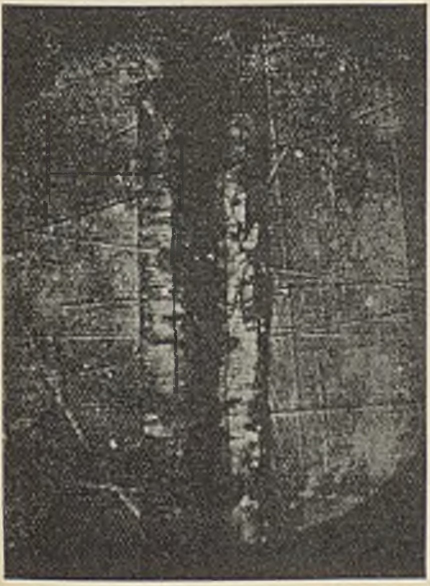

FIG. 3.—As Fig. 2. Another Part of the Same Specimen.

FIG. 4.—Zinc Sheet between Polished Steel Plates. Heated for 71 hrs. at 354° C. × 21.

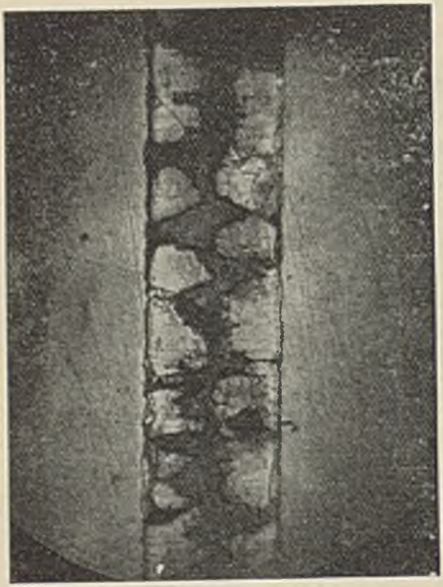

FIG. 5.—Zinc Sheet between Steel Plates Ground with Coarse Emery. Heated for 91 hrs. at 358° C. × 28.

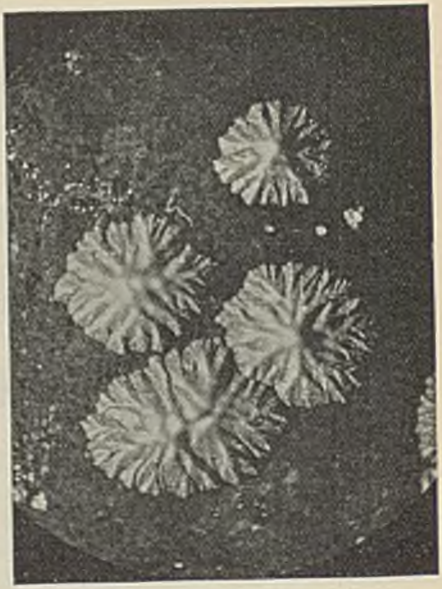

FIG. 6.—Pure Electrolytic Zinc Heated in Contact with Polished Steel Plate for 40 hrs. at 345° C. Showing Cones on Steel. × 21.

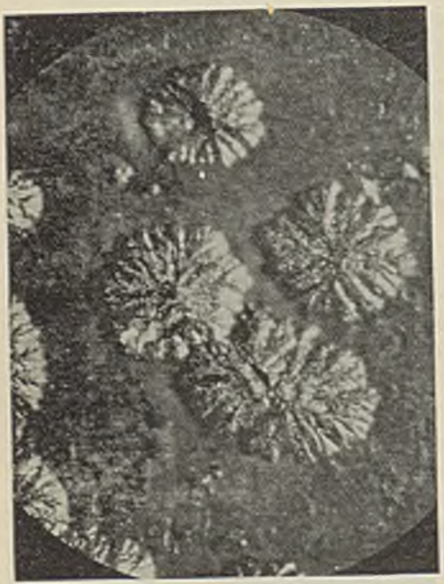

FIG. 7.—Same as Fig. 6. Showing Pits in Zinc.

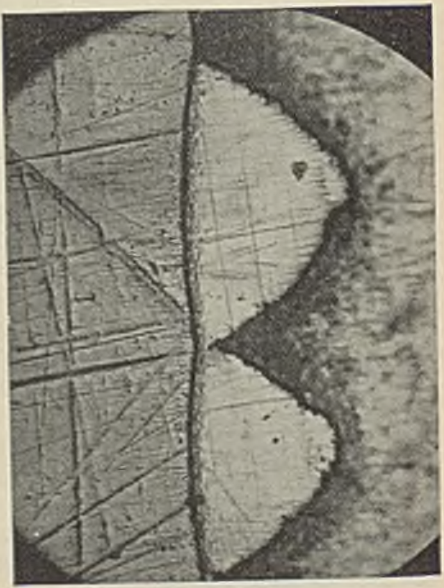

FIG. 8.—Same Specimen as Fig. 2. Section of Two Cones. × 140.

PLATE III.

FIG. 9.—Zinc Sheet Heated between Steel Plates. Showing Band between the Two Alloy Layers on Either Side of Central Dark Band of Unaltered Zinc.

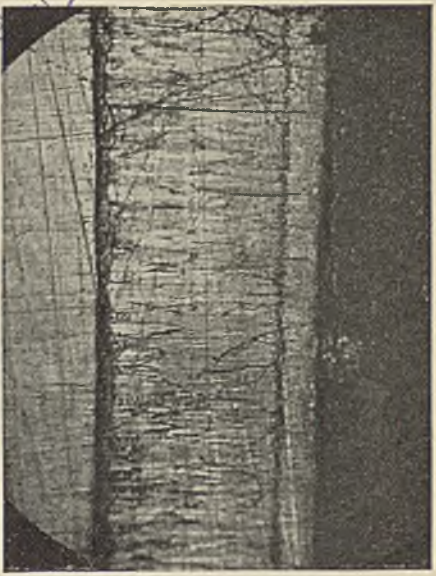

FIG. 10.—Zinc Sheet Heated between Steel Plates. Showing Thick Outer Layer, Thick Inner Layer and Additional Thin Layer next to Steel. × 80.

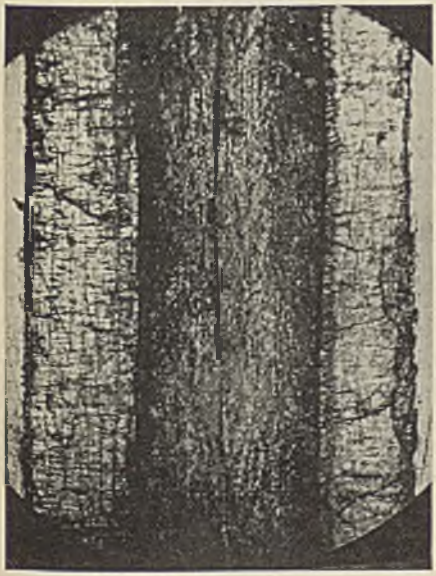

FIG. 11.—Six Sheets of Common Zinc Foil Heated between Steel Plates. × 44.

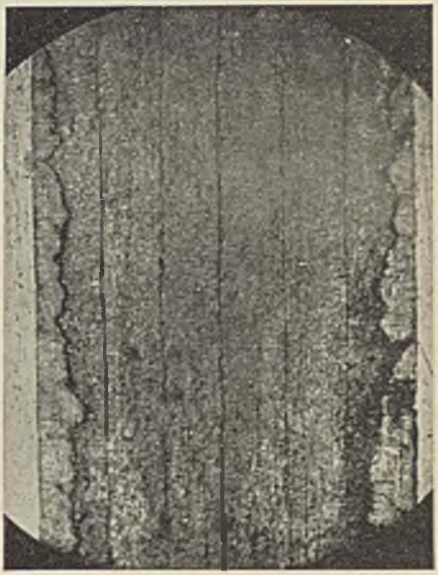

FIG. 12.—Same as Fig. 11. Beginning of Diffusion.

This reagent was generally used with all polished specimens. The metals were strongly adherent and showed no signs of separating under the stress of sawing. The white areas at the sides of the photograph are the steel, and the dark area in the middle is the zinc. At the top of the photograph the zinc has not been attacked at all. On the left-hand side is a row of cones, sharply marked off from the steel on the one hand and from the zinc on the other. It will be noticed that the bases of the cones show a curve convex to the steel. On the right-hand side the action is less marked and more irregular, probably owing to the contact being less perfect than on the left.

Fig. 3 shows another part of the same specimen, where the action has progressed much further than that exhibited in Fig. 2. The contact between the diffusion product and the steel is a straight line, which is clearly seen on the left side and is somewhat broken on the right. The diffusion product now consists of two layers separated by a nearly straight line, the inner one, which is in contact with the zinc, showing a tendency to cone formation, particularly on the right-hand side of the specimen.

This formation of cones on the contact between the inner layer and the zinc is not by any means of general occurrence. Fig. 4 shows a specimen similar in most respects to that in Fig. 3, but the steel plates received a metallographic polish and the specimen was heated for 71 hrs. at a temperature of 354° C. This photograph shows a remarkable regularity in the development of the two layers. The parallelism of the layers of diffusion product and of the residual zinc is very marked.

In Fig. 5 (Plate II) there is the absolute reverse of this condition. The same grades of steel and zinc were used and the heating was carried out at 388° C. for 91 hrs. The preparation of the steel surfaces, however, was done by grinding wet with coarse emery (0·01 in. diameter grains). The diffusion had taken place very irregularly, the rough irregular cones penetrating the zinc from opposite sides and leaving unattacked zinc between them. This result doubtless follows from the rough surface of the steel.

It has already been remarked that complete metal-to-metal contact is essential to the diffusion process. Apparently in these experiments this contact does not occur near the edges of the sheets. There is always a selvage of unattacked zinc surrounding the area of diffusion product. Inside this is a zone of more or less isolated cones, and inside this again a continuous layer of the product.

This reduced activity at the margin of the metal plates may be due to a slight bevelling of the steel plates during grinding and polishing, or to oxidation of the surfaces owing to penetration of air, or to both. In some cases, again, diffusion may take place almost entirely from one steel plate, the zinc being subsequently attacked from one side only. In these circumstances, individual marginal cones may grow to such a size as to pass almost through the zinc plate. This is shown in Figs. 6 and 7 (Plate II).

A possible explanation of these structures is as follows:

Diffusion begins at a number of points of contact between zinc and steel which are more perfect than in the areas between. As the iron diffuses into the zinc a depression is formed in the steel surface, the diffusion product remaining adherent to it and drawing down with it the zinc to which it also adheres, so that as the process continues the surface of the zinc surrounding the original projecting point comes into contact with the steel, and the iron begins to diffuse into it. The depression, consequently, increases in area, but is always deeper at the centre, as the process of diffusion has been going on longer at the centre than at the periphery.

In Fig. 8 two cones are shown in vertical section, photographed from the same specimen as in Fig. 2 (Plate I). The magnification is 140 diameters. It will be noticed that at the base of the cone there is a curved depression in the steel, so that the cone is standing on the surface of the segment of a sphere. In all specimens examined this condition is present.

When two adjacent depressions have come into contact, the ridge between them will soon be eaten away, and the final result will be a flat depressed surface which gives the straight line of contact seen in the cross section (Figs. 3 and 4, Plate I).

Zinc vapour does not apparently play any part in this action between the metals. A thin piece of paper laid between the steel and the zinc plates completely inhibits it, although the paper is reduced to a charred condition by the heat.

The structure of the layers at higher magnifications is illustrated in Figs. 9 and 10 (Plate III). In both of these photographs the different structure of the two layers is well shown, and in Fig. 9 the dark band of separation between the two layers is seen to have a granular structure. The outer layer shows a columnar structure oriented at right angles to the steel surface, and the inner layer a finer and less regularly oriented one. In Fig. 10, magnified 80 diameters, the columnar structure of the outer layer (here very thick relatively to the inner one) is well defined. In this specimen there is an additional thin layer present between the outer layer and the steel. This is not always shown, probably owing to imperfect preparation of the polished and etched surface (see Fig. 5).

The dark band between the outer and inner layer of diffusion product is probably due to the effect of difference in hardness of the two layers affecting the polishing and etching. These differences are accentuated by the etching, owing to the difference in solubility of the various layers in the etching reagent.

In the photographs of cross-sections the relative thickness of the two layers of diffusion product shows great variability. In Fig. 9, for example, the inner layer is slightly thicker than the outer, whilst in Fig. 10 the inner layer is only about one-fifth the thickness of the outer. If, however, the actual thickness of the inner layer in different specimens be compared, a considerable degree of uniformity is found, as is shown in Table I, which shows that in spite of large differences in the thickness of the outer layer, in the time and temperature of the heat-treatment, and in the quality of the zinc used, the thickness of the inner layer varies but little.

TABLE I.

Fig. No.	Thickness, mm.		Time, Hrs.	Temperature, ° C.	Grade of Zinc.
	Outer.	Inner.			
3	0·15	0·07	24	388	Common.
4	0·19	0·07	71	354	Common.
9	0·07	0·08	40	340	Pure electro.
10	0·31	0·06	316	382	Common.

In order to obtain some light on the cause of this double layer and the difference in structure between the outer and inner layers, it was decided to make a series of extractions with dilute hydrochloric acid and compare the iron : zinc ratio in the series of solutions so obtained.

For this purpose the specimen shown in Fig. 11 Plate III (× 44 diameters) was chosen. In this experiment six sheets of common zinc foil were used, sandwiched between two low carbon steel plates. The aggregate thickness of the zinc sheets was 1·16 mm. The arrangement is shown in Fig. 12, where the action has not made much progress. The specimen was held in a clamp. Fig. 11 shows the condition of the specimen which was used in the extraction experiment. The aggregate thickness of the layers of diffusion product was 0·61 mm. The specimen was removed from the clamp and the plates were pulled apart at a surface of contact between two unattacked zinc foils. The unattacked zinc foils were peeled off the surface of the diffusion product, and the steel was painted with acid-proof enamel, the enamel covering the thin layer of diffusion product and isolated cones round the periphery of the area of diffusion product.

Five extractions were made, the acid used being cold dilute hydrochloric acid, 5 c.c. of concentrated acid in 50 c.c. of water. Both sides of the specimen were used, the first to work out a technique and the second for the final result. After the fifth extraction the layer had become so thin that there was a risk of iron being dissolved from the steel. The sixth extraction was made, therefore, by chipping, the chips being treated with a magnet to remove the steel. The thin bottom layer coating the steel was not removable.

The specimen was exposed to the cold acid for 10 minutes on the first extraction and for 15 minutes on the four succeeding ones. The results obtained are shown in Table II, from which it will be seen that there is a steady increase in the iron content of the diffusion product except in the last item. This variation is probably due to the dissolution of the enamel before the chipping was done, thus exposing some of the low iron product round the margin, some of which no doubt got into the final sample. There was no sign, under the microscope, of free zinc on the original surface of the diffusion product.

TABLE II.

Fraction.	Iron, mg.	Zinc, mg.	Iron, Per Cent.	Zinc, Per Cent.
1	2·1	44·5	4·5	95·5
2	10·5	118·0	8·2	91·8
3	10·5	102·5	9·3	90·7
4	9·8	82·5	10·6	89·4
5	17·8	83·0	17·7	82·3
6 (chips)	8·0	42·5	15·8	84·2
	58·7	473·0	11·0	89·0

In order to test the possibility of the fractions being contaminated by iron from the steel, a specimen of the latter, having a total surface area of 1 in.^{2}, was prepared and cleaned with a file free from grease. After exposure to the cold 5 per cent. hydrochloric acid for 15 minutes, only 3 mg. of iron were dissolved. As this area is vastly greater than any area of exposed steel which could have been present during the extractions (none was visible under the microscope), contamination from this source would appear to be negligible.

The surface exposed by the first extraction was of a different character from that shown in the later ones. It had a silvery-white appearance, and under the microscope the white material showed as an irregularly-corroded surface with here and there a smooth grey surface showing through from below. After the second extraction the white material was in very small amount. Its appearance, however, was quite distinct from the underlying layer, which maintained a uniform appearance throughout the subsequent extractions.

Bearing in mind the fact that the thickness of the inner layer was only one-fifth that of the outer, it would appear that the white material corresponded with the inner layer.

In order to obtain a figure for the composition of the layers as a whole, four specimens were chipped and their iron contents determined. The results were as follows :—

	Iron, Per Cent.
Specimen A	8·5
„ B	8·6
„ C	9·1
„ D	11·5

These figures are of the same order as those found in the fractions. The differences shown probably depend on the relative proportions of the outer and inner layers, which vary with different specimens, the inner layer being lower in iron than the outer, as shown by the extraction test.

So long as the iron content remains above a certain critical figure the structure is that of the outer layer; below it, of the inner layer. As long as the diffusion continues, the boundary line between the two continually advances towards the zinc, the inner being progressively converted into the outer.

It is possible that there is some diffusion of the zinc into the inner layer, but the constancy of the thickness of this layer suggests that the principal diffusing constituent is the iron.

For the grade of steel used, the rate of penetration depends on time and temperature. The grade of zinc, whether of high purity as the electrolytic, or impure as the common spelter, seems to have little if any effect.

Following Arnemann,[1] the alloys of iron and zinc fall into three groups :—

(*a*) 0·0–7·3 per cent. iron. Two structural elements: (1) Solid solutions of $FeZn_7$ and zinc, containing a maximum of 7·3 per cent. iron; (2) Pure zinc.

(*b*) 7·3–11·0 per cent. iron. Homogeneous alloys (one structural element) consisting entirely of the solid solution of $FeZn_7$ and zinc.

(*c*) 11–22 per cent. iron. Two structural elements: (1) $FeZn_3$, (2) $FeZn_7$.

In composition the inner layer of diffusion product corresponds with " *a* " in the above classification; the inner part of the outer layer up to 11 per cent. iron would correspond with " *b*," whilst the outer part (17 per cent. iron) would correspond with " *c* "; whether, however, $FeZn_3$ is actually present seems doubtful.

Tammann and Rocha [2] carried out experiments on the diffusion of electrolytic iron and zinc. In this case, however, the iron plates were dipped into molten zinc at temperatures up to 535° C., and after a fixed time the specimens were quickly cooled, cut through at right angles to the surface, and etched with alcoholic picric acid. They describe two examples prepared in this way. In the first the iron plate was kept in the molten zinc for 5 minutes at 450° C. Next to the zinc they found a layer of mixed crystals $FeZn_7$ and zinc, and next to that a further layer which they ascribe to the alloy $FeZn_3$. Between this latter and the iron there was a third layer much thinner than the other two and of unknown composition. In the second example the duration of the immersion was 10 minutes and the temperature 535° C. The sequence was similar to the first.

The experimental conditions here, however, are very different from those obtaining in the present author's experiments. In the latter the diffusion took place in the solid metals at temperatures never exceeding 400° C., and in some cases at 350° C. or less. From Arnemann's diagram it seems scarcely likely that $FeZn_3$ could form at such low temperatures, and there is no change in structure in the outer layer recognizable under the microscope from 8 per cent. iron to 17 per cent. iron. On the other hand, in the figures yielded by the fractional extractions there is a sudden break in the continuity of the percentages of iron between fractions 4 and 5, the figures being 10·6 and 17·7 per cent. This certainly suggests that two distinct compounds are present in the outer layer of diffusion product.

Further work on a larger scale is now being commenced in order to clear up this question.

It has been already stated that there is no evidence of the zinc diffusing into the iron under the conditions of the author's experiments. In this connection a recent paper by G. von Hevesy and W. Seith,[3] on the diffusion of metals in the solid state, may be mentioned. The authors compare, for example, the rate of diffusion of gold into lead and *vice versa*, the diffusion constant of gold into lead being given as 4×10^{-3} cm.^{2} per day at 150° C., and that of lead into gold as only 3×10^{-11} cm.^{2} per day at 141° C. They say further: "When we substitute in lead alloys other metals than gold, whose properties approximate more and more to those of lead, then these elements show a continuously diminishing diffusion rate. The interval between the rate of diffusion of these elements and that of lead becomes, therefore, less and less and the one-way diffusion becomes less and less marked." It would appear, therefore, that with solid iron and zinc one-way diffusion takes place at the iron–zinc and iron-diffusion product contact, but with the inner layer in contact with the zinc, and low in iron, zinc may diffuse into it.

In this connection the curved bases of the individual cones become of interest. If the explanation of cone formation which has been put forward earlier in this paper is correct, then the volume of the circular depression in the steel (see Fig. 8) is equal to the volume of the iron which has diffused into the zinc, and the volume of the cone above is that of the zinc into which it has diffused. By multiplying these volumes by the specific gravities of iron and zinc, respectively, the proportions by weight of the two metals can be obtained.

The results are, of course, only approximate, as neither cone nor segment is mathematically perfect, but they are nevertheless sufficiently close to be of interest. Three cones were taken at random and measured, with the following result :—

Per Cent.	Cone A.	Cone B.	Cone C.
Fe	10·6	13·1	13·5
Zn	89·4	86·9	86·5

These figures are well within the limits obtained in the various analyses already quoted. As the inner layer of diffusion product which is low in zinc is at the apex of the cone, and therefore small in amount, the percentage of iron in the cone would be expected to be on the high side.

In the conditions existing during these experiments the zinc plates show recrystallization, and where several are clamped together they become mutually adherent and show, when pulled apart, bright streaks where welding has taken place.

These experiments are now being extended to include high-carbon steels and alloy steels, and various classes of cast iron and also to zinc-bearing alloys.

References.

[1] P. T. Arnemann, *Metallurgie*, 1910, **7**, 204.
[2] G. Tammann and H. J. Rocha, *Z. anorg. Chem.*, 1931, **199**, 299–301.
[3] G. von Hevesy and W. Seith, *Z. Elektrochem.*, 1931, **37**, 528–531.

AUTHOR INDEX TO ABSTRACTS

Author Index to Abstracts

METALLURGICAL ABSTRACTS

(GENERAL AND NON-FERROUS)

Volume 1 JANUARY 1934 Part 1

NEW SERIES

Metallurgical Abstracts, published under this title since January 1931 and issued monthly as a supplement to the monthly *Journal of the Institute of Metals*, has been bound hitherto as a part of the *Journal* series.

The present issue of *Metallurgical Abstracts* commences Volume 1 of a New Series which will be bound annually as an entirely separate publication complete with its own index.

SYMBOLS

In order to facilitate the ready identification of abstracts of certain types of papers, the following two signs will be used in future and will appear immediately preceding certain of the titles of articles abstracted:

* Denotes abstract of a paper describing the results of an original investigation.

† Denotes a first-class critical review.

I.—PROPERTIES OF METALS

***On the Single Potential of Aluminium.** Hikozô Endô and Shigenori Kanazawa (*Sci. Rep. Tôhoku Imp. Univ.*, 1933, [i], **22**, 537–552; and (in Japanese) *Kinzoku no Kenkyu*, 1933, **10**, 471–487).—[In English.] The single electrode potential of aluminium in normal potassium chloride solution depends on the nature of the gas which is passed over the surface of the solution. No effect is produced by hydrogen, nitrogen, or carbon dioxide, but the presence of oxygen produces a marked lowering of the absolute potential, due probably to the formation of an oxide film. The influence of impurities in the aluminium is marked; the addition of iron steadily lowers the electrode potential, but that of silicon does not. The most probable value for pure aluminium is − 1·29 v.—E. S. H.

Characteristics and Uses of Beryllium. Anon. (*Canad. Mach.*, 1933, **44**, (11), 16, 28).—A summary of the properties of beryllium, with some details as to its occurrence. Alloys briefly mentioned include beryllium–copper (beryllium up to 2·5%), 1% beryllium steel, and an aluminium–beryllium alloy.—P. M. C. R.

***On Structural Anomalies of Bismuth and Antimony.** Alfred Schulze (*Z. physikal. Chem.*, 1933, [A], **165**, 188–194).—Very pure polycrystalline antimony exhibits a reversible discontinuity on the temperature–electrical resistance curve at 105°–110° C. even if tempered for several hours at 200° C.; the discontinuity is not observed in single crystals or after tempering at 600° C., and cannot therefore be due to a transformation. The effect is attributed to elastic displacements between neighbouring crystals and to the mechanical deformations thereby produced. The observations made by Drucker (*J. Inst. Metals*, 1933, **53**, 113) on bismuth can be explained similarly.
—B. Bl.

***On the Elastic Constants of Single Crystals of Copper.** Ren'iti Kimura (*Sci. Rep. Tôhoku Imp. Univ.*, 1933, [i], **22**, 553–564).—[In English.] Cf. *J. Inst. Metals*, 1933, **53**, 177. The elastic constants have been determined by a static method at room temperature. The results are not in agreement with Cauchy's relation. The following values are given for Young's modulus E and for the modulus of torsion n in the directions of the principal crystallographic axes: $E_{[100]}$ 0·775 × 10^{12}, $E_{[110]}$ 1·261 × 10^{12}, $E_{[111]}$ 1·905 × 10^{12}, $n_{[100]}$ 0·611 × 10^{12}, $n_{[110]}$ 0·380 × 10^{12}, $n_{[111]}$ 0·337 × 10^{12} dyne/cm.^{2}.—E. S. H.

Chemistry of Indium. Alfred W. Downes and Louis Kahlenberg (*Trans. Electrochem. Soc.*, 1933, **63**, 155–158; discussion, 158–159).—For abstract of the paper see *J. Inst. Metals*, 1933, **53**, 290. In the discussion *U. C. Tainton* stated that the recovery of indium from zinc ores was difficult, since most of it passed into the iron oxide residues together with germanium, arsenic, and antimony. *Leon R. Westbrook* gave details of the therapeutic uses of indium.—A. R. P.

***On the Question of the Anodic Passivity of Lead.** P. Porfirov (*Zhurnal Obschchey Khimii* (*Journal of General Chemistry*), 1933, [A], **3**, 590–595).—[In Russian.] The anodic passivity of lead has been studied by measuring the changes which occur in the anode resistance when dilute sulphuric acid is electrolyzed with a lead anode. The results indicate that passivation occurs in two stages: first lead dissolves normally and the lead sulphate found is deposited on the anode, thus reducing the exposed area and increasing the effective current density, which, in turn, accelerates crystallization of the sulphate and causes colloid formation accompanied by a sharp increase in the film resistance and current density. The second stage of the process begins when the current density reaches a certain limiting value at which oxygen is evolved at the anode and the sulphate converted into peroxide, thus rendering the anode insoluble. In the first stage the film resistance is high and the electrode potential constant, hence the passivity is mechanical; in the second stage the film resistance is small and the potential markedly different from the original, hence the passivity is chemical. In anhydrous sulphuric acid only mechanical passivation occurs.—M. Z.

American Cable Practice. [Failure of Lead Sheathing.] R. Spieser (*Bull. Assoc. Suisse Elect.*, 1933, **24**, 544–545).— A summarized account of the 932 cases of failure in service submitted to the Testing Laboratory of the Electrical Supply Grid (U.S.A. and Canada) in 1931. Stress is laid on the comparatively frequent failures of lead sheathing; these are stated to be due mainly to variations in temperature or to too low a radius of curvature at bends. —P. M. C. R.

***Oxidation-Reduction Equilibrium of Metallic Manganese.** Shin-Ichi Aoyama and Yoshinaga Oka (*Sci. Rep. Tôhoku Imp. Univ.*, 1933, [i], **22**, 824–834).—[In English.] By heating manganese in an atmosphere of hydrogen and water vapour the existence of the reaction $Mn + H_2O = MnO + H_2$ was confirmed. A linear relation holds between log H_2/H_2O and $1/T$. The heat of formation and the free energy at 298° abs. in the reaction $Mn + \frac{1}{2}O_2 = MnO$ are given by $\Delta H_{298} = -96{,}680$ grm.-cal., $\Delta F_{298} = -96{,}240$ grm.-cal.—E. S. H.

***Effect of High Electrostatic Fields upon the Vaporization of Molybdenum.** G. B. Estabrook (*Univ. Pittsburgh Bull.*, 1933, (29), 65–77).—A paper read before the American Physical Society, of which only an abstract has previously appeared. See *J. Inst. Metals*, 1933, **53**, 483.—S. G.

†The Strength and Ductility of Nickel Wires of Small Diameter. Edmund R. Thews (*Draht-Welt*, 1932, **25**, 755–757).—Discusses investigations of the mechanical properties of nickel wires made in both England and America and cites the work of Ransley and Smithells (*J. Inst. Metals*, 1932, **49**, 287–298) very largely. Tables of strengths and ductilities of commercial, pure, and alloyed nickel wires annealed at various temperatures are given.—A. B. W.

The Contamination of Nickel Crystals Grown in a Molybdenum Resistance Furnace. Andrew Dingwall, Jerrold Zacharias, and Sidney L. Siegel (*Trans. Electrochem. Soc.*, 1933, **63**, 395–400).—See *J. Inst. Metals*, 1933, **53**, 484. —S. G.

The Relation of Hydrogen to Nickel with Special Reference to the Catalytic Power of the Latter. Harry N. Huntzicker and Louis Kahlenberg (*Trans. Electrochem. Soc.*, 1933, **63**, 349–367).—See *J. Inst. Metals*, 1933, **53**, 610.—S. G.

***The Electrical Resistance of Palladium Wires Charged with Hydrogen.—II.** Harro Hagen and Adolf Sieverts (*Z. physikal. Chem.*, 1933, [A], **165**, 1–11).—Cf. *J. Inst. Metals*, 1933, **53**, 290. The electrical resistance of palladium wires has been measured in a hydrogen atmosphere at temperatures up to 470° C. and pressures up to 140 kg./$cm.^2$.—B. Bl.

***Change of Magnetic Susceptibility of Platinum, Copper, and Silver Caused by Cold-Working.** Kotarô Honda and Yosomatsu Shimizu (*Nature*, 1933, **132**, 565–566).—Eliminating effects due to ferromagnetic materials, the following magnetic susceptibilities have been determined: platinum $1{\cdot}100 \times 10^{-6}$, copper $-0{\cdot}0848 \times 10^{-6}$, silver $-0{\cdot}185 \times 10^{-6}$. The susceptibility of cold-worked platinum is slightly less than that of annealed platinum, whilst in the case of copper and silver cold-working increases the susceptibility. Although the effect of the volume change is considered, the change in susceptibility appears to be real.—E. S. H.

***Inertia and Chemical Activity of Rare Gases—Action of Helium on Platinum under the Influence of Electric Discharge at Low Pressure and Determination of Helium in the Product Formed.** Horacio Damianovich (*Anales Inst. Investigaciones cient. tecnol.*, 1932, **1**, 30–37; *C. Abs.*, 1933, **27**, 4993).—An electric discharge is formed with platinum electrodes in the presence of helium at low pressure. The product formed is decomposed by heat, leaving metallic platinum and dissolves in *aqua regia* more easily than platinum and than the products obtained under similar conditions with oxygen, nitrogen, and hydrogen. In the action of helium on platinum a new product is formed with properties differing from its components.—S. G.

***Properties of the Product Formed by the Combination of Helium with Platinum and an Excess of Platinum.—Comparison with the Properties of Products Obtained from the Action of Oxygen, Nitrogen, and Hydrogen on the Same Metals under Similar Conditions.** Horacio Damianovich (*Anales Inst. Investigaciones cient. tecnol.*, 1932, 1, 37–44).—Cf. preceding abstract.—S. G.

***Density of the Product Obtained from the Action of Helium on Platinum.** Horacio Damianovich and Jose Piazza (*Anales Inst. Investigaciones cient. tecnol.*, 1932, 1, 45–48; *C. Abs.*, 1933, 27, 49–93).—The density of the product obtained in the above experiments (cf. preceding abstracts) is considerably lower than that of ordinary platinum; it approaches the latter if the product is heated to 380° C. for 2 hrs., supporting the theory of the existence of chemical combinations with helium and platinum.—S. G.

***Action of Oxygen on Platinum under the Influence of Electric Discharge at Low Pressure.** Horacio Damianovich and Jose Piazza (*Anales Inst. Investigaciones cient. tecnol.*, 1932, 1, 49–53; *C. Abs.*, 1933, 27, 4993).—By the method previously described (cf. preceding abstracts) oxygen is made to combine with platinum under the influence of electric discharges at low pressure. The product obtained appears to be an oxide of the approximate formula Pt_2O_3, which is very stable at ordinary temperatures and decomposes only under strong heat. Its density is much lower than that of platinum or platinum-helium product and it does not absorb air.—S. G.

***Action of Hydrogen on Platinum under the Influence of Electric Discharge at Low Pressure.** Horacio Damianovich and Carlos Christen (*Anales Inst. Investigaciones cient. tecnol.*, 1932, 1, 54–57; *C. Abs.*, 1933, 27, 4993).—In continuation of the above investigations (cf. preceding abstracts). A deposit is obtained from the action of hydrogen on platinum which is similar to finely powdered platinum; under these conditions hydrogen does not combine with platinum.—S. G.

***Action of Nitrogen on Platinum under the Influence of Electric Discharge at Low Pressure.** Horacio Damianovich and Guillermo Berraz (*Anales Inst. Investigaciones cient. tecnol.*, 1932, 1, 58–63; *C. Abs.*, 1933, 27, 4993).—By the use of a technique analogous to that of the previous experiments (cf. preceding abstracts), nitrogen was found to combine with platinum; the product is relatively stable, and its properties, in particular density and solubility in *aqua regia*, are decidedly different from those of platinum or of platinum combined with helium, oxygen, or hydrogen.—S. G.

***The Kongsberg Silver.** Einar Jensen (*Tids. Kjemi Bergvesen*, 1933, 13, 70–73; *C. Abs.*, 1933, 27, 5687).—The first results of an extensive analytical research are given. Six samples of native silver and argentite have been analyzed for silver, mercury, bismuth, lead, copper, arsenic, antimony, iron, nickel, cobalt, zinc, manganese, calcium, and sulphur.—S. G.

***Preparation of Macroscopic Thallium Crystals by Electrolysis.** A. Sprantsman (*Acta Commentationes Univ. Tartuensis*, 1933, **A24**, 3–5; *C. Abs.*, 1933, 27, 5650).—The crystals were prepared by electrolyzing aqueous Tl_2SO_4 by means of a platinum anode and a copper cathode covered with a film of paraffin. The form of the crystals depends on the concentration and temperature of the solution, and on the product of the free acid and applied p.d., but is independent of current density between 0·01 and 0·10 amp./dm.^{2}.
—S. G.

***The Transformation of Single Crystals of White Tin into Grey Tin.** A. Komar and B. Lasarev (*Physikal. Z. Sowjetunion*, 1933, 4, 130–131; *C. Abs.*, 1933, **27**, 5600).—[In German.] The linear velocity of transformation can be increased 200–300-fold.—S. G.

Zinc as a Printing Surface. J. Bekk (*Deut. Druck.*, 1932, 39, 11–14; *Phot. Abs.*, 1933, 13, 178).—A study of the physical and chemical properties of zinc used in the production of relief and lithographic plates has particular reference to the influence of impurities on zinc etching.—S. G.

***The Evaporation of Atoms, Ions, and Electrons from Cæsium Films on Tungsten.** John Bradshaw Taylor and Irving Langmuir (*Phys. Rev.*, 1933, [ii], **44**, 423–458).—Detailed experiments are described on the evaporation of neutral atoms, positive ions, and electrons from films of cæsium deposited on tungsten, and methods are given for determining θ, the fraction of the tungsten surface covered with cæsium. The results support the postulate that all properties of an adsorbed film on an underlying surface of given composition are uniquely determined by θ and T (the temperature). At low temperatures and high pressures of cæsium vapour, the adsorbed cæsium atoms first form a true monatomic layer, the formation of a second layer beginning only at filament temperatures corresponding with a nearly saturated cæsium vapour. A theory of the formation of further layers is discussed, the essential assumption being that an atom in the nth layer can exist only on a group of at least 4 atoms on the $(n - 1)$th layer. The absorption coeff. of atoms striking the tungsten surface is shown experimentally to be unity from $\theta = 0$ to $\theta =$ nearly 1, and the bearing of this on the process of evaporation and condensation is discussed.—W. H.-R.

***Remarkable Optical Properties of the Alkali Metals.** R. W. Wood (*Phys. Rev.*, 1933, [ii], **44**, 353–360).—Thin films of the alkali metals deposited on quartz are opaque to visible light, but highly transparent in the ultra-violet region. The point at which transparency begins moves towards shorter wavelengths with decreasing atomic number, the critical values being cæsium 4400, rubidium 3600, potassium 3150, sodium 2100, and lithium 2050 A., the value for lithium being slightly uncertain. The transparency continues into the ultra-violet as far as the limits of the experiments (1860 A.), and the effect of the thickness of the film has been studied for potassium. Plane polarization by reflection was observed, and the reflecting powers for different wavelengths were measured for all these metals except lithium. The refractive index of a potassium film varied from 0·90 at 2147 A. to 0·50 at 3100 A., and total reflection was observed although the critical angle was not very sharply defined. These properties are shown only by coherent films deposited at liquid air temperature under thoroughly outgassed conditions, and details of preparation are given. (See following abstract.)—W. H.-R.

Remarkable Optical Properties of the Alkali Metals. R. de L. Kronig (*Nature*, 1933, **132**, 601).—K. applies his quantum theory of metallic dispersion to the phenomena described by Wood (preceding abstract).—E. S. H.

Optical Properties of the Alkali Metals. E. L. Hill (*Rev. Sci. Instruments*, 1933, [N.S.], **4**, 525–526).—Wood's work on the optical properties of thin films of lithium, sodium, potassium, rubidium, and cæsium of thickness about 3000 A., in the ultra-violet region between 3000 and 1860 A. is briefly referred to. Cf. abstract above.—J. S. G. T.

A Method for the Production of Single Crystals. A. I. Froiman and P. A. Polibin (*Physikal. Z. Sowjetunion*, 1933, 3, 627–631; *C. Abs.*, 1933, **27**, 4146).—[In German.] By using a modification of Bridgman's method, it is possible to determine in advance where the crystal axes of the sample will be after the crystal is grown. This is done by means of a special apparatus that allows only that crystal nucleus to grow further which has, at the start of crystallization, the desired orientation.—S. G.

The Behaviour of Metallic Materials under Static and Dynamic Deformation. P. Ludwik (*Z. Metallkunde*, 1933, **25**, 221–228).—A lecture to the Deutsche Gesellschaft für Metallkunde. The phenomena of plasticity, strengthening by cold-deformation and age-hardening, recrystallization, crystal recovery, internal stress, damping capacity, and sensitivity to notch effect are discussed. Results are given of determinations (previously published) of the endurance strength of notched test-pieces in bending and torsion tests and of the corrosion fatigue of various ferrous and non-ferrous alloys. Recent work by Ludwik and Krystof (*Z.V.d.I.*, 1933, **77**, 629) on the relation between the applied stress and the endurance strength under bending and torsional stress of polished, notched, and corroded specimens is reviewed (cf. *J. Inst. Metals*, 1933, **53**, 487).—M. H.

***The Serrated Discontinuity on Load–Extension Diagram and Age-Hardening of Metals and Alloys.** Tadashi Kawai (*Sci. Rep. Tôhoku Imp. Univ.*, 1933, [i], **22**, 354–374).—[In English.] A study of cold-drawn bars of copper, aluminium, nickel, 60 : 40 brass, 70 : 30 brass, 80 : 20 brass, 90 : 10 brass, phosphor-bronze, manganese–brass, copper–iron alloys (0·5 and 1% iron), Delta metal, and Duralumin, wires of nickel and Nichrome, as well as of many steels, shows that only metals which undergo age-hardening after stretching show a serrated discontinuity on the load–extension diagram, when they are tested at a temperature at which the age-hardening is significant. The phenomenon is explained by successive yielding and ageing.—E. S. H.

***X-Ray Investigations on the Thermal Expansion of Solids.—I.** Gunji Shinoda (*Mem. Coll. Sci. Kyoto Imp. Univ.*, 1933, [A], **16**, 193–201).—[In English.] Determinations of thermal expansion coeff. and lattice constants of some metals by the X-ray method have yielded the following results: expansion coeff. $\times 10^{-6}$, aluminium α 22·9; tin $\alpha_{\parallel}$ 45·8, $\alpha_{\perp}$ 25·7; indium $\alpha_{\parallel}$ 45·0, $\alpha_{\perp}$ 11·7; zinc $\alpha_{\parallel}$ 64·5, $\alpha_{\perp}$ 10·8; thallium $\alpha_{\parallel}$ 72, $\alpha_{\perp}$ 9; lattice constant, tin a 5·824 A., c/a 0·5415; indium a 4·581 A., c/a 1·077.—E. S. H.

Some Notes on Fractures. J. Blundell (*J. Inst. Locomotive Eng.*, 1933, **23**, 270–285).—Descriptions, with 46 photographs, are given of fractures in locomotive parts arising from unsuitable material, manufacturing faults, design faults, or improper use. The danger of having sudden changes in section and of sharp edges in general is shown in a number of instances.—J. C. C.

***Determination of Size of Particles in Metallic Powders.** N. M. Zarubin (*Zavodskaya Lab.*, **1933**, (2), 29–34).—[In Russian.] The Stokes, the microscopic, and the chemical rate of solution methods were used to determine the size of particles in tungsten, molybdenum, cobalt, nickel, and other powders.—S. G.

Removal of Metallic Deposits by High-Frequency Currents. J. K. Robertson and C. W. Clapp (*Nature*, 1933, **132**, 479–480).—A mirror deposit of metal (especially silver) in a tube is removed when a high-frequency luminous discharge is passed in air, oxygen, or hydrogen at a pressure of a few mm. Little effect is obtained in the presence of nitrogen.—E. S. H.

***The Effect of Heat-Treatment on the Production of Frictional Electric Charges on Metals.** P. A. Mainstone (*Phil. Mag.*, 1933, [vii], **16**, 1083–1096).—Prolonged heating of aluminium and nickel at low pressures reduces considerably the normal negative frictional charge on the metal. A partial slow recovery of the charge occurs on re-cooling. A similar effect occurs with the metals in nitrogen at atmospheric pressure. Widely varying results are obtained if the metals are de-gassed and re-heated at about 300° C. in hydrogen or nitrogen. Re-polishing or etching restores the surface to its original state. The frictional charge on polished palladium changes sign from negative to positive when the metal is de-gassed and heated in hydrogen at about 250° C.
—J. S. G. T.

II.—PROPERTIES OF ALLOYS

***Dilatometric Study of an Aluminium Alloy.** Otakar Quadrát and Rudolf Pospíšil (*Chim. et Ind.*, **1933**, Special No. (June), 620–622; *C. Abs.*, 1933, **27**, 5703).—Analysis of 6 samples taken from different parts of a commercial aeroplane engine piston made of aluminium–copper–nickel–magnesium alloy showed segregation of up to nearly 10% of the added elements, the thinner portions of the casting having higher copper, nickel, and magnesium contents. Variations in the coeff. of expansion of test-pieces taken from the same places as the portions used for analysis were only about 1%, which is practically within the limit of experimental error.—S. G.

***On the Equilibrium Diagram of the Iron–Aluminium System.** Atomi Ôsawa (*Sci. Rep. Tôhoku Imp. Univ.*, 1933, [i], **22**, 803–819).—[In English.] See abstract from the Japanese, *J. Inst. Metals*, 1933, **53**, 616.—E. S. H.

On the Influence of Aluminium on Cast Iron. E. Piwowarsky and E. Soehnchen (*Metallwirtschaft*, 1933, **12**, 417–421).—Data are given on the castability, tensile properties, and corrosion-resistance of cast iron with up to 20% aluminium.—v. G.

***On the Compounds of Aluminium and Silver.** F. E. Tischtchenko (*Zhurnal Obschtchey Khimii* (*Journal of General Chemistry*), 1933, **3**, 549–557).—[In Russian.] Cf. Petrenko, *Z. anorg. Chem.*, 1905, **46**, 49. The system has been re-examined by thermal analysis. The β-phase, Ag_3Al, is formed at 771° C. and undergoes a transformation at 606° C. into β'. Aluminium is insoluble in β:, but is soluble in β to a maximum of 10·22% at 722° C., the eutectic point between β and Ag_3Al_2; the latter is stable only between 752° C. and 711° C. Below 711° C. Ag_3Al_2 decomposes into γ'', which is a solid solution of aluminium in Ag_2Al containing a maximum of 14·33% aluminium. Between 711° C. and 400° C. over a range of 13% there is a duplex field of $\beta + \gamma'$, and below 400° C. with 7·7–11·1% aluminium the structure consists of β' and γ. The results of Hoar and Rowntree (*J. Inst. Metals*, 1931, **45**, 119) and Westgren and Bradley (*J. Inst. Metals*, 1928, **40**, 576) are reviewed and compared with those of T. —M. Z.

***On the Eutectoidal Decomposition of Aluminium–Zinc Alloys.** V. Bugakov (*Physikal. Z. Sowjetunion*, 1933, **3**, 632–652; *C. Abs.*, 1933, **27**, 4512).—[In German.] A study was made of the β-phase of the zinc–aluminium system. Hardness, electrical conductivity, and specific volume were determined for samples subjected to a variety of heat-treatments at temperatures at which the β-phase is unstable (*i.e.* temperatures below 256° C.). Decomposition of the β-phase proceeds practically to completion at room temperature, but the process is accelerated by annealing at higher temperatures. When the rate of decomposition of the β-phase is decreased by additions of small amounts (less than 1%) of magnesium to the mixture, determinations of electrical conductivity indicate that the alloy passes through a metastable condition before the β-phase changes to a state stable at room temperature. Hardness tests, on the other hand, seem to show that, even after electrical conductivity has become constant and a stable state apparently reached, a slow ageing continues for some time.—S. G.

The Resistance of High-Strength Aluminium Alloys to Axial Loading. Anon. (*Alluminio*, 1933, **2**, 221–223).—Some data are given on the buckling strength to axial loading of heat-treated aluminium alloys (and steel), and the mathematical means for calculating it. A diagram is appended.—G. G.

Non-Corrodible Aluminium [N.C.A. Alloy]. Anon. (*Syren and Shipping*, 1933, **149**, 244).—It is claimed that N.C.A. metal, an aluminium alloy, resists sea-water corrosion exceptionally well, as shown by Admiralty tests over a period of 6–7 years. Sand-cast bars possess the following properties: ultimate tensile stress 11–14 tons/in.^{2}, yield-point 6–7 tons/in.^{2}, elongation 5–7% on

2 in., scleroscope hardness 12, Brinell hardness 63. The alloy is also available in extruded bars, tubes and angles, and as rolled sheet.—P. M. C. R.

Hydronalium. Anon. (*Met. Ind.* (*Lond.*), 1933, **43**, 85). **A New Aluminium Alloy—Hydronalium.** Anon. (*Metallurgia*, 1933, **9**, 31).—See *J. Inst. Metals*, 1933, **53**, 490.—S. G.

A New Alloy for High-Speed Automobile and Aircraft Engines. Anon. (*Automobiltech. Z.*, 1933, **36**, 517).—A piston alloy of aluminium, with 14% silicon and small additions of nickel, copper, and magnesium, remainder aluminium. It is claimed to have a sp. gr. nearly equal to that of aluminium, with a higher thermal conductivity and a thermal expansion 18% less than that of other piston alloys. It is especially recommended for aircraft and motor-boat engines. Details are given as to performance and working.—P. R.

The Future of Light Metals. W. Kollrepp (*Z. ges. Giesserei-Praxis : Das Metall*, 1933, **54**, 348–349).—Gives a brief, general discussion of the mechanical properties and corrosion-resistance of light metal alloys and an indication as to how these will influence their application in the future.—J. H. W.

***Effect of Silicon on the Critical Points and the Constitution of Chromium Alloys.** E. Valenta and F. Pobořil (*Chim. et Ind.*, **1933**, Special No. (June), 633–648; *C. Abs.*, 1933, **27**, 5704).—The effect of silicon on the constitution of chromium alloys was studied on the 2 pseudo-binary sections of the ternary system : iron–carbon–chromium, the carbon content being 0·8% and the chromium content 25%, at the bases of the 2 sections of the quaternary system : iron–carbon–chromium–silicon with a constant silicon content of 2·5%, carbon 0·8%, and chromium 25%. Special study was made of the alloys having the characteristics of cast irons, which solidify as the eutectic forms. The methods of investigation were microscopic examination, thermal analysis, dilatometric analysis, and determination of the hardness after quenching. Silicon decreases the homogeneous zone of the γ-phase and widens the zone of primary separation of the α-phase. By considerably raising the critical points it increases the zone of the alloys having no critical points. Moreover, silicon considerably reduces the carbon content of the eutectic. In order to facilitate the visualization of the extent of the changes caused by the presence of silicon in the iron–carbon–chromium system, a diagram of the ternary crystallization was drawn which was made possible by using both the data in the literature, particularly those of Westgren, Phragmen, and Negresco, and the personal deductions of V. and P.—S. G.

***Copper–Lead Alloy System.** M. Nishikawa (*Suiyokai-shi*, 1933, **8**, 239–243; *C. Abs.*, 1933, **27**, 5702).—[In Japanese.] The constitution of the copper–lead system has been investigated by thermal and microscopic analyses, and the equilibrium diagram has been constructed. A monotectic reaction : liquid + Cu $\rightleftharpoons$ liquid was found to occur at 957° C. and in 13–48% of copper.—S. G.

***The Electrical Conductivity of Cu_3Pd- and Cu_3Pt-Alloys with Disordered and Ordered Atomic Distributions at Low Temperatures.** H. J. Seemann (*Z. Physik*, 1933, **84**, 557–564).—The specific electric resistance of Cu_3Pd- and Cu_3Pt-alloys with orderly atomic distribution at low temperatures, down to about − 253° C., is found to decrease with decrease of temperature, only a little more than is the case with a disorderly atomic distribution, and in this respect the results are in marked contrast with results obtained with Cu_3Au-alloys, where a marked difference in the two cases was found to occur. The difference is discussed with reference to the systems of valency electrons in the several cases.—J. S. G. T.

Silver–Copper Alloys Containing Phosphorus. H. Moser, E. Raub, and K. W. Fröhlich (*Metallwirtschaft*, 1933, **12**, 497–501).—An account of work the results of which have already been published by K. W. F. in *Mitt. Forschungsinst, Edelmetalle*, 1933, **7**, 75. See *J. Inst. Metals*, 1933, **53**, 696.—v. G.

Tests Several Possibilities of Tin-Free Leaded Bearing Bronzes. Anon. (*Automotive Ind.*, 1933, 69, 678).—A short account of recent researches carried out at the U.S. Bureau of Standards on copper–lead alloys containing small additions of other metals. See *J. Inst. Metals*, 1933, 53, 620.—P. M. C. R.

The Effect of the Addition of Lead on the Hardness of Certain Tin-Base Bearing Alloys at Elevated Temperatures. J. N. Kenyon (*Met. Ind.* (*Lond.*), 1933, **43**, 495–499).—Read before the American Society for Testing Materials. See *J. Inst. Metals*, 1933, 53, 495.—J. H. W.

The Mechanism of Inverse Segregation. Alloy Group 3.—Tin–Bronzes, 89 : 11 Type. Owen W. Ellis (*Met. Ind.* (*Lond.*), 1933, 43, 194–196, 225–226). —An introduction to the Symposium on Deoxidation and Degasification of Bronze Foundry Alloys held by the American Foundrymen's Association. —J. H. W.

Phosphor–Bronze. Anon. (*Automobile Eng.*, 1933, 23, 387).—A note on the analysis, characteristics, qualities, and applications of phosphor–bronzes, in which the alloy is divided into 3 groups: (*a*) phosphorus 0·05–0·10%; (*b*) phosphorus 0·35–0·5%; (*c*) phosphorus 0·5–1·25%, and where the tin content of (*a*) and (*b*) varies from 8 to 10%; (*c*) shows considerable hardness and much resistance to wear.—J. W. D.

Properties of Bronze Bearing Metals. Anon. (*Machinist* (*Eur. Edn.*), 1933, 77, 597–598).—The mechanical properties of Admiralty bronze, and of 80 : 10 : 10 : 0, 83 : 7 : 7 : 3, 70 : 10 : 20 : 0, 85 : 5 : 9 : 1, and 70 : 5 : 25 : 0 copper–tin–lead–zinc bearing alloys are tabulated.—J. H. W.

The Effect of Cold-Working on the Strength of Bronze and the Possibility of Improvement by Suitable Heat-Treatment. F. Freude (*Metallbörse*, 1932, 22, 225–227).—The danger of season-cracking after very hard cold-working, *e.g.* drawing, of 70 : 30–60 : 40 brass is illustrated, and the effect of low-temperature annealing in reducing internal stress is shown graphically. Annealing for 3 hrs. at 250° C. is sufficient to prevent all danger of season-cracking, but has no effect on the hardness or strength of the metal.—A. R. P.

***An Electrochemical Investigation of Brass.** Arne Ölander (*Z. physikal. Chem.*, 1933, [*A*], **164**, 428–438).—The potential of the cell: zinc|lithium, rubidium, zinc chloride|(copper, zinc)$_{\text{solid}}$, and its temperature coeff. have been determined for 46 alloys between 333° and 626° C.; the results confirm Bauer and Hansen's equilibrium diagram except that the left-hand boundary of the γ-phase is more inclined to the left. The activity coeff. of zinc in the η-phase is unity, the γ-phase has the ordered structure Cu_5Zn_8, and the β and β' phases both have the ordered structure CuZn with a degree of disorder of 1%. The heat of transformation of β into β' is 87 grm.-cal./grm.-atom; apparently the transformation is not due to atomic changes, but to electronic movements which have no other action than to cause a slight lattice expansion, similar to that which occurs at the Curie point in iron. The heat of the transformation in the δ-phase is 195 grm.-cal./grm.-atom and the latent heat of fusion of zinc 28·4 grm.-cal./grm.—B. Bl.

***The Constitution of Magnesium-Rich Magnesium–Zinc–Silicon Alloys.** E. Elchardus and P. Laffite (*Compt. rend.*, 1933, **197**, 1125–1127).—The magnesium-rich alloys of the system magnesium–zinc–silicon have been studied by thermal analysis. It is confirmed that a definite ternary compound does not exist. The following stages are observed at each point in the region of immiscibility, beginning with a liquid alloy: (1) separation of two liquid phases; (2) deposition of a solid phase; (3) disappearance of one of the liquid phases; (4) deposition of the binary eutectic; (5) deposition of the ternary eutectic, corresponding with the composition: magnesium 53·3, zinc 43·5, silicon 3·2%, at a constant temperature (335° C.). The limit of the ternary solid solution is at the approximate composition: zinc 5·25, silicon 0·25, magnesium 94·5%. The constitution of the different zones was determined microscopically.—J. H. W.

***The Determination of the Vapour Pressure of Amalgams by a Dynamic Method.** John S. Pedder and Sidney Barratt (*J. Chem. Soc.*, **1933**, 537–546).—An apparatus for the measurement of the vapour pressures of amalgams or alloys by the dynamic gas-streaming method at temperatures between 250° and 400° C. is described. The partial pressures of mercury above cadmium, zinc, and potassium amalgams of various compositions and at different temperatures have been measured. From the measurements of the partial pressures of mercury and potassium above potassium–mercury amalgams, containing 41·1–72 mols.-% potassium at 387·5° C., it is deduced that a considerable amount of a compound, probably KHg, is present in the vapour of these amalgams at that temperature.—S. V. W.

***Electron Emitting Alloys of Nickel and Barium.** D. W. Randolph, O. S. Duffendack, and R. A. Wolfe (*Electronics*, 1933, **6**, 244–246).—The addition of up to 0·20% barium to nickel greatly increases the thermionic emission of the latter. Alloys containing up to 10% barium are being studied. Small quantities of other elements influence the emission of the low percentage barium alloys. The electron emission increases with the amount of chromium up to a maximum at 3·5% chromium and then decreases again. The addition of chromium has been found to be beneficial in other ways. The alloys containing chromium are more resistant to corrosion and have a greater tensile strength at 800°–900° C. The rate of evaporation is lower than for pure nickel, and when slightly oxidized they form a very suitable core metal for oxide-coated emitters.—S. V. W.

***On the Magnetostriction of Nickel–Cobalt Alloys.** Yosio Masiyama (*Sci. Rep. Tôhoku Imp. Univ.*, 1933, [i], **22**, 338–353).—[In English.] The longitudinal and transverse effects are in different senses and the total volume change is a differential effect. A marked discontinuity in the concentration curve occurs at about 75% of cobalt, which corresponds with the change from a face-centred cubic lattice to a hexagonal, close-packed lattice.—E. S. H.

The Mechanical Properties of Certain Samples of Monel Metal. T. W. Hardy (*Canad. Dept. Mines, Mines Branch, Rep.* No. 728, 1932, 161–163; *C. Abs.*, 1932, **27**, 4198).—Tensile properties, Izod impact tests, and Brinell hardness of 14 samples of Monel metal purchased in the open market agree with the trade data of the International Nickel Co.—S. G.

X-Ray Study of the Electrolytic Fe–Ni Alloys. Keizô Iwasé and Nobuyuki Nasu (*Sci. Rep. Tôhoku Imp. Univ.*, 1933, [i], **22**, 328–337).—[In English.] See abstract from the Japanese, *J. Inst. Metals*, 1933, **53**, 190.—E. S. H.

Magnetically Permeable Alloys. Anon. (*Arch. tech. Messen*, 1933, **3**, (26), F22).—An account of 5 proprietary alloys of high permeability; their composition and magnetic properties are tabulated. The alloys are: "BR 50," and Hyperm 36, 50 A, 5 B, and 4.—P. M. C. R.

Anti-Friction Metals: Their Composition, Structure, &c. Anon. (*Commonwealth Eng.*, 1933, **20**, 363–367).—The chief characteristic of tin-base and lead-base anti-friction alloys and their fundamental properties are described. The formulæ for friction at high speeds, at constant speed, and at constant load are given.—J. H. W.

***Electrical Conductivity Measurements of the Systems Zinc–Cadmium and Lead–Antimony with Reference to the Attainment of Stable Equilibrium.** M. le Blanc and H. Schöpel (*Z. Elektrochem.*, 1933, **39**, 695–701).—The specific electrical conductivity of the zinc–cadmium and lead–antimony systems has been measured with reference to the attainment of stable equilibrium. In the zinc–cadmium system, the attainment of equilibrium occurs almost immediately in most alloys, except at the extremes of concentration (less than 10 atomic-%). In the lead–antimony system, the attainment of equilibrium is slower throughout the whole range. The limits of the single phase regions were determined by means of temperature–resistance curves. At

263° C., the saturation limit of zinc in cadmium occurs at 97·5 atomic-% of zinc (95·8% by weight), and that of cadmium in zinc at 6 atomic-% of zinc (3·6% by weight). In the lead–antimony system, the saturation limit of lead in antimony occurs at 94·2 atomic-% of lead (96·5% by weight) at 249° C., and that of antimony in lead at 1·5 atomic-% of lead (2·5% by weight). Micrographic examination confirmed these points in the case of the zinc–cadmium alloys and the point at 1·5 atomic-% of lead in the case of the lead–antimony alloys. On the other hand, the indication of the maximum electrical conductivity at 5 atomic-% of lead was not confirmed by micrographic examination. The lead side could not be determined more exactly.—J. H. W.

On the Solid Diffusion of Metallurgical Products. J. Laissus (*Chim. et Ind.*, 1933, **29**, 515–526).—A study of cementation processes in which various pairs of metals are considered under different conditions of temperature and time. The results are considered from the theoretical and practical aspects. The effect of cementation in offering resistance to oxidation and general corrosion in certain instances is studied.—W. A. C. N.

***The Crystallization of Eutectic Mixtures.** G. Tammann (*Z. Metallkunde*, 1933, **25**, 236–238).—The linear rate of crystallization of eutectic mixtures depends on undercooling in the same way as that of chemically homogeneous melts. In tubes the linear rate of crystallization of the latter is determined only by the flow of heat from the ends of the crystal filaments, whereas in the former case the separation of the constituents into individual crystal filaments is an additional process which is performed by diffusion. By increasing the rate of the eutectic crystallization the thickness of the crystal filaments may be decreased to submicroscopic proportions, hence, the relatively slow diffusion process is sufficient to produce separation of the constituents; this action is promoted by the close juxtaposition of the two kinds of crystal filament, as this causes more uniform diffusion. Since the separation of both constituents is necessary, the maximum linear rate of crystallization of binary eutectic mixtures is much less than that of either of the constituents. This has been verified by observations made on eutectic mixtures of organic compounds.—M. H.

***On Vapour Pressures and Activities of Some Binary Alloys.** Ernst Burmeister and Karl Jellinek (*Z. physikal. Chem.*, 1933, [*A*], **165**, 121–132).—The activities of cadmium over cadmium–tin alloys at 540° C., of zinc over tin–zinc alloys at 684° C., and of cadmium and zinc over cadmium–zinc alloys at 682° C. have been determined by vapour pressure measurements by an improved method; the values obtained agree closely with those determined by Taylor's electromotive method.—B. Bl.

***Entropy in Intermediate Phases.** Arne Ölander (*Z. physikal. Chem.*, 1933, [*A*], **165**, 65–78).—Intermediate phases which have an extended field of existence can have either a random or an ordered lattice orientation. In the latter case the variation in composition of the phase can occur either by substitution or by the introduction or removal of atoms from the lattice. To determine whether an intermediate phase is ordered or not a new method is given: the electrolytic dissolution potentials of the constituents of the compounds and their temperature coeff. are measured. Formulæ of the partial molar entropy are derived and the calculated figures are compared with the experimental results for β-CuZn, β'-AgCd, γ-$Zn_{16}Cu_{10}$, γ-$Cd_{16}Ag_{10}$, Au_3Cd, and $AuCd_3$.—B. Bl.

Methods of Graphic Representation of Four-Component Systems. Ya. E. Vilnyanskii and Z. S. Bannuih (*Kaliĭ*, 1933, (5), 23–35; *C. Abs.*, 1933, **27**, 5625).—The construction of diagrams for the graphic representation of the system $MgCl_2$–KCl–NaCl–H_2O is discussed. Regular and right-angle tetrahedra are found best suited for the graphic solution of problems of a four-component system.—S. G.

III.—STRUCTURE

(Metallography; Macrography; Crystal Structure.)

Organization of the Metallographie Section of the Trinec Steel Works. Bohuslav Otta (*Chim. et Ind.*, 1933, Special No. (June), 606–611; *C. Abs.*, 1933, **27**, 5694).—Descriptive, with examples of the practical application of metallography to the control of operations in steel plants and to the discovery of the causes of failure of metal parts in service.—S. G.

***Synthetic Metal Bodies. VII.—Crystallization Between Surfaces in Structural Equilibrium.** F. Sauerwald and L. Holub (*Z. Elektrochem.*, 1933, **39**, 750–753).—By pressing synthetic bodies, internal strains are produced which cause a fading of the K_α-doublets in the X-ray photograph. Between unpressed surfaces in structural equilibrium in copper single crystals, crystal growth from one crystal to another was observed at 900° C., but not at 500° C. Such crystal growth therefore occurs at higher temperatures than recrystallization of mechanically deformed crystals. It is probably not the result of nucleus formation, but of grain boundary displacement. Even at 900° C., recrystallization between crystals from the melt seldom occurs. This crystallization inertia is similar to that which occurs in ordinary polycrystalline metals obtained from the melt. From these results it is concluded that the crystallization tendency of such substances the single crystals of which are formed out of the melt is generally smaller than that of substances the single crystals of which are produced, for example, in the solid state by the reduction of oxides.—J. H. W.

***On the Recrystallization and Crystal Recovery of Pure Aluminium and of Several Al–Cu Basis Alloys Following Cold-Work.** H. Bohner and R. Vogel (*Kalt-Walz-Welt* (Monthly Suppt. to *Draht-Welt*), 1933, (3), 17–24).—A paper read before the Deutsche Gesellschaft für Metallkunde. See *J. Inst. Metals*, 1933, **53**, 128.—A. B. W.

***Influence of the Initial Grain-Size on the Final Grain-Size of Crystals During Recrystallization.** R. Alexandru (*Bull. Sci. Polytech. Timisoara*, 1933, **4**, 122–129; *C. Abs.*, 1933, **27**, 5285).—Samples of electrolytic iron with grain-sizes between 200 and 24 grains per mm.^{2} were deformed by rolling, and allowed to recrystallize at 650°–750° C. An initial grain-size of approximately 157 grains per mm.^{2} gave a maximum grain-size in the product.—S. G.

†Recrystallization of Metals. M. I. Zakharova (*Zvetnye Metally* (*The Non-Ferrous Metals*), 1932, 346–351; *C. Abs.*, 1933, **27**, 4198).—[In Russian.] A review of the modern conceptions of recrystallization of metals. 12 references are given.—S. G.

***The Photographic Development of Slip Lines on Deformed Crystals of Silver Chloride.** G. Tammann and G. Bandel (*Z. anorg. Chem.*, 1933, **214**, 403–406).—Treatment with a photographic developer of a bent cast plate of silver chloride reveals slip lines as darkened bands of metallic silver. These slip lines are not due to an increase in the reactivity of the silver chloride caused by the slip process but are produced by impurities with which the material is supersaturated, which accelerate the process of development. The separation of these impurities takes place preferably on the slip planes just as is the case with deformed supersaturated metallic solid solutions.—M. H.

***On the Relation Between the Crystal Orientation in Rolled Aluminium Sheet and the Thickness of the Sheet.** G. v. Vargha and G. Wassermann (*Metallwirtschaft*, 1933, **12**, 511–513).—In the middle zones of rolled aluminium sheet the crystals are oriented with a [112] direction in the direction of rolling and a (110) plane parallel to the rolling plane. In the edge zones the orientation of the crystals is much more imperfect; with considerable dispersion a (100) plane lies in the rolling plane and a [110] direction in the direction of rolling. With sheet 5 mm. thick the edge zones are about 1·3 mm. thick, and relatively well defined, but with thinner sheet the difference between the two zones is much less clearly marked. The middle of a sheet 5 mm. thick shows, despite the smaller deformation, a more perfect crystal orientation than is the case with the more strongly deformed, thinner sheet.—v. G.

***Precision Measurements of the Lattice Constants of Beryllium.** M. C. Neuberger (*Z. Krist.*, 1933, **85**, 325–329; *C. Abs.*, 1933, **27**, 5603).—The values are $a = 2·2679 \pm 0·0002$ A.; $c = 3·5942 \pm 0·0003$ A. The axial ratio $a/c = 1·5848$. The density as calculated is 1·857 at 20° C.—S. G.

***X-Ray Determination of the Phase Boundary Lines in the Copper–Zinc Diagram.** Axel Johansson and A. Westgren (*Metallwirtschaft*, 1933, **12**, 385–387).—X-ray examination of carefully prepared and homogenized copper–zinc alloys has confirmed the equilibrium diagram of Bauer and Hansen, except that the $\beta/(\alpha + \beta)$ phase boundary above 450° C. is placed about 1 atomic-% further towards the zinc side.—v. G.

***The Structure of the *A* Phase of the Ag–Li System.** Harald Perlitz (*Z. Krist.*, 1933, **86**, 155–158; *C. Abs.*, 1933, **27**, 5604).—The *A* phase of the system silver–lithium has a simple cubic structure, with $a = 9·94$ A., containing 52 atoms per unit cube. Identical X-ray data were obtained through the range from 76·3 to 80·2 atoms-% lithium.—S. G.

***The Crystal Structure and Lattice Constants of α-(β-)-Tungsten.** M. C. Neuberger (*Z. Krist.*, 1933, **85**, 232–238; *C. Abs.*, 1933, **27**, 5603).—The structure of a new form of tungsten has been determined by means of X-rays. In order to be conventional N. proposes to designate the α-form as the new modification of tungsten, and the β-form as the well-known body-centred cubic form. The α-form contains 8 atoms in the unit cell, arranged in a specific type of lattice with 2 tungsten atoms in the positions [0 0 0] [$\frac{1}{2}$, $\frac{1}{2}$, $\frac{1}{2}$] and 6 tungsten atoms in the positions [$\frac{1}{2}$, 0, $\frac{1}{4}$] [$\frac{1}{4}$, $\frac{1}{2}$, 0] [0, $\frac{1}{4}$, $\frac{1}{2}$] [$\frac{1}{2}$, 0, $\frac{3}{4}$] [$\frac{3}{4}$, $\frac{1}{2}$, 0] [0, $\frac{3}{4}$, $\frac{1}{2}$]. The edge of the unit cell is 5·038 ± 0·003 A. The specific type of the cubic class is T_d^4, O^2, O_h^3.—S. G.

***The Solubility of Copper in Zinc.** M. Hansen and W. Stenzel (*Metallwirtschaft*, 1933, **12**, 539–542).—The lattice constants of pure zinc ($a = 2·6590$ A., $c = 4·9351$ A., $c/a = 1·8560$; $d_{\text{calc.}} = 7·140$) are changed by addition of 2·66% copper to $a = 2·6732$ A., $c = 4·8152$ A., $c/a = 1·8012$; $d_{\text{calc.}} = 7·236$. The reduction of almost 3% in the axial ratio is particularly noteworthy. X-ray determinations of the solid solubility of copper in zinc gave the following results: at the peritectic point (424° C.) 2·66%, at 400° C. 2·41%, 350° C. 1·95%, 300° C. 1·53%, 250° C. 1·12%, 200° C. 0·77%, and 150° C. 0·51%. These figures have been confirmed by density measurements and micrographic examination.—v. G.

***X-Ray Proof of the Compound ZrW_2.** A. Classen and W. G. Burgers (*Z. Krist.*, 1933, **86**, 100–105; *C. Abs.*, 1933, **27**, 5600).—Powder photographs give evidence of a cubic compound of zirconium and tungsten. No analysis was made, but the data indicate a cell with $a = 7·61$ A., containing 8 molecules of ZrW_2. The calculated density = 13·78.—S. G.

Binding Forces in the Alkali Metals According to the Free Electron Theory. O. K. Rice (*Phys. Rev.*, 1933, [ii], **44**, 318).—Abstract of a paper read before the American Physical Society. Although there have been a considerable number of attempts to work out in some detail the nature of the cohesive forces in the alkali metals, it seemed worth while to see how far one could go with the simplest possible hypothesis, according to which the metal consists of singly-charged positive ions imbedded in a sea of free electrons. Frenkel first showed that the fact that the electrons in the metal obey the Fermi statistics, results in an effective repulsive force which will be balanced by attractive electrical forces; but, as he pointed out, the finite size of the ions prevents this being more than a qualitative picture, and he suggested taking this into account by

including repulsive forces between electrons and ions. In the present work, R. has introduced an intrinsic ionic volume, into which the electrons are supposed to be unable to penetrate, this simply being subtracted from the atomic volume in the Fermi expression for the kinetic energy of the electrons. For the attractive potential an expression involving a Madelung constant of a size about equal to those occurring in cases of uniunivalent crystals, and the same for all the alkali metals, is used. It is possible then to calculate the energy of the metals from the experimental value of the atomic volume, getting excellent agreement with experiment. The method is not so successful in calculating the compressibilities, but, apart from the fact that the compressibilities at absolute zero may only be inferred from measurements around room temperature, it appears that a relatively small correction to the Fermi energy expression can give the correct compressibility without greatly upsetting the calculation of the energy. The latter is, then, to be considered as significant.
—S. G.

Lattice Distortion and Fibre Structure in Metals. W. A. Wood (*Nature*, 1933, **132**, 352).—As the temperature of a cold-worked metal is increased, removal of lattice distortion occurs before removal of fibre structure. This intermediate state persists as the metal is slowly cooled. The observation explains the inability to establish a relation between the changes in properties brought about by cold-working and the onset of the fibre structure. The fibrous state does not necessarily represent a state intermediate between that of the normal metal with grains oriented at random and that of the large metallic crystal.—E. S. H.

***Investigation of the Orientations in Thin Evaporated Metallic Films by the Method of Electron Diffraction.** K. R. Dixit (*Phil. Mag.*, 1933, [vii], **16**, 1049–1064).—The effect of temperature on the orientations of the small crystals in thin metallic films is investigated. The films, of thickness 10^{-4}–10^{-6} cm., of silver on molybdenum, quartz, and glass, of aluminium on molybdenum, and of zinc on molybdenum are studied at temperatures ranging from room temperature up to, in some cases, 950° C. Different orientations, not depending on the support, are observed. A theory, assuming that these thin deposits behave as a two-dimensional gas, is proposed.—J. S. G. T.

***Optical Method for the Determination of the Orientation of Single-Crystal Specimens.** E. Jakowlewa (*Physikal. Z. Sowjetunion*, 1933, **3**, 429–438; *C. Abs.*, 1933, **27**, 3879).—[In German.] A new optical method is described which simplifies and facilitates the determination of crystal orientation and indices. It is suitable for crystals of any symmetry. The crystal is suspended within a glass sphere. Diverging light rays pass into the sphere and strike the crystal as a parallel beam. They are diffracted from the crystal surfaces and emerge from the sphere, converging at twice their focal length. Apparatus and measurements are described. An accuracy of 1° to 30′ is possible.—S. G.

The Determination of Crystal Orientation. J. Thewlis (*Z. Krist.*, 1933, **85**, 74–88; *C. Abs.*, 1933, **27**, 3879).—This new method involves the use of graphs obtained by plotting as ordinates and abscissæ the indices or the direction cosines of all directions in a crystal and on these curves are drawn curves of constant angle for different reflecting planes. By using measurements from X-ray photographs it is possible with these graphs to determine the orientation of the crystal. Formulæ for constructing the graphs and also for the determination of crystal orientation without the aid of the graphs are included.
—S. G.

IV.—CORROSION

***Relation Between the Constitution of Some Chromium Alloys and Their Rate of Solution in Hydrochloric Acid.** P. Herasymenko, J. Pech, and F. Pobořil (*Chim. et Ind.*, **1933**, Special No. (June), 649–654; *C. Abs.*, 1933, **27**, 5704).—The rate of solution of some chromium alloys in hydrochloric acid depends on their constitution and increases considerably in passing from the α-phase to the γ-phase. Measurement of the solution potential of these alloys showed that the differences in the rate of solution are due to variations in the difference of their potential and that of hydrogen.—S. G.

The Corrosion of Copper Rollers Used in Cloth Printing by Alkaline Printing Colours. Karl Reinking and Gustav Bernardy (*Melliand Textilber.*, 1931, **12**, 328; *C. Abs.*, 1933, **27**, 3826).—The observation of Runge (1842) that potassium hydroxide and potassium carbonate corrode copper and brass in the presence of air is correct; sodium carbonate acts in the same manner. The addition of mineral oils to the printing colours, as done in practice, is apparently intended to exclude air. The covering of the copper cylinder by a sulphide layer is said to have proved of advantage.—S. G.

Copper in Water Distributing Systems: Its Physical, Chemical, and Hygienic Aspects. L. W. Haase and O. Ulsamer (*Kleine Mitt. preuss. Land-, Wasser-, Boden-, u. Lufthygiene, Berlin-Dahlem*, VIII Beiheft, **1933**, 3–47).—The time required for the formation of the protective oxide (chiefly cuprous oxide) film on the inner surface of copper water-pipes is dependent on the hardness of the water and its content of neutral salts and gases. In acidic, gassy waters the formation of the film is greatly retarded; in normal, soft surface and underground waters the film forms in about a year if the oxygen content of the water is sufficient, and in hard and medium-hard waters in a few weeks. During the formation of the film the copper content of the water is dependent on its chemical composition and is less the harder is the water. A distinction is drawn between copper compounds in true solution which impart taste to the water, and suspended tasteless copper compounds; the latter are formed in water of more than 4° of permanent hardness. When formation of the protective film is complete, the copper content of hot or cold water taken from the pipes never exceeds 0·1–0·3 mg./litre. Further growth of the film and consequent narrowing of the cross-section of the pipe does not occur under any conditions; iron pipes are much inferior to copper in this respect. Soluble copper salts in amounts sufficient to cause acute copper poisoning cannot pass unnoticed into the human organism, and chronic copper poisoning is unknown. The copper content of tap-water can in no case increase by more than a few % the amount of copper taken into the human body in the ordinary foodstuffs. Some other physiological aspects of the problem are discussed.—J. W.

Lead as a Construction Material—Its Contact with Plaster, Lime, and Cement. Jacques Mahul (*J. Usines Gaz*, 1933, **57**, 243–245; *C. Abs.*, 1933, **27**, 5039).—Plaster-of-Paris does not attack lead. In the presence of wet lime and air lead oxidizes to Pb_3O_4. In saturated lime water up to 0·108 grm. of lead per 100 c.c. dissolves in 1 month (0·009 grm. in distilled water), whilst even more (0·183 grm. of lead per 100 c.c.) dissolves in a saturated solution of Portland cement. Any other cement which can liberate free lime is corrosive to lead, the lime dissolving the protective layer of lead suboxide and allowing air oxidation. Aluminous cements and old mortars without free lime are non-corrosive. It is suggested that lead in construction work be protected against these corrosive effects by either a previous bituminous coating or the use of plaster-of-Paris or aluminous cement.—S. G.

On the Question of Corrosion. IV.—Nickel, Tin, Zinc, and Alloys. E. Naumann (*Gas u. Wasserfach*, 1933, **76**, 146–147).—Cf. *J. Inst. Metals*, 1933, **53**, 193. The behaviour of nickel-plated materials, Monel metal, tinned lead tubes, bronze, red brass, galvanized iron pipes, and brass towards the corrosive action of water is briefly described.—B. Bl.

Corrosion Phenomena in Hot-Water Geysers. R. Scherrer (*Bull. Assoc. Suisse Élect.*, 1933, **24**, 517–543).—Cases of rusting are frequent in the boilers of geysers where a galvanized iron vessel is employed, whether electrical or gas heating is used. The zinc coating becomes detached, and eventually forms a sediment of basic zinc carbonate. S. considers that attack is the result of the severe working conditions rather than of defective material or poor galvanizing. The hot-galvanizing process and the methods of testing galvanized material are described. The immunity of such boilers in certain neighbourhoods is explained by local differences in the feed-water. Severe attack is caused by the presence of much free oxygen and carbon dioxide in solution. Analyses of 6 typical samples of water are tabulated. The importance of p_H value and of temporary hardness is discussed, and certain methods of decalcifying water and of estimating its hardness are described. Illustrations show the special types of attack due to dissolved oxygen. The attack by carbon dioxide is held to be comparatively slight. In the case of galvanized heaters, the presence of chlorides is always harmful. The phenomena of passivation are briefly discussed, as are the factors influencing the corrosive power of a feed-water. An improved method for estimating corrosion attack is described, with comparative curves for waters of stated hardness. Among alternative materials to galvanized iron and steel, stainless steel and enamelled iron gave results much inferior to tinned copper, which is recommended for general use.—P. M. C. R.

Salt Effect in Metal Corrosion. R. Podhorsky (*Arhiv Hem. Farm.*, 1933, **7**, 97–113 (113–114 in German); *C. Abs.*, 1933, **27**, 5295).—It is concluded from experiments with zinc plates and iron wire in sodium chloride that the changes in metal potential are much more important in the establishment of salt effect than the changes in solution velocity for oxygen conforming to the Adeney convection currents. Visible protective layers of corrosion products have no influence on the velocity of corrosion of iron and zinc in sodium chloride solution. As the corrosion intensity is not directly proportional to the duration of action, the form of corrosion curve is dependent on the duration of the experiment.—S. G.

Relative Corrodibility of Some Common Metals and Alloys. Anon. (*Metal Progress*, 1933, **24**, (5), 41).—A table of 43 ferrous and non-ferrous metals and alloys gives, in addition to their approximate compositions, the grade of corrosion-resistance of each to the following agencies: sea-shore and industrial atmospheres; domestic, mine and sea-water, saline water containing hydrogen sulphide, and wet steam; fruit and vegetable juices, dairy and other food products; hydrochloric, sulphuric, acetic, nitric, and phosphoric acids (moderate concentration — 5–15%); alkalis in 1–20% solution and fused; solutions of medium concentration containing ammonium chloride, magnesium chloride, magnesium sulphate; hot sulphite liquor, dye liquor, and crude refinery liquors. In addition the maximum safe temperature (in deg. Fahrenheit) is given for a number of the materials with respect to oxidizing, reducing, and sulphur-rich gases.—P. M. C. R.

***The Effect of Traces of other Metals on the Rate of Corrosion of Tin by Citric Acid.** J. M. Bryan (*Dept. Sci. Indust. Res., Rep. Food Investigation Board*, **1932**, 163–165; *C. Abs.*, 1933, **27**, 5296).—2 p.p.m. of iron in solution had no effect but 5 p.p.m. caused a marked increase in the rate of corrosion of tin by 0·5% citric acid. Copper had less effect than iron. The results show the importance of considering the rate of oxidation of stannous to stannic tin.—S. G.

***The Corrosion of Steel and Tinplate by Acids Other than Citric.** T. N. Morris (*Dept. Sci. Indust. Res., Rep. Food Investigation Board*, **1932**, 170–171; *C. Abs.*, 1933, **27**, 5295).—Tartaric, malic, acetic, and hydrochloric acids, alone or buffered with their own sodium salts or with sodium citrate over the p_H range met with in canned fruits, were similar in action to citric acid. Oxalic acid behaved differently.—S. G.

***The Corrosion of Various Metals in a 1 Per Cent. Solution of Citric Acid at 25°.** Anon. (*Dept. Sci. Indust. Res., Rep. Food Investigation Board*, **1932**, 173–178; *C. Abs.*, 1933, **27**, 5295).—Nickel, cobalt, tin, and Monel metal corrode very much more in the presence of air than in its absence. The effect of air is not noticeable with aluminium and its alloys. Most chromium-nickel alloys (stainless steel) are highly resistant, but, if not, the absence of air is no protection. Silver is not attacked, but silver and copper in contact accelerate the corrosion of the copper.—S. G.

Injurious Action of Fruit Acids on Metals. W. Lohmann (*Mineralwasser-Fabrikant*, 1932, **36**, 581–582; *Chem. Zentr.*, 1932, **103**, II, 2891; *C. Abs.*, 1933, **27**, 5835).—The yellow coal-tar dye in lemonade is decolorized by contact with tin. Beverages containing lactic acid attack brass, especially in presence of sugar. In a 1% acid solution the metal losses in 10 days at room temperature (and at 30°–35°) are for lactic acid 0·52 (1·6), citric acid 0·87 (2·13), tartaric acid 0·86 (1·5), and for acetic acid 0·13 (1·9)%. Further data are given for 20-, 32-, and 40-day periods.—S. G.

The Chemistry of Cider. V. L. S. Charley (*Chem. and Ind.*, 1933, **52**, 743–744).—An abstract of a lecture to the Food Group of the Society of Chemical Industry. Apple juice and cider have slight action on tin or aluminium, but attack zinc, lead, and copper rapidly. Heavily-tinned copper is generally used for filters, &c., which come into contact with cider for prolonged periods.—E. S. H.

***Some Inhibitors of Acid Corrosion.** Emilio Jimeno and Isidro Grifoll (*Anales Soc. españ. Fís. Quím.*, 1933, **31**, 582–593; *C. Abs.*, 1933, **27**, 5044).—Both hydrogen formation and oxide solution contribute simultaneously to corrosion. Many inhibitors were tested. Their use reduces attack on metals to 0·1 of that without them. Inhibitors can be used hot or cold. Those which readily assume a colloidal, stable form are best. Oily substances are often effective inhibitors, but their aqueous dispersions are unstable.—S. G.

***Action of Sulphur on Certain Metals.** René Dubrisay (*Chim. et Ind.*, **1933**, Special No. (June), 631–632; *C. Abs.*, 1933, **27**, 5705).—From a study of the mechanism of the blackening of copper and silver under the effect of sulphur and its compounds, it is concluded that this phenomenon can be produced by elemental sulphur without the intervention of sulphides. Extremely small traces of sulphur (of the order of 0·001 mg.) can produce a marked effect on silver.—S. G.

Chemistry of the Corrosive Action of Ammonium Nitrate. V. Oborin (*Khimstroĭ*, 1933, **5**, 2316–2319; *C. Abs.*, 1933, **27**, 5705).—[In Russian.] The corrosion of copper by weak solutions of equal concentrations of ammonia, nitric acid, and ammonium nitrate decreases in the order given.—S. G.

Power Alcohol and Petrol Mixture. Anon. (*Indust. Australian*, 1933, **88**, 271–272).—Two types of corrosion by fuel are distinguished: (1) attack on the metal surfaces of the fuel system; (2) attack on cylinder and on exhaust by acid combustion products. The influence of moisture, of incomplete combustion, and of a change of fuel are briefly considered.—P. M. C. R.

On the Evolution and Present State of Microphonic Technique. P. Chauasse (*Ann. Postes, Télég. et Téléph.*, 1933, **22**, 9–57).—(Section on secondary characteristics, p. 41; effects of moisture.) Moisture enters microphones by absorption from the atmosphere or by condensation from expired air. It causes deterioration in the properties of the carbon employed, and also attacks the metallic parts. Aluminium, unless of extreme purity, is especially liable to such attack. Accelerated tests show that effective protection can be given by coating with cellulose varnish or by plating. Nickel-plated brass is found to be especially resistant to corrosion of this type.—P. M. C. R.

On the Limiting Current in Anodic Polarization of Metals in Aqueous Solutions.—III. Kurt Schwabe (*Z. Elektrochem.*, 1933, **39**, 791–799).—The investigation of the anodic polarization of metals is continued. The behaviour of zinc in unsaturated solutions of zinc chloride, zinc perchlorate, and zinc nitrate, and of zinc in a saturated solution of zinc perchlorate and of silver in a solution of silver perchlorate in water-free propyl alcohol is discussed. (See *J. Inst. Metals*, 1932, **50**, 610, and 1933, **53**, 555.)—J. H. W.

Fatigue Failure Caused by Corrosion. P. Nettmann (*Automobiltech. Z.*, 1933, **36**, 459–460).—The mechanism of lubrication is considered from a theoretical viewpoint. The effects of the viscosity of the lubricant, of its dilution with liquid fuel, and of its emulsification are discussed. The influence of temperature on cylinder wear is considered, and is illustrated by a diagram. —P. M. C. R.

V.—PROTECTION

(Other than Electrodeposition.)

***Corrosion and Protection.** Ulick R. Evans (*Chem. and Ind.*, 1933, **52**, 910–911).—A lecture to the Yorkshire Section of the Society of Chemical Industry. Deals in a general way with corrosion at high and low temperatures, and protection by the use of resistant materials, water treatment, metallic layers, and paint coats.—E. S. H.

The Protal Process for the Protection of Light Alloys. J. Cournot (*Chem. and Ind.*, 1933, **52**, 891–892).—Protection of aluminium by "Protalizing" consists in immersing the object for about 40 minutes in a solution of certain salts at 100° C. The solution used contains an alkaline salt of a metal capable of forming two oxides, the higher oxide being soluble in alkali and the lower oxide insoluble. Reduction occurs and the lower, insoluble oxide becomes attached as a protective film to the aluminium. Liberation of gas occurs at the end of the process. It is usual to impregnate the film with an appropriate finish.—E. S. H.

***Anodic Films of Aluminium and Their Applications.** Shoji Setôh and Akira Miyata (*J. Electrochem. Assoc.* (*Japan*), 1933, **1**, 15–24; *C. Abs.*, 1933, **27**, 4742).—[In Japanese.] Thick and tough films were obtained with an oxalic acid bath. The thickness of the active layer is proportional to the voltage. The layer is subjected to an electric stress of the order of 10^6 to 10^8 v./cm.^{2} and to a pressure of 10^3 to 10^4 atm. A concentrated solution lowers the energy consumption 4–8%. Superposition of a.c. on d.c. prevents the aluminium from pitting during electrolysis. Thick, porous films are treated with high-pressure steam for a few minutes to make them waterproof and more corrosion-resistant than by ordinary impregnating or painting.—S. G.

The M.B.V. Surface Treatment for Aluminium and Its Alloys. G. Eckert (*Found. Trade J.*, 1933, **49**, 281–282, and *Machinist* (*Eur. Edn.*), 1933, **77**, 553E).—Abstracts of a pamphlet published by the British Aluminium Co., Ltd., on the M.B.V. process for improving the corrosion-resistance of aluminium and its copper-free alloys, being a translation of a paper by E. See *J. Inst. Metals*, 1932, **50**, 438, 481, and also 1933, **53**, 84, 443.—J. H. W.

New English Galvanizing Process (Crapo). —— Bauer (*Draht-Welt*, 1933, **26**, 211–212).—A recently patented development of the Crapo process of galvanizing wires, &c., involves annealing and surface chemical treatment prior to galvanizing. Strong smooth uniform coatings are obtained with lower working costs than with the older methods. The wire is first drawn through a lead bath maintained at 800° C. and provided with a fused salt cover (10% sodium cyanide, 35% sodium carbonate, 55% sodium chloride), and then through hydrochloric acid, wash water, and neutralizing baths before it enters the zinc bath maintained at 450°–460° C. This process was developed by W. H. Potter, an Englishman. The process of the American Crapo which has also been patented is similar in general principle and in the claims made for it, but a bath of fused salts (60% NaCN, 20% Na_2CO_3, and 20% sodium chloride) maintained at 650°–700° C. and covered with a thin layer of coke, is used.—A. B. W.

Galvanizing of Small Iron Articles and the Like. —— Beisel (*Draht-Welt*, 1933, **26**, 19–21; and (in German, English, and French) *Draht-Welt Export Ausgabe*, **1933**, (4), 25–31).—Describes in detail all the operations essential to the efficient hot-galvanizing of small articles—degreasing, descaling, fluxing, drying, preheating, and the final dip and drain. The use of a centrifugal machine to enable thorough removal of superfluous zinc is also explained. It is claimed that small articles can often be coated advantageously with a metal-spraying pistol operating in a rotating drum. Two examples of cementation processes are also given with all essential practical data.—A. B. W.

Testing Zinc Coatings on Galvanized Wires. Anon. (*Draht-Welt*, 1933, **26**, 515–516).—The need for a simple, easily applied test of zinc coatings has led the British Non-Ferrous Metals Research Association to consider the whole problem. Complicated methods necessitating the resources of a laboratory or costly apparatus must be ruled out. Although the copper sulphate dip process has definite limitations, it is widely known amongst producers and users and has long been employed by them. There is also the bend test; for soft wires round an 8-diameters mandrel and for hard quality round a 4-diameters mandrel. The copper dip test may also be advantageously applied following a bending test to determine whether the coating has cracked or not. If these tests were standardized and recommended procedures defined the needs of the trade would be satisfactorily met.—A. B. W.

The Electro Coppering of Galvanized Iron Sheets. A. Wogrinz (*Kalt-Walz-Welt* (Monthly Suppt. to *Draht-Welt*), **1933**, (5), 38–39).—A brief discussion of the technical and economic requirements for plating 2 m. × 1 m. galvanized iron sheets on one side only. The copper is deposited from a cyanide bath at 30° C. with a current density of 0·5 amp./dm.^{2}, 30 minutes' plating usually being sufficient.—A. B. W.

Metallizing Process. Anon. (*Indust. Finishing*, 1933, **9**, 30–33).—A general review of the process, including a table showing standard wire size, pressures of acetylene, oxygen, and air, speed of wire, thickness of coat, and weight in lb. of metal sprayed per hr. for lead, tin, zinc, aluminium, copper, brass, phosphor-bronze, nickel–brass, and Monel metal.—E. S. H.

Application and Economics of the Process of Metal Spraying. Chas. Stipp (*Welding Eng.*, 1933, **18**, (3), 12–14, and (abstract) *Indust. Gases*, 1933, **14**, 82).—After a brief description of the process and its technique, various applications are discussed. These include the spraying of aluminium in combustion chambers of high-compression internal-combustion engines, corrosion protection in chemical, dairy and food-production plant, renewing the zinc coating on welded galvanized sheet, salvaging of castings, building-up worn parts, and ornamental work.—H. W. G. H.

The Protection of Aluminium and Its Alloys by Paints and Varnishes. H. Rabaté (*Rev. Aluminium*, 1933, **10**, 2133–2148).—The protection of aluminium and its alloys by painting and varnishing is fully described as follows: (1) preparation of the metal surfaces before the application, (*a*) for electrolytic coating, (*b*) before painting; (2) different types of protective coatings, (*a*) oxidation, including anodic oxidation, modification of anodic oxidation, chemical oxidation and bronzing, (*b*) electrolytic protection with cadmium, zinc, nickel, copper, chromium, or cobalt, (*c*) Schoop metallization; (3) types of varnish and paint protectors; (4) other types of coating, such as fats and phenol.—J. H. W.

Painting Galvanized Iron and Sheet Zinc. E. Perry (*Indust. Finishing*, 1933, **9**, 11–12).—It is recommended to clean the surface with a solution containing 30 grm. of dry sodium phosphate and 4 grm. of sodium hydroxide in 200 grm. of water at 140°–176° F. (60°–147° C.) and then to etch by immersing for 30 seconds at room temperature in a solution of 20 grm. ammonium nitrate and 200 grm. commercial hydrochloric acid in 1000 grm. of water. Portland cement paint acts as a good primer, especially when the material has to undergo considerable temperature variations, as in the linings of refrigerators.—E. S. H.

VI.—ELECTRODEPOSITION

A New Stripping Test for Cadmium Coatings. Gustaf Soderberg (*Metal Cleaning and Finishing*, 1933, **5**, 341–343; *C. Abs.*, 1933, **27**, 5251).—A discussion of the factors affecting the distribution of electroplated cadmium and an outline of a new stripping method by which the minimum thickness as well as the actual thickness of the plate at any one point may be determined.—S. G.

Udylite Develops New Test Method for Cadmium. Anon. (*Platers' Guide*, 1933, **29**, (10), 11–12).—Briefly describes a new stripping test for determining the thickness of deplated cadmium coatings.—J. H. W.

Matt Chromium Plating. Herbert Kurrein (*Metallwaren-Ind. u. Galvano-Tech.*, 1933, **31**, 341–343).—A matt finish on chromium-plated brass or steel may be obtained by (*a*) treating in the usual way to obtain first a copper, then a nickel plate of high lustre, matting the latter plate by sand-blasting or pickling, and applying an outer coat of chromium; (*b*) sand-blasting the original material before any plating, or (*c*) roughening the original surface with emery before plating. Matt chromium finishes produced by method (*a*) are generally the best and most resistant to corrosion.—A. R. P.

The Production of Hard Chromium Plate. Arthur Willink (*Metal Cleaning and Finishing*, 1933, **5**, 368–371; *C. Abs.*, 1933, **27**, 5649).—Important factors which influence the wear-resistance of chromium plate are discussed.—S. G.

Chromium Plating in the Cold. L. Richard (*Galvano*, **1933**, (19), 18–20).—Practical notes are given on chromium-plating baths maintained at 15° C., including a discussion of the composition of the bath, temperature, size, and disposition of anodes, regulation of current density, and mode of suspension, drying, and polishing of the objects.—E. S. H.

Some Notes on Chromium Plating. Lucien Richard (*Galvano*, **1933**, (17), 22–23, (18), 21–22).—Practical notes, based on answers to correspondents, are discussed briefly.—E. S. H.

Chromium Plating on Zinc. M. de Kay Thompson and F. C. Jelen (*Trans. Electrochem. Soc.*, 1933, **63**, 141–148; discussion, 148).—For abstract of the paper see *J. Inst. Metals*, 1933, **53**, 27. In the discussion *E. A. Anderson* stated that outdoor exposure tests indicated that a single nickel coating was more protective than a composite copper–nickel coating.—A. R. P.

Utility of Chromium Plating in Calico Printing. John B. Dick (*Amer. Dyestuff Reporter*, 1933, **22**, 305–309; *C. Abs.*, 1933, **27**, 3826).—The advantages of chromium plating are enumerated. Means of plating copper rolls are described.—S. G.

Chromium Plating. A New Portable Equipment for the Electrodeposition of Metals. Anon. (*Chem. and Ind.*, 1933, **52**, 837–838).—A portable plating apparatus, allowing metal parts to be electro-plated *in situ*, is described.—E. H.

Chromium Plating of Small Tools and Mandrels with a View to Increasing their Resistance to Wear. Anon. (*Galvano*, 1933, (18), 23–26, (19), 24–26).—Translated from *Machinery* (*Lond.*), 1932, 40, 549–553. See *J. Inst. Metals*, 1933, 53, 88.—E. S. H.

A Cyanide-Free Bath for the Deposition of Copper on Steel. Colin G. Fink and Chaak Y. Wong (*Trans. Electrochem. Soc.*, 1933, 63, 65–72; discussion, 72–73; also (abstracts) *Met. Ind.* (*Lond.*), 1933, 43, 110; and *Daily Metal Reporter*, 1933, 33, (92), 11).—For abstract of the paper, see *J. Inst. Metals*, 1933, 53, 252. In the discussion *Raymond R. Rogers* stated that chromium can be deposited on copper plated from oxalate baths without danger of peeling. *Leonard Shepley* stated that cyanide baths have certain advantages over oxalate baths, and considered that their toxicity and comparative instability are not serious drawbacks; in reply *Colin G. Fink* stated that cyanide baths are really suitable only for "flashing," and that oxalate baths have the advantage of being much cheaper, less toxic, and more stable than cyanide baths, have a throwing power equal to that of sulphate baths and require little attention in use.—A. R. P.

Nickel Plating of Fabricated Zinc in a Barrel. Albert Hirsch (*Trans. Electrochem. Soc.*, 1933, 63, 135–139; discussion, 139–140; also *Metal Cleaning and Finishing*, 1933, 5, 299–300; and *Iron Age*, 1933, 131, 991).—For abstract of the paper see *J. Inst. Metals*, 1933, 53, 312. In the discussion *E. A. Anderson* expressed the opinion that an intermediate copper coating is undesirable and that nickel plating from a solution of p_H 8 will give an extremely hard nickel deposit which will almost certainly contain numerous cracks if it is built up to any great thickness; he considered a minimum thickness of 0·0003 in. of nickel necessary, and this would require 2 hrs.' plating in H.'s solution. *Charles H. Eldridge* considered a minimum thickness of 0·0005 in. of nickel necessary in the absence of a copper intermediate coating.—A. R. P.

Nickel Plating in the Barrel and the Treatment of Small Parts. Anon. (*Galvano*, 1933, (19), 14–17).—A description of existing practice.—E. S. H.

Electrolytic Deposition of Platinum on Copper. Shao-Tze Leo and Tsing-Nang Shen (*Sci. Quart. Nat. Univ. Peking*, 1931, 3, 7–19; *C. Abs.*, 1933, 27, 5650).—Copper dishes are plated from a phosphate bath with a current density of 0·75 amp./dm.^{2} at 45° C. They have been successfully used as a substitute for platinum ware in evaporating hydrofluoric acid mixtures. The platinum deposit loosened, however, on being heated to high temperatures. —S. G.

Rhodium Plating. Colin G. Fink and George C. Lambros (*Trans. Electrochem. Soc.*, 1933, 63, 181–186; discussion, 186).—For abstract of the paper see *J. Inst. Metals*, 1933, 53, 447. In the discussion *W. L. Mancher* said that the reflectivity of rhodium in the range 4500–6500 A. is 50–56%, *C. G. F.* said the U.S. Bureau of Standards figure for melted rhodium was 45%, and *A. H. Taylor* stated that 3 samples of rhodium plate from different baths gave reflectivities of 66, 70, and 78%, respectively; the best deposit consisting of 1 mg. of rhodium per in.^{2} on an undercoat of nickel. *C. G. F.* stated that rhodium reflectors were used for searchlight and cinema mirrors in the U.S.A. —A. R. P.

A Study of Cyanide Zinc Plating Baths Using the Aluminium–Mercury–Zinc Anode. A. Kenneth Graham (*Trans. Electrochem. Soc.*, 1933, 63, 121–132; discussion, 133).—For abstract of the paper see *J. Inst. Metals*, 1933, 53, 313. In the discussion *U. C. Tainton* suggested that the cause of the anode sludge obtained by G. was the 0·07% of impurity in the zinc, and stated that zinc of 99·99% purity was now readily obtainable. In reply *A. K. G.* stated that the use of this latter type of zinc in the alloy anodes gave no better results than when 99·93% zinc was used.—A. R. P.

The Electrolytic Finishing of Die-Cast Metal. —— Rössler (*Werkstatt u. Betrieb*, 1933, 66, 409–411).—The formation of a poorly adhesive or blistered coating is attributed to incorrect treatment rather than to the unsuitability for plating of zinc, tin, or aluminium die-castings. Tin, having little tendency to oxidize, presents the least difficulty, but efficient deoxidation and degreasing are necessary for all three materials. A coating of copper or brass is found to improve the quality of subsequent nickel-plating. Special precautions are indicated for each type of material.—P. M. C. R.

The Electroplating of Wires. H. Berlet (*Draht-Welt*, 1933, 26, 435–436).—A simple mathematical investigation of the relationships obtaining between the various factors involved in the continuous plating of wires.

If M = weight of wire plated in kg.; t = time of plating in hours; D = density of wire material; r = wire radius in mm.; L = length immersed in metres; v = wire velocity in metre/sec.; Q = weight of metal in grm. deposited per kg. of wire; A = electrochemical equivalent of metal deposited in grm./coulomb; B = current efficiency (fractional); J = current in amps.

Then
$$M = 3{\cdot}6t \,.\, v \,.\, r^2 \,.\, \pi \,.\, D,$$
$$L = \frac{5MQ}{B \,.\, A \,.\, t \,.\, C \,.\, \pi \,.\, r,}$$
and
$$J = \frac{M \,.\, Q}{B \,.\, A \,.\, t}\,.$$

Discretion must, of course, be exercised in subdividing the immersed length (L) found according to the ability of the wire to carry the current (J).
—A. B. W.

Electrodeposition of Metals and Alloys from Formamide Solutions. R. D. Blue and F. C. Mathers (*Trans. Electrochem. Soc.*, 1933, 63, 231–238).—See *J. Inst. Metals*, 1933, 53, 511.—S. G.

The Heating of Electrolytic Baths in Winter. Anon. (*Galvano*, 1933, (18), 15–16).—Electrical heating is recommended.—E. S. H.

The Application of X-Rays in the Field of Electrodeposition. N. Promisel (*Met. Ind.* (*Lond.*), 1933, 43, 437–441).—The work of earlier experimenters on the X-ray analysis of electrodeposits is summarized and the reasons for the preferential orientation of the deposits normal to certain crystallographic planes, characteristic of the metal concerned, are discussed. These directions depend on the nature of the metal deposited and the nature of the plating solutions and conditions of deposition. The influence of the crystal arrangement on the reflectivity, and the work of Roux and Cournot and Stillwell and Stout on the deposition of alloys are discussed. X-ray analysis yields a large range of information on the nature of electrodeposits, and this information can be applied to studies of the adherence and physical properties of the deposits, of the effect of addition agents and of anions on their nature, and of the structure of dull, bright, and burnt deposits.—J. H. W.

The Removal of Cyanide from Plating-Room Wastes. E. F. Eldridge (*Mich. Eng. Exper. Sta. Bull.* No. 52, 1933, 1–20; *C. Abs.*, 1933, 27, 4741).—Dilute cyanide waste from plating rooms was treated by several methods in an effort to remove the toxicity. (1) KCN treated with Cl_2 yields CNCl, which appears to be nearly as toxic as the KCN. (2) Fe^{++} and Fe^{+++} salts were used in an effort to precipitate prussian blue. After precipitation the solution was toxic. (3) KCN was oxidized by $KMnO_4$ in alkali solution to KOCN with the precipitation of $Mn(OH)_4$. After oxidation the clear supernatant liquid when diluted 1–1 with water was not toxic to fish. High concentration of $Mn(OH)_4$ sludge was toxic. (4) KCN, on addition of acid, is converted to HCN which can be removed by aeration. When the p_H was maintained at about 5 in a solution containing initially 200–500 p.p.m. KCN, the HCN was completely removed in 8–16 hrs. The aerated liquid when diluted 1–1 was not toxic to the fish.—S. G.

VII.—ELECTROMETALLURGY AND ELECTROCHEMISTRY

(Other than Electrodeposition and Electro-Refining.)

***Preparation and Electrolysis of Aluminium Sulphide.** Paul Roentgen and Heinz Borchers (*Metallwirtschaft*, 1933, **12**, 431–434).—Crude aluminium reacts vigorously with iron sulphide forming aluminium sulphide containing only about 1·5% alumina, 0·2% silicon, and 0·01% iron, the greater part of the impurities in the aluminium being absorbed by the iron. Sodium chloride may be added to the reaction mixture to prevent oxidation. Aluminium sulphide can be electrolyzed at 700° C. in fused chloride or fluoride electrolytes without difficulty to give pure aluminium; the decomposition voltage is about 1 volt less than that of the alumina–cryolite bath, the current yield is very high, and the carbon anodes are unattacked by the sulphur.—v. G.

***Critical Voltage Phenomena at the Critical Current Density in the Deposition of Spongy Copper, and Microscopic Examination of these Deposits.** Keinosuke Hirakoso (*J. Electrochem. Soc.* (*Japan*), 1933, **1**, 61–68).—[In Japanese.]

—S. G.

Electrothermic Preparation of Cupro-Silicon. V. Verigin (*Zvetnye Metally* (*The Non-Ferrous Metals*), **1932**, 369–374; *C. Abs.*, 1933, **27**, 4176).—[In Russian.] The alloy, prepared in the electric furnace, contained silicon 58, copper 40, and iron about 1%, and possessed good physical and chemical properties. The semi-commercial process was made continuous.—S. G.

***Electrolytic Production of Metallic Lithium.** N. A. Isgarischev and S. A. Pletnev (*Zvetnye Metally* (*The Non-Ferrous Metals*), **1932**, 536–542; *C. Abs.*, 1933, **27**, 4175).—[In Russian.] Fused lithium chloride plus potassium chloride (1 : 1) was electrolyzed in a magnesium silicate-lined iron cell with graphite anode and iron cathode. The output of the cells was 1 kg./day lithium at 225 amp. and 17 v., or 75 kw.hr./kg. lithium. Efficiency was about 85%. The lithium analyzed potassium 0·23, magnesium 0·19, and sodium 0·5%. The sodium was an impurity in the potassium chloride used. The magnesium came from the lining.—S. G.

Choice of an Electrolytic Method for the Preparation of Metallic Magnesium. I. G. Scherbakov (*Tech. Urals*, 1931, **7**, (5/6), 12–16; *Chem. Zentr.*, 1932, **103**, I, 2075; *C. Abs.*, 1933, **27**, 5649).—[In Russian.] The comparative advantages and disadvantages of the methods for the electrolytic preparation of magnesium are discussed: (1) magnesium oxide and fluoride; (2) magnesium chloride; (3) magnesium chloride and carnallite; (4) carnallite.

—S. G.

Electrolytic Parting of the Noble Metals. Fr. Vogel (*Russko-Germanski Vestnick Nauk i Tech.*, **1932**, (11/12), 21–28; *Chem. Zentr.*, 1932, **103**, II, 2519; *C. Abs.*, 1933, **27**, 5649).—From a critical consideration of the methods of separation of gold and silver, V. concludes that the most satisfactory process is to fuse a poor gold–silver alloy with a rich silver alloy, *i.e.* increase the silver content. The Siemens and Halske process for electrolytic refining of silver is better than that of Dietzel.—S. G.

†On the Theory of the Cathodic Evolution of Hydrogen. J. Hoekstra. M. Volmer (*Z. physikal. Chem.*, 1933, [A], **166**, 76–79, 80).—A critical discussion of Volmer's work on hydrogen overvoltage and V.'s reply to the criticisms.

—B. Bl.

Note on the Theory of Hydrogen Overvoltage. O. Essin (*Z. physikal. Chem.*, 1933, [A], **166**, 270–272).—The theory of Erdey-Grúz and Volmer explains the effect of hydrogen-ion concentration on overvoltage if the rate of the opposed reaction is taken into consideration.—B. Bl.

The Theory of Passivity. XX.—The Passivity of Nickel. W. J. Müller and E. Löwe (*Z. Elektrochem.*, 1933, 39, 872–879).—Georgi's criticism (see *J. Inst. Metals*, 1933, 53, 338) of M.'s film theory (*Bedeckungstheorie*) of passivity is shown to rest on a misconception of that theory, and it is claimed that Georgi's experimental results can be completely explained by this theory. Von Foerster's explanation of passivity (see *J. Inst. Metals*, 1933, 53, 131), namely that the potential displacement of the nickel depends on the retardation of the solution of the nickel, is based on current density and strength curves without consideration of the time factor. His hypothesis is contrary to the fundamental law that the charged hydrogen ions on the anode are repelled according to Coulomb's law and therefore cannot come into the reaction zone of the anode. Experimental results showed, in conformity with M.'s theory, that a depression of the nickel potential is accompanied by an increase in porosity.—J. H. W.

The Theory of Passivity. XXI.—Film or Absorption Theory. W. J. Müller (*Z. Elektrochem.*, 1933, 39, 880–883).—M. replies to the criticisms of E. Müller and Kurt Schwabe. See *J. Inst. Metals*, 1933, 53, 555, and preceding and following abstracts.—J. H. W.

The Theory of Passivity. Erich Müller and Kurt Schwabe (*Z. Elektrochem.*, 1933, 39, 884).—Reply to W. J. Müller's criticism (preceding abstract).
—J. H. W.

***On the Potential Difference between Copper and Its Amalgam, and the Reproducibility of the Copper Electrode.** Mitzugu Oku (*Sci. Rep. Tôhoku Imp. Univ.*, 1933, [i], 22, 288–300).—[In English.] A standard copper electrode is prepared by electrolyzing a copper sulphate solution containing sulphuric acid, using a high current density and a platinum cathode. The deposited copper is preserved in the electrolyte, with occasional shaking to remove occluded hydrogen. Atmospheric oxidation should be avoided. Good results can be obtained with copper, reduced from cupric oxide by hydrogen at 500° C., which is stored in copper sulphate solution containing sulphuric acid. The p.d. between the standard copper electrode and the amalgam is given by $E_{298} = 0{\cdot}00512 \pm 0{\cdot}00004$, $dE/dT = - 0{\cdot}0000737$ volt/degree ($t = 0°$–$35°$ C.).
—E. S. H.

***On the Law of Mass Action with Concentrated Non-Ideal Solutions.** F. Sauerwald and F. Neubert (*Metallwirtschaft*, 1933, 12, 459–460).—Since the quotient of the activity coeff. is either equal to unity or a constant it can be concluded that the mass action law, referred to the concentration of the components, is apparently valid for concentrated solutions. Measurements of the equilibria in the reaction $PbCl_2 + Sn = Pb + SnCl_2$ are given as examples.
—v. G.

Cathodic Films in Electrolytic Condensers. Frank W. Godsey, Jr. (*Trans. Electrochem. Soc.*, 1933, 63, 223–229).—See *J. Inst. Metals*, 1933, 53, 256.—S. G.

VIII.—REFINING

(Including Electro-Refining.)

Refining Lead by Chlorination. F. M. Loskutov (*Zvetnye Metally* (*The Non-Ferrous Metals*), 1932, (9), 87–98; *C. Abs.*, 1933, 27, 5693).—[In Russian.] Chlorination was compared with fire-refining of lead. In the conditions at the works where the experiments were carried out the chlorination process showed little superiority, but it is hoped that some improvements suggested will increase greatly the advantages of the chlorination process.—S. G.

IX.—ANALYSIS

Electrolytic Analysis of Bronze and Brass. W. J. Ugniatchev (*Zhurnal Obschtchey Khimii* (*Journal of General Chemistry*), 1933, 3, 500–504).—[In Russian.] Difficulties encountered in the electrolytic analysis of bronze and brass are reviewed and a combined electrolytic and chemical method of analysis is described in detail. Cu and Pb are first determined electrolytically in HNO_3 solution, the Ni is removed from the solution with dimethylglyoxime, and the filtrate used for the electrolytic determination of Zn. P is determined by the molybdate method as usual. Sn is determined by dissolving in $H_2C_2O_4$ the metastannic acid produced by treatment of the alloy with HNO_3 and electrolyzing the solution.—M. Z.

Assay of Refined Electrolytic Gold. I. A. Kadaner (*Zvetnye Metally* (*The Non-Ferrous Metals*), 1932, 7, 137–138; *Chim. et Ind.*, 1933, **30**, 101; *C. Abs.*, 1933, **27**, 5272).—[In Russian.] Dissolve 10 grm. on the sand bath with 18 c.c. HNO_3 (*d* 1·4) and 36 c.c. HCl, let cool, add 3 vol. distilled H_2O; if the sample contains Ag even in very small quantities the solution becomes turbid because of precipitation of AgCl, allow to settle, warm slightly, filter and weigh.—S. G.

Analysis of Bearing Metal. F. Schwarz (*Bul. facultatii stiinte Cernauti*, 1933, 6, 225–228; *C. Abs.*, 1933, **27**, 4754).—A modification of the Treadwell method for the analysis of bearing metals is given. By use of the original method, it was found that Sn was lost in large amounts as $SnCl_4$, when high-lead alloys were dissolved by *aqua regia* on the water bath, and that a loss also occurred when the alcoholic filtrate from the Pb determination was evaporated to dryness. This difficulty was overcome by dissolving the sample in a tall beaker with cover and keeping the temperature between 60° and 70° C. on a Costeanu bath. The alcoholic filtrate was evaporated at the same temperature from this bath; a conical porcelain dish was used to help to obviate creeping. With these modifications, the method gave correct results.—S. G.

Analysis of Babbitt Metal by a Volumetric Method. E. S. Gavrilenko and V. S. Kobzarenko (*Nauk. Zapiski Tzukrovoī Promishlenosti*, 1933, **10**, (29/30), 27–32; *C. Abs.*, 1933, **27**, 5678).—[In Russian.] Dissolve 0·5–1·0 grm. of alloy in 10 c.c. of concentrated H_2SO_4 and boil for 5–7 minutes after the metal has dissolved. Dilute with 50 c.c. of water, add 20 c.c. of concentrated HCl, boil for 5 minutes, add 150 c.c. of cold water and 5 c.c. of saturated $MnSO_4$ solution. Titrate the cold solution with $KMnO_4$ to determine Sb. Reduce the Sn^{++++} in the filtrate by heating with Fe in a stream of CO_2 and titrate the resulting Sn^{++} with I_2 solution. To determine Pb, take a fresh portion of alloy and treat 0·5 grm. with 3–5 c.c. of water and 10–15 c.c. of concentrated HNO_3. Evaporate to dryness, digest the residue with 15 c.c. of $5N$-HNO_3 and filter off the oxides of Sn and Sb. Wash with 1% NH_4NO_3 solution, evaporate to about 100 c.c., neutralize with NH_4OH and precipitate the Pb as oxalate. Titrate the precipitate with $KMnO_4$ in the usual manner. In the filtrate from the PbC_2O_4 determine Cu iodometrically after evaporating to about 75 c.c. and properly neutralizing.—S. G.

***Spectrographic Investigations of Technical and Very Pure Metals. I.—Zinc.** Walther Gerlach and E. Riedl (*Metallwirtschaft*, 1933, **12**, 401–405).—Methods of exciting spectra are critically reviewed. The most suitable method depends on the nature of the problem in hand. In zinc, lead is best detected by the line 4057·8 A., cadmium by the line 2288 A. or by the line 3611 A. in the longer wave ultra-violet region. The sensitivity of the test is 10^{-1} % for Pb, 10^{-5} % for Cu, 10^{-4} % for Cd, and 10^{-3} % for Fe. Very pure (99·9996%) New Jersey zinc contains Cu and Pb but no Cd or Ag. In testing Zn the condensed spark is unsuitable; the interrupted arc discharge should be used. Qualitative analyses of various kinds of zinc are given.—v. G.

Methods of Chemical Analysis for Zinc Plants. B. Zuhoene and M. I. Fugov (*Tsvetnye Metally* (*The Non-Ferrous Metals*), 1932, 214–228; *C. Abs.*, 1933, 27, 3681).—[In Russian.] A detailed description is given of methods used in European zinc plants.—S. G.

The Qualitative Detection of Vanadium. Darwin Harris (*Chemist-Analyst*, 1933, 22, (3), 11, 15).—The method depends on the blue colour developed by treating V_2O_5 solutions with $C_6H_5 \cdot NH_2 \cdot HCl$.—A. R. P.

Colorimetric Determination of Aluminium. F. Alten, H. Weiland, and H. Loofmann (*Angew. Chem.*, 1933, 46, 668–669).—The method depends on the yellowish-red compound produced by coupling the Al compound of 8-hydroxyquinoline with diazotized sulphanilic acid in HCl solution and adding NaOH in excess. The Al is separated from Mg, Co, Ni, and Zn by boiling with $(CH_2)_6N_4$, and from Fe by boiling with 0·5N-NaOH; it is then precipitated from dilute acetic acid solution by addition of 8-hydroxyquinoline.—A. R. P.

Determination of Bismuth in Copper by Spectral Analysis. B. A. Lomakin (*Trudy Vsesoyuznogo Nauchno-Issledovatelskogo Instituta Metrologii i Standartizatsii* (*Trans. Inst. Metrol. Standardization* (*U.S.S.R.*)), No. 2, 1932, 139–165; *C. Abs.*, 1933, 27, 4189).—[In Russian, with French summary.] A study of the relationship between the log of the percentage of Bi in Cu and the density of the Bi spectral lines (cf. *J. Inst. Metals*, 1930, 43, 550).—S. G.

Volumetric Determination of Bismuth as Oxychloride. E. von Migray (*Chem.-Zeit.*, 1933, 57, 774).—The metal is precipitated as BiOCl in the usual way and the precipitate dissolved in dilute HNO_3; the solution is then treated with an excess of 0·1N-$AgNO_3$ and the excess titrated with NH_4CNS.

—A. R. P.

Determination of Cadmium in Zinc. M. I. Shchin (*Tsvetnye Metally* (*The Non-Ferrous Metals*), 1932, (12), 81–94; *C. Abs.*, 1933, 27, 5675).—[In Russian.] The method, essentially, consists in separation from solution of the sample, of all metals with the exception of Zn and Cd, and in separation of the Cd from the Zn in ammoniacal solution by means of Na_2S. The Cd precipitate is dissolved in HCl, and the Cd then precipitated by H_2S. The precipitate is dissolved and the ammoniacal solution electrolyzed. One or two samples can be analyzed in 10–14 hrs. The accuracy of the method is within the following limits: with Cd contents of up to 0·05 ± 0·002%, from 0·05 to 0·20 ± 0·003%, and from 0·20 to 0·30 ± 0·005%; the accuracy is 0·005, 0·003, and 0·01%, respectively. The method is good for all grades of zinc. The details of the procedure and the methods of separation of the metals, such as Cu, Pb, Fe, Bi, As, Sb, Sn, are described.—S. G.

Volumetric Determination of Cobalt by Means of Ferrous Sulphate and Potassium Dichromate. Landon A. Sarver (*Indust. and Eng. Chem.* (*Analyt. Edn.*), 1933, 5, 275–276).—The Co is precipitated from a $CoSO_4$ solution by addition of $NaBO_3$ and an excess of NaOH. After boiling to expel O_2, $FeSO_4$ is added, without admitting air, followed by an excess of H_2SO_4, and the unoxidized $FeSO_4$ is titrated with $K_2Cr_2O_7$ in the presence of H_3PO_4 and Ba diphenylaminesulphonate.—A. R. P.

Electrolytic Zinc: The Determination of Small Amounts of Germanium. Harald Lundin (*Trans. Electrochem. Soc.*, 1933, 63, 149–158; discussion, 159).—For abstract of the paper see *J. Inst. Metals*, 1933, 53, 520. In the discussion *U. C. Tainton* said that the flue dust produced at the East Helena plant of the American Smelting and Refining Co. contained about 2 lb. of germanium per ton and that about 1000–2000 lb. of the metal per month could be produced from this source if there were any demand for it.—A. R. P.

Determination of Molybdenum and Lead by [illegible]'s Method. Z. Raichinstein and N. Romanov (*Zhurnal Obshchei Khimii* (*Journal of General Chemistry*), 1933, [A], 3, 331–333).—[In Russian.] The method previously described (*J. Inst. Metals*, 1933, **53**, 321) is shown to be more rapid than other procedures for the determination of Mo or Pb.—M. Z.

A New Volumetric Determination of Niobium in the Presence of Tantalum. Victor Schwarz (*Angew. Chem.*, 1933, **46**, 552–553).—The mixed oxides are fused with $KHSO_4$, the fused cake is leached with concentrated H_2SO_4, and the solution poured into dilute H_2SO_4 containing 5 grm. of tartaric acid. The solution is then shaken in a bulb-shaped stoppered funnel with 3% Zn amalgam in a current of CO_2 for 1 hr., whereby complete reduction of Nb_2O_5 to Nb_2O_3 is stated to occur. The dark-coloured liquid is treated with an excess of $FeCl_3$ and the excess is titrated with $TiCl_3$ using KCNS as indicator.—A. R. P.

Influence of Iron and Aluminium on the Accuracy of Determination of Tin in Copper–Zinc Alloys. M. I. Shubin (*Zavodskaya Lab.*, 1933, (1), 25–33; *C. Abs.*, 1933, **27**, 5676).—[In Russian.] At 1% Sn absorption of Fe raises the result 0·05% for 0·2% Fe, 0·10–0·15% for 1–3% Fe, and 0·03–0·06% for 1–4% Al.—S. G.

Determination of Tin in Babbitt Metal by Reduction with Zinc. A. A. Botchvar and A. M. Potapova (*Zvetnye Metally* (*The Non-Ferrous Metals*), **1932**, 319–321; *C. Abs.*, 1933, **27**, 3895).—[In Russian.] Dissolve a 0·2–0·5 grm. sample in 30 c.c. HCl (*d* 1·2) with a small quantity of $KClO_3$ (0·5–1 grm.). Boil for 10 minutes to remove Cl_2, add 3 grm. Zn, boil for 15–20 minutes until all Zn is dissolved, and then 1–2 minutes more to ensure the complete solution of the Sn. Remove from the flame, introduce a small piece of coarse-grained marble, cool rapidly under tap-water without shaking, and titrate with I_2. —S. G.

Determination of Small Quantities of Zinc in Aluminium. M. I. Shubin (*Zvetnye Metally* (*The Non-Ferrous Metals*), **1932**, 147–162; *C. Abs.*, 1933, **27**, 3681).—[In Russian.] Dissolve 5–10 grm. of metal in 125–250 c.c. of 20% NaOH solution. Dilute to 250–400 c.c. and filter. To the filtrate add 10–15 c.c. of 20% NaOH solution which has been saturated with H_2S. Boil and filter off the insoluble sulphides. Discard the filtrate. Dissolve the precipitate in 25–32 c.c. of $6N$-H_2SO_4, boil to remove H_2S and oxidize with H_2O_2. Make the solution slightly basic by adding NH_4OH, boil off excess NH_3 and filter after adding 1–2 c.c. of 25% NH_3 solution. To the filtrate add 4–5 c.c. more of the strong NH_3 solution and electrolyze.—S. G.

†**Rapid Methods for the Determination of Zinc in Galvanized Iron.** E. Azzarello, A. Accardo, and A. Scalzi (*Riv. tec. ferrovie ital.*, 1933, **43**, 267–289; *C. Abs.*, 1933, **27**, 5677).—The methods for examining galvanized metals are reviewed and a *bibliography* is appended. Two methods for determining total Zn are modified as follows: (*A*) Treat the sample of galvanized Fe (in a special apparatus) with dilute H_2SO_4 and measure the volume of H_2 evolved. Titrate the Fe^{++} in the solution with $KMnO_4$. (*B*) Plunge the sample into dilute H_2SO_4 for 10–20 seconds, whereby the greater part of the zinc is dissolved with relatively little Fe. Electrolyze the solution for Zn, using as anode the material undissolved by the dilute H_2SO_4 and as cathode Pt gauze.—S. G.

X.—LABORATORY APPARATUS, INSTRUMENTS, &c.

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

A New Differential Dilatometer. Otakar Quadrát and Rudolf Pospíšil (*Chim. et Ind.*, 1933, Special No. (June), 623–630; *C. Abs.*, 1933, **27**, 5582).—A detailed description is given of the construction, operation, and application to the calculation of the true expansion coeff. of an optical dilatometer, in which the defects of previously proposed instruments have been eliminated.—S. G.

The Thermal Expansions of Certain Crystals with Layer Lattices. Helen D. Megaw (*Proc. Roy. Soc.*, 1933, [A], **142**, 198–214).—Apparatus for the X-ray measurement of the expansion of crystals between 0° and 100° C., with possible extension down to the temperature of liquid air, is described.—J. T.

A Simple Universal Camera for Röntgen Crystal Structure Analysis. E. Sauter (*Z. Krist.*, 1933, **85**, 155–159; *C. Abs.*, 1933, **27**, 3643).—A new type of camera is described in which the film may be in the form of a sheet, cone, or cylinder. The apparatus is particularly useful in investigations in the field of X-ray studies of metals.—S. G.

***The Dependence of the Focussing Effect Associated with the Use of Bent Crystals in X-Ray Spectroscopy on the Bending Mechanism of the Crystal.** Erik Carlsson (*Z. Physik*, 1933, **84**, 801–810).—The focussing effect associated with the use of a crystal bent into the form of part of a circular cylinder in X-ray spectroscopy is discussed mathematically and experimentally.—J. T.

***A High-Vacuum X-Ray Spectrometer Employing a Concave Crystal as Suggested by Johann.** Arne Sandström (*Z. Physik*, 1933, **84**, 541–556).—A high-vacuum, focussing X-ray spectrometer is described and its use and accuracy are discussed.—J. S. G. T.

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

***A Plane-Bending Fatigue-Testing Machine of the D.V.L. (Deutsche Versuchsanstalt für Luftfahrt) and Some Results Obtained with It.** Kurt Matthaes (*Metallwirtschaft*, 1933, **12**, 485–489).—Sheets, profiles and tubes of metal can be tested in the new machine, in which the applied bending moment is approximately constant throughout the length of the specimen. Alternating bending tests with a superimposed constant bending stress and alternating torsion tests can also be made with the machine. The results for round rods agree exactly with those obtained on the Schenck machine. The fatigue limit of shaped sections is generally much lower than that of plain test-pieces.—v. G.

***On the Endurance Testing of Various Materials with the MAN Alternate Bending Machine.** A. Jünger (*Mitt. Forsch. Anst. G.H.H. Konzern*, 1930, **1**, (1), 8–18).—A modification of the Wöhler alternate bending test is described, with the results of tests on 25 materials, mainly ferrous, but including sand-cast Elektron and 2 samples of Duralumin. The method is further applied to the testing of welded samples and to investigating the effects of surface finish.
—P. M. C. R.

Further Endurance Tests on Various Materials with the MAN Alternate Bending Machine. A. Jünger (*Mitt. Forsch. Anst. G.H.H. Konzern*, 1931, **1**, (3), 45–58).—The MAN apparatus (see preceding abstract) is applied to further investigations of the effects of surface finish, to the endurance testing of welded samples, including aluminium alloy sheet and 70 : 30 copper–nickel sheet, and to combined corrosion and endurance tests. The last-named series were performed on ferrous pieces only.—P. M. C. R.

***Testing of Thin Sheets.** M. v. Schwarz and K. Christoph (*Metallwirtschaft*, 1933, **12**, 476–477).—If t mm. is the depth of penetration in the Erichsen test for sheet d mm. thick having a tensile strength of s_B kg./mm.^{2} and an elongation of δ_{10}% then the following expression holds for numerous metals and alloys: $t - \sqrt{10d} = 0{\cdot}019 s_B + 0{\cdot}15\, \delta_{10} + 1{\cdot}7$.—v. G.

***Grain Measurements on Technical Compression Test-Specimens.** W. Tafel and H. Waschek (*Metallwirtschaft*, 1933, **12**, 445–447, 460–463).—A mathematical method is given for calculating the true grain-size of a metal from measurements made of the area of grains in two sections. With the aid of this method the deformation of the crystal grains during compression tests has been followed. The compression of the grains increases from the edges towards the centre. A relatively large deformation also occurs in the vicinity of the end-surfaces. This is in direct opposition to the theory that cone-shaped regions under the end-surfaces take no part in the deformation.—v. G.

Wire and Tube Flaw Locator. Anon. (*Instruments*, 1933, **6**, 88).—Tungsten or molybdenum wire or copper tubing is passed through one or two coils connected in oscillator circuits. The presence of flaws is detected by changes in the induced currents.—J. C. C.

The Modulus of Elasticity of Metals at Different Temperatures. A. Mitinsky (*Chim. et Ind.*, 1933, Special No. (June), 616–619; *C. Abs.*, 1933, **27**, 5696).—A simplified bending tester is placed in a furnace; the test-piece lies freely on 2 supports and the load is applied in the centre; the displacement of the free end projecting outside the furnace is measured by means of a delicate micrometer. Results are given and discussed of determinations of the modulus of elasticity of various steels and brasses carried out at temperatures of 20°–800° C.—S. G.

A New Method of Determining Elastic Moduli. Paul Le Rolland and Pierre Sorin (*Technique moderne*, 1933, **25**, 472).—Full abstract of a paper read before the Académie des Sciences. See also *J. Inst. Metals*, 1933, **53**, 518.—R. B. D.

The Determination of Tensile Strength of Welded Joints. W. Hoffmann (*Elektroschweissung*, 1933, **4**, 87–88).—The usual type of tensile test-piece is of little use owing to the reduction of area of the parent metal on each side of the weld. Reliable figures are given on test-pieces in which the weld is at the centre of a reduced section formed by removing equal circular segments, the radius of which is proportional to the thickness of the material. Test-pieces made from deposited metal gave unreliable results. (The results refer to steel.)—H. W. G. H.

New Tensile Strength Tester. Anon. (*Instruments*, 1933, **6**, 103).—A simple testing machine, in which the load is indicated on a dial-type spring dynamometer, is described and illustrated.—J. C. C.

Tensile Strength Tester. Anon. (*Instruments*, 1933, **6**, 199).—A small motor-driven horizontal pendulum-type testing machine for testing wires or light sheet material is briefly described.—J. C. C.

Measurement of Abrasive Hardness of Metallic Surfaces. R. J. Piersol (*Metal Cleaning and Finishing*, 1933, **5**, 321–325; *C. Abs.*, 1933, **27**, 5285).—A discussion of hardness testing methods and experimental equipment developed to measure the abrasive resistance of metal surfaces.—S. G.

***The Influence of a Linear State of Stress on the Ball Hardness [of Metals].** Hans Kostron (*Metallwirtschaft*, 1933, **12**, 473–476).—To determine the effect of internal stresses on the Brinell hardness of metals hardness measurements have been made during loading of the specimens in a tensile machine or in a press. Tensile stresses reduce the hardness (by up to 10% for the mild steel tested), whilst compression stresses are without action.—v. G.

A Simple Hardness Testing Apparatus. G. Oehler (*Werkstatt u. Betrieb*, 1933, **66**, 412–413).—A method is described for determining approximate hardness values by comparison with standard pieces. The application is mainly to ferrous materials.—P. M. C. R.

Apparatus for the Control of Materials. Anon. (*Technique moderne*, 1933, **25**, 403).—Hardness testing machines of new design of the Rockwell and direct-reading Brinell types are described—particularly adapted for the testing of nitrided steels and thin sheets. The internal construction of the Guillery machine is schematically depicted.—R. B. D.

New Apparatus for Measuring Hardness [Microbilleur]. —— (*Technique moderne*, 1933, **25**, Suppt. (June 15), 29).—A brief description of the "Microbilleur" in which a hammer falls on a head carrying a penetrator (ball, or sphero-conical diamond). The hardness is determined by the diameter of the impression. The apparatus is stated to be particularly suitable for thin sheet and for very hard surfaces; up to 980 Brinell can be accurately determined. —R. B. D.

Wire Hardness Tester [Duroskop]. Anon. (*Instruments*, 1933, 6, 104).—The "Duroskop" measures hardness by the angle of rebound of a falling pendulum. For testing wire, a cylindrical anvil is used which strikes across the wire. Cf. *J. Inst. Metals*, 1932, **50**, 246, 369, 627.—J. C. C.

Instrument for Testing Hardness of Wire [Duroskop]. Anon. (*Canad. Mach.*, 1933, **44**, (10), 37).—The Duroskop is described. Cf. *J. Inst. Metals*, 1932, **50**, 246, 369, 627.—P. M. C. R.

Die Filling, Hardness, and Wedging of Dust Pressed Tiles. Harry W. Webb (*Trans. Ceram. Soc.*, 1933, **32**, 218–246).—Contains a useful general note on hardness.—S. V. W.

Micro-Calipers for Measurement of External Diameters. Anon. (*Anz. Berg-, Hütten- u. Masch.*, 1933, **55**, (76), 5–6).—Some recent improvements in calipers and snap gauges are described.—B. Bl.

The Development of Testing of Wire Mesh. Hans Hecht (*Tonind. Zeit.*, 1933, **57**, 483–484).—Apparatus, *e.g.* micrometers and microscopes, for testing wire mesh is described.—B. Bl.

RADIOLOGY

Recent Progress in X-Ray Inspection of Welds. Herbert R. Isenberger (*Canad. Mach.*, 1933, **44**, (11), 34 and 36).—Abbreviated from a paper read before the American Society of Mechanical Engineers. See *J. Inst. Metals*, 1933, **53**, 569.—P. M. C. R.

New Method for [Making] Angle-Exposures in X-Ray Investigations on Welded Joints. W. Grimm and F. Wulff (*Autogene Metallbearbeitung*, 1933, **26**, 120–123).—Faults in V- and X-welded joints can be clearly identified only if the X-ray beam is parallel to the chamfered edges of the sheets. This necessitates two exposures. It is proposed that these should be made on the same film. Examples are illustrated of the two exposures separately and superimposed.—H. W. G. H.

***Gamma-Ray Radiographic Testing.** Gilbert E. Doan (*J. Franklin Inst.*, 1933, **216**, 183–216, 350–385).—A comprehensive survey of the subject. The nature and properties of γ-rays are described together with the sources and their rates of decay. The rate of action of the rays on photographic films, exposure times for steel and other objects, the sensitivity of the method for detecting flaws and the like, are discussed at some length. If 7 or more objects of steel 1 in. thick are exposed simultaneously, the cost of testing objects of this thickness is less than for testing single objects by X-rays. Above 4 in. the cost is less with γ-rays even for single exposures. The principal advantages of the method are: (*a*) portability of the apparatus; (*b*) the simplicity of its operation; (*c*) the capacity to test very thick sections of metal; (*d*) the ability to test a great many objects at one time; (*e*) the low operation, maintenance and obsolescence costs. 23 references are given. —S. V. W.

XII.—TEMPERATURE MEASUREMENT AND CONTROL

Temperature Measuring Apparatus and Its Application in the Foundry. Erich Becker (*Z. ges. Giesserei-Praxis: Das Metall*, 1933, **54**, 389–390, 409–411, 455–457).—The principles, method of use, and applications in the foundry of the 4 chief types of pyrometer equipment are described. These types are those depending on (1) alteration of volume or length, (2) alteration in electrical conductivity, (3) alteration of e.m.f. of metal couples, and (4) alteration of radiation from heated bodies.—J. H. W.

†**Colour Pyrometry.** Gustav Haase (*Arch. tech. Messen*, 1933, 3, (28), T133–T134).—A survey of the principles of colour pyrometry, with descriptions of Mesuré and Nouel's pyroscope, Arons' chromoscope, Helmholtz's leucoscope, the Naeser pyrometer, and of a recent development involving two photo-cells, sensitive respectively to red and green radiations. The working range, sensitivity, and accuracy of each type are described.—P. R.

Thermo-Elements. Georg Keinath (*Arch. tech. Messen*, 1933, 2, (19), T10).—The e.m.f. developed at various temperatures is shown graphically for tellurium/platinum, 1% tellurium/1% antimony–platinum, Constantan/nickel–chromium, platinum/platino–rhenium H_2, and H_1, platinum/platinum–rhodium, molybdenum/1% ferro–tungsten. The properties and appropriate temperature ranges of several types of "noble" and "base" metal couples are discussed; the tungsten–molybdenum couple is placed with the former on account of its high working range (up to 3000° C., if the molybdenum is alloyed with 1% iron), although it requires special protection against deterioration. Among base-metal couples, nickel/chrome–nickel, "platinum substitute," nickel/carbon, tellurium/platinum are especially discussed: working temperatures are given for these, as well as for several base-metal couples in common use.—P. M. C. R.

***Investigations on Platinum/Platinum–Rhodium Thermocouples.** V. N. Bozhovskij and B. V. Drozdov (*Trudi Vsesoiznago Nautchno-Issledovatelskago Instituta Metrologii i Standardizatzii* (*Trav. Inst. Métrol. Standardisation* (*U.S.S.R.*)), 1932, 2, 3–19; *C. Abs.*, 1933, 27, 4142).—[In Russian, with French abstract.] The e.m.f. produced by Russian-made platinum/platinum–rhodium (alloy 10% rhodium) thermocouples, and the variation of e.m.f. due to time of heating and purity of platinum were determined. Tests carried out with the thermocouples made by the (Russian) Institute of Metals, Platinum Institute, Sverdlovsk Works, and others showed that the e.m.f. is near to or within 10·20–10·40 mv. at 1063° C. (temperature of cold-junction 0°), being of the same accuracy as the non-Russian makes. The variation of e.m.f. after prolonged heating at 1000° C. was ± 20 microvolts corresponding to ± 2°. Considerable variation of the platinum potential was observed after heating, especially for platinum of inferior purity, while the platinum–rhodium alloy potential remained practically the same.—S. G.

***Thermoelectric Temperature Scale of the Pt/Pt–Rh Thermocouple.** Katashi Bitō and Mototarō Matsui (*Kōgyō Kwagaku Zasshi* (*J. Soc. Chem. Ind., Japan*), 1933, 36, (7); *C. Abs.*, 1933, 27, 4970).—[In Japanese, with English abstract in supplemental binding, pp. 421–424.] Experimental procedure and results are reported of a comparison of the International Temperature Scale (calculated from $E = a + bt + ct^2$ with melting points of antimony, silver, and gold as fixed points) with scales obtained by calculation from $t = a + bE + cE^2$ for the same fixed points and from both equations for melting points of zinc, antimony, and silver as fixed points. In these equations E is the e.m.f. in µv. and t the temperature. The cold-junction is at 0° C.—S. G.

***The Treatment of a Pt/Pt–Rh Thermocouple.** Katashi Bitō and Mototarō Matsui (*Kōgyō Kwagaku Zasshi* (*J. Soc. Chem. Ind., Japan*), 1933, 36, (7); *C. Abs.*, 1933, 27, 4970).—[In Japanese, with English abstract in supplemental binding, pp. 424–426.] Cf. preceding abstract. Freezing point determinations on gold, silver, antimony, and zinc were made to determine the results of exposure of the couple, in a porous porcelain tube, to a reducing atmosphere. The couple was seriously contaminated, especially by antimony, but it could be restored by cleaning with dilute hydrochloric acid, or nitric acid, molten borax, and electric annealing at 1500° C.—S. G.

The Measurement of Thermal Radiation. Ernst Otto Seitz (*Arch. tech. Messen*, 1933, 3, (25), T93).—Total radiation is defined in terms of wave-length, and the general principles of its measurement are explained. The thermocouple, the bolometer, the radiometer and micro-radiometer, and the pyrheliometer are described in detail, and their calibration is considered. The pyrometric application of radiation instruments is described.—P. M. C. R.

†**Electrical Temperature Measuring Apparatus.** Fritz Beck (*Metallwirtschaft*, 1933, **12**, 561–562, 575, 589–590, 605).—The following types of instrument are described: resistance thermometers, thermocouples, contact thermocouples, optical and total radiation pyrometers, and information is given on their use in technical measurements, on the physical principles on which they are based, and on their manipulation.—v. G.

New Line of Indicating Pyrometers. Anon. (*Instruments*, 1933, **6**, 129).—An illustrated note describing some recently-introduced thermo-electric instruments.—J. C. C.

Multi-Point Temperature Indicator. Anon. (*Instruments*, 1933, **6**, 125).—A Wheatstone-bridge type of indicator which can be connected to any of 8 thermo-sensitive resistance coils is illustrated and briefly described.—J. C. C.

A Simple Constant Temperature Control Circuit. H. Clarke (*J. Sci. Instruments*, 1933, **10**, 329–330).—A note describes a valve circuit for use with temperature controlling devices.—W. H.-R.

Apparatus for Thermal Control. Anon. (*Technique moderne*, 1933, **25**, 425–426).—The toroidal mercury transmitter (consisting of a coiled glass tube with a platinum wire sealed into it and containing a certain quantity of mercury) can be used for transmitting to a distance measures of pressure, &c., or of the degree of movement of a movable member, by the movement of the mercury causing a variation of the circuit resistance. This variation can be used to reinstate equilibrium of a Wheatstone bridge in the case of temperature registration or to vary the equilibrium in the case of temperature regulation. In conjunction with this the " logometre " is used to overcome the effect of variation (during test) of the voltage applied to the Wheatstone bridge, whilst the mercury transmitter is applied in the " de programme " regulator to the regulation of heating and cooling to specific heating or cooling curves.—R. D.

XIII.—FOUNDRY PRACTICE AND APPLIANCES

Recommendations for the Design of Non-Ferrous Castings. H. F. Seifert, L. H. Fawcett, and T. D. Stay (*Trans. Amer. Found. Assoc.*, 1933, **41**, 518–526).—Report of a sub-committee of the A.F.A. giving recommendations for the detailed design of castings, selection of alloy, and choice of pattern equipment, with the object of enabling, by a better co-operation between founder and designer, the production of better and cheaper castings.—R. B. D.

Piston Manufacture. Anon. (*Automobile Eng.*, 1933, **333**, 411–415).—The foundry practice involved in the manufacture of B.H.B. self-adjusting pistons in Hiduminium R.R. 53 alloy is dealt with. The pistons are die-cast and the selection of material, method of melting, type of dies used, casting procedure, and temperature control are considered in detail. After casting, two heat-treatments are given in the foundry, the pistons being heated in a continuous muffle furnace and quenched in boiling water, and this treatment is followed by ageing at carefully controlled temperatures for 18 hrs., followed by quenching in cold water. Heat-treated pistons and small castings up to 5 and 6 lb. are produced in quantity.—J. W. D.

The Utilization of Copper from Secondary Metals and Slags. P. S. Belonogov (*Zvetnye Metally* (*The Non-Ferrous Metals*), **1932**, 357–360).—[In Russian.]—S. G.

How is Flawless " Aluminium-Bronze " Made? E. T. Richards (*Z. ges. Giesserei-Praxis: Das Metall*, 1933, **44**, 411–421).—"Aluminium-bronze" (copper with 7–10% aluminium) may contain up to 5·5% iron, 3–4% manganese, and 5% nickel; zinc, lead, and especially silicon are harmful, although lead up to 1–2% is sometimes added to improve the machinability of the alloy. Careful deoxidation before the addition of aluminium to the melt is necessary; aluminium-containing scrap should not be used in the charge. The preparation of the moulds, charging in the constituents, and melting and casting the alloy are described. A casting temperature of 1175°–1200° C. is recommended. —J. H. W.

On the Question of Melting and Casting Copper–Nickel Alloys. W. O. Hagen-Torn (*Metallurg* (*The Metallurgist*), 1932, **7**, 65–112).—[In Russian.] Experiments on the melting of copper–nickel alloys have shown that porosity in alloys free from volatile metals, such as zinc, is due to adsorbed gases. Good, non-porous castings may be obtained (*a*) by melting under charcoal in a slightly oxidizing atmosphere using solid deoxidizers, or (*b*) by melting in a reducing atmosphere under conditions which promote the escape of adsorbed gases. The alloys should be cast at about 150° C. above the melting point with a slow rate of pour. When flat open moulds are used method (*b*) should not be employed; only method (*a*) gives sound castings.—M. Z.

***A Practical Foundry Test on the Effect of Phosphorus, Aluminium, and Silicon on Leaded Bronze.** Harold J. Roast (*Trans. Amer. Found. Assoc.*, 1933, **41**, 82–97, with discussion; and *Met. Ind.* (*Lond.*), 1933, **43**, 33–36, 443–446).—Experiments on (*A*) journal bearing castings of bronze with copper 70, tin 6, lead 21, and zinc 3% and with (*B*) large locomotive drivers cast in copper 75, tin 8, lead 15, and zinc 2% show that (1) phosphorus up to 0·05% is not injurious to either alloy but necessitates lower casting temperatures, (2) aluminium up to 0·05% gave a fracture of poor appearance with both alloys and, whilst having no effect on the surface appearance of (*B*), caused a silvery-white surface on (*A*), and (3) 0·05% silicon produces a white surface with both alloys, but with (*B*) has no influence on the fracture structure.—R. B. D.

†The Influence of Design on Brass and Bronze Castings. L. H. Fawcett (*Trans. Amer. Found. Assoc.*, 1932, **40**, 360–374; and (abstracts) *Met. Ind.* (*Lond.*), 1933, **42**, 471–474; *Found. Trade J.*, 1933, **47**, 111–113).—The relation of design to ease of production in the foundry, choice of suitable alloy, and arrangement of pattern in order to attain soundness are discussed. Composition and properties of some U.S. Navy bronzes and brasses are given. Examples are given showing the effect of design on the properties of the casting. Great stress is laid on evenness of section.—R. B. D.

Magnesium—Its Founding and Metallurgy. P. Bastien (*Bull. Assoc. Tech. Fonderie*, 1933, **7**, 383–390).—The physical and chemical properties are reviewed with particular reference to their effect on the founding and on the corrosion-resistance, and the classes of alloys normally used are briefly described. Magnesium produced industrially either by electrolysis of fused minerals containing $MgCl_2$, or by converting $MgCO_3$ into $MgCl_2$ followed by electrolysis, contains inclusions of $MgCl_2$ and/or KCl which deleteriously affect the corrosion-resistance. The sublimation process of Chaudron and Hérenguel, which removes these and other impurities, has reached semi-industrial scale. The methods of melting and alloying, the melting and refining fluxes used, and the means employed to prevent oxidation and nitration during casting are discussed in relation to sand and chill casting as well as pressure die-casting. The castability of magnesium and its alloys and the effect of repeated remelting and of mould materials on this property are considered at some length, as is the effect of alloy composition on the total (patternmakers) contraction. Several references are given.—R. B. D.

Melting of Elektron from Magnesium Produced by a Soviet Magnesium Plant. P. S. Maiboroda (*Zvetnye Metally* (*The Non-Ferrous Metals*), 1932, 374–377; *C. Abs.*, 1933, **27**, 4201).—[In Russian.] Describes some difficulties encountered in melting Elektron made from Soviet-manufactured magnesium, and means of overcoming them.—S. G.

Melting of Zinc in the Ajax Induction Furnace. P. A. Zakharov (*Zvetnye Metally* (*The Non-Ferrous Metals*), **1932**, (5/6), 66–68; *C. Abs.*, 1933, **27**, 5648).—[In Russian.] Experiments showed that 300–600 kg. charges of zinc may be melted without superheating or volatilization, with 220 v. and 620 amp. The loss in melting (1%) was found to be considerably less than when melting in crucible, reverberatory, or other types of furnace (3–4%). A study of the structure of the melts of zinc with addition of lead and cadmium showed a very uniform distribution of these additions, attributable to the self-stirring of the molten charge in the induction furnace.—S. G.

Light Metal Die-Castings. —— Nohl (*Werkstatt u. Betrieb*, 1933, **66**, 372–374).—Successful die-casting depends on the combination of casting machine, mould, and material. Each factor is considered. Light alloy castings will take a high surface finish, or will afford a good base for subsequent electrodeposition. Cost, accuracy, life of moulds, and applicability of the method are considered. Illustrations show the use of inserts in avoiding great variations in the thickness of the casting, and a number of other precautions are enumerated.—P. M. C. R.

The Standardization of Moulding Boxes. André Debar (*Bull. Assoc. Tech. Fond.*, 1933, **7**, 477–484).—Detailed description with drawings and tables of sizes of the suggestions of D. for the standardization of moulding boxes in metric dimensions.—R. B. D.

†**Mould Materials for Non-Ferrous Strip Ingot Casting.** G. L. Bailey (*Rolling Mill J.*, 1933, **7**, 137–138, 146).—Copper is considered the most satisfactory material for brass-strip ingot moulds, its high thermal conductivity preventing serious temperature gradients and consequent distortion. The article is a detailed discussion of Bailey's findings given in his paper (*J. Inst. Metals*, 1932, **49**, 203–226).—A. B. W.

Some Practical Applications of Sand Tests. G. Hénon (*Bull. Assoc. Tech. Fond.*, 1933, **7**, 506–513).—The relation between various sand tests and the applicability of those sands to different types of foundry work are discussed and permissible variations of cohesion and permeability for certain moulds are given. The methods of test are indicated and references are given.—R. B. D.

The Control of Methods of Sand Preparation and the Control of Moulds. H. W. Dietert (*Bull. Assoc. Tech. Fond.*, 1933, **7**, 471–477).—Exchange paper from the American Foundrymen's Association. Tests on three different types of sands show that (1) the cohesion of green-sand moulds is affected by the method of sand preparation used and the method used has more effect on natural than synthetic sands; (2) the hardness of the rammed mould is less when the sand has been aerated; (3) aerated sand is more sensitive to intensity of ramming; (4) the hardness increases as the " green-cohesion " increases; (5) preparation methods which increase the density (green) increase the hardness; (6) the greater the initial plasticity of the bonding material the more effect has the method of preparation on the cohesion of dry-sand moulds; (7) the permeabilities both green and dry are increased in relation to the amount of aeration and the grain size produced by the preparation; (8) the permeability of a green mould decreases, as the amount of ramming increases, up to a limit, after which it decreases; and (9) the permeability decreases as the mould height increases. Many figures and several formulæ are given.
—R. B. D.

Monorail Materials Handling in the Foundry. J. B. Forker (*Trans. Amer. Found. Assoc.*, 1932, **40**, 375–386).—Brief consideration of methods of handling materials in foundries and general survey of applicability of overhead monorail system together with brief details of advantages for specific uses.—R. B. D.

XVI.—REFRACTORIES AND FURNACE MATERIALS

***On the Ceramic Properties of Calcium–Aluminium Silicates and Other Refractories.** E. Berl and Fritz Löblein (*Forschungsarbeiten*, 1930, (325), 1–28).—An investigation of the thermal properties of the ternary system calcium oxide–silica–alumina reveals the presence of two minima at 1320° and 1300° C., and two maxima at 1512° and 1525° C. A 3-dimensional model is reproduced. The properties of a series of 20 chemically pure refractory bricks are investigated. Their mechanical strength is found to depend on the silica content, and especially on the temperature of the quartz–cristobalite transformation. The factors influencing softening under load, sensitiveness to changing temperature, and thermal conductivity are discussed. Porosity is shown to decrease the thermal conductivity; basic slags cause the most severe attack. Details as to manufacture are given. Other materials considered are Westerwald quartzite, Austrian magnesite, French and Istrian bauxites, two carborundum–clay preparations, and corundum.—P. M. C. R.

The Manufacture of Slag-Resisting Crucibles in Magnesia and Alumina. H. Salmang and N. Planz (*Technique moderne*, 1933, 25, 617–618).—Short abstract of an article published in *Arch. Eisenhüttenwesen*, 1933, 6, 341. See *J. Inst. Metals*, 1933, 53, 664.—R. B. D.

XVII.—HEAT-TREATMENT

***A Study of the Heat-Treatment of Alloys of the Aldrey Type.** F. A. Borin, A. A. Botchvar, I. P. Velichko, K. V. Gorey, and M. O. Kuznetzov (*Zvetnye Metally* (*The Non-Ferrous Metals*), **1932**, (12), 94–108; *C. Abs.*, 1933, **27**, 5701).—[In Russian.] A series of aluminium–magnesium–silicon alloys containing silicon 0·2–0·9, magnesium 0·36–1·54, and iron 0·2–0·3% was made and rolled according to the usual commercial practice. By a combined variation in composition and heat-treatment a product was obtained of better mechanical properties than had been possible heretofore. Tensile strength values of 36 and 38 kg./mm.^{2} were obtained, with corresponding elongations of 15 and 8%. Excess silicon considerably improved the mechanical properties of the alloys with low Mg_2Si content, and 0·5% excess silicon improved the qualities of all the alloys studied; these phenomena are explained on the basis of the solubility relations of the alloy. Quenching from 525° C. followed by tempering at 140°–150° C. for 48 hrs. or longer is recommended for alloys of this type. The most beneficial effect of heat-treatment on the mechanical properties was obtained in the alloys containing 0·7, 0·75, and 0·90% silicon, and 0·40, 0·50, and 0·90% magnesium, respectively, or generally, in the aluminium–magnesium–silicon alloys with 0·4–0·9% magnesium and with an excess of 0·4–0·5% silicon over the amount of silicon theoretically required for the formation of Mg_2Si.—S. G.

XVIII.—WORKING

Stresses in Wire-Drawing. A. C. Blackall (*Wire and Wire Products*, 1933, 8, 232–233).—A *résumé* of research work carried out by F. C. Lea at Sheffield University and by F. C. Thompson at Manchester University on the stresses in wire during drawing especially when the wire is subjected to back tension. The chief points to be considered are: (1) lubrication; hard soap was used in T.'s experiments; (2) die material; T. used a tungsten carbide die with a Vickers diamond hardness of 1350; (3) surface finish of the die; (4) die angle; 5°–8° is recommended.—J. H. W.

Wet Drawing in Wire Manufacture. Richard Saxton (*Machinist* (*Eur. Edn.*), 1933, 77, 533–534E).—The use of a lubricant in wire-drawing facilitates slip, prevents excessive wear, and exercises a restraining influence on the heat generated by the friction. It is the best method of drawing the finer sizes (20 S.W.G. and smaller), but does not permit as great a reduction per draft as dry drawing. The precautions to be taken in drawing various metals and alloys by this method and its practical applications are described.—J. H. W.

The Wire-Drawing Die.—II, III. Kenneth B. Lewis (*Wire and Wire Products*, 1933, 8, 234–239, 243, 251, 266–269).—The die stresses and strains during the drawing operation have been studied and a theoretical discussion of the mechanism of wire-drawing is given.—J. H. W.

Sizing and Resizing Carbide and Diamond Dies for Copper Wire-Drawing. J. J. Kehoe and F. D. Ruhl (*Wire and Wire Products*, 1933, 8, 305–308, 330).—Read before the Wire Association. Describes the process and methods of die sizing and resizing used by the General Electric Co., New York.—J. H. W.

Extruded Condenser Tubes. Anon. (*Marine Eng. & Shipping Age*, 1933, 38, 420–421).—A recent development in condenser tube manufacture is the production of extruded, rolled, and drawn tubes. Tubes are produced by extruding cast billets and the extruded tubes are cold swaged-rolled on a mandrel by a new process which preserves and improves the smoothness of the inside surface. This last operation, which is a combination of forging and rolling, is followed by annealing and cold-drawing, and a final low-temperature annealing in an electric furnace to ensure a fine and uniform grain structure. The tubes manufactured by the process include super-nickel tubes, aluminium-brass tubes, and tubes of an alloy of copper 75, nickel 20, and zinc 5%. The results of physical tests on the various tubes manufactured by the process are given.—J. W. D.

Methods for Fabrication of Nickel-Clad Steel Sheet, Strip, and Wire. Anon. (*Boker Bull.*, 1933, 1, 12 pp.; *Bull. B.N.-F.M.R.A.*, 1933, (60), 7).—Deals with properties, sizes, and finishes, hot- and cold-working, drawing and stamping, joining: welding, soldering, and brazing.—S. G.

"Ferrane" [Aluminium–Iron Bi-Metal]. L. E. Miller (*Zvetnye Metally* (*The Non-Ferrous Metals*), 1932, 360–369; *C. Abs.*, 1933, 27, 4198).—[In Russian.] Describes experiments carried out with the object of improving the process of manufacture and the properties of "Ferrane" (aluminium–iron bi-metal) sheet and strip.—S. G.

New Special Oils for the Working of Aluminium. K. Krekeler (*Werft, Reederei, Hafen*, 1933, 14, 264–266).—The use of cylinder oils in the rolling of aluminium sheet and foil, whilst to some extent obviating fire, was the cause of surface defects owing to the formation of gummy residual products. Oil specially refined with sulphur dioxide gives better results: its uses and limitations are discussed, together with methods of adapting it to lubricating systems in common use. A suitable oil–water emulsion is recommended for the lubrication of grinding, turning, and drilling; a testing apparatus for such emulsions is described, with directions for use. The increasing use of bitumen in "silvering" paper with aluminium foil is due to the close bond and absence of undesirable products; the process is described.—P. M. C. R.

Drawing Tools for Aluminium Sheet 0·5 mm. or Less in Thickness. F. Habeland (*Werkstatt u. Betrieb*, 1933, 66, 369–370).—Suitable tool forms are described, and shown diagrammatically, for the deep-drawing of aluminium sheet of small section. The various stages of the operation are described, with the necessary adaptations for various thicknesses.—P. M. C. R.

Unique Stamping Process. Anon. (*Metal Stampings*, 1933, 6, 72).—A new process for producing metal stamping blanks has been developed in America, and employs neither the wafer temporary die nor the "tin die." The dies are

said to be particularly adaptable for blanking thin steel, brass, copper, aluminium, bronze, and similar materials of 0·015 in. thickness and thinner.
—J. H. W.

Press Work Pressures. XI.—Embossing. XII.—Coining. XIII.—Forming. XIV.—Coining. Anon. (*Machinist* (*Eur. Edn.*), 1933, **77**, 472–473, 506–507, 538–539, 568–569).—The sizes and pressures for various operations in working steel, brass, bronze, and aluminium alloys are given.—J. H. W.

Standardization in Cutting and Stamping Tools. H. Stein (*Anz. Berg-, Hütten- u. Masch.*, 1933, **55**, (64), 4–6, (65), 4–5).—Discusses the standardization of tools for cutting and stamping metals and gives special examples.—B. Bl.

Machining Aluminium and Its Alloys. Anon. (*Machinist* (*Eur. Edn.*), 1933, **77**, 501–502).—Selection of tools, cutting speeds, lubricants, angle of tool, use of milling cutters, threading tools, twist drills, and saws are discussed.
—J. H. W.

Getting Optimum Results from Modern Cutting Tool Materials. Joseph Geschelin (*Automotive Ind.*, 1933, **69**, 580–583).—The factors governing the selection of tool materials for a given piece of work are considered and summarized. A list of such materials is given; special reference is made to the use of cobalt and molybdenum as ingredients in high-speed steels, to Stellite and its development, J-metal, to the carbides of tungsten and tantalum, and to the recently developed "548" alloy. The latter, an iron–tungsten–cobalt derivative, is capable of profound modification by suitable heat-treatment. A table of recommended practice for J-metal gives average cutting-speeds and feeds for turning, facing, and boring bronze and a variety of ferrous materials.
—P. M. C. R.

Modern Metal-Cutting Materials and How to Select Them. J. M. Highducheck (*Machinery* (*N.Y.*), 1933, **40**, 12–17).—Recommendations, based on tests carried out by the Westinghouse Electric and Manufacturing Co., are given for cutting speeds and feeds for rough-turning and boring ferrous and non-ferrous metals with tools made of high-speed steels, Stellite No. 3, Stellite J-metal, tungsten carbide, and tantalum carbide. Factors governing the choice of cutting material are discussed.—J. C. C.

XIX.—CLEANING AND FINISHING

Polishing Agents for Metal Coatings and Artificial Materials. E. Belani (*Kunststoffe*, 1933, **23**, 156–157; *C. Abs.*, 1933, **27**, 4633).—The use of micro-asbestos, *i.e.* asbestos fibres broken up very finely, in polishing agents is recommended.—S. G.

Developments During 1932 in New and Improved Materials and Equipment. Anon. (*Indust. Finishing* (*U.S.A.*), 1933, **9**, 7–10, 40–41).—A summary of recent developments in metal finishes, including one-coat finishes, metal primers, heat-resistant finishes, refrigerator enamels, lacquers for tinplate food containers, and for other purposes.—E. S. H.

Black Finish on Metal Chemically. C. F. Scribner (*Indust. Finishing* (*U.S.A.*), 1933, **9**, 15–16).—Directions are given for obtaining a black finish on copper, brass, or bronze, and a steel grey on brass.—E. S. H.

XX.—JOINING

V.D.M. Process for Joining Copper Tubes. Anon. (*Apparatebau*, 1933, **45**, 88–89; also *Z.V.d. Kupferschmied.*, 1933, **45**, 117–118).—Description of a simple joining method (by means of a suitable thread) for copper tubes in water installations.—M. H.

Assembly Involving Many Welds Now Produced in Single Operation by Hydrogen–Electric Welding Process. T. M. Rude (*J. Amer. Weld. Soc.*, 1933, 12, (4), 4–6).—Copper brazing in an atmosphere of hydrogen is particularly applicable to quantity production, on which basis it possesses great advantages in time-, material-, and labour-saving over other methods of joining steel parts. Joints stronger than the steel itself are obtained, an interstitial alloy of approximately 97% iron and 3% copper being formed. A large furnace for continuous operation is illustrated.—H. W. G. H.

The Resistance Welding of Aluminium and Its Alloys. D. I. Bohn and G. O. Hoglund (*Welding Eng.*, 1933, 18, (6), 25–29).—Spot and seam welding are discussed at some length, and butt-welding more briefly. Resistance welds of aluminium alloys must be made with the metal in the molten state. The temperature gradient from the weld to the surface of the sheet must therefore be extremely high, and the great thermal conductivity of the material necessitates the application of immense power for a very short period. Synchronous control of the welding current is highly desirable for spot welding, although good results may be obtained without it by the use of " projection " electrodes; for seam welding, it is essential. Seam welding is recommended in preference to spot welding. Butt-welding offers no special difficulties except the need for great power, but experiments in flash welding have met with little success.
—H. W. G. H.

Some Economic Aspects of Welding Aluminium. D. E. Roberts (*Welding*, 1933, 4, 111–114).—See *J. Inst. Metals*, 1933, 53, 586, 720.—H. W. G. H.

Welding Non-Ferrous Process Piping. Anon. (*Oxy-Acetylene Tips*, 1933, 12, 197–201).—Describes modern practice in jointing aluminium and copper piping for chemical work. In addition to true welds, bronze-welded, silver soldered, and sweated joints are suggested for copper piping.—H. W. G. H.

Welding Copper-Alloy Tanks with the Carbon Arc. Anon. (*Welding Eng.*, 1933, 18, (4), 13).—Everdur shells for hot-water heaters are welded by carbon arc, using not a filler rod, but a flux consisting of 90% fused borax and 10% sodium fluoride.—H. W. G. H.

Welding with Copper Alloys. G. T. Piersol (*J. Amer. Weld. Soc.*, 1933, 12, (2), 22–24).—The effect of cuprous oxide in copper on welding behaviour is discussed, and some remedies—the use of deoxidized copper, brazing, or silver soldering—are suggested. Everdur is recommended as the most weldable of the high copper alloys, and its properties are described. Everdur No. 9, containing 57% copper, 42% zinc, ½% manganese, and some silicon, is used in the form of extruded sections for architectural work, and can be gas welded to give joints which are undetectable after polishing. Tobin bronze is the most satisfactory material for general oxy-acetylene welding, being used as filler rod for all brasses, nickel silver, steel, cast-iron, copper, and Monel metal.—H. W. G. H.

Notes on Welding Sheet Brass. Anon. (*Indust. Gases*, 1932, 13, 215–217). —The usual instructions in technique are given.—H. W. G. H.

The Use of Lead Burning in the Manufacture of Lead Batteries. Anon. (*Electric Vehicles and Batteries*, 1932, 16, 244–247).—An illustrated account is given of the lead-burning operations carried out in an accumulator factory. For train cells, the plates are laid flat in a jig and welded to cast bridge lugs. For bus lighting cells, the plates and bridges are cast in one piece, and the bridges subsequently built up and strengthened by lead burning. For car starter batteries, the plates are held upright in a jig, and the bridge, instead of being cast, is built up by lead burning.—J. C. C.

Welding Technique for Nickel and Nickel-Rich Alloys. Herbert Herrmann (*Iron Age*, 1933, 132, 25–26, 70).—Abstracted from the *Metallurgist* (Suppt. to *Engineer*), 1933, 9, 30–32. See *J. Inst. Metals*, 1933, 53, 587.—J. H. W.

Instructions for Finishing Welded Plates of Monel Metal and Pure Nickel. W. F. Burchfield (*Welding Eng.*, 1933, **18**, (7), 24–26).—Abstracted from the International Nickel Company's Bulletin No. T.S.-5.—H. W. G. H.

First Nickel-Clad Water Storage Heater. Anon. (*Welding*, 1933, **4**, 12 and 21).—An illustration, showing design details, and description of a 1000-gall. water storage heater, working at 90 lb./in.^{2}, fabricated from $\frac{5}{16}$-in. nickel-clad plate.—H. W. G. H.

Left- or Right-Hand Welding? [for Steels, Monel Metal, and Nickel]. F. Hermann (*Autogene Metallbearbeitung*, 1933, **26**, 145–150).—The advantages of "rightward" over "left-hand" welding, for steels, Monel metal, and nickel, are reviewed. The former method, in which the blow-pipe precedes the welding rod, is faster and more economical in gas, gives a smaller and neater bead, and produces less distortion. Greater protection of the molten metal by the welding flame results in more ductile welds, on account of their freedom from oxides and nitrides. Greater heat concentration produces lower cooling stresses.—H. W. G. H.

The Use of Monel Metal for Obtaining Workable Welds in Pieces of Iron. Anon. (*Rev. Nickel*, 1933, **4**, 92–94).—The use of Monel metal instead of iron electrodes in arc welding is suggested, in order to obviate the formation of the very hard and unworkable cementite. Photomicrographs and illustrations of work done by this method are included.—W. A. C. N.

Welding Tests on Cast-Iron and Non-Ferrous Metals. Th. Weiss (*Welding Industry*, 1933, **1**, 83–85).—An account, illustrated by photomicrographs, of the results of tests on welds produced in wrought and cast aluminium, brass, and cast-iron, using "RU" universal flux.—H. W. G. H.

Informal Communications of the Committee on Welding of the Verein Deutscher Ingenieure. —— (*J. Amer. Weld. Soc.*, 1933, **12**, (5), 27–30).—A list of researches, giving the name of the worker, the state of progress, and the publication reference, if any.—H. W. G. H.

Macrography Applied to Welds. E. C. Rollason (*Welder*, 1933, **4**, (41), 9–14).—Defects which can be detected by macroscopic examination are classified and described. The technique recommended is suitable mainly for steel. The Schmuckler milling test is mentioned and its application illustrated.
—H. W. G. H.

Welding Design—No. 1, Distribution of Stresses in Welded Structures. C. Helsby (*Welding Industry*, 1933, **1**, 5–9, 45–48).—Refers to structural steel welding, but is of wider interest. The necessity for ductile welds is emphasized. Two types of distortion are produced: that from the relief of rolling and straightening stresses in the members, and that from the contraction of the weld metal. The design of welded structures follows closely the practice usual for reinforced concrete, the joints being almost rigid connections. Allowance must be made for induced wracking stresses, which are usually considerable. Excessive deflection must be guarded against by suitable cross-bracings. Butt joints require careful preparation, and lap joints, with fillet welds, are more frequently employed on account of the greater tolerances permissible. A table is given, showing the relative value of welds in tension, compression, and shear, their cubic contents, and the approximate times taken to execute them. An example is also given to explain the application of this table to the design of a typical welded joint.—H. W. G. H.

Stress Distributions in Fusion Joints of Plates Connected at Right Angles. E. G. Coker and R. Russell (*Welder*, 1933, **4**, (42), 11–13; also *Electric Welding*, 1933, **2**, 148; discussion, 149–151; and *Syren and Shipping*, 1933, **147**, 59–60).—An abstract of a paper read before the Institution of Naval Architects, describing the application of photo-elastic methods to examine the effects of bending moment. Stress concentration is found to take place at points where changes of angle or of cross-section occur, especially where the change is abrupt. Internal discontinuities are a serious source of danger.—H. W. G. H.

Tests on the Fatigue Limit of Welded Joints Subjected to Repeated Tension Stresses. Otto Graf (*J. Amer. Weld. Soc.*, 1933, **12**, (8), 30–32).—It is shown that butt-welds can be made of higher fatigue strength than riveted joints of similar design, but faults in the former are of far greater effect than faults in the latter, so that the relation between the fatigue strength and work stress must be different for each type of joint, except where the weld can be proved flawless by careful tests. Joints made by straps with longitudinal fillet welds and with fillet welds at the butt ends, although in considerable use for withstanding static loads, are not to be recommended where the stressing is due to repeated loads. Cover-plates over a butt-weld, with fillet welds to the plates, give a stronger joint only if the butt-weld is unsatisfactory. Considerations of design are illustrated in the article, the purpose of which is to prove that existing specifications, for fixing safe stresses on welded joints, require revision.
—H. W. G. H.

Stresses in Butt-Welds. A. C. Vivian (*Welder*, 1933, **4**, (37), 1–6).—Poor test-results on welded joints may be due to faulty design as well as to faulty material or workmanship. Distortion after welding may cause the test-piece to be eccentrically loaded in the testing machine, thus giving low results. The internal stresses in a butt-weld may be illustrated by rubber models. The stresses due to temperature differences are higher than the yield-point at various temperatures during cooling, so that there must be high initial stress in an unannealed welded joint.—H. W. G. H.

Heat Stresses in Welded Bars. Karl Melcher (*Elektroschweissung*, 1933, **4**, (1), 7–9).—An account of experiments made by sawing off strips for the specimens and noting the amount of distortion.—H. W. G. H.

Welding of Pressure Vessels. Anon. (*J. Amer. Weld. Soc.*, 1933, **12**, (2), 13–15).—Some recent additions to the American Society of Mechanical Engineers' boiler construction code are discussed, with special reference to the proper method of attachment of nozzles, the reinforcement of openings cut in shells or heads, and the weakening effect of holes cut in a cylindrical shell. Dimensioned drawings are given to show acceptable types of fusion welded nozzle construction.—H. W. G. H.

Welded Spiral Seams in Pressure Vessels and Boilers. Anon. (*Welding Industry*, 1933, **1**, 17–19).—The stresses on longitudinal seams are double those on circumferential seams. A spiral seam at 45° or less to the highest ring stress may be considered about 50% stronger than an ordinary longitudinal seam.—H. W. G. H.

Removing the Hazards in Welding Tanks Containing Inflammable Vapours. W. E. Archer (*Welding Eng.*, 1933, **18**, (5), 14–15).—It is found practicable to conduct welding operations on a petrol tank without the expense and trouble of steaming, or loss of petrol, by injecting sufficient carbon dioxide to give a content of 40% in the gases in the tank. The actual safety limit is 28% of carbon dioxide.—H. W. G. H.

Effect of Fillet Welds on Eccentricity. James R. Griffith (*Welding*, 1933, **4**, 9–11).—When a structural angle is connected to a gusset plate by means of one leg, eccentricity exists. There is little difference in stress distribution with rivets or fillet welds. It is shown to be unsound to compute the distribution of the fillets from the distance from the neutral axis of the angle, and equal distribution gives the best results.—H. W. G. H.

Representation of Fillet Welds by Symbols. —— Faltus (*Elektroschweissung*, 1933, **4**, 113).—It is not considered sufficient to specify a fillet weld by the "throat" only, and it is suggested that the leg-length be given with an indication of the shape of fillet—concave, flat, or convex.—H. W. G. H.

Welding Symbols. James W. Owens (*J. Amer. Weld. Soc.*, 1933, **12**, (8), 24).—A list is given of the codes of symbols approved by the American Welding Society for use on drawings and the fundamental principles on which these have been developed are explained.—H. W. G. H.

Abbreviations and Symbols for Use on Drawings of Buildings, Bridges, and Other Framed Structures. —— (*J. Amer Weld. Soc.*, 1933, **12**, (8), 25).—A tentative standard issued by the Committee for Nomenclature, Definitions, and Symbols of the American Welding Society.—H. W. G. H.

Outline of Welding Processes. D. Richardson (*Welding Industry*, 1933, **1**, 3–4, 49–50, and 120–121).—Various systems of classification of welding processes are considered and the following processes are briefly discussed: forge, hammer, and roll welding; electric resistance welding—butt, flash, seam, spot, projection, and percussive; Thermit welding; oxy-acetylene—high- and low-pressure systems, equal-pressure systems, multi-flame blowpipes, the Linde self-fluxing process; mixed gas processes—coal-gas and acetylene; oxy-hydrogen, oxy-coal gas, oxygen with ethylene, methane, and vaporized liquid fuels.—H. W. G. H.

Characteristics and Application of Various Welding Processes. P. L. Roberts (*Welding Industry*, 1933, **1**, 95–97; discussion, 97–98).—The following processes are reviewed: metallic arc; carbon arc; atomic hydrogen; oxy-gas; resistance (butt, spot, seam, and flash); Cyc-arc and percussive arc; Thermit; and fire welding. For non-ferrous metals, the oxy-acetylene process is considered almost without rival.—H. W. G. H.

Classification and Electric Welding. R. Schmidt (*Werft, Reederei, Hafen*, 1933, **14**, 223–226, 238–242).—An extended survey of electric welding and its recent developments in their relation to the shipping industry and to the question of registration.—P. M. C. R.

The Design of Jigs and Fixtures for Welding. Owen C. Jones (*J. Amer. Weld. Soc.*, 1933, **12**, (8), 35–40)—Cf. *J. Inst. Metals*, 1933, **53**, 673. Essentials of good design and the principles underlying them are summarized. Various methods of location and clamping are described and illustrated.—H. W. G. H.

Dynamic Characteristics of Welding Machines. Karl Meller (*Elektroschweissung*, 1933, **4**, 101–110).—The "static" characteristics of welding generators are explained. The importance of the "time constant" and its dependence on self-induction and resistance is demonstrated. It is shown, moreover, how, of two machines with similar static characteristics, one may weld more easily than the other, and the reasons, as shown by oscillographic determinations, are explained. The instantaneous values of current and voltage given by the oscillogram are plotted and the resulting curves are discussed—particularly those obtained when a drop of metal falls from the electrode and when the arc is suddenly lengthened until it breaks. It is emphasized that much more research is needed, before it is possible to forecast exactly the welding characteristics of a generator from its electrical characteristics, as at present determined.—H. W. G. H.

New Improvement in Welding Machine Construction. H. Langkau (*Elektroschweissung*, 1933, **4**, 48–50).—A full description, with characteristic curves and oscillographic photographs, of a self-excited welding generator.—H. W. G. H.

Advances in Metal Surgery. C. W. Brett (*Gas J.*, 1933, **204**, 410–411).—The Barimar system of welding, applicable both to ferrous and non-ferrous alloys, is briefly described and illustrated.—J. S. G. T.

Joint Discussion on Reports on Technical Classification of Generators and of Electric Welding Practice; and on Generators and Transformers for Arc Welding. Marcel Mathieu, Marcel Moneyron, *et al.* (*Bull. Soc. Franç. Élect.*, 1933, [v], **3**, 145–161).—A joint discussion on the reports presented by Mathieu and Moneyron. Cf. *ibid.*, 1932, [v], **2**, 1081, 1088.—P. M. C. R.

Automatic Weld Timer. Anon. (*Instruments*, 1933, **6**, 198–199).—An illustrated note on an automatic device consisting of a rectifier tube which charges a fixed condenser in proportion to the rate of current flowing in the welding circuit. At the required instant, a discharge takes place across two neon tubes and the welding circuit is broken through a relay. Uniformity in the resulting welds is claimed irrespective of variations in such factors as line voltage, electrode condition, and thickness and surface condition of the work. —J. C. C.

Innovations and Tendencies in Autogenous Welding. R. Granjon (*Soudure et Oxy-Coupage*, 1933, **10**, 180–181).—Abstract from *Rev. Soudure autogène*, 1933, **25**, 2750–2758. See *J. Inst. Metals*, 1933, **54**, 673.—H. W. G. H.

The Fundamental Characteristics and Technique of Spot Welding Various Metals. Lawrence Ferguson (*Welding Eng.*, 1933, **18**, (7), 14–16; (8), 20–23). —The fundamental factors of the spot-welding machine, of the shape, size, and material of the electrodes, and of the mechanical pressure applied, are explained. Some of the practical problems involved and their solution are discussed. Welding characteristics of various metals are described and charts are given showing which of 250 combinations of metal can and cannot be spot welded, and the open-circuit voltages are recommended.—H. W. G. H.

Vacuum-Tube Control Applied to Spot Welding Equipment. E. U. Lassen (*Welding Eng.*, 1933, **18**, (1), 28–29).—Thyratron valve control of resistance welding machines permits current regulation in terms of cycles, ensuring perfect welds without possibility of burning.—H. W. G. H.

Thyratron Control of Welding in Tube Manufacture. H. W. Lord and O. W. Livingston (*Electronics*, 1933, **6**, (7), 186–187).—Details of a specially controlled electrical circuit for spot-welding machines used in the manufacture of vacuum tubes.—S. V. W.

Shot Welding. Anon. (*Machinery* (*Lond.*), 1933, **42**, 521–522).—Shot welding is a process of spot welding in which the current is passed for the minimum time possible in order to localize the weld sharply. The equipment, which can be fitted to any standard welding machine, provides an automatic record of the duration of each weld and employs an alarm bell to direct attention to unsatisfactory welding conditions. The method was developed for welding austenitic steels, which suffer a serious reduction in corrosion-resistance if heated within the range 500°–900° C.—J. C. C.

Electric Resistance Welding. D. Richardson (*Welding Industry*, 1933, **1**, 183–184).—A review of the various methods, their sphere of application, and some causes of defects.—H. W. G. H.

Electrodes for Resistance Welding Machines. Eberhard Rietsch (*Elektroschweissung*, 1933, **4**, 51–54).—Recommendations of electrodes to use for welding different materials by spot, projection, and butt methods. The methods themselves are briefly discussed from the point of view of electrode requirements.—H. W. G. H.

Standard Specifications for Resistance Welding Transformers. Resistance Welder Manufacturers' Association (*J. Amer. Weld. Soc.*, 1933, **12**, (6), 25–26).—The following points are covered: duty cycle; name-plate rating; primary and secondary windings; taps; cooling; insulation; core; inspection and test; mechanical protection.—H. W. G. H.

Investigations on Phenomena of Arc Welding and Gas Cutting by Slow-Motion Pictures. A. Hilpert (*J. Amer. Weld. Soc.*, 1933, **12**, (7), 4).—A review of investigations made and results obtained by the use of cameras capable of taking some thousands of pictures per second. The deposition of metal in the metallic arc has been examined by means of infra-red film and by the "outshining" method (Thun), in which the welding arc is illuminated by a powerful arc light on the opposite side from the camera lens and on its optical axis. The electrode, drop, and bead are sharply silhouetted, and the arc shows as a very bright spot on a bright background. It has been proved that the number of drops per second from a bare electrode is very much greater than from a coated electrode, and that, whilst the arc of the former extinguishes with every drop owing to short circuit, in the case of the latter, the slag forms a conductor of second degree. The time of transition of metal is found to be 15% of the total welding time for bare electrodes and 4% for heavily coated electrodes. The infra-red film is useless in the investigation of gas-cutting and the "in shining" method (Conrady) is used. In this, the gas beam absorbs part of the light, but the slag reflects it.—H. W. G. H.

Concerning the Phenomena of the Electric Welding Arc. H. v. Conrady and G. Müller (*Elektroschweissung*, 1933, 4, 1–6).—The mechanism of the electrical discharge with hot and cold cathodes is investigated. Photographs of arcs between poles of different kinds are reproduced and discussed.—H. H.

The Use of Carbon in Arc Welding. K. L. Hansen (*Welding News*, 1932, 3, 27–29).—Abstracted from *Welding*, 1932, 3, 222. The carbon arc has been used with greater success than the metallic arc for welding copper, but still presents great difficulty. "Everdur," however, can be successfully welded by the carbon arc method. Copper alloys containing a high percentage of zinc are unweldable by this process, but the indirect carbon arc, in which the flame is struck between two carbons and the current does not pass through the work, has given very promising results. This "carbon arc torch" has successfully welded ornamental bronzes containing lead as well as zinc, for which the oxy-acetylene flame and the usual arc processes fail.—H. W. G. H.

Carbon Shapes and Paste. Anon. (*Indust. Gases*, 1933, 14, 52).—Abstract from *Oxy-Acetylene Tips*, 1933, 12, 41. See *J. Inst. Metals*, 1933, 53, 673.
—H. H.

The Carbon Arc Process. Anon. (*Welding Industry*, 1933, 1, 149–150, and 152).—A survey of the process, including its history, development, and difficulties.—H. W. G. H.

Carbon Arc Welding. Karl Reiter (*Welding Industry*, 1933, 1, 173).—The article deals mainly with the Elin process, in which the arc is stabilized by a rotating magnetic field. The hardened seam often produced by carbon arc welding is said to be due to oxidation, and not carbonization of the weld metal. The application of the process to automatic welding is described.—H. W. G. H.

Atomic Hydrogen Arc Welding and Its Applications. J. A. Dorrat (*Welding J.*, 1933, 30, 6–14; discussion, 14–16).—A comprehensive description of the process, equipment, and technique. Curves showing welding speed and consumption of electricity, hydrogen, and tungsten, are given. The process is recommended for steels, especially of the austenitic variety, brass and bronze, copper and aluminium. Adaptations for use with three-phase current supply, for using split ammonia instead of hydrogen, and for automatic welding, are discussed. In the discussion, D. gave the cost of atomic hydrogen welding as approximately 25% less than oxy-acetylene.—H. W. G. H.

Atomic Hydrogen Arc Welding. Anon. (*Welding Industry*, 1933, 1, 141–143, 185–188, 278 and 284).—Based on information given by the Metropolitan-Vickers Electrical Co., Ltd. The process and apparatus are described. Welding costs, when using hydrogen and dissociated ammonia, are discussed and curves are given to show the costs of gas, tungsten, power, and labour for welding different thicknesses of material.—H. W. G. H.

Producing Strong Joints by Hydrogen Welding. Anon. (*Machinery* (*N.Y.*), 1933, 39, 778–780).—A description is given of a tubular furnace, heated by six resistance elements, and equipped with an endless chain conveyor, designed for "hydrogen welding." The parts to be welded are pressed together, copper wire is wrapped round the joint, and the parts are conveyed to the heating zone of the furnace. This is maintained at 2100° F. (1150° C.) and supplied with an atmosphere of "Electrolene," which is made by treating city gas with steam and contains hydrogen 58·4% and carbon monoxide 30%. The copper melts and flows freely under these conditions, uniting the joint. It is claimed that alloying of the copper and iron takes place, an alloy containing 3% of copper being formed.—J. C. C.

Recent Advances and Future Expectations of the Oxy-Acetylene Process. James H. Critchett (*Indust. Gases*, 1933, **13**, 220–221; and *Welding J.*, 1933, **30**, 17–18).—Read before the American Welding Society. See *J. Inst. Metals*, 1933, **53**, 588.—H. W. G. H.

Oxy-Acetylene Welding of Very Thick Plates. R. Meslier (*Rev. Soudure autogène*, 1933, **25**, 2805–2806; and (abstract) *Soudure et Oxy-Coupage*, 1933, **10**, 190).—Refers to steel plate of ⅞–1¼ in. thickness, but the technique described may have wider interest. Backward welding is recommended and three blowpipes are used at once, the tips being water-cooled.—H. W. G. H.

Oxy-Acetylene Construction of Apparatus and Containers. The International Advisory Committee for Carbide and Welding Technique, Geneva (*J. Amer. Weld. Soc.*, 1933, **12**, (2), 27–29).—Refers primarily to steel. A concise review of good practice in technique and design.—H. W. G. H.

Brewers Modernize Their Equipment. Anon. (*Indust. Gases*, 1933, **14**, 86–90).—From *Oxy-Acetylene Tips*, 1933, **12**, 149–153. See *J. Inst. Metals*, 1933, **53**, 673.—H. W. G. H.

Increasing Welding Speed and Decreasing Gas Consumption by the Use of Angular Filler Rods. C. F. Keel (*Welding Industry*, 1933, **1**, 145).—Test figures are given to show the influence of the shape of filler rods. Square and triangular bars melt first at the corners and taper off at the point, whereas round bars melt to a blunt end. Considerable economy in oxygen and acetylene is obtained by the use of angular rods. [*Note*: Ferrous welding only is considered.]—H. W. G. H.

Avoiding Failures in Gas Welding. Otto Lehmann (*Autogene Metallbearbeitung*, 1933, **26**, 185–186).—Important precautions are tabulated. A flame, adjusted to have excess of oxygen, is recommended for welding brass, nickel-brass, and "aluminium-bronze," a "neutral" flame for steel, copper, and aluminium, and a flame with excess acetylene for cast iron.—H. W. G. H.

Procedure for Testing the Strength of Hydraulic Back-Pressure Valves for Acetylene Apparatus Against Explosion Pressures. W. Rimarski and H. Friedrich (*Autogene Metallbearbeitung*, 1933, **26**, 49–54).—Cases had been observed of explosion, due to back-firing, which had ruptured the welded seams of high-pressure hydraulic valves. Since these were of a type tested by the Reichsanstalt, it was concluded that the test conditions did not reproduce those met in practice, and that the pressures resulting from explosion of a moving gas mixture differed from those obtained when the mixture was stagnant. An apparatus was devised to test back-pressure valves under the latter conditions, *i.e.* those which had caused failure in practice. The results, obtained with different designs of welded joint for the top and bottom of the valve, are described. It is claimed that suitable designs can now be specified, and it is expected that the present practice of using seamless tube for the valve bodies may not be necessary in all cases.—H. W. G. H.

Equipment for Testing Low-Pressure Hydraulic Back-Pressure Valves for Reliability in Case of Back-Fire. W. Rimarski and H. Friedrich (*Autogene Metallbearbeitung*, 1933, **26**, 81–88).—A detailed description of the apparatus and method used for testing hydraulic back-pressure valves at pressures from 300 mm. (12 in.) to 500 mm. (20 in.) water-gauge. Tests are possible both with and without the suction-effect of an injector burner, and this suction can be increased if desired to cause entry of air to the valve through its water seal.—H. W. G. H.

Prize Competition for the Construction of Safety Receivers for Low-Pressure Acetylene Generators. Anon. (*Autogene Metallbearbeitung*, 1933, **26**, 150–153).—Four prize-winning safety valves are illustrated and their mode of operation is explained. They are judged on their ability to check back-pressure of oxygen from the blowpipe or back-firing if an oxygen-acetylene or air-acetylene mixture is present in the pipe between blowpipe and generator.
—H. W. G. H.

Safe Handling of Oxygen and Acetylene Cylinders. T. C. Fetherston (*J. Amer. Weld. Soc*, 1933, **12**, (6), 23–24).—Good advice, often neglected.—H. H.

The Purification of Acetylene. Anon. (*Soudure et Oxy-Coupage*, 1933, **10**, 171).—Emphasizes the importance of removing all traces of sulphuretted and phosphoretted hydrogen.—H. W. G. H.

Determination of the Air Content in Acetylene. Paul Schuftan (*Autogene Metallbearbeitung*, 1933, **26**, 88–90).—The method depends on the absorption of acetylene by acetone; it is claimed to be simple, rapid, and accurate. The apparatus is described and the possible errors are discussed.—H. W. G. H.

The Training of Welders. D. Richardson (*Welding Industry*, 1933, **1**, 201–202 and 205).—Emphasis is laid on the need for better correlation, in this country, of syllabuses for welding instruction. It is prophesied that, in the future, technical schools, colleges, and universities will include welding as an important part of their engineering courses.—H. W. G. H.

A New Type of Welding Course. L. F. Jackson (*J. Amer. Weld. Soc.*, 1933, **12**, (5), 17–18).—An outline of a lecture course of a very comprehensive nature, embracing all types of welding.—H. W. G. H.

Teaching Metallic Arc Welding. E. Tutt (*Welder*, 1933, **4**, (38), 28–31).—Students of arc welding are divided into four groups: journeymen in other branches of metalwork; technical men who wish to become competent supervisors of welding; semi- or non-skilled workmen; and youths who have had no previous employment. The general principles of instruction are briefly discussed, and the importance of such details as the welder's position and grip of his electrode-holder is emphasized.—H. W. G. H.

To Make Good Welders. Anon. (*Soudure et Oxy-Coupage*, 1933, **10**, 187).—Abstract of an article by M. Couturier in *Rev. Soudure autogène*, 1933, **25**, 2773–2775. See *J. Inst. Metals*, 1933, **53**, 674.—H. W. G. H.

Effect of Training on Welding Skill. C. R. Nailler and J. S. Anderson (*Welding Eng.*, 1933, **18**, (3), 23).—Abstract of a thesis by N. and A., reporting the results of tests to determine the effects of systematic training on skill in welding.—H. W. G. H.

XXI.—INDUSTRIAL USES AND APPLICATIONS

The Toxicity of Aluminium Compared with that of Iron, Nickel, and Other Metals. Gabriel Bertrand and P. Serbescu (*Compt. rend.*, 1931, **193**, 128–131; *Ann. Inst. Pasteur*, 1931, **47**, 451–454; and (abstract) *Technique moderne*, 1931, **23**, 673; *C. Abs.*, 1932, **26**, 524).—The toxicity of aluminium (as $Al_2(SO_4)_3.18H_2O$) is of the degree of magnitude of that of iron, and considerably less than that of nickel or copper. Fears of toxic effects from aluminium cooking vessels are unfounded, since the amount so consumed is no greater than is normally found in plant and animal tissues.—S. G.

Feeding Experiments with Foods Canned in Aluminium. Gulbrand Lunde, Valborg Aschehoug, Hans Breien, and K. Wülfert (*Tids. Hermetikind.*, 1933, **19**, 174–185; *C. Abs.*, 1933, **27**, 5829).—In continuing prior experiments on fish canned in aluminium, storage tests for periods up to 3·5 years with sardines in oil, kippered and fresh herring and fish-balls showed no hydrogen swells with one exception, in which case the fish had been improperly processed. Tests with crab, lobster, and shrimp were also very successful. Feeding tests on mice and rats in which canned food with high aluminium content in comparison with similar but aluminium-free food is used, showed quantitative elimination of the administered aluminium, with no harmful effects whatever. This is in accord with results of tests on foods cooked in aluminium utensils.—S. G.

Handling of Distilled Water in Aluminium. H. V. Churchill (*Indust. and Eng. Chem.* (*Analyt. Edn.*, 1933, **5**, 264–266).—Aluminium equipment for the production and storage of distilled water is described and illustrated. Water distilled from aluminium apparatus contains less than 0·8 p.p.m. of total solids, of which less than 0·03 p.p.m. consists of aluminium.—A. R. P.

Aluminium as a Structural Material. Walther Zarges (*Werft, Reederei, Hafen*, 1933, **14**, 248–254).—Discusses the selection of light-alloy structural elements. Tables give the mechanical properties, prices (in marks per kg.), applications, and names of makers of aluminium, and of 18 alloys in the rolled condition, with some details as to ageing and heat-treatment and also of aluminium, and 16 alloys, sand- and chill-cast. Dimensions for round-headed and countersunk rivets, and the shear strengths and permissible loads of 9 standard alloys are also shown in tables.—P. M. C. R.

A New Alloy for Pistons. Anon. (*Alluminio*, 1933, **2**, 219).—A note on a new alloy of aluminium containing chromium, studied by Metal Castings, Ltd., Worcester, and specially intended for cast pistons.—G. G.

The Manufacture of Light Metal Pistons for Motor Engines. E. Mahle (*Werft, Reederei, Hafen*, 1933, **14**, 255–256).—The development of the light-alloy piston is considered historically. The principal difficulties attending its adoption were excessive wear, the high thermal expansion of the new materials, and wear on piston-rings; modern practice in combating these is described, and certain types of piston are illustrated, including two examples intended for marine work.—P. M. C. R.

Light Alloys in the Construction of Land Transport. G. Py (*Rev. Aluminium*, 1933, **10**, 2157–2164; and (translation) *Aluminium Broadcast*, 1933, **4**, (14), 2–9).—The applications of Duralumin for the manufacture of bicycles are described and details of the preparation and working of the alloy for this purpose are given.—J. H. W.

The Choice of Light Metals for Transport Construction. Erich Eichwald (*Automobiltech. Z.*, 1933, **36**, 501–506).—This summary of the characteristics of alloys suitable for vehicle and aircraft construction includes a table of commercial light-alloy products, with sp. gr. and standard dimensions. A second table gives the trade mark, name, state of treatment, makers, tensile strength, elastic limit, elongation, modulus of elasticity, Brinell hardness, sp. gr., thermal expansion, and principal applications of numerous cast and worked alloys with aluminium or magnesium base. A more highly specialized selection of alloys for vehicle construction is given, followed by a list, for the guidance of users, of important considerations as to properties, purpose, surface finish, &c. Percentage compositions are given for 22 alloys in common use. The dimensions, with weights, of some standard forms are given. An extensive *bibliography* is furnished.—P. M. C. R.

The Influence of Recent Research on Aero-Construction. Paul Brenner (*Z. Flug. u. Motor.*, 1933, **24**, 497–505).—A major problem in aircraft construction is the combination of progressive lightening with sufficient strength, each member being worked as closely as possible to its permissible limits. Advances in this field must be conditioned by the progress of research: the great developments due to the introduction of Duralumin and the magnesium alloys are cited in illustration. Certain newer alloys are expected to modify existing practice. The properties of Silumin and Copper-Silumin are tabulated. Other alloys considered are Silumin-gamma, Elektron A 9, and a similar alloy of composition aluminium 7%, manganese 0·4%, remainder magnesium. A second table summarizes the mechanical properties of some alloys of the Duralumin class (681 B, 681 ZB, DM 31, 17 SRT). The protection of such alloys from corrosion has been developed by the results in three directions—plating, anodic oxidation, and the development of alloys of high resistance to corrosion. The results of corrosion tests on certain of these are tabulated (Duralumin 681 A, 681 ZB, 681 K, Duralplat, Hydronalium and KS-Seewasser), and in other tables the mechanical properties of certain of these and of BS-

Seewasser and Duranalium are given. Methods of mechanical testing are discussed, with special reference to endurance tests. The influence of surface finish, abrupt alterations in cross section, sharp corners, slots and rivet-holes is considered, and the sensitiveness of some common structural materials to varying stresses is investigated and compared. The possibilities of X-ray examination, especially of welds, are indicated. A *bibliography* is appended. —P. M. C. R.

Light Metal Construction in Shipbuilding. F. Gentzcke (*Werft, Reederei, Hafen*, 1933, **14**, 256–260).—The lightening effected by the adoption of light alloys in ship construction should make for increased stability, for greater carrying power corresponding with the decrease in dead weight, and for improved design. Much of the superstructure of small vessels, as well as deck plating, engine parts, fireproof partitions, and heat-insulation, is now frequently of light-metal: a list of such parts, with appropriate materials, is given, and an example of cabin-construction in Bondur and aluminium is shown in plan. A table classifies common structural alloys according to their purpose and to the probable degree of exposure, and gives approximate strengths.—P. M. C. R.

The "Mythen," a Passenger Motor Vessel with Welded Hull and Riveted Aluminium Superstructure. —— Lottmann (*Werft, Reederei, Hafen*, 1933, **14**, 91–93).—This vessel, which carries 200 passengers, was built for service on Lake Lucerne. The hull is of arc-welded steel, protected by a sprayed zinc coating. Apart from the external deck stringers, the deck plates are of 5 mm. Anticorodal, riveted with aluminium rivets to the steel supports; corrosive action is prevented by coating with zinc and painting with zinc white. Anticorodal is also used for deck-houses, seats, window-frames, and other portions of the superstructure; only occasionally, as in the case of skylights, is the material welded. The use of light alloys in deck and superstructure is stated to result in a 20% economy in weight. Several plans, sections, and views of various parts are given.—P. M. C. R.

Aluminium Alloy in Light-Weight Accumulators. Anon. (*Electric Vehicles and Batteries*, 1932, **16**, 219).—The use of aluminium sheets sprayed with lead by the Schoop process is proposed in a recent patent as a means of reducing the weight of accumulator plates.—J. C. C.

Electric Cables of Aluminium. E. Soleri (*Alluminio*, 1933, **2**, 1–13).—The possible applications of aluminium in the electrical industry are discussed, and its value is compared with that of copper for the same purposes. The use of anodically oxidized aluminium on an insulating material, in the form of ribbons and wires, as a screen, in high-voltage telephone and telegraph cables, and for external protection, as a substitute for lead, for small flexible conductors, and as a continuous support under the lead for under-sea cables for great depth, the protection of lead conductors by "metallization" with aluminium and the use of aluminium for light, non-inductive and non-magnetic support, and for uni-polar a.c. cables are also described.—G. G.

Heat Insulation with Aluminium Paper. Ralph B. Mason (*Aciers spéciaux*, 1933, **8**, 276–290).—J. H. W.

Aluminium Foil—Its Use in Modern Packing. D. C. Brookes (*World's Press News*, **1933**, Sept. 21; *Aluminium Broadcast*, 1933, **4**, (13), 16–18).—Includes a table of the covering area per lb. of aluminium, tin, and copper foils for thicknesses between 0·006 and 0·200 mm.—J. C. C.

Alfol in Shipbuilding. H. Niemann (*Werft, Reederei, Hafen*, 1933, **14**, 260–263).—P. M. C. R.

Aluminium Paints for Exteriors and Interiors. R. Schwarz (*Farbe u. Lack*, **1933**, 437–438, 449–450, 463; *C. Abs.*, 1933, **27**, 5991).—The American assumption that the value of "aluminium-bronze" powder lies in its leafing properties is not generally accepted in Germany. The same ideas were once applied to micaceous iron oxide and found to be erroneous. For plaster and moist wood, an aqueous vehicle "Dilutin" is recommended Ammoniacal casein solutions are also satisfactory. Oil vehicles should contain considerable stand oil. —S. G.

The Cæsium–Oxygen–Silver Photoelectric Cell. M. J. Kelly (*Bell Laboratories Record*, 1933, 12, 34–39).—A photoelectric cell having a cathode of pure silver on which is formed a matrix of cæsium oxide, silver oxide, and finely-divided silver and which is then covered by an adsorbed layer of atomic dimensions of cæsium is more than fifty times as sensitive as the potassium hydride-cathode type. The construction of such cells is described.—J. C. C.

Chromium on Copper for Washing Machines. Anon. (*Bull. Copper and Brass Res. Assoc.*, 1933, (75), 14).—The use of chromium-plated copper for the construction of domestic washing machines is illustrated.—J. S. G. T.

Cobalt and Its Uses. L. Sanderson (*Sands, Clays, and Minerals*, 1933, 1, (4), 51–57).—A brief account is given of the mineralogy and uses of cobalt. —A. R. P.

Copper Vessels for Decomposing Fats. R. Heublum (*Metallwirtschaft*, 1933, 12, 121–122).—Copper is slightly attacked by fatty acids at first, but a protective film is soon formed which prevents further attack and has no effect on the fat hydrolysis reaction: copper vessels are, therefore, suitable for the decomposition of fats by the Twitchell method.—v. G.

Copper in Modern Breweries. Josef Mederer (*Apparatebau*, 1933, 45, 121–128; and *Z.V.d. Kupferschmied.*, 1933, 45, 145–152).—An illustrated article on the uses of copper in making brewery plant.—M. H.

Sheet Copper Combats Corrosion by Salt Water. Anon. (*Bull. Copper and Brass Res. Assoc.*, 1933, (75), 5).—The use of copper in the construction of swimming pools and buildings at Jones Beach, New York, is briefly referred to and illustrated.—J. S. G. T.

Copper in Window Frames and Shop Fronts. Anon. (*Cuivre et Laiton*, 1933, 6, 163–176, 216–223, 269–278).—The advantages of copper in the construction of such exposed parts as window frames are summarized. Their manufacture is described, and illustrations are given of the various types of sections in most common use. Of the materials used, pure copper, brass containing 50–80% copper, Tombac with 80–90% copper, special brasses containing small proportions of nickel, iron, manganese, or aluminium, "aluminium-bronze" or ordinary bronze containing 90–70% of copper and 10–30% tin are most frequently employed. To illustrate the construction of different types of window frames, examples are shown from actual buildings, mainly in America. Straight opening, pivoting, and bascule windows are included.—W. A. C. N.

Methods of Covering in Copper. Anon. (*Cuivre et Laiton*, 1933, 6, 319–322).—Deals with: (1) general technical methods for the execution of copper coverings; (2) methods for making gutters and down-pipes; (3) methods for flat copper coverings with hammered sections; and (4) coverings with raised joints.—W. A. C. N.

America's First Copper House Strikes a New Note in Construction. Anon. (*Bull. Copper and Brass Res. Assoc.*, 1933, (76), 6).—The construction of a copper-covered house is illustrated. The entire exterior is copper-covered; about 75% of the copper is lead-coated.—J. S. G. T.

Million and Quarter Pounds of Copper Alloys in New Structure. Anon. (*Bull. Copper and Brass Res. Assoc.*, 1933, (76), 2–3).—The use of copper and bronze in the construction of Bronx County Court House is described and illustrated.—J. S. G. T.

New Low-Cost Paper-Thin Copper Finds Variety of Uses. Anon. (*Bull. Copper and Brass Res. Assoc.*, 1933, (76), 10).—The application of "Electrosheet" (copper as thin as paper) for roofing and decorative purposes is briefly described and illustrated.—J. S. G. T.

Copper Alloy Wire. James T. Kemp (*Wire and Wire Products*, 1933, **8**, 310–317, 342).—Read before the Wire Association. Outlines the development and principal uses of wire consisting of pure copper, copper containing small amounts of cadmium, tin, silicon, aluminium, manganese or beryllium, and 80 : 20 red brass.—J. H. W.

Applications of Bronze in the Construction of Electric Tramway Accessories. I.—Trolley-Head. Anon. (*Cuivre et Laiton*, 1933, **6**, 246–247).—W. A. C. N.

Historical and Technical Notes on the Greatest Statue in the World in Hammered Bronze—The Statue of Liberty, New York. A. Chaplet. J. B. Gauthier (*Cuivre et Laiton*, 1933, **6**, 297–304).—An interesting description of the construction, both from a historical and a technical point of view, of the Statue of Liberty.—W. A. C. N.

Bronze Railroad Bearings Improved through Research. Anon. (*Bull. Copper and Brass Res. Assoc.*, 1933, (75), 15).—A "circulating" type of bearing effecting improvement of lubrication is illustrated and briefly described.—J. T.

Iron Wire (Bronze-Plated), Its Applications and Technical Requirements. V. N. Zvetkov and I. Dembo (*Ovladenie Tekhnikoi : Kozhobuvnoe Proizvodstvo*, 1932, (2), 41–43; *C. Abs.*, 1933, **27**, 5702).—[In Russian.] Various tests are described.—S. G.

Tentative Standards for "Universal" Bronze-Plated Wire. Anon. (*Ovladenie Tekhnikoi : Kozhobuvnoe Proizvodstvo*, 1932, (2), 43–44; *C. Abs.*, 1933, **27**, 5702).—[In Russian.] Various tests are described.—S. G.

Applications of "Tungum." Anon. (*Met. Ind.* (*Lond.*), 1933, **43**, 447–448).—A brief description of the principal uses of the alloy Tungum.—J. H. W.

The Manufacture of Electric Cables. G. Martinez (*Met. Ind.* (*Lond.*), 1932, **41**, 463–465, 491–494).—Slightly condensed from a paper read before the Portsmouth Branch of the Institution of Mechanical Engineers. The processes considered are confined to the manufacture of paper-insulated cables. Copper of high purity is used as conducting material: full details are given of the drawing process, of the necessary annealing, and of its effects on the mechanical properties of the wire. Stranding, shaping, and laying up are described. The sheathing process utilizes either lead or lead alloy; a frequent source of failure is the formation of oxide films at the junction of consecutive charges during extrusion. Typical microstructures are illustrated. The production of the oil-filled cable is discussed, and a special feeding tank is described. Some details as to oil-filled high-tension cable lines actually in use are appended.—P. M. C. R.

Lead Alloys for Building Applications. —— (*Engineering*, 1933, **136**, 127).—Abstract of report entitled "B.N-F. Ternary Alloys of Lead—Their Use in Buildings," published by H.M. Stationery Office. See *J. Inst. Metals*, 1933, **53**, 459.—W. P. R.

Vaporization of Lead in Homogeneous Lead Coating Processes. Hans Engel and Victor Froboese (*Metallwaren-Ind. u. Galvano-Tech.*, 1931, **29**, 360; and *Indust. Gases*, 1933, **14**, 44).—Abstract of a paper in *Arch. Hygiene*, 1925, **96**, 69–101; see *J. Inst. Metals*, 1926, **36**, 592.—A. R. P.

Construction of Welded [Magnesium Alloy] Gondolas for Stratospheric Balloons. Jean Piccard (*Welding Eng.*, 1933, **18**, (6), 30–31).—Describes the construction of the gondola to be used by P. and Settle in their ascent from Chicago. A magnesium alloy was used.—H. W. G. H.

Rolled Nickel in Composite Metal Products. Anon. (*Welder*, 1933, **4**, (30), 3–8).—A description of nickel-clad steel including its physical and mechanical properties, structure, working, advantages, and uses.—H. H.

The Place of Nickel in Radio Tube Manufacture. A. J. Marino (*Electronics*, 1933, **6**, (1), 4–5).—Summarizes the properties of nickel which render it suitable for use in the manufacture of radio valves. For grid wires the alloys of nickel with manganese or chromium are largely used and are replacing more expensive metals such as molybdenum. The requirements of the valve industry call for very careful control of the melting and subsequent working and annealing of nickel and its alloys. The percentage elongation is usually specified when ordering.—S. V. W.

Experiences and Hints on the Manufacture of Tanks from Monel Metal Sheet. Rudolf Müller (*Apparatebau*, 1933, **45**, 97–99; and *Z.V.d. Kupferschmied.*, 1933, **45**, 129–131).—The bending, welding, and soldering of Monel metal sheet in making tanks are described.—M. H.

Sterilization of Domestic Drinking Waters with Metallic Silver. André Kling (*Bull. Acad. Méd.*, 1932, **107**, 830–839; *C. Abs.*, 1933, **27**, 5450).—Pure, especially distilled, water acquires bactericidal properties after having been in contact with large surfaces of silver for 15 minutes. The antiseptic power remains unchanged after the addition of chlorine ions; it is destroyed by hydrogen sulphide. The precipitate of calcium carbonate formed by boiling natural waters removes the acidity. Electric current has no influence. 1 litre contained 0·05 mg. silver.—S. G.

A Sodium Glow Lamp. F. H. Newman (*Phil. Mag.*, 1933, [vii], **16**, 1109–1114).—Characteristics of glow lamps of the ordinary type containing fillings of sodium and either neon or argon are briefly discussed.—J. S. G. T.

Gas-Free Metals Used in X-Ray Tubes. W. D. Coolidge and E. E. Charlton (*Metal Progress*, 1933, **24**, (5), 36–40).—From a paper presented before the International Electrical Congress, Paris, 1933. A historical survey of the evolution of the X-ray tube is followed by an account of the production of tungsten in a ductile form. The metal so treated is now substituted for platinum in the target; the copper block employed for backing must be carefully deoxidized by treatment with boron, and is then attached to the tungsten by very carefully controlled heating *in vacuo*. The effects of various gases on the life of the tungsten target are summarized. The substitution of tungsten for aluminium in the cathode proved successful in the hot-cathode type of tube, an example of which is described and illustrated. Here the whole target consists of tungsten, its supports being of molybdenum. The importance of de-gassing the metals in question is emphasized, and the influence of time and temperature on this process is discussed.—P. M. C. R.

Cathode Tubes. Rudolf Sewig (*Arch. tech. Messen*, 1933, **2**, (20), T28).—The principle of the cathode tube is stated, and the relative merits of tungsten, thorium, and barium as cathodes are discussed, with the special adaptations required by each. Certain important developments are described, and their nomenclature is explained.—P. M. C. R.

Price, Patent Position, and Uses of Sintered Hard Metals. Karl Becker (*Metallwirtschaft*, 1933, **12**, 375, 391–392, 407–408).—A review.—v. G.

Price, Patent Position, and Performance of Sintered Hard Metals. —— (*Metallwirtschaft*, 1933, **12**, 531).—Remarks of the Krupp A.-G. on K. Becker's article (preceding abstract) and B.'s reply—v. G.

Battery Manufacture at Dagenham. Anon. (*Electric Vehicles and Batteries*, 1932, **16**, 214–216).—A brief illustrated description of the manufacture of accumulator plates at the works of Pritchett and Gold and E.P.S. Co., Ltd., Dagenham.—J. C. C.

On the Specifications for Sheet Zinc for Galvanic Batteries and Methods of Testing. E. Zalesinski (*Metallwirtschaft*, 1933, **12**, 699–704).—The manufacture of zinc elements for batteries, especially by the cold-spray process, is described. After reviewing the usual methods used for corrosion testing it is suggested that measurement of the rate of gas evolution in 10% sulphuric acid gives the best results. Iron, copper, arsenic, and antimony are the most objectionable impurities in the zinc.—v. G.

Stability of Vitamin-A During Canning Process. G. Lunde, H. Kringstad, and K. Vestly (*Tids. Hermetikind.*, 1933, **19**, 305–313; *Bull. Brit. N.-F. Metals*

Res. Assoc., 1933, (60), 17).—[In Norwegian, with an English abstract.] These investigations show that the vitamin-*A* content of canned brisling sardines is almost as high as that of fresh fish, loss of vitamin-*A* during canning being negligible. Brisling sardines stored for 2 yrs. in tins as well as in aluminium cans have a vitamin-*A* content equal to that of the newly-packed product.—S. G.

Prescriptions of Quality for Sheets, Tubes, Screws, Rivets, and Wires. Georg Richter (*Anz. Berg, Hütten- u. Masch.*, 1933, **55**, (62), 5–6).—Present German standard specifications for brass, bronze, copper, nickel–silver, and aluminium sheets, for copper tubes, screws, and rivets of special brasses, copper wires, overhead trolley wires, and steel-cored aluminium transmission cables are summarized.—B. Bl.

Laminated Metals. George A. Ruehmling (*Machinist* (*Eur. Edn.*), 1933, **77**, 567–568E).—The requirements of metals suitable for use in laminations, the forms these laminations may take, and their applications are described.—J. H. W.

Structural Materials for Heavy Vehicles. —— Kracht (*Automobiltech. Z.*, 1933, **36**, 551–552).—Abstract *in extenso* of a paper read before the Automobil- und Flugtechnische Gesellschaft. Structural materials are reviewed from the view-point that metals or alloys should preferably be of German origin. The supply of aluminium is seriously threatened by the shortage of German bauxite, but advances in remelting practice have facilitated the use of scrap. Elektron is of increasing importance, but its greater corrodibility prevents its entirely replacing aluminium. The possibility of replacing tin and antimony in bronzes and bearing-metals is considered.—P. M. C. R.

Metals in Aircraft Construction. Robert Jones (*Heat-Treating and Forging*, 1933, **19**, 35–37).—The application of various metals and alloys to aircraft construction, their heat-treatment, and anodic hardening are briefly described.
—J. H. W.

Brewers Find Changes Among Construction Materials. Anon. (*Chem. and Met. Eng.*, 1933, **40**, 272–273).—During the long period of inactivity in the brewing industry in the U.S.A., rapid strides have been made in new methods, equipment, and construction materials. Tons of copper and brass are now being fabricated into kettles, filter presses, and pumps, and such materials as "Nickel-Clad," metallized wood, and "bonded" metal (metal to which a felted material is attached by a metal adhesive) have become available. Stainless steels have also been exploited during the depression and become firmly established in the process industries. Sterling silver at its present record low price is within reach of the chemical engineers, and some of its applications are given. Illustrations are given of a bronze filter press with copper sheet strainers and two ammonia beer coolers of stainless steel.—F. J.

The Problem of the Water-Cooled Piston Rod in Two-Stroke Cycle Double Acting Oil Engines. S. F. Dorey (*Trans. Inst. Naval Arch.*, 1933, **75**, 200–236).—In dealing with problems connected with the water-cooled piston, reference is made to the corrosion-fatigue of such pistons, and among the methods suggested as a means of protecting the steel rod from such influences, is the use of a sleeve of cupro-nickel. Protection by the electrodeposition of metals such as nickel, cadmium, and chromium is also considered, but is not recommended.—J. W. D.

Economical Construction of Complicated Punch- and Die-Sets. A. Eyles (*Mech. World*, 1933, **93**, 141–142).—Apart from the mass of expensive steel used, a one-piece die of any complication means much intricate and costly handwork. The work can be cheapened by the use of alloys of low melting-point to form a matrix for holding the various parts of the dies together. Another application of these alloys is in moulds for pressing composition and fibre. The compositions and some physical properties of a number of suitable alloys are tabulated.—F. J.

Heat Technology Turns to New Mediums. Anon. (*Chem. and Met. Eng.*, 1933, **40**, 262–264).—Perhaps the outstanding tendency in heat application to-day, in all cases, where high temperatures must be maintained, is to get away from direct firing of equipment and to substitute some of the new high-temperature heat-transfer media that have recently come into use. The best-known of these applications is probably the Sun Oil Co.'s mercury-vapour process for lubricating oil distillation. This process is briefly described. In the field of power-generation, the principle of the Emmett mercury boiler has recently been used in the large new mercury-vapour plant built at Schenectady by the General Electric Co. Reference is also made to the drum, made of alternate bands of rubber and Monel metal, on which thin sheets of ice are formed. The properties and uses of Alfol are also briefly discussed.—F. J.

XXII.—MISCELLANEOUS

What a Non-Ferrous Metallurgist Should Be. Sylvain F. Perin (*Chim. et Ind.*, 1931, Special No. (March), 499–503).—I. M.

The Function of the Chemical and Metallurgical Industries in an Economic European Entente. I. J. Moltkehansen (*Chim. et Ind.*, **1930**, Special No. (March), 287–290).—I. M.

Chapters in Crystal Chemistry for College Freshmen. Part II. Chapter III. Metals and Alloys. The Metallic State. Charles W. Stillwell (*J. Chem. Education*, 1933, **10**, 669–674).—The characteristics of metals and alloys and the nature of metallic compounds, especially those of copper and zinc, are described.—J. H. W.

Materials of Industry. Anon. (*Machinery* (*Lond.*), 1933, **42**, 527–528).—A brief review of some recent developments in non-ferrous metals and alloys. —J. C. C.

Knowledge of the Metals in Ancient India. R. N. Bhagvat (*J. Chem. Education*, 1933, **10**, 659–666).—Abstracts are given of a "Treatise on Polity," written by Chanakya or Kautilya in the 4th century B.C., describing briefly the metallurgy, extraction, testing, and purification of gold, silver, and copper. Mention is made of mercury, iron, steel, lead, tin, and other materials. —J. H. W.

Introduction to the Hamburg "Aluminium Day." E. Roth (*Werft, Reederei, Hafen*, 1933, **14**, 247–248).—A survey of the growth of the German aluminium and light-metal industry.—P. M. C. R.

Report of the Aluminium Meeting in Hamburg, 1933. Anon. (*Werft, Reederei, Hafen*, 1933, **14**, 283–289).—An account of the Aluminium Festival Meeting, Sept. 14, 1933. Abstracts are given of the Presidential Address by *E. Roth*, on "Aluminium, the German metal"; and of the following papers: *E. Foerster*: The present application and future significance of aluminium and its alloys in shipping and aviation; *W. Pabst*: Structural problems and the investigation of strength in seaplane construction; *Hans Schmitt*: Electric oxidation of aluminium and its alloys; —— *Herlig*: Protection of light metal surfaces; *Walther Zarges*: On the conception of light metal construction; *H. Gerrens*: The joining of light metal.—P. M. C. R.

Transformation of Aluminium into Nickel? Anon. (*Metallwirtschaft*, 1933, **12**, 331).—A newspaper report that aluminium has been converted successfully into nickel should be received with caution.—v. G.

Prevention of Lead Poisoning in Industry. G. H. Gehrmann (*Amer. J. Public Health*, 1933, **23**, 687–692).—S. G.

Manganese: Its Occurrence and Uses. Robert Ridgway (*Met. Ind.* (*Lond.*), 1933, **43**, 83–84).—Abstract of *U.S. Bur. Mines Information Circ.* No. **6729**. See *J. Inst. Metals*, 1933, **53**, 681.—J. H. W.

Swansea Spelter, Sulphuric Acid Production. T. Benson Gyles (*Times Trade and Eng. Suppt.* (Industrial Wales Section), 1933, 33, (799), 23).—New zinc alloys, calling for zinc of a high purity, have been developed. Of these the Mazak type of alloys are being extensively used as pressure die castings. Reference is also made to the use of zinc in pigments and also to the production of sulphuric acid.—S. V. W.

Magnetic Pulleys in the Non-Ferrous Metal Industries. C. H. S. Tupholme (*Met. Ind.* (*Lond.*), 1933, 43, 485–486).—The construction, requirements, and applications of a magnetic pulley, suitable for removing magnetic material from non-ferrous metals and for treating foundry sands, are described.—J. H. W.

Reducing Material Waste. C. H. McKnight (*Mech. Eng.*, 1932, 54, 109–112; and (abstract) *Mech. World*, 1932, 91, 243–244).—Much waste of material, hitherto considered inevitable, can be saved by intelligent co-ordination of design, process, and labour efficiency. Some useful adaptations of design and process are described and illustrated.—P. M. C. R.

Workshop Practice in Automobile Engineering. (Sir) Herbert Austin (*Trans. Inst. Eng. Ship. Scotland*, 1931–1932, 75, 368–378; discussion, 378–390; and (abstract) *Mech. World*, 1932, 91, 215–218).—Recent developments include the extended use of automatic or semi-automatic machinery, necessitating careful alignment and inspection, and requiring rigidly standardized material. Certain cutting, grinding, and forging assemblies are described, the application of electric welding is considered, the electrical upset method of valve manufacture is summarized, and the close correlation of all manufacturing processes is justified by a brief statement of output and prices.—P. M. C. R.

1932 Stimulated Ingenuity. Joseph Geschelin (*Automotive Ind.*, 1933, 68, 71–72, 80).—A review of recent developments in manufacturing equipment, heat-treatment, plating, welding, and evolution of new materials in 1932.
—P. M. C. R.

Glossary of Technical Terms. Anon. (*Light Metals Research*, 1933, 2, (31), 38 + xv pp.).—A glossary of metallurgical terms in English, German, French, and Italian.—J. C. C.

A Slide Rule for Converting Weight Percentages into Atomic Percentages. C. Herrmann (*Metallwirtschaft*, 1933, 12, 104–105).—The slide rule can be obtained from the editorial offices of the periodical *Metallwirtschaft*.—v. G.

Engineering Research at the National Physical Laboratory. H. J. Gough (*Trans. Inst. Eng. Ship. Scotland*, 1932–1933, 76, 205–258).—In a description of the various activities of the N.P.L., special attention is given to the work carried out in the Engineering Department, particularly in connection with the mechanical properties of materials at high temperatures, and tensile, creep, fatigue, impact, and torsion tests at such temperatures are discussed. Special consideration is also given to the testing of chains and lifting gear components. In the discussion important points are raised both in regard to high-temperature testing and in the testing and annealing of chains.—J. W. D.

The Torsion and Flexure of Shafting with Keyways or Cracks. W. M. Shepherd (*Proc. Roy. Soc.*, 1932, [A], 138, 607–634).—The stresses in shafts of circular cross-section, having keyways or slits cut in them and subjected to torsion or bent by a transverse load at one end, are investigated mathematically.—J. S. G. T.

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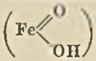
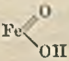
[Contains the following papers: G. Schikorr: "Über Theorie und Systematik der Korrosion der Metalle"; G. Schikorr: "Über die Theorie der Korrosion des Eisens"; G. Schikorr: "Über die Auflösung von Aluminium in Laugen"; G. Schikorr: "Über die Korrosion des Aluminiums durch Natriumchloridlösung unter Wasserstoffentwicklung"; O. Bauer u. G. Schikorr: "Über die Einwirkung von alkoholhaltigen Treibstoffen auf Aluminium und Aluminiumlegierungen"; E. Deiss u. H. Blumenthal: "Die Analyse von Kupfer–Nickel–plattiertem Stahlmaterial"; E. Schürmann u. K. Charisius: "Zur gewichtsanalytischen Bestimmung des Gehalts an Bleioxyd in Mennige"; H. Blumenthal: "Antimontrichloridverfahren zur Bestimmung des Bleidioxydgehaltes in Mennige"; H. Blumenthal: "Zur Bestimmung des Kupfergehaltes von Handelsmennige"; H. Blumenthal: "Zur Bestimmung des Magnesiums in manganhaltigen Aluminium–Magnesiumlegierungen"; V. Rodt u. K. Charisius: "Über das Verhalten von Eisen–II–salzlösungen beim Oxydieren mit Brom"; V. Rodt: "Zur Entstehung von Eisen–II–III–oxyd (Fe_3O_4 × aq.) in wässeriger Lösung"; V. Rodt: "Zur Einwirkung des braunen hydratischen Eisenoxydes (Fe_2O_3 × aq.) und des gelben Eisenoxydhydrates  $\left(\mathrm{Fe}\begin{smallmatrix}\mathrm{O}\\\mathrm{OH}\end{smallmatrix}\right)$ auf einige Metallhydroxyde in alkalischer Lösung"; V. Rodt: "Zur Entstehung von gelbem Eisenoxydhydrat  $\mathrm{Fe}\begin{smallmatrix}\mathrm{O}\\\mathrm{OH}\end{smallmatrix}$ aus den Eisensulfiden."]

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[Includes statistics regarding the following metallic materials: aluminium, antimony, arsenic, barium minerals, bismuth, cadmium, chrome ore and chromium, cobalt, copper, gold, iron and steel, lead, magnesite, manganese, molybdenum, nickel, platinum, pyrites, quicksilver, silver, strontium minerals, tin, titanium minerals, tungsten, uranium minerals, vanadium, and zinc. A useful list of statistical publications is appended.]

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[Contains the following: J. H. Critchett, "Recent Advances and Future Expectations of the Oxy-Acetylene Process"; J. J. Feichter, "Sales Advantages of Welded Products"; S. L. Land, "Training Journeymen in Welding"; R. D. Williams, "Welded Piping in a Central Heating and Power Plant"; F. J. Maeurer, "Economic Advantages of Welded Piping in Homes"; A. J. Williams, "Engineering as Applied to Aircraft in Flight"; E. W. Clexton, "Welding in the Construction of Naval Aircraft"; W. Constance, "Building Up and Heat-Treating Rail Ends"; L. H. Scheifele, "Maintenance of Railroad Equipment by Oxy-Acetylene Welding"; J. W. Cottrell, "Maintenance of Bus and Motor Truck Equipment."]

***International Acetylene Association.** *Report of Oxy-Acetylene Committee.* Presented at the Annual Meeting, Chicago, Ill., September, 1933. Med. 8vo. Pp. 18. 1933. New York: International Acetylene Association, 30 East 42nd St.

International Beratsgesstelle für Karbid und Schweisstechnik. Herausgegeben von der. Sammelwerk der Autogen-Schweissung. Band IV.—*Schweissen der Nichteisenmetalle.* 80 Bl. 1933. Halle: Carl Marhold. (Lw. M. 6.)

Jukkola, Elmer Ely. *The Preparation and Properties of Some Rare Earth Metals.* Pp. 6. 1933. Urbana: University of Illinois. (25 cents.)

Langeron, M. *Précis de Microscopie.* 5 édition ref. Pp. 1205. 1933. Paris: Masson et Cie. (Br., 86 francs; cart, 100 francs.)

Lavroff, S. I. *Lichtbogen-Schweisselektroden. Praxis und Theorie des Lichtbogen-Schweissverfahrens und des Herstellung des Elektroden.* Pp. 64. 1933. Berlin: Siemens. (Lw. M. 8.50).

Library Association. Issued by the. *The Subject Index to Periodicals,* 1932. Roy. 4to. Pp. x + 270. 1933. London: Library Association. (70*s.*)

***Liddell, Donald M.,** and **Gilbert E. Doan.** *The Principles of Metallurgy.* Med. 8vo. Pp. vii + 626, with numerous illustrations. 1933. New York: McGraw-Hill Book Co., Inc. ($ 5.50); London: McGraw-Hill Publishing Co., Ltd. (30*s.* net.)

***Lottner, Gottfried.** *Störungen beim Betrieb von Azetylenapparaten und ihre Beseitigung.* Cr. 8vo. Pp. 63, with 19 illustrations. 1934. Halle a.S.: Carl Marhold. (Kart, R.M. 1.70.)

***National Research Council of Japan.** *Report.* Volume II, No. 1. April, 1931–March, 1932. Demy 8vo. 1933. Tokyo: National Research Council of Japan, Imperial Academy House, Ueno Park.

***Royal Mint.** *Sixty-Third Annual Report of the Deputy Master and Comptroller of the Royal Mint,* 1932. Med. 8vo. Pp. iv + 155, with 4 plates. 1933. London: H.M. Stationery Office. (3*s.* 6*d.* net.)

***Sachs, G.** *Praktische Metallkunde. Schmelzen und Giessen, spanlose Formung, Wärmebehandlung.* Erster Teil: *Schmelzen und Giessen.* Med. 8vo. Pp. viii + 272, with 323 illustrations in the text and 5 plates. 1933. Berlin: Julius Springer. (R.M. 22.50.)

Schack, Alfred. *Industrial Heat Transfer.* Translated from the German by Hans Goldschmidt and Everett P. Partridge. Med. 8vo. Pp. xxiii + 371. 1933. New York: John Wiley and Sons, Inc.; London: Chapman and Hall, Ltd. (31*s.* net.)

Schmidmer, E. L. *Ein Beitrag zur statischen und dynamischen Härteprufung.* (Forschungsarbeiten über Metallkunde und Röntgenmetallographie, F. 5.) Roy. 8vo. Pp. 102. 1933. München: Verlag Vogelrieder. (R.M. 4.50.)

***Scientific and Learned Societies.** *The Official Year-Book of the Scientific and Learned Societies of Great Britain and Ireland.* With a record of publications issued during session 1932–1933. Compiled from official sources. Fiftieth Annual Issue. Foreword by Sir Richard Gregory. Demy 8vo. Pp. viii + 171. 1933. London: Charles Griffin and Co., Ltd. (10*s.* net.)

Ssobolew, M. N. *Cadmium and the Possibilities of Production in the U.S.S.R.* [In Russian.] Pp. iv + 68. 1933. Moscow, Leningrad, and Swerdlowsk: Metallurgisdat. (Rbl. 1.)

***Statens Provningsanstalt, Stockholm.** *Berättelse över Statens Provningsanstalts Verksamhet under år* 1932–1933. Med. 8vo. Pp. 24. 1933. Stockholm: Statens Provningsanstalt.

Steger, H. *Metallgiesserei.* (System Karnack-Hachfeld: Technische Selbstunderreichts-Briefe.) Lieferung I. Roy. 8vo. Pp. 30. 1933. Potsdam: Bonness und Hachfeld. (R.M. 0.90.)

Trapesnikow, A. K. *Fundamentals of Röntgenography.* [In Russian.] Pp. 188. 1933. Moscow and Leningrad: Gos. techn.-theoret. isd. (Rbl. 5.)

***Union des Industries Métallurgiques et Minières, de la Construction Mécanique Électrique et Métallique, et des Industries qui s'y rattachent.** *Annuaire,* 1933. Demy 8vo. Pp. xix + 457. 1933. Paris: Union des Industries Métalliques (&c.): 7 Rue de Madrid.

***U.S. Department of Commerce, Bureau of Standards.** *Fourdrinier Wire Cloth.* (Second edition.) Commercial Standard CS 36–33. Med. 8vo. Pp. 15. 1933. Washington, D.C.: Superintendent of Documents. (5 cents.)

***U.S. Department of Commerce, Bureau of Standards.** *Report of the National Screw Thread Commission.* (Revised 1933.) (Miscellaneous Publication No. 141). Med. 8vo. Pp. viii + 171, with 56 illustrations. 1933. Washington, D.C.: Government Printing Office. (15 cents.)

Velten, Andreas. *Spanlose Formung der Metalle in Maschinenfabriken durch Giesserei, Schmieden, Schweissen, und Härten.* Band I.—*Formerei und Giesserei.* (Bibliothek der gesamten Technik, 339.) 10, neubearb. Auflage. Pp. xiv + 148. 1933. Leipzig: Max Jänecke. (R.M. 3.20.)

***Verö, J.** *On the Influence of the β-Constituent upon the Properties of* 63 : 37 *Brass.* (Aus den Mitteilungen der berg- und hüttenmännischen Abteilung an der kg. ung. Hochschule für Berg- und Forstwesen zu Sopron, Ungarn. Band V.) 4to. Pp. 7, with 1 figure. 1933. Sopron: Fachter der Rottig Romwalter Druckerei.

***Verö, J.** *Untersuchungen über Gleichgewichtsverhältnisse weiterlegierter Bronzen. III.—Die Kupferreichen Cu–Mn–Sn-Legierungen.* (Aus den Mitteilungen der berg- und hüttenmännischen Abteilung an der kg. ung. Hochschule für Berg- und Forstwesen zu Sopron, Ungarn. Band V.) 4to. Pp. 28, with 26 illustrations. 1933. Sopron: Fachter der Rottig Romwalter Druckerei.

Wagner, Hermann. *Untersuchungsmethoden für die Vernicklungs- und Verchromungspraxis.* Pp. 61. 1933. Leipzig: Jänecke. (M. 1.80.)

***Who's Who, 1934.** An Annual Biographical Dictionary with which is incorporated "Men and Women of the Time." Eighty-sixth year of issue. Post 8vo. Pp. lxiv + 3691. 1934. London: A. and C. Black, Ltd. (60*s.*)

v. Zeerleder, A. *Technologie des Aluminiums und seiner Legierungen.* Pp. 224. 1933. Leipzig: Akademische Verlagsgesellschaft G.m.b.H. (R.M. 14.)

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***Borchers, Heinz.** *Untersuchungen über Beryllium und das System Kupfer–Beryllium.* Dissertation zur Erlangung der Würde eines Doktor-Ingenieurs. Vorgelegt von der Technischen Hochschule, Aachen. 4to. Pp. 13, with 11 illustrations. 1930. Aachen: Bibliothek der Technischen Hochschule.

***Demmer, Arthur.** *Beiträge zur Kenntnis der Lagermetalle auf Blei–Zinn–Basis.* Inaugural-Dissertation zur Erlangung der Doktorwürde einer Hohen Philosophischen Fakultät der Rheinischen Friedrich-Wilhelms-Universität zu Bonn. Med. 8vo. Pp. 46. 1931. Bonn: Verein Studentenwohl e.V.

***Doktár, Boris.** *Produktionsabbau in der Eisengiesserei bei Depressionen.* Betriebliche Massnahmen zur Erhaltung der Wirtschaftlichkeit. Von der Eidgenössischen Technischen Hochschule in Zürich zur Erlangung der Würde eines Doktors der technischen Wissenschaften genehmigte Promotionsarbeit. (Nr. 703.) Med. 8vo. Pp. 91, with 8 illustrations. 1933. Zürich: Bibliothek d. Eidg. Technischen Hochschule.

***Einecke, Werner.** *Das Wolfram in der Weltwirtschaft.* Inaugural-Dissertation zur Erlangung der Staatswissenschaftlichen Doktorwürde der Rechts- und Staatswissenschaftlichen Fakultät der Universität Hamburg. Med. 8vo. Pp. 74. 1930. Hamburg: Universitäts Bibliothek.

***Günther, Georg.** *Die deutsche Rohaluminiumindustrie.* Inaugural-Dissertation zur Erlangung der Staatswissenschaftlichen Doktorwürde der Hohen Philosophischen Fakultät der Universität Leipzig. Med. 8vo. Pp. 78. 1931. Leipzig: Universitäts Bibliothek.

***Moegen, Otto.** *Kritische Untersuchungen zur Kolorimetrischen Bestimmung kleinster Aluminiummengen.* Inaugural-Dissertation verfasst und der Hohen Medizinischen Fakultät der Bayerischen Julius-Maximilians-Universität zu Würzburg zur Erlangung der Doktorwürde. Demy 8vo. Pp. 19. 1931. Würzburg: Universitäts Bibliothek.

***Oesterle, Kurt M.** *Zur Kenntnis der Vorgänge an der Kathode bei der elektrolytischen Nickel–Abscheidung.* Von der Eidgenössischen technischen Hochschule in Zürich zur Erlangung der Würde eines Doktors der technischen Wissenschaften genehmigte Promotionsarbeit. (Nr. 539.) Med. 8vo. Pp. 102, with 22 illustrations. 1928. Zürich: Bibliothek d. Eidg. Technischen Hochschule.

***Rajnfeld, Seweryn.** *Studio di alcuni problemi elastici a due dimensioni.* Tesi presentata al Politecnico Federale Svizzero in Zurigo per il Conseguimento del Grado di Dottore in Scienze Techniche. (N. 730.) 8¾ × 12¼ in. Pp. 24, with 43 illustrations. 1933. Zürich: Bibliothek d. Eidg. Technischen Hochschule.

***Schallbroch, Heinrich.** *Untersuchungen über das Senken und Reiben von Eisen-, Kupfer- und Aluminium-Legierungen.* Von der Technischen Hochschule Aachen genehmigte Dissertation zur Erlangung der Würde eines Doktor-Ingenieurs. 4to. Pp. 23, with 37 illustrations and 8 tables. 1930. Aachen: Bibliothek der Technischen Hochschule.

***Schweitzke, Gunther.** *Über Porositäts-Erscheinungen und- Ursachen in Nichteisenmetallguss.* Dissertation zur Erlangung der Würde eines Doktor-Ingenieurs. Vorgelegt der Technischen Hochschule, Aachen. 4to. Pp. 43, with 57 illustrations. 1931. Aachen: Bibliothek der Technischen Hochschule.

***Wehner, Günter.** *Untersuchungen über die Umwandlungen in fester Phase beim System Kupfer-Gold.* Inaugural-Dissertation zur Erlangung der Doktorwürde einer Hohen Philosophischen Fakultät der Universität, Leipzig. Med. 8vo. Pp. 78, with 11 illustrations. 1931. Leipzig: Universitäts Bibliothek.

***Wiegner, Alfred.** *Über das Verhalten von Carbiden und Siliciden in Legierungen bei der Zersetzung durch Säuren.* Von der Eidgenössischen Technischen Hochschule in Zürich zur Erlangung der Würde eines Doktors der technischen Wissenschaften genehmigte Promotionsarbeit. (Nr. 630.) Med. 8vo. Pp. 51, with 9 illustrations. 1930. Zürich: Bibliothek d. Eidg. Technischen Hochschule.

***Zielinski, Emil.** *Beitrag zur Erforschung der Bedingungen für die chlorierende Verflüchtigung von Metallen.* Dissertation zur Erlangung der Würde eines Doktor-Ingenieurs. Vorgelegt der Technischen Hochschule, Aachen. 4to. Pp. 16, with 19 illustrations. 1930. Aachen: Bibliothek der Technischen Hochschule.

***Zürcher, Max.** *Ein Beitrag zur Analyse der Platinmetalle.* Von der Eidgenössischen Technischen Hochschule in Zürich zur Erlangung der Würde eines Doktors der technischen Wissenschaften genehmigte Promotionsarbeit. (Nr. 558.) Med. 8vo. Pp. 84, with 9 illustrations. 1929. Zürich: Bibliothek d. Eidg. Technischen Hochschule.

XXIV.—BOOK REVIEWS

The Crystalline State. Edited by Sir W. H. Bragg and W. L. Bragg. Volume I.—**A General Survey.** By W. L. Bragg. Med. 8vo. Pp. xiv + 352, with 187 illustrations. 1933. London: G. Bell and Sons, Ltd. (26*s*. net.)

The two text-books, "X-Rays and Crystal Structure" and "An Introduction to Crystal Analysis," published first of all in 1915 and 1928, respectively, which we owe to Sir William Bragg and his son, have been standard English works on the subject of crystal structure and analysis since their appearance. Progress in the science has been so rapid within the last few years that those two books no longer give anything like an adequate picture of the present state of development of the science. Sir William and his son have therefore decided to recast the whole form of the previous books, and here is Volume I of the completely new publication. It gives a complete survey of the whole subject, and forms at the same time an introduction to Volumes II and III, which will be contributed by expert collaborators, and which will deal with X-ray optics, crystallography, space-group theory, technique of analysis, growth and deformation-structures, semi-crystalline bodies, and technical applications. The present volume reviews these and allied subjects in a manner that can be followed by anyone who is interested in the main principles of the subject. It is hoped that the volume will be useful to students who do not require a full treatment. Attempt to commend the book I cannot—the authors' names and their work are more than adequate commendation. I would like, however, to point out how scrupulously fair the author has been in allotting credit to Ewald for the part he played in precipitating the discovery of X-ray diffraction by Laue, Friedrich, and Knipping. One scarcely ever hears of Ewald in this connection. The author's debt to C. T. R. Wilson in the early development of the subject—the author being then a supporter of his father's corpuscular theory of X-rays—is duly acknowledged. One minor point of adverse criticism may, I hope, be permitted. The insertion of 32 plates in the text has apparently interfered greatly with the order of the illustrations. Thus, *e.g.*, I find illustrations 161, 160, 163, 162, 166, 164 following one another in this order of sequence. The same sort of thing occurs in other parts of the book.

The book is well printed on fairly good paper, is well illustrated, and is sold at a reasonable price. Subject and name indices are provided. From the latter I miss the name of Owen; his co-worker, Preston, is referred to in the index, but I can find no reference to the latter's work on the page quoted.—J. S. G. Thomas.

Neuere Wege in der Metallurgie der Lager- und Weissmetalle. Von Friedrich Vogel. Med. 8vo. Pp. iv + 97, with 8 illustrations. 1933. Halle (Saale): Wilhelm Knapp. (Br., R.M. 7.50.; geb., R.M. 8.80.)

This book is intended for the process metallurgist concerned with the recovery of usable metals and alloys from commercial white-metal residues and scrap. From the point of view of physical metallurgy it is of interest in that existing liquation processes are critically examined in the light of a detailed application of the equilibrium diagram of the ternary lead–tin–antimony system. The author rejects the idea that with the type of material which he is considering the liquation operation should be based necessarily on the formation of the so-called eutectic mixture containing tin 55, lead 41·3, antimony 3·6, and copper 0·1 per cent. He points out how the course of liquation and the nature of the final product are influenced by the formation of the tin–antimony β-phase containing 50 per cent. each of tin and antimony, and why in general it is desirable to prevent the formation of this constituent. Methods of working with this object are outlined, and the relation of the character of the product to other dry and wet recovery processes is discussed.

The declared object of the author is not so much to give a detailed account of procedure as to stimulate the re-examination of the theoretical bases of methods of recovery, with special reference to raw materials arising from bearing metals, type metals, die-cast white-metals, and various ashes. In pursuance of this idea, the author, after dealing with the characteristics of the available raw materials, considers the application to these classes of material of pure smelting processes, the Harris process, and electrolysis.

The book should be useful to metallurgists working in this rather specialized field, to whom the list of more than 120 process patents will no doubt be of particular interest.—A. J. Murphy.

Working in Precious Metals. By Ernest A. Smith. With an Introduction by Sir Harold Carpenter. Med. 8vo. Pp. xiv + 400, with 20 illustrations. 1933. London: N.A.G. Press, Ltd., 26–34 Old Street, E.C.1. (15*s*. net.)

The aim of this book, which is especially written for working goldsmiths and silversmiths, is to provide the craftsman with "a scientific insight into the properties and behaviour of the materials with which he works." To this end the author first gives an account of modern views of the nature of metals and alloys and methods of investigating their properties; this is followed by a description of the crystalline structure of metals and the constitution of alloys, in which the construction and use of equilibrium diagrams are explained. Having thus dealt with the theoretical side of the subject, the practical side is introduced by a discussion of the methods and apparatus of melting, casting, mechanical and heat-treatment, and pickling. Gold, silver, and platinum are then each considered, together with their important technical alloys, methods of making and working the alloys being described and an account of their valuable properties given. Finally, the problems associated with soldering, polishing, and enamelling are discussed and a brief survey is given of the methods of collecting, evaluating, and treating waste products from the workshops for the recovery of their precious metal content. A short chapter on substitutes for precious metals (*e.g.* rolled gold, gilt, and plated base metals) concludes the book.

From a life-time spent in the study and working of the precious metals Mr. Smith has obtained a thorough theoretical and practical knowledge of every branch of the subject, and, in addition, he has the gift of presenting his knowledge to others in an easily readable and readily assimilable form, and the book should therefore be of considerable value to those craftsmen who desire to carry out their work in a scientific manner. Unfortunately, there are still far too many workers in precious metals who adopt the old rule-of-thumb methods, and who, when they meet trouble, are inclined to blame the makers of the alloys for supplying faulty metal, whereas the real cause of the trouble is to be found in their incorrect methods of working. With the fierce competition of the present day, satisfactory products are obtained only by the strict adherence to scientific principles in all stages of the fabrication of metals and alloys into useful articles; this applies equally well to precious metals as to base metals, but it is to be regretted that many workers in the precious metals have not yet appreciated this. This book should, however, bring home to them the facts, since one of its chief features is to point out the various faults which can develop by bad working, and to indicate their causes and means for their prevention.

The book is well printed in a large, clear type on good paper, and is well worth the price charged. The only adverse criticism the reviewer can find is to lament the absence of illustrations of modern furnaces, working tools, and testing appliances.—A. R. POWELL.

Das Quecksilber, seine Gewinnung, technische Verwendung und Giftwirkung, mit eingehender Darstellung der gewerblichen Quecksilbervergiftung, nebst Therapie und Prophylaxie. Von Ernst W. Baader und Ernst Holstein. Med. 8vo. Pp. 239, with 21 illustrations. 1933. Berlin: Richard Schoetz. Wilhelmstrasse 10. (Br., R.M. 12.60; geb., R.M. 14.80.)

This work is sub-divided into seven sections, the first of which deals with the chemistry and technology of mercury. Here the occurrence, methods of extraction, and physical properties of the metal are described. This is followed by an account of the uses of (i) the metal, (ii) the inorganic compounds, (iii) the organic derivatives, in industry, scientific work, and in medicine. A brief description of the more important properties and methods of preparation of the better-known inorganic and organic compounds is included in this section. The second and third sections deal with the pathogenic action of mercury and the compounds of mercury, the methods by which it enters the body, and the fate of the metal in the body. The effects of mercury poisoning are also described with illustrative diagrams, some of which are in colour. The fourth and fifth sections deal with pathology and the therapeutics of mercury poisoning. The sixth section deals with the hygiene of the workers in mercury and mercurial compounds, and the final section considers the laws set up in the various countries for the protection of the workers in trades using mercury or mercury compounds.

This is a work which should be read by everyone engaged in work in which mercury takes any part; there is little strictly chemical information in the book, but much information which the worker with mercury ought to possess for his personal safety and well-being.—JAMES F. SPENCER.

Das Rhenium. Von Ida und Walter Noddack. Roy. 8vo. Pp. viii + 86, with 7 illustrations. 1933. Leipzig: Leopold Voss. (R.M. 7.80.)

This monograph presents an account of the knowledge of the newly discovered element rhenium. After a historical introduction the authors discuss the occurrence of rhenium in minerals, extra-terrestrial bodies, and technical residues. They follow this with an account of the isolation of rhenium compounds from (i) oxide minerals, (ii) sulphide minerals, (iii) molybdenum glance, and (iv) technical residues. The fourth chapter deals with the metal itself, and here the preparation, physical and chemical properties are described. The methods of detection and estimation are discussed in Chapter V. In the succeeding six chapters the septa-, sexa-, quinqui-, quadri-, ter-, bi-, and uni-valent compounds of rhenium are dealt with in the order stated. The final chapter discusses the position of rhenium in the periodic classification, and here a table of the wave-lengths of the lines of the arc spectrum of rhenium is included. A bibliography containing 152 references is appended to the book.

The book is exceedingly interesting; it is clearly written and presents an authoritative account of all that is known of the element. The work is most valuable, and it is rendered especially so by the bibliography, and should be in the hands of all chemists.—JAMES F. SPENCER.

Gmelins Handbuch der anorganischen Chemie. Achte völlig neu bearbeitete Auflage. Herausgegeben von der Deutschen Chemischen Gesellschaft. Bearbeitet von R. J. Meyer. System-Nummer 54: **Wolfram.** Sup. Roy. 8vo. Pp. xviii + xi + 397, illustrated. 1933. Berlin: Verlag Chemie G.m.b.H. (R.M. 64; subscription price, R.M. 56.)

The present section of Gmelins *Handbuch* deals with the chemistry of tungsten, and opens with an historical account of the discovery of the metal and the development of its chemistry and industrial applications. This, as is usual in this work, is followed by an account of the distribution of the element in Nature and of the many minerals in which it is found. The element is then considered at great length (88 pages) and in great detail. This is a most illuminating chapter; the following points are considered in order: methods of preparation and manufacture, the physical and chemical properties of the metal, and the methods by which it may be detected and estimated. The alloys of tungsten with antimony, bismuth, zinc, aluminium, titanium, zirconium, tin, hafnium, thorium, lead, vanadium, tantalum, and chromium are described together after the treatment of the metal. The remainder of the book (200 pages) is devoted to the description of the compounds of tungsten, and here, in addition to the better-known compounds, a large number of salts of the homo- and hetero-complex tungstic acids are included.

The work has been compiled with care, thoroughness, and discrimination and presents a very useful and complete account of the state of knowledge of tungsten. It is a book which must find a place in every chemical library.—James F. Spencer.

Der Einfluss der Korrosion auf die Biegungsschwingungsfestigkeit von Stählen und Reinnickel. Von Otto Behrens. (Mitteilungen des Wöhler-Instituts, Braunschweig, Heft 15.) Demy 8vo. Pp. iv + 73, with 38 illustrations. 1933. Berlin: NEM-Verlag G.m.b.H., Schöneberger Ufer 34. (R.M. 3.60.)

Dr. Behrens' research at the Wöhler-Institut is a logical continuation of earlier work, notably that of Hottenrott, conducted in the same institution. Hottenrott confined himself mainly to carbon steels, but Dr. Behrens has now extended the investigation to steels containing nickel, chromium, and tungsten, as well as to pure nickel. The tests were carried out in a machine giving alternating flection under six conditions: (*a*) in air, (*b*) in a jacket through which Brunswick water was run, (*c*) in air, using specimens subjected to a process of surface pressure between rollers, (*d*) in water, using specimens subjected to surface pressure, (*e*) in water with electrochemical protection, (*f*) in water with electrochemical protection, using specimens subjected to surface pressure.

The results show the marked reduction produced by corrosion on the fatigue-strength of most of the ferrous materials; one nickel–chrome steel, tested over 2×10^6 cycles, resisted 44·8 kg. per sq. mm. in air, but only 16·2 kg. per sq. mm. in water. For pure nickel the reduction was merely from 16·4 to 15·8 kg. per sq. mm., whilst a certain nitride-covered steel was found to be almost uninfluenced by corrosion, except where the covering had been damaged. Perhaps the most remarkable feature of the results is the good showing of the specimens subjected to surface pressure between rollers (except in the case of nitride-covered steel). This treatment not only raises considerably the fatigue-strength as obtained by testing in air, but it also brings up the value obtained in water to a level similar to that reached by untreated specimens in air. The character of the attack is also changed in most cases; untreated steels show local rusting starting at surface defects; these defects seem to be removed by the surface pressure, for the treated specimens show comparatively uniform attack leading to rust-coats which tend gradually to peel off. If the results given are typical of the bulk of materials, surface pressure deserves serious consideration as a means of combating both ordinary fatigue and corrosion-fatigue.

The research is a valuable contribution to our knowledge of corrosion-fatigue, and the book, which is well illustrated and satisfactorily printed, should be read by all concerned with that subject.—U. R. E.

Atlas Metallographicus. Von H. Hanemann und A. Schrader. Lieferung 12: Tafel 89–96; Lieferung 13: Tafel 97–104; Lieferung 14: Tafel 105–108. 1933. Berlin: Gebruder Borntraeger. (Lief. 12, R.M. 14; Lief. 13, R.M. 14; Lief. 14, R.M. 16; Band I. (Lief. 1–14) komplett gebunden beträgt, R.M. 128.)

These three parts complete the first volume of the "Atlas," and are concerned principally with the structural appearance of iron and steels after various degrees of working with and without subsequent heat-treatment. Especially interesting to workers in both ferrous and non-ferrous metallurgy are the effects of ball impressions made in hardness testing on the structure of steel immediately under the impression, and crystal growth after recrystallization.

The value of the " Atlas " is considerably enhanced by the four indices included in Part 14: (1) table of contents arranged according to the text in the order in which it appears, (2) index of parts, tables, photomicrographs, and titles in the order of their appearance, (3) author index, and (4) alphabetical index of the subject matter. The volume, as a whole, provides a beautiful and comprehensive yet concise summary of the structural appearance of carbon steels after long cooling and annealing, and should be invaluable as a reference book on the behaviour of this material. (Cf. *J. Inst. Metals*, 1927, **38**, 712; 1929, **42**, 730; 1930, **44**, 762; and 1933, **53**, 606.)—J. H. WATSON.

Journal of the Electrodepositors' Technical Society. Volume VII, 1931–1932. Demy 8vo. Pp. 194, illustrated. 1932. London: Electrodepositors' Technical Society, Northampton Polytechnic Institute, St. John St., E.C.1. (Members, 10*s.* 6*d.*; non-members, 15*s.*)

This volume contains the 13 papers (with discussions) read before the Society during the 1931–1932 session, together with accounts of the Annual Meeting of the Society and of the Faraday Centenary Exhibition. The papers deal with the deposition of nickel, chromium, zinc, and tin, the throwing power of plating baths, metal cleaning prior to plating, and certain historical aspects of plating; all have been abstracted in the *Journal*.—A. R. POWELL.

Handbook for Oxy-Acetylene Welders: a Practical Guide to Oxy-Acetylene Welding. 8vo. Pp. 254. 1933. London: The British Oxygen Company, Ltd. (3*s.* 6*d.* net.)

This is a revised and enlarged edition of the " Handbook for Oxy-Acetylene Welders " by L. M. Fox, published in 1928 by Allen Liversidge, Ltd. Both high-pressure and low-pressure systems are considered. The plant and accessories, instructions for assembling and handling are dealt with in the first six chapters. Elementary instructions in welding technique (including a very short note on " rightward " welding) are then given, with a chapter on precautions as to expansion and contraction, preheating, cooling and annealing, and the use of chills. A general chapter on the properties of metals follows, and detailed instructions are given for welding steels, Cast-iron and malleable iron, aluminium, nickel, copper, and its alloys, Monel metal and Elektron. After a chapter on metal cutting, a discussion of air–acetylene processes—brazing, plumbing, soldering, paint-burning—concludes the main part of the book. Some useful appendices give melting points of metals, flame temperatures, compositions of common alloys, gas cylinder calculations, temperature conversion tables, and the Home Office " Safety Measures " concerning the use of acetylene.

As in the majority of welding text-books, the non-ferrous metals are not treated at sufficient length or with sufficient care. We are amazed to learn that " at the present time, welding processes are not extensively applied to copper and its alloys." Can it be that Cauzler rod is regarded as a solder? The binding, printing, and illustrations of the book are excellent: blank pages are inserted at intervals for welders' notes; and there is a very fine two-page plate showing various types of flame.—H. W. G. HIGNETT.

Electrical Machinery and Apparatus Manufacture. A Complete Work by Practical Specialists Describing Modern Practice in the Construction and Manufacture of Apparatus and Machinery. Edited by Philip Kemp. Cr. 8vo. In seven volumes. Pp. 1820, illustrated. 1931; 1932. London, Bath, Melbourne, Toronto, and New York: Sir Isaac Pitman and Sons, Ltd. (6*s.* per volume.)

In these volumes, the principal products of the electrical industry are grouped under 19 headings, and a series of accounts—more or less detailed—is given of the salient features of each product and the methods used in its manufacture. In addition, four general sections are included, dealing with drawing office practice, electrical materials, testing methods, and works organization, respectively.

The treatment of the various sections is somewhat uneven (perhaps inevitably so where so many authors are concerned), but on the whole it may be said that each presents a readable and interesting account of modern practice in the industry with which it deals.

From the metallurgical viewpoint, it is unfortunate that the section on " Electrical Materials " is one of the weakest. It is decidedly sketchy, and gives an impression of having been " written up " at second hand. For instance, the statement regarding aluminium that " for most engineering purposes the product (of the reduction furnace), which has a purity of 99·2 per cent., need not be further refined " indicates a fundamental misconception of the process. It is admittedly no easy matter to give an intelligible and comprehensive survey of the properties of the large range of raw materials used in the electrical industry in the compass of a few pages. The task is obviously one of selection, and omissions are inevitable. The presence of irrelevant matter is, however, all the more difficult to excuse. Conversational statements such as that tungsten is " the strongest metal known " (p. 462) or that selenium is occasionally found in the metallic state (p. 466) could only be regarded as out of place, even if they were true.

As a contrast, the section contributed by *A. G. Robiette*, on "Electric Furnaces," can be unreservedly recommended. All the principal types of arc and induction melting furnaces and resistance heating furnaces are described and illustrated by photographs and clear diagrammatic sketches. The outstanding constructional details are discussed, and the methods of lining melting furnaces deals with in some detail. The result is a remarkably complete account of modern electric furnace construction. Few omissions call for notice. Rather more attention might perhaps have been given to the use of forced air circulation in low-temperature furnaces (American practice is not mentioned) and to the precautions necessary to secure uniform heating in resistance furnaces generally.

Two other sections, "Primary Cells" and "Accumulators," may be mentioned for their metallurgical interest. These contain, respectively, descriptions of the construction of zinc electrodes and accounts of the casting and welding of lead accumulator plates.

Regarding the volumes as a whole, their greatest appeal will undoubtedly be to the young student. They are not sufficiently detailed to be reference books, and in general are too elementary to be of great value to those engaged in the industries described. They do, however, contain in convenient form a good deal of information which is not generally available. The complete series could be read with considerable profit by any engineering student.

—J. C. Chaston.

Seibt Export Catalogue. Official Handbook of the Federation of German Industries. (Reichsverband der Deutschen Industrie.) 1932–1933. Edited by Artur Seibt. 8¼ × 11¼ in. Pp. 32 + 55 + 520 + 200. München: M. Müller & Son.

The first section of the catalogue deals with the Federation of German Industries and its organization, the second section gives a list of products with their classification number arranged alphabetically, and the third section provides a classified list of suppliers of the various products with their addresses, the products supplied being given in red in a side-column under their classification number. In the fourth section the firms which supply the goods in the 164 classes are arranged in alphabetical order in each class. With this arrangement it is possible to discover very quickly the firms who supply a given article or the products manufactured by a given firm. Spanish, French, German, and English equivalents of the names of the products are given in most cases.—A. R. Powell.

Chemical Engineering and Chemical Catalogue. A Catalogue of Heavy and Fine Chemicals, Raw Materials, Machinery, Plant, and Equipment Applicable to Production Industries, Standardized, Condensed and Cross-Indexed. Edited by D. M. Newitt. Compiled with the co-operation of leading British manufacturers. Ninth edition. Demy 4to. Pp. 107 + 62 + 25 + 10 + 77 + lxxiii. 1933. London: Leonard Hill, Ltd., 231–232 Strand, W.C.2. (10*s.* net.)

This year's edition of this now well-known catalogue is almost identical with the 1932 edition except that the thumb indentations for finding the various sections have been replaced by protruding bookmarks. The Main Index and the Book Bibliography section have been brought up-to-date, but no changes appear to have been made in the section devoted to Data and Tables. The firms taking space this year number 77; in addition, there are advertisements of seven publishers.—A. R. Powell.

Who's Who, 1934. An Annual Biographical Dictionary with which is incorporated "Men and Women of the Time." Eighty-sixth year of issue. Post 8vo. Pp. lxiv + 3691. 1934. London: A. & C. Black, Ltd. (60*s.*)

Each year "Who's Who" increases in usefulness and in bulk. The 1934 volume is 40 pages larger than its predecessor—a fact that suggests the addition of many hundreds of new biographies to last year's total of "about 40,000" (the publisher's estimate). "Who's Who" is far from being merely a chronicle of those who have achieved distinction in Britain. It knows no international boundaries. Workers of all countries are included in its extensive pages. Thus the first two entries refer to a Welshman and a Persian, respectively; whilst the two biographies ending the volume deal with "Z.'s" residing, respectively, in Natal and U.S.A.

This monumental work is invaluable to those who have occasion to keep in touch with the activities of leaders in the various branches of human activity throughout the world.

Of all the non-technical books of reference received at the Institute of Metals the one that would be missed most—could its non-appearance be imagined—would be this splendidly compiled set of biographical notices.—Ed.


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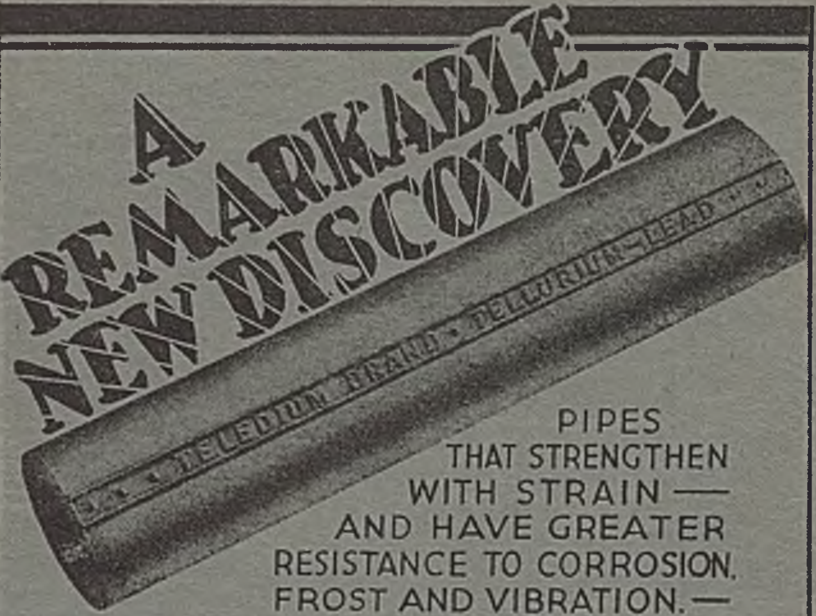

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