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

Vol. 1. Part 2.

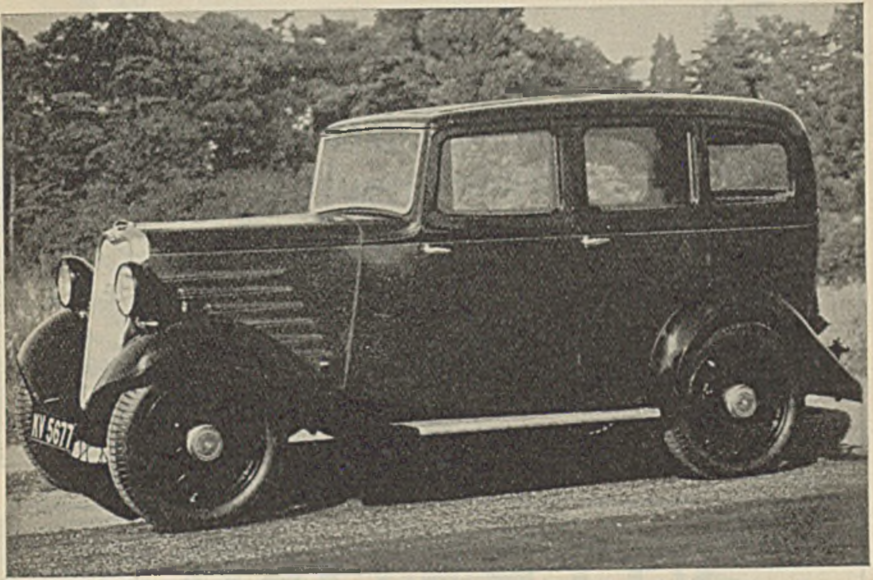
The Monthly Journal of the
INSTITUTE OF METALS

and

METALLURGICAL ABSTRACTS

FEBRUARY, 1934

THE "MONTHLY JOURNAL" NOW CONTAINS ADVANCE COPIES OF PAPERS TO BE PRESENTED AT THE GENERAL MEETINGS OF THE INSTITUTE. NO OTHER ADVANCE COPIES WILL BE ISSUED.



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This is the first American book since 1924 which attempts a complete restating of metallurgical ideas in terms of the new discoveries of physics. The German and English viewpoints are fully recognized and reviewed. Emphasis is placed on properties, treatment, and fabrication, with less than the usual attention to methods of concentration.

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By Members of the Institute of Metals.

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

METALLURGIST (1st Class Hons.), aged 27, seeks new post. 1 year's research oxidation of mild steel; 5 years works' assistant large non-ferrous company, with experience in casting, drawing office, furnace design and construction, erection, concrete work, etc. (Box No. 15.)

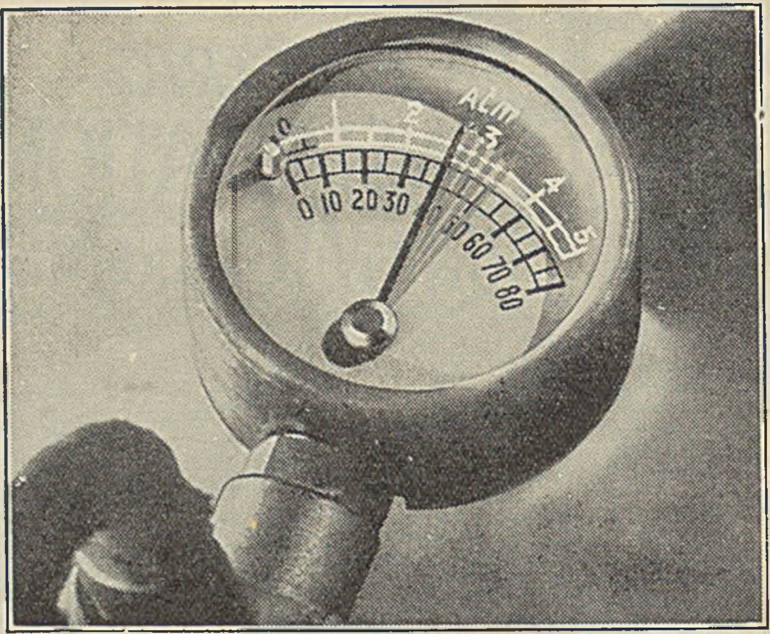
Enquiries in connection with these advertisements should be addressed to the Box numbers given, Institute of Metals, 36 Victoria Street, London S.W.1.

PAPERS FOR AUTUMN MEETING

Authors who desire to submit papers for presentation at the Autumn Meeting of the Institute should advise the Secretary of the subject of their proposed papers as early as possible.

MSS. must be submitted in duplicate not later than April 30. For requirements as to the form of illustrations, see p. 4 of the January issue of the *Monthly Journal*.

View of a G.E.C. Furnace installation for the Grünewald process at the works of the Hall Street Metal Rolling Co., Ltd., Birmingham.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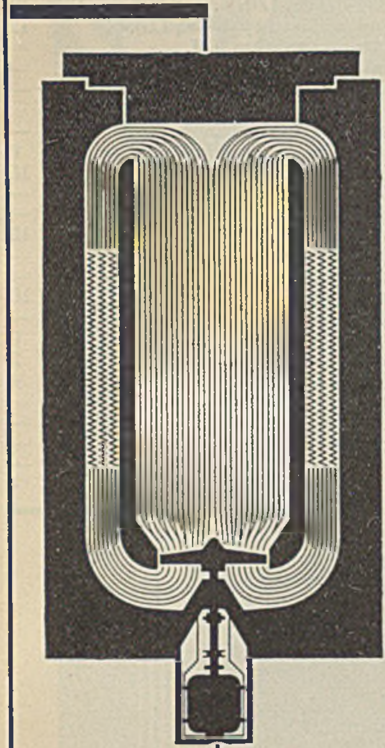
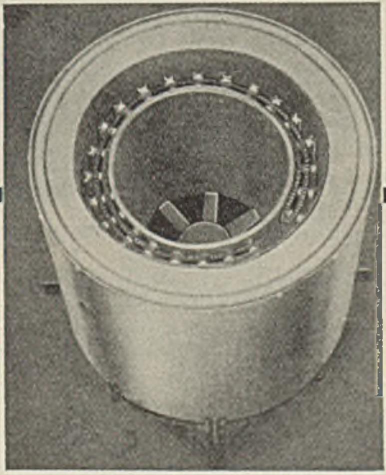
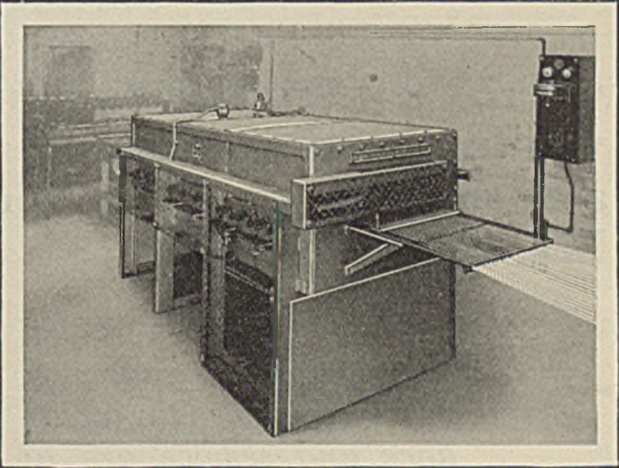




INDEX TO ADVERTISERS

FEBRUARY, 1934



EDITORIAL OFFICE:
36 Victoria Street,
London, S.W.1.

TELEPHONE:
Victoria 3320.

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

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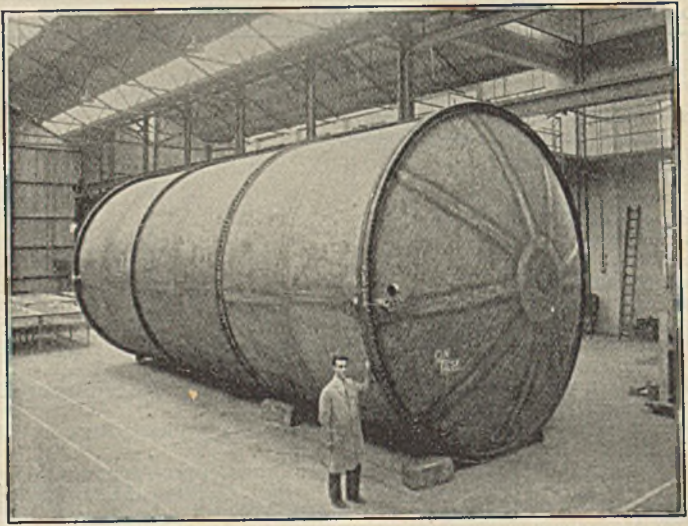
S. C. GUILLAN.

Volume 1 **FEBRUARY, 1934** **Part 2**

CONTENTS

METALLURGICAL ABSTRACTS

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



ANNUAL GENERAL MEETING, LONDON

MARCH 7–8, 1934.

As announced in the *Monthly Journal* for January, the Twenty-Sixth Annual General Meeting will be held in the Hall of the Institution of Mechanical Engineers, Storey's Gate, Westminster, London, S.W.1 (by kind permission of the Council of that Institution), on Wednesday, March 7, and Thursday, March 8. A detailed programme of the meeting was posted to each member on January 26, together with a form intended to be used to apply for tickets for the Annual Dinner and Dance on March 7; the visit to the Post Office Engineering Research Station, Dollis Hill, on March 8; and for luncheons on March 7 and 8.

Members are requested to return the reply form as soon as possible if they propose to take part in any of the functions outlined in the programme. Additional copies of the programme and/or reply form will be forwarded should they not have been received, or should they have been mislaid.

Papers at Annual General Meeting.

The following is a list of the papers that are expected to be presented for discussion at the Annual General Meeting (in the order given in the programme already posted to members):—

Serial No.

651. Gough, H. J., M.B.E., D.Sc., Ph.D., F.R.S., H. L. Cox, B.A., and D. G. Sopwith, B.Sc.Tech.: "A Study of the Influence of the Intercrystalline Boundary on Fatigue Characteristics."
652. Pearson, C. E., M.Met.: "The Viscous Properties of Extruded Eutectic Alloys of Lead–Tin and Bismuth–Tin."
653. Hankins, G. A., D.Sc.(Eng.), A.R.C.S., and C. W. Aldous, B.Sc.(Eng.), A.C.G.I.: "Minimum Dimensions of Test Samples for Brinell and Diamond Pyramid Hardness Tests."
654. Portevin, Professor A., and P. Bastien, Dr.-es-Sci.: "Castability of Ternary Alloys."
655. Taylor, R., B.A., B.Sc.: "Transformations in the Copper–Palladium Alloys."
656. Sloman, H. A., M.A.: "Alloys of Silver and Beryllium."
657. Rigg, Gilbert: "The Diffusion of Zinc and Iron at Temperatures below the Melting Point of Zinc."
658. Phillips, C. E., A.C.G.I., D.I.C., and J. D. Grogan, B.A.: "Transverse Tests on Sand-Cast Aluminium Alloy Bars."
659. Hanson, Professor D., D.Sc., Vice-President, and E. G. West, Ph.D.: "The Constitution of Copper–Iron–Silicon Alloys."
660. Fell, E. W., Dr.-Ing., M.Sc.: "A Note on Some Formulæ Concerning Viscous and Plastic Flow in Soft Metals."
661. Slater, I. G., M.Sc., Ph.D.: "Note on the Influence of Gases in an 8 Per Cent. Copper–Aluminium Alloy on Normal and Inverse Segregation."

The following papers will be formally presented on March 8, but will not be discussed; they will be printed in the *Monthly Journal* for March:—

662. Ellis, O. W., M.Sc.: "The Malleability of Nickel and Monel Metal."
663. Haughton, J. L., D.Sc., and R. J. M. Payne, B.Sc.: "The Constitution of the Alloys of Magnesium in Nickel."

With the exception of the two latter papers, all the above have been published in recent issues of the *Monthly Journal*, beginning with that dated November 1933.

Annual General Meeting

Members should bring to the meeting copies of the *Monthly Journal* containing papers in which they are interested as no separate copies will be available.

Members who are unable to attend the meeting are invited to discuss the papers by correspondence. Such written discussion should be received by the Secretary not later than the date mentioned at the head of each paper.

Annual Dinner and Dance.

It is hoped that as many members as can possibly do so will attend the meetings, visit, and dinner. At the latter the speeches will be short, in order to leave as much time as possible for the dance that follows. Tickets for the dinner and dance—price 15s. each—can now be obtained from the Secretary. Application may conveniently be made on the previously circulated reply form.

Among those who have accepted the invitation of the Council to be the guests of the Institute at the dinner are:

Engineer Vice-Admiral H. A. Brown (Engineer-in-Chief, The Admiralty), Sir John Campbell (Chairman, International Tin Research and Development Council), Lieut.-General Sir J. Ronald E. Charles (Master-General of the Ordnance, War Office), C. Day, Esq. (President, Institution of Mechanical Engineers), Air-Marshal Sir Hugh Dowding, Dr. J. T. Dunn (President, Society of Chemical Industry), Sir George Higgins (President, Institute of Marine Engineers), Miss E. M. Kennedy (President, Women's Engineering Society), Sir William Larke (President, Institute of Fuel), W. Macnab, Esq. (President, Institution of Chemical Engineers), The Rt. Hon. The Lord Melchett of Landford, Sir Joseph Petavel (Director, National Physical Laboratory), Bryan Pontifex, Esq. (Master, Worshipful Company of Armourers and Braziers), J. H. Silley, Esq. (President-Elect, Institute of Marine Engineers), Sir Frank Smith (Secretary, Department of Scientific and Industrial Research), Professor J. F. Thorpe (President, Institute of Chemistry of Great Britain and Ireland), H. T. Tizard, Esq. (Rector, Imperial College of Science and Technology), C. E. Williams, Esq. (President, Institute of British Foundrymen), H. E. Wimperis, Esq. (Director of Scientific Research, Air Ministry).

The Post Office Engineering Research Station.*

The Post Office Engineering Research Station at Dollis Hill, which members are to visit on March 8, consists of a main general research block with a large frontage facing south, connected to a central block and to independent laboratories by covered ways, with workshops at the rear, covering a site of 8 acres. The architectural features of the building have been kept on simple lines, brick being used for the facings generally, with a limited amount of stone dressings added in the case of the General Research block.

Internally, the laboratories and offices are finished in a simple manner, rubber being used on the corridors and staircases. The allocation of the various buildings can be seen from the key plan (Fig. 2).

This Research Station was designed by A. R. Myers, Esq., O.B.E., F.S.I., A.R.I.B.A., of His Majesty's Office of Works, and was officially opened by the Prime Minister in October 1933. Previously from 1921, research work was carried out in ex-army huts on the same site.

The following short account of metallographic, spectrographic, and chemical work carried out will be of special interest to the members of the Institute of Metals.

The small Metallographic Laboratory is equipped with two metallurgical microscopes of the Le Chatelier type, one Leitz (arc illumination) and the

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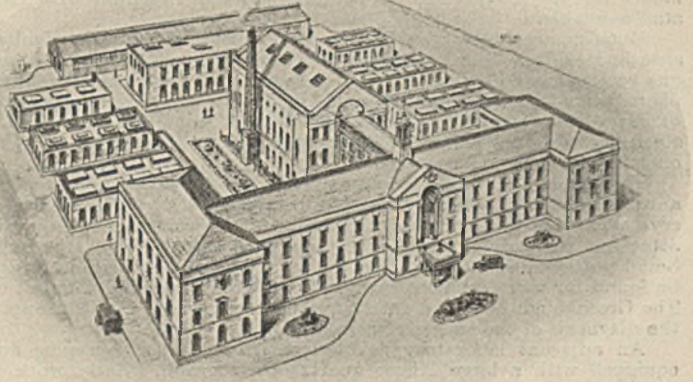
* We are indebted to the Institution of Electrical Engineers for permission to reproduce the two figures illustrating this article.—Ed.



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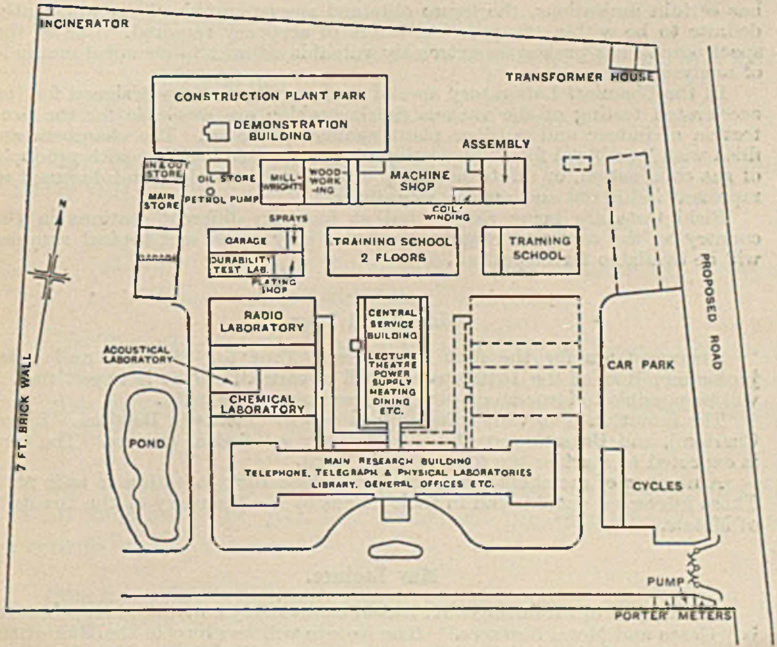
INCINERATOR
TRANSFORMER HOUSE
CONSTRUCTION PLANT PARK
DEMONSTRATION BUILDING
ASSEMBLY
IN & OUT STORE
MAIN STORE
GARAGE
OIL STORE
PETROL PUMP
MILL-WRIGHTS
WOOD-WORK-ING
MACHINE SHOP
COIL WINDING
SPRAYS
N
GARAGE
DURABILITY TEST LAB.
PLATING SHOP
TRAINING SCHOOL 2 FLOORS
TRAINING SCHOOL
PROPOSED ROAD
RADIO LABORATORY
CENTRAL SERVICE BUILDING
LECTURE THEATRE POWER SUPPLY HEATING DINING ETC.
ACOUSTICAL LABORATORY
CHEMICAL LABORATORY
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POND
MAIN RESEARCH BUILDING
TELEPHONE, TELEGRAPH & PHYSICAL LABORATORIES
LIBRARY, GENERAL OFFICES ETC.
CYCLES
PUMP
PORTER
METERS

FIG. 2.

other Beck (Pointolite illumination). The final polishing and etching of the samples for examination and the development of the photographic negatives obtained from the metallographs are carried out in the same room. This makes for speed and ease of working, which is essential with the limited staff available.

Much pioneer work was done in connection with extrusion faults in lead-sheathed cables. The metallurgical sub-group is consulted by other groups and sections in connection with the diagnosis of the cause of failure of telephone parts with a view to change of material or alteration in design. Moreover, problems come from further afield. The undue wearing of the hardened steel discs used for the cancellation of postage stamps may be instanced as one submitted by the postal side.

The corrosion of underground cables is a problem of considerable importance to the Post Office. Generally speaking, electrolysis causes an inter-crystalline attack of the metal, whilst chemical corrosion shows no preferential attack at the crystal boundaries, but gives a dendritic etch of the metal. Small potholes, which when cleaned show an inter-crystalline attack, are to be found far more frequently with electrolytic than with chemical corrosion. The Greenhough binocular microscope is used extensively in connection with the diagnosis of the causes of corrosion.

An adjacent laboratory devoted entirely to spectrographic analyses is equipped with a large Hilger quartz spectrograph. Early work was of a qualitative nature, and chiefly concerned with such parts as thoriated tungsten valve filaments and relay contacts. During the past two or three years calibration data have been obtained enabling results from certain alloys to be expressed on a quantitative basis. The method adopted has been that using the rotating logarithmic sector, and the Post Office was one of the pioneers in the use of this method for cable sheath alloys. While the method has certain limitations, the figure obtained spectrographically is sufficiently definite to be within the practical limits of accuracy required. Use of the spectrograph has proved an extremely valuable adjunct to chemical methods of analysis.

In the Chemical Laboratory special chambers have been designed for the accelerated testing of the various finishes which are available for the protection of indoor and outdoor plant against corrosion. The chambers are filled with "artificial fogs" consisting of either water together with products of gas combustion, or dilute sulphuric acid, or salt solution, and designed to represent industrial and marine atmospheres.

Field tests are being carried out at fourteen different stations in the country on the corrosion of galvanized-iron stay wires, and typical samples will be available for inspection.

Educational Tour.

Arrangements for the first Educational Tour for Students and other junior members of the Institute are well advanced, and it is hoped that it will be possible to issue a complete programme very shortly.

The intention is to visit metallurgical establishments in Belgium. Liége, Charleroi, and Brussels have been tentatively selected as centres. The tour is expected to start in the first week in April.

A number of members have already signified their intention to take part. Those interested should send in their names to the Secretary of the Institute of Metals.

May Lecture.

The subject of Professor E. K. Rideal's previously announced May Lecture is "Gases and Metal Surfaces." The lecture will be given in the Hall of the Institution of Mechanical Engineers, at 8 p.m., on Wednesday, May 9. Cards of invitation will be issued next month. Visitors are cordially invited.

1934 Autumn Meeting.

The Council has received from local members and friends of the Institute "a cordial invitation to hold the Institute's Autumn Meeting this year in Manchester."

The invitation has been gladly accepted, and arrangements are now being made to draw up a programme for the meeting, which will be held in September. This will be the third meeting of the Institute to take place in Manchester, previous Autumn Meetings having been held in that city in 1909 (under the presidency of the late Sir William White) and in 1923, when Mr. Leonard Sumner occupied the presidential chair.

Papers are invited for the Manchester Meeting. The Editor should be advised as soon as possible by intending authors when their MSS. may be expected.

Membership Additions.

The following persons were duly elected on January 18, 1934 :—

As Members.

Name.	Town.
Beddows, John Derek, B.Sc.	Birmingham.
Burkhardt, Arthur, Dr.-Ing.	Frankfurt-am-Main, Germany.
McFarland, David Ford, A.B., A.M., M.S., Ph.D.	Pennsylvania, Pa., U.S.A.
Mazzola, Mario	Turin, Italy.
Mehl, Robert Franklin, B.S., Ph.D.	Pittsburgh, Pa., U.S.A.
Mitchinson, Robert	Newcastle-on-Tyne.
Mukumoto, Wasaburow, B.Sc. (Tokyo)	Osaka, Japan.
Siff, Alfred, M.A., A.R.S.M.	Johannesburg, South Africa.
Slater, Horace	Sydney, N.S.W., Australia.
Storke, Arthur Ditchfield	London.
Warrington, Harold George	Slough.

As Student Members.

Homer, Charles Egbert, B.Sc., Ph.D.	London.
Jenkins, John Ephraim	Treharris, Glamorgan.

Nomination of New Members.

The Council would welcome the assistance of members in making good the losses that have occurred recently through deaths and resignations, though these are appreciably lower than was the case a year ago. Intending members might usefully be advised that the present is a particularly appropriate moment to apply for membership. **The first subscription covers the extended period ending June 30, 1935,** instead of the usual twelve months; whilst it brings a corresponding extra number of *Journals*. A convenient means of introducing the work of the Institute to non-members is to be found in the newly issued folder—"The Institute of Metals; Its Aims and Objects"—copies of which can be obtained from the Secretary. A membership form will be found in each folder, as well as in each recently issued (bound) volume of the *Journal*. Nominations should be addressed to the Secretary; **the next election is due to take place on April 5, 1934.**

LETTERS TO THE EDITOR

The Monthly Journal.

Extracts from letters received recently from members overseas :

D. M. Davidson (Germiston, Transvaal) writes : "I have pleasure in stating that the *Monthly Journal* reaches me regularly. Overseas members look forward very much to the *Journal* and *Proceedings* of the Institute, and to be constantly in touch through them with the latest developments of the metal industries."

O. W. Ellis (Toronto, Canada) writes : "It is an excellent idea to keep contacts between the parent organization and outlying posts through the *Monthly Journal.*

"The new development regarding the issue of papers I feel to be well worth while. I noticed in one of the recent *Monthly Journals* that such a move was likely to be made, but had not realized the significance of the new arrangement until my attention was called to the effect it might have on overseas members."

N. Hackney (Moghalpura, Punjab, India) writes : "The Council are to be congratulated on the marvellous 'service' that the Institute gives its members. I assure you that I look forward to the regular arrival of the *Monthly Journal* and the *Proceedings* with eagerness, as I find that the information they afford is not only of scientific interest, but of the greatest practical value to me in my professional work."

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 March issue of the Monthly Journal *should reach the Editor not later than February 25.*

Mr. A. J. Aiers has been appointed Works Superintendent, Sunbeam Motor Company, Wolverhampton.

Mr. John Cartland, M.C., M.Sc., has been appointed a Director of Fry's Metal Foundries, Ltd., London. He joined the Institute in 1910, being then a student of metallurgy in the University of Birmingham working under Professor Turner. He graduated in 1911 and was afterwards with Messrs. James Cartland and Sons, brassfounders, Birmingham, until the outbreak of war when he obtained a commission in the Royal Warwickshire Regiment. On demobilization in 1920 he was appointed Manager of the Manchester branch of Fry's Metal Foundries, leaving there in 1929 to take up a London appointment with the firm. Jointly with other authors he contributed papers in 1922 on "White Metals" and in 1923 on "Stereotyping".

Mr. G. W. Gibson has been appointed a Director of Messrs. Fry's Metal Foundries, Ltd. He has been a member of the Institute since 1918.

Mr. Harold J. Roast is now acting in the capacity of technical advisor to the Canadian Bronze Company, Ltd. This organization operates six plants between Montreal and Calgary.

Dr. W. Rosenhain, F.R.S., has been elected an Honorary Fellow of the Society of Engineers.

Mr. J. P. Saville has recently returned from the Taquah & Aboso Mines, Gold Coast Colony, West Africa. Letters may be addressed to him at 33 Astley Road, Handsworth, Birmingham.

Obituary.

Professor William Edward Gibbs, D.Sc., Ramsay Professor of Chemical Engineering at University College, London, died of blood-poisoning on January 18 at the age of 44. A member of the Institute since 1917, he had acted as Investigator to the Corrosion Research Committee of the Institute and was joint author of the Third Report to the Committee.

Grand'uff.-Ing. Luigi Orlando, President of the Societa Metallurgica Italiana, Milan, and a member of the Institute since 1925, died on November 1, 1933. His son, Cav. Uff. Dr. Salvatore Orlando, has been elected a member of the Institute in his place, Dr. Orlando being Managing Director of the Societa.

LOCAL SECTIONS NEWS

SYNOPSES OF PAPERS TO BE READ IN MARCH.

London Section.

Spectroscopic and Microchemical Analysis of Metals and Alloys. By G. Barr, B.A., D.Sc., and Miss I. H. Hadfield, M.Sc. (*March* 15.)

Spectroscopic methods of examination will be described with reference to: (1) apparatus and technique for the production of spectrograms; (2) identification of important lines: simplification of mixed spectra by the use of *raies ultimes*; (3) qualitative work: (*a*) detection of traces of impurities; (*b*) examination of very small quantities; (4) quantitative analysis: (*a*) by comparison with standard samples; (*b*) by the internal standard method: (i) as used by Gerlach, (ii) with the aid of densitometric accessories. Qualitative microchemical analysis will be dealt with under the following headings, with illustrations from tests for cations: (1) early development; (2) essential features of a test to be used in chemical microscopy; (3) apparatus and technique; (4) separations; (5) spot tests.

North-East Coast Section.

The Flow of Metals in the Extrusion Process. By C. E. Pearson, M.Met. (*March* 13.)

A brief survey of the chief methods which have been used in studying the course of flow in material undergoing extrusion. These involve the use of (*a*) composite wax or plasticine billets, (*b*) composite metal billets, (*c*) etched sections of extruded billets. An adaptation of Siebel and Hühne's method, in which metal billets are sectioned longitudinally and inscribed with a grid pattern prior to extrusion, will be described and its application to the comparison of flow in the direct and inverted processes illustrated. This method has also been used in tracing the origin of extrusion defects and in investigating the flow of metal through dies of varying profile.

Scottish Section.

Annual General Meeting. (*March* 12.)

Following the business of the Annual General Meeting of the Section, a paper will be read by Mr. J. Arnott.

Sheffield Section.

" Nickel–Chrome " Plating. By F. Mason. (*March* 9.)

A historical survey of chromium plating leading to the introduction of " nickel–chrome " plating. The interest displayed in the industry is shown by the number and type of patents on the subject. Some notes are given on the preparation of various metals (ferrous and non-ferrous) prior to chromium plating, and the following are also dealt with; treatment after plating; types of electrolytes and anodes used; electrical and temperature conditions employed for specific deposits and their influence on the resultant deposited metal; properties of " direct " and " nickel–chrome " plating; thick deposits for " building up " and corrosion protection; porosity of deposits in relation to life of the latter; throwing power; dull and bright deposits; methods of exhausting fumes from plating baths; the applications of " direct " and " nickel–chrome " plating to many industries are indicated.

Swansea Section.

Discussion on Rolling. Professor L. Taverner, A.R.S.M., will open a general discussion on " Rolling." (*March* 13.)

Local Sections News

DISCUSSIONS AT RECENT MEETINGS

Scottish Section.

Factors in the Solidification of Molten Metals. By S. W. Smith, C.B.E., D.Sc., A.R.S.M. (*Jan.* 15.)

In the course of the discussion the lecturer was thanked for his exposition of the phenomenon of "inverse segregation," and in reply referred to an interesting experiment by Rosenhain and Archbutt who found that by making a cylindrical "slush" casting of an aluminium–copper alloy containing 12 per cent. copper, *e.g.* by pouring out the central portions before solidification was completed, evidence was obtained that inverse segregation had taken place even in the short time necessary to bring about the solidification of the cylindrical shell.

It was pointed out that, in the case of alloys having a range of solidification, inverse segregation usually occurs when the metal is cast under ordinary working conditions in chill moulds, but that if heat is withdrawn more uniformly, as in the case of sand castings, there is less tendency towards segregation.

The question was raised as to whether it is possible that the first formed "primaries" of certain alloys may not form crystal aggregates before actual solidification. In reply, the lecturer expressed his belief that some analogy might be found to the "liquid crystals" originally described by Lehmann. Certain dendritic structures often appear to show clear evidence of the stages by which portions have become detached from the "stalks" and have formed rounded globules during solidification.

Conversely, it has been shown by Bornemann that during the stages of melting, the aggregates of Cu_2Sb have a continued existence in the molten state, and Ellis has suggested a similar possibility in regard to the aggregates of SnSb.

Arising from certain analogies between under-cooled eutectics and the effects of "modification" by the addition of certain well-known reagents, some discussion arose regarding the change of balance which occurs as the result of the application of this process to the aluminium–silicon alloys and to certain complex manganese–bronzes containing aluminium and zinc.

The lecturer's remarks on the relative miscibilities of metals were further illustrated by examples in which metals, such as silver and nickel, although immiscible, could be rendered miscible within certain limits by the intervention of copper and zinc.

Sheffield Section.

Modern Application of Electric Heat. By J. C. Howard, B.Met. (*Dec.* 8.)

In the discussion it was explained that there was no reason why induction furnaces of the Ajax–Wyatt type should not be used for the melting of standard silver, but, so far as the author knew, this had never been done, most probably because it was doubtful if any firm had sufficient output of silver to keep such a furnace in regular use. It was explained that since it is necessary to leave some molten metal in the furnace after each heat, uninterrupted working was essential to reap full benefit from the furnace. High-frequency induction furnaces are being used for silver melting.

It was suggested that blisters formed on standard silver when annealed in a hydrogen atmosphere were caused by the reduction of oxides, and that high furnace temperature and high hydrogen concentration both promoted the formation of blisters.

If care were used, there was no risk of dangerous explosion due to the use of hydrogen in bright heat-treatment furnaces. The air could either first be swept out by some inert gas such as nitrogen or alternatively before the furnace was closed the hydrogen could be lit to form a jet at its point of entry, then after the furnace was closed all the oxygen would be burnt away without any explosion. Risk of explosion was also obviated by incorporating blow-off valves or seals in the furnace design.

In the prevention of dezincification from zinc-containing alloys, it was pointed out that over-correction of the zinc vapour pressure in the furnace chamber had to be avoided, and that by annealing in the presence of free zinc over-correction could result in the deposition of zinc.

MEETINGS OF OTHER SOCIETIES

FRIDAY, FEBRUARY 16.

INSTITUTION OF WELDING ENGINEERS, MIDLANDS BRANCH.—R. A. Stephen: "Developments in Connection with the X-Ray Testing of Welds." (James Watt Memorial Institute, Gt. Charles St., Birmingham.)

SATURDAY, FEBRUARY 17.

INSTITUTE OF BRITISH FOUNDRYMEN, EAST MIDLANDS BRANCH, LINCOLNSHIRE SECTION.—J. Sherwood: "General Foundry Practice." (Technical College, Monks Rd., Lincoln, at 7 p.m.)

INSTITUTE OF BRITISH FOUNDRYMEN, WALES AND MONMOUTH BRANCH.—E. Wautier: "Coke and its Use in Modern Foundry Practice." (University College, Newport Rd., Cardiff, at 6.30 p.m.)

TUESDAY, FEBRUARY 20.

UNIVERSITY OF LONDON, KING'S COLLEGE.—H. J. Gough: Course of three Lectures on "Fatigue of Metals." Lecture I.—"General Characteristics of Fatigue." (Dept. of Mechanical Engineering, King's College, Strand, London, W.C.2, at 5.30 p.m.)

THURSDAY, FEBRUARY 22.

ELECTRODEPOSITORS' TECHNICAL SOCIETY.—Birmingham Conference. A. W. Hothersall, S. G. Clarke, and D. J. Macnaughtan: "The Electrodeposition of Tin from Sodium Stannate Solutions with the Use of Insoluble Anodes"; L. Wright: "The Maintenance of Solutions for Plating Rolled Zinc and Zinc-Base Die-Castings." (James Watt Memorial Institute, Gt. Charles St., Birmingham, at 4.30 p.m. and 6.45 p.m.)

INSTITUTE OF BRITISH FOUNDRYMEN, LANCASHIRE BRANCH, JUNIOR SECTION.—E. Flower: "Foundry Progress during the Past Thirty Years." (Engineers' Club, Albert Sq., Manchester, at 7 p.m.)

INSTITUTION OF STRUCTURAL ENGINEERS.—W. Rosenhain: "Metallic Materials of Construction." (10 Upper Belgrave Sq., London, S.W.1, at 6.30 p.m.)

SATURDAY, FEBRUARY 24.

INSTITUTE OF BRITISH FOUNDRYMEN, NEWCASTLE-ON-TYNE AND DISTRICT BRANCH.—A. Logan: "The Work of the Institute's Technical Committee." (Neville Hall, Newcastle-on-Tyne, at 6.15 p.m.)

TUESDAY, FEBRUARY 27.

UNIVERSITY OF LONDON, KING'S COLLEGE.—H. J. Gough: Course of three Lectures on "Fatigue of Metals." Lecture II.—"Corrosion-Fatigue." (Dept. of Mechanical Engineering, King's College, Strand, London, W.C.2, at 5.30 p.m.)

WEDNESDAY, FEBRUARY 28.

INSTITUTION OF WELDING ENGINEERS, NORTH-WESTERN BRANCH.—J. H. Patterson: "Recent Advances in the Technique and Application of Electric Welding." (College of Technology, Sackville St., Manchester, at 7.30 p.m.)

NORTH-EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS, GRADUATES' SECTION.—W. Pratt: "Thermocouples." (Bolbec Hall, Newcastle-on-Tyne, at 7.15 p.m.)

SATURDAY, MARCH 3.

INSTITUTE OF BRITISH FOUNDRYMEN, LANCASHIRE BRANCH.—A. Logan: "Some Aspects of Non-Ferrous Founding." (Engineer's Club, Albert Sq., Manchester, at 4 p.m.)

TUESDAY, MARCH 6.

UNIVERSITY OF LONDON, KING'S COLLEGE.—H. J. Gough: Course of three Lectures on "Fatigue of Metals." Lecture III.—"More Fundamental Aspects of Fatigue." (Dept. of Mechanical Engineering, King's College, Strand, London, W.C.2, at 5.30 p.m.)

WEDNESDAY, MARCH 7.

INSTITUTE OF BRITISH FOUNDRYMEN, LANCASHIRE BRANCH, PRESTON SECTION.—H. P. Smith: "Metal Treatment by the Oxy-Acetylene Process." Illustrated by Cinematograph Film. (Technical College, Corporation St., Preston, at 7.30 p.m.)

SATURDAY, MARCH 10.

INSTITUTE OF BRITISH FOUNDRYMEN, WEST RIDING OF YORKSHIRE BRANCH.—E. Longden: "Porosity." (Technical College, Bradford, at 6.30 p.m.)

WEDNESDAY, MARCH 14.

INSTITUTION OF WELDING ENGINEERS, LONDON BRANCH.—H. W. Hawkins: "The Collation of Research and Application for Welded Fabrications." (Institution of Mechanical Engineers, Storey's Gate, London, S.W.1, at 7.45 p.m.)

MANCHESTER METALLURGICAL SOCIETY.—A. R. Raper: "The Platinum Metals." (Engineers' Club, Albert Sq., Manchester, at 7 p.m.)

FRIDAY, MARCH 16.

INSTITUTION OF WELDING ENGINEERS, MIDLANDS BRANCH.—S. E. Evans: "Some Aspects of Weld Strengths as Affecting Design." (James Watt Memorial Institute, York Rd., Gt. Charles St., Birmingham.)

Subject to revision. Not to be published, wholly or in part, until presented at a Meeting to be held on March 7, 1934, at 10 A.M., in the Hall of the Institution of Mechanical Engineers, Storey's Gate, Westminster, London, S.W.1.

REPORT OF COUNCIL

for the Year ended December 31, 1933.

The Council has pleasure in submitting its report upon the activities of the Institute during the past year, a period that was specially notable both for the celebration of the twenty-fifth anniversary of the Institute's formation and the setting up of improved methods of publication.

The Institute ended another year of the long-continued industrial depression with a slight reduction in its membership and financial resources. In spite of the difficulties encountered, it is felt that the usefulness of the Institute to its members has not only been fully maintained, but even increased. This has been made possible by the encouraging and continued support given by members—financially, in committee, and in other ways—and by the unwearying efforts of the staff of the Institute.

Roll of the Institute.

The number of members on the roll of the Institute, for the second year in succession, shows a fall on December 31, when the totals for the various classes of membership were as indicated in the following table, which gives the membership during the past five years :—

	Dec. 31, 1929.	Dec. 31, 1930.	Dec. 31, 1931.	Dec. 31, 1932.	Dec. 31, 1933.
Honorary Members	5	5	5	5	5
Fellows . .	9	7	7	8	8
Ordinary Members	2035	2083	2146	2073	2038
Student Members .	73	65	74	79	80
	2122	2160	2232	2165	2131

On December 31, 1933, the names of 122 Original Members were included in the total of 2038 Ordinary Members. On December 31, 1908—the end of the Institute's first year—the Original Members numbered 355. 133 members and students were elected during the year, a figure that compares with 120 in 1932 and 205 in 1931.

Obituary.

Many losses by death occurred during the year. Among the Original Members who died were P. T. Caird and W. Cleland. In addition to the above the deaths of the following were notified to the Secretary : Dr. N. Fukushima; E. A. Hadley; Dr. K. Hallmann; D. F. John; Colonel A. F. Masury; W. D. Pomeroy; J. Rolland; J. Kent Smith; Professor H. Speeketer; Sir Gilbert Vyle; and C. E. Whiteley.

Meetings of the Institute.

At the Annual General Meeting, which took place in London on March 8 and 9, thirteen papers were presented, the meeting being followed by a Dinner and Dance at the Trocadero Restaurant. In the afternoon of March 9 members were privileged to pay a visit to the headquarters of the British Non-Ferrous Metals Research Association.

On the occasion of the Annual May Lecture—the second general meeting of the year—a distinguished French member, Professor Albert Portevin, delivered a Lecture on " Quenching and Tempering Phenomena in Alloys."

The twenty-fifth Annual Autumn Meeting was appropriately held in Birmingham, in which city the first Autumn Meeting had been held in 1908. The " Silver Jubilee " meeting was well attended. Fourteen papers were presented at the meeting, and the Autumn Lecture was given by Mr. W. R. Barclay, on " Twenty-Five Years' Progress in Metallurgical Plant." Following the reading and discussion of the papers, members visited works and other places of interest in Birmingham and neighbourhood.

The proposal to hold the 1934 Autumn Meeting on board ship was investigated by a Committee of the Council. As a result of a referendum of all members, showing that fewer than 100 persons were prepared to take part in the proposed meeting, the Council decided to abandon the scheme.

By kind invitation of the Organizers of the Shipping, Engineering, and Machinery Exhibition at Olympia, members were enabled to visit the exhibition on Sept. 15 and were entertained to tea.

A joint meeting with the Manchester Metallurgical Society was held on October 25, when two papers that had been read at the Birmingham meeting were re-presented and discussed.

Silver Jubilee Fund.

To commemorate the 25th anniversary of the Institute's foundation, the Original Members contributed the sum of £525 to a " Fund in connection with the Silver Jubilee." Subsequently additional contributions, totalling £144 2*s.*, were received from other members who desired to be associated with the fund. As the Fund was established since the end of the last financial year, it is not referred to in the accounts which follow the Treasurer's Report. The Fund is still open.

Publications.

The past year saw considerable activity in connection with the Institute's publications. In response to suggestions made by members the Council arranged for advance copies of papers to be printed in the *Monthly Journal.* It is hoped by the Council that the new method of publication will be generally appreciated by the members, and will result in better discussions, since in many cases members will receive papers some months earlier than would have been possible under the old system.

Members are reminded that the papers now being sent out in the *Monthly Journal* will not be issued again except when they appear in the half-yearly bound volumes of the *Journal.*

Local Sections.

The work of the Local Sections of the Institute was successfully continued. Before each of the six sections papers were read during the winter months. A list of these papers appears in an appendix to this Report. In the *Monthly Journal* a short account was given, in advance of each meeting, of the papers to be read in the month following its appearance.

Institute of Metals Lectures.

Five " Institute of Metals Lectures " were delivered between January and March, 1933. No lectures were arranged for the session 1933–1934, but as several applications were received for further lectures, it is possible that similar lectures will be arranged for the session 1934–1935. Hitherto the lectures have been delivered by members before metallurgical societies of Universities and University Colleges, and it is possible that the scheme may be extended to include Technical Colleges and Polytechnic Institutes.

BEILBY MEMORIAL AWARD.

The Council are glad to report that a member—Mrs. G. H. Tipper (Constance F. Elam, D.Sc., M.A.)—received a Beilby award of one hundred guineas.

GIFT BY THE TREASURER.

The Honorary Treasurer, Mr. John Fry, presented to the Institute a Victoria Cross, "as representing the highest use to which a piece of bronze could be put." The Cross has been suitably mounted in a case containing the history of the award; it can be inspected by members.

LIBRARY.

During the past year nearly 3000 books and periodicals were loaned to members. Eighty-five new text-books were acquired. The number of members visiting the library increased considerably. Many of these callers as well as correspondents have applied for information which it has, in the main, been possible to furnish.

Members have been particularly interested in the new arrangement, inaugurated this year, whereby copies of Local Section papers are filed, and are thus made available for loan in the ordinary way. These papers have been much in request.

It is desirable to emphasize once again the connection between the abstracting service and the library. Many members make a practice of studying the abstracts which they receive monthly and then apply to the library for the loan of the articles or books which appear to be of interest to them. Many more members could undoubtedly obtain much benefit from this service; it is surprising to find it is not better known. Many who visit the library often say that they are unaware of this valuable privilege of membership. Those in particular who have not access to a good works' library have found the Institute's library and abstracting service particularly useful.

The resources of the Science Library have again been largely drawn upon, and members are reminded that books and periodicals available in this huge library may be obtained on loan (by post) on application to the Librarian of the Institute. Books and periodicals outside the Institute's field of work are thus obtainable through this channel. The assistance that the Science Library is rendering to research by the facilities for loan which are offered cannot be over-estimated, and the Council desires to thank the Director, Brigadier E. E. B. Mackintosh, D.S.O., R.E., and his Staff for their assistance.

Members, particularly those overseas, are reminded of the photostat service, by which they may obtain copies of papers not otherwise easily obtained at a moderate cost. Conditions on which these can be supplied are set out on p. 387, Volume XLII of the *Journal*.

COMMITTEES.

The following Committees of the Council have held frequent meetings during the past year:—

AUTUMN MEETINGS.
COUNCIL NOMINATION.
DINNER.
FINANCE AND GENERAL PURPOSES.
JOURNAL PRINTING COSTS.
LIBRARY.
LOCAL SECTIONS.
MEMBERSHIP.
MEETING AND PAPERS.
PUBLICATION.

Representatives.

The following representatives of the Institute were appointed by the Council:

Sir Charles Parsons Memorial Committee: Sir Henry Fowler (President).

British Standards Institution (Committee on Lead Alloys for Cable Sheathing): H. C. Lancaster.

Chemical Engineering Conference, 1935: Dr. Richard Seligman.

British Science Guild Parliamentary Committee: Sir Henry Fowler (President) and Mr. G. Shaw Scott (Secretary).

Advisory Committee on Metallurgy, City & Guilds of London Institute: Professor T. Turner.

Professional Classes Aid Council: Mr. H. B. Weeks.

Corresponding Members to the Council.

The Council would again extend its thanks to the following members who have acted as Corresponding Members during the past year: Mr. H. Norman Bassett (*Egypt*); Professor C. A. F. Benedicks, Ph.D. (*Sweden*); M. L. Boscheron, O.B.E. (*Belgium*); Professor P. A. J. Chevenard (*France*); Mr. W. M. Corse, S.B. (*United States of America*); Professor J. Neill Greenwood, D.Sc. (*Australia*); Dr.-Ing. Max Haas, Dipl.Ing. (*Germany*); Mr. J. Hamburger, Jazn. (*Holland*); Dr.-Ing. E. Honegger (*Switzerland*); Mr. R. Mather, B.Met. (*India*); Dr.-Ing. C. Sonnino (*Italy*); Professor G. H. Stanley, D.Sc., A.R.S.M. (*South Africa*); Professor A. Stansfield, D.Sc., A.R.S.M. (*Canada*); and Professor K. Tawara, Sc.D. (*Japan*).

Signed on behalf of the Council,

Henry Fowler, *President.*
H. Moore, *Vice-President.*

G. Shaw Scott, *Secretary and Editor.*

January 4, 1934.

APPENDIX.

LOCAL SECTIONS' PROGRAMMES, 1933–1934.

BIRMINGHAM LOCAL SECTION.

Chairman: W. E. Ballard.

Hon. Secretary: J. W. Jenkin, B.Sc., Ph.D., Messrs. Bromford Tube Co., Ltd., Erdington, Birmingham.

1933.	Programme.
Oct. 5.	V. E. Pullin, C.B.E., B.A., B.Sc. "The X-Ray Analysis of Metals."
Nov. 7.	J. W. Jones, M.Sc. "Interpretation of a Photomicrograph."
Nov. 14.	G. L. Bailey, M.Sc. "Deoxidizers and Fluxes."
Nov. 30.	Symposium on Defects in Cold-Working. Arranged by A. L. Molineaux.
Dec. 2.	Dinner and Dance (Midland Hotel).
Dec. 7.	D. W. Aldridge. "The New Copper Refinery at Prescot."
1934.	
Jan. 4.	W. R. Barclay, O.B.E. "Nickel and Nickel Alloys."
Jan. 16.	C. A. Hadley. "Electric Welding."
Feb. 1.	Open Discussion on the Metallurgical Inspection of Engineering Materials.
Feb. 13.	Maurice Cook, Ph.D., M.Sc. "Age-Hardening Copper Alloys."
Mar. 1.	J. C. Hudson, D.Sc. "Field Tests on Corrosion."
Mar. 20.	G. A. V. Russell, Wh.Ex. "Rolling Mill Practice."

All meetings are held in The James Watt Memorial Institute, Birmingham, at 7 p.m. They form part of a joint programme arranged by the Midland Metallurgical Societies (consisting of the Birmingham Local Section of the Institute of Metals, the Birmingham Metallurgical Society, and the Staffordshire Iron and Steel Institute).

LONDON LOCAL SECTION.

Chairman : S. L. Archbutt.

Hon. Secretary : J. McNeil, A.R.T.C.,
Messrs. The Mond Nickel Co., Ltd.,
Thames House, Millbank, S.W.1.

1933. Programme.

Oct. 5. S. L. Archbutt. Chairman's Address.
Nov. 9. R. Annan. "Gold—Its Sources and Production." (Meeting at the Royal School of Mines, South Kensington, S.W.7.)
Dec. 7. J. R. Handforth, M.Sc. "A Metallurgist's Outlook on Modern Foundry Productions." (Joint Meeting with the Institute of British Foundrymen.)

1934.
Jan. 11. H. A. Sloman, M.A., B.Sc. "Beryllium and Its Alloys."
Feb. 8. A. G. Lobley, M.Sc. "Electric Annealing and Heat-Treatment Furnaces."
Mar. 15. G. Barr, B.A., D.Sc., and Miss Hadfield, M.Sc. "Spectroscopic and Microchemical Analysis of Metals and Alloys."
Apl. 12. Annual General Meeting and open discussion.

The Meetings are held in the Rooms of the Society of Motor Manufacturers and Traders, Ltd., 83 Pall Mall, S.W.1 (unless otherwise stated), at 7.30 p.m.

NORTH-EAST COAST LOCAL SECTION.

Chairman : J. E. Newson, M.Met.

Hon. Secretary and Treasurer : C. E. Pearson, M.Met., Armstrong College,
Newcastle-on-Tyne.

1933. Programme.

Oct. 10. Exhibition of Cinematograph Films.
Nov. 14. W. E. Ballard. "Metal Spraying." (Joint Meeting with the Newcastle Branch of the Society of Chemical Industry.)
Dec. 12. J. E. Hurst. "Addition of Non-Ferrous Metals to Cast Iron." (Joint Meeting with the Institute of British Foundrymen.)

1934.
Jan. 9. C. R. Deglon and L. Miller. "The Physical Properties of Deposited Weld Metal in the Arc-Welding and Atomic Hydrogen Processes."
Feb. 13. J. E. Newson, M.Met. Chairman's Address.
Mar. 13. C. E. Pearson, M.Met. "The Flow of Metals in the Extrusion Process." Annual General Meeting.

The Meetings are held in the Electrical Engineering Lecture Theatre, Armstrong College, Newcastle-on-Tyne, at 7.30 p.m.

SCOTTISH LOCAL SECTION.

Chairman : Professor Robert Hay, B.Sc., Ph.D.

Hon. Secretary : Harold Bull, Messrs.
Bull's Metal and Melloid Co., Ltd.,
Yoker, Glasgow.

1933. Programme.

Oct. 9. Display and demonstration at the Royal Technical College, arranged by Professor Robert Hay, B.Sc., Ph.D. (Chairman).
Nov. 13. Discussion of three papers presented at the Autumn Meeting of the parent Institute.
Dec. 11. T. Tyrie. "The Use of Fluxes and Slags in Non-Ferrous Foundry Practice."

1934.
Jan. 15. Sydney W. Smith, C.B.E., D.Sc., A.R.S.M. "Factors in the Solidification of Molten Metals."
Feb. 12. J. A. C. Edmiston. "Combustion Efficiency."
Mar. 12. Annual General Meeting, and paper by J. Arnott.

The Meetings (except the first) are held in the Rooms of the Institution of Engineers and Shipbuilders in Scotland, 39 Elmbank Crescent, Glasgow, at 7.30 P.M.

SHEFFIELD LOCAL SECTION.

Chairman : Captain F. Orme, M.Met.

Hon. Secretary : H. P. Gadsby, Assoc.Met., 193 Sandford Grove Road, Sheffield 7.

1933. Programme.

Oct. 13. F. W. Rowe, B.Sc. "Centrifugal Casting of Non-Ferrous Alloys."
Nov. 10. W. E. Ballard. "Metal Spraying."
Dec. 8. J. C. Howard, B.Met. "Modern Application of Electric Heat."
1934.
Jan. 12. N. D. Pullen. "Protection from Corrosion of Aluminium and Its Alloys."
Feb. 9. H. G. Dale. "Recovery and Refining of Precious Metals."
Mar. 9. Frank Mason. "'Nickel–Chrome' Plating."

The Meetings are held in the Non-Ferrous Section of the Applied Science Department of the University, St. George's Square, at 7.30 P.M.

SWANSEA LOCAL SECTION.

Chairman : A. G. Ramsay, B.Sc., Ph.D.

Hon. Secretary : Roosevelt Griffiths, M.Sc., Metallurgical Department, University College, Singleton Park, Swansea.

1933. Programme.

Oct. 10. A. G. Ramsay, B.Sc., Ph.D. Chairman's Address.
Nov. 14. Cecil H. Desch, D.Sc., Ph.D., F.R.S. "Ageing and Age-Hardening."
Dec. 12. Exhibition of Industrial Films (at University College, Singleton Park).
1934.
Feb. 20. Professor F. Bacon, M.A. "Cracking and Fracture of Metals, with Special Reference to Service Breakages."
Mar. 13. Discussion on Rolling, to be opened by Professor L. Taverner, A.R.S.M.

The Meetings are held at the Y.M.C.A. at 6.15 P.M. Tea is served before the Meetings.

REPORT OF THE HONORARY TREASURER

(Mr. JOHN FRY)

For the Financial Year ended June 30, 1933.

The period covered by this report was one of widespread depression in all directions, and though the non-ferrous industries were not so severely affected as many others, the year was somewhat disappointing from the point of view of the Institute's finances. On the income side there was a decrease in annual subscriptions of £387 2*s*. 4*d*., and £63 6*s*. 8*d*. in interest on War Loan, although against the latter there was a non-recurrent receipt of £51 2*s*. 2*d*. on conversion. The total expenditure was £230 14*s*. 4*d*. less than in the previous year, as reductions were shown in salaries, *Journal* account, and expenses of meetings. The net result was an excess of expenditure over income of £401 19*s*. 6*d*. as against £226 4*s*. 11*d*. in the previous year. In addition, in the Balance Sheet £585 6*s*. 1*d*. is treated as a liability in respect of a half-yearly volume of the *Journal* which was printed but not actually due to be dispatched to members, and the corresponding cost of which, in previous years, had been included in the accounts of the subsequent year. In reference to the *Journal* Account (£1911 2*s*. 3*d*.), it should be explained that this is the net cost after allowing for receipts from sales and advertisements, and making no allowance for overhead expenses. It is not possible to give an actual figure for the total cost of publication of the *Journal*, owing to the difficulty of correctly apportioning overhead charges, but it is approximately three times the net cost, and thus is far the largest item in the expenditure of the Institute. The financial position of the Institute is a cause of some anxiety to the Council and is receiving careful consideration. By the publication of the *Monthly Journal*, earlier printing of the papers and abstracts, and in other directions, members are receiving considerably increased advantages, and these can only be continued or extended if funds are available. Members can help by encouraging suitable persons to join the Institute; by purchasing its publications and by supporting the advertisements in the *Monthly Journal*. It is hoped that brighter times ahead will lead to increased income, particularly from countries in which the Institute has a considerable membership, and which have been suffering so severely from the world depression.

THE INSTITUTE OF METALS

BALANCE SHEET AS AT JUNE 30, 1933.

30.6.1932. £	£	LIABILITIES.	£ s. d.	£ s. d.
		Creditors :		
	136	Sundry Creditors for Accrued Expenses, less proportions in advance . .	126 6 10	
	284	*Journal* Accounts	1,144 1 9	
	766	Subscriptions paid in advance . .	737 11 1	
1,186				2,007 19 8
		Cash :		
	940	Balance due to Bank—Current Account	947 5 11	
	67	Petty Cash in hand	79 12 8	
873				867 13 3
		Entrance Fees Account :		
	890	Balance as at June 30, 1932 . .	1,112 7 4	
	222	Amount receivable for year to June 30, 1933	201 12 0	
1,112				1,313 19 4
20		*Woodhouse Fund Account* . . .		13 8 6
1,050		*House Fund Account*		1,049 19 7
		Excess of Assets over Liabilities :		
	5,775	Balance at June 30, 1932 . .	2,794 14 7	
	226	*Less* Excess of Expenditure over Income for the year ended June 30, 1933	401 19 6	
	5,549		2,392 15 1	
	2,754 *	*Deduct* Adjustments on *Journal* Account for year to June 30, 1932, including the half-yearly volume to that date, produced and paid for during the current year ending June 30, 1933	585 6 1	
2,795				1,807 9 0
£7,036				£7,060 9 4

* Amount written off *Journal.*

30.6.1932. £	£	ASSETS.	£ s. d.	£ s. d.
		Office Furniture :		
200		As at June 30, 1932 . . .		200 0 0
		Library Books, &c. :		
100		As at June 30, 1932 . . .		100 0 0
		Sundry Debtors :		
	10	For Entrance Fees	12 12 0	
	480	,, Subscriptions	664 13 9	
	182	,, *Journal* Accounts, &c. . .	151 11 2	
	672		828 16 11	
	90	*Less* Reserve for Doubtful Subscriptions	215 15 6	
582				613 1 5
		Stock of Journals :		
1		At Nominal Valuation . . .		1 0 0
		Investments :		
5,083		£5,111 1*s.* 8*d.* 3½% War Loan at cost .		5,082 19 10
		House Fund :		
	1,045	£1,000 3½% War Loan at cost . .	1,044 19 1	
	5	Cash at Bank	5 0 6	
1,050				1,049 19 7
		Woodhouse Fund :		
20		Balance at Lloyds Bank . . .		13 8 6
£7,036				£7,060 9 4

AUDITORS' CERTIFICATE.

We report that we have obtained all the information and explanations we have required. In our opinion the above Balance Sheet is properly drawn up so as to exhibit a true and correct view of the state of the affairs of the Institute of Metals as on June 30, 1933, according to the best of our information and from the explanations given to us and as shown by the books of the Institute.

POPPLETON & APPLEBY, AUDITORS,
BIRMINGHAM, LONDON, AND CARDIFF.

December 20, 1933.

THE INSTITUTE OF METALS

INCOME AND EXPENDITURE ACCOUNT FOR THE YEAR ENDED JUNE 30, 1933.

30.6.1932. £		£	s.	d.	30.6.1932. £		£	s.	d.
2,176	To Salaries	2,035	0	0	6,127	By Annual Subscriptions	5,391	19	2
346	" Wages and National Insurance	360	6	0	280	" Interest on War Loan	211	4	4
2,063	" Journal Account	1,911	2	3	—	" Bonus on Conversion of 5% War Loan	51	2	2
830	" Rent, Telephone, Lighting, and Insurance	831	9	10	8	" Bank Interest			
203	" Printing and Stationery	193	13	9	19	" Sundry Donations	11	17	0
413	" Postages, Travelling, and Sundry Expenses	413	15	10	50	" House Fund Rent	52	10	0
77	" Library Expenses	43	6	1	525	" Excess of Expenditure over Income for Year	401	19	6
160	" Subscriptions and Grants to Local Sections	178	11	6					
160	" Expenses of Meetings	97	4	10					
31	" Rebates and Renewals	9	0	1					
—	" Bank Charges	14	5	6					
26	" Audit Fee	26	5	0					
£7,009		£6,118	11	8	£7,009		£6,118	11	8

JOURNAL ACCOUNT FOR THE YEAR ENDED JUNE 30, 1933.

		£	s.	d.			£	s.	d.
1	To Stock of Journals at June 30, 1932	1	6	8	1,855	By Sundry Creditors at June 30, 1932	281	7	6
355	" Sundry Debtors for Journals sold and Advertisements at June 30, 1932	181	12	6	2,071	" Sales of Journals and Index and Advertisements	1,741	5	3
5,598	" Cost of Production of Journals including Abstractors' Fees	2,759	5	3	1	" Stock of Journals	1	0	0
281	" Sundry Creditors at June 30, 1933	1,144	1	9	188	" Sundry Debtors for Journals sold and Advertisements	151	11	2
					2,063	" Balance transferred to Income and Expenditure Account	1,911	2	3
£6,178		£4,086	6	2	£6,178		£4,086	6	2

"HOUSE FUND" ACCOUNT FOR THE YEAR ENDED JUNE 30, 1933.

		£	s.	d.			£	s.	d.
50	To Rent paid to the Institute of Metals	52	10	0	1,050	By Balance at June 30, 1932	1,049	19	7
1,050	" Balance at June 30, 1933	1,049	19	7	50	" Interest on War Loan	42	10	0
						" Bonus on Conversion of 5% War Loan	10	0	0
£1,100		£1,102	9	7	£1,100		£1,102	9	7

PAPER No. 658. 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 April 2, 1934.

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

TRANSVERSE TESTS ON SAND-CAST ALUMINIUM ALLOY BARS.*

By C. E. PHILLIPS,† A.C.G.I., D.I.C., and J. D. GROGAN,‡ B.A., MEMBER.

SYNOPSIS.

This investigation was carried out to determine the value of the transverse test in the measurement of the ductility of alloys of low elongation. From the results obtained the transverse test does not seem to yield any information concerning ductility which is not obtained equally readily from the tensile test when a high degree of accuracy of measurement is available; in fact the tensile test appears to be preferable to the bend test.

INTRODUCTION.

MANY of the aluminium alloys at present employed in industry possess, particularly in the sand-cast state, so little ductility that measurements of elongation made on broken tensile test-pieces are of but small value. It has been suggested recently that a bend test such as is already employed in the testing of cast iron might prove to be of greater value. The investigation described in this paper was carried out to examine this point.

RANGE OF INVESTIGATION.

The beam test-bar employed was 8 in. long × 1 in. in diameter, cast in sand in accordance with the British Standards Institution specification for sand-cast test-bars and tested by single-point loading. This bar is the longest light alloy sand-cast bar for which detailed information on casting conditions is available. A range of alloys was employed varying in elongation from a very low value to 12 per cent. Bars were tested unmachined and also machined to a uniform diameter of $\frac{7}{8}$ in. Full tensile tests were also made on machined test-pieces of 0·25 in.^{2} in effective cross-sectional area.

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† Engineering Department, National Physical Laboratory, Teddington.

‡ Department of Metallurgy and Metallurgical Chemistry, National Physical Laboratory, Teddington.

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ALLOYS EMPLOYED.

Alloys were selected to provide a series covering a range of ductility. The alloys were made from commercial aluminium containing slightly more than 0·2 per cent. iron and slightly less than 0·2 per cent. silicon. All the casts were analyzed, and in every case composition agreed satisfactorily with that intended. The metal was melted in Salamander crucibles in a gas-fired furnace and was treated with carbon tetrachloride and raw nitrogen to remove dissolved gases. The metal was poured (generally at 680° C.) in green-sand moulds, surface dried, 8·5 in. long × 1 in. in diameter, provided with a feeding head.

The density of each bar was determined after removal of the feeding head, but before machining. Satisfactory agreement among different bars of the same composition was obtained. Where necessary the material was heat-treated to give the required ductility. Table I gives the alloys employed in order of increasing ductility as measured by elongation in tension and the heat-treatment used to develop the ductility. The heat-treated material was allowed to age at room temperature prior to testing.

TABLE I.

Batch Mark.	Composition.	Heat-Treatment.
A	" Y " alloy	6 hrs. at 520° C. Quenched in boiling water; reheated for ½ hr. at 250° C.
B	,,	6 hrs. at 520° C. Quenched in boiling water.
C	Copper 4%. Silicon, 3%	6 hrs. at 520° C. Quenched in cold water; reheated for 48 hrs. at 150° C.
D	,,	6 hrs. at 520° C. Quenched in cold water.
E	Copper 4%	As cast.
F	,,	6 hrs. at 520° C. Quenched in cold water.
G	,,	48 hrs. at 520° C. Quenched in cold water.

METHODS OF TEST.

Tensile Tests.

Each bar employed for tensile test was machined to give a test-piece of 0·25 in.^{2} effective cross-sectional area and 2·25 in. parallel length, the test-length being finished by polishing with grade " 00 " emery cloth. The tests were carried out in a 10-ton single-lever testing machine, a Martens-type mirror extensometer being used to measure extension on a gauge-length of 2 in. If the test-piece extended beyond the range of the extensometer, scratch marks were made with a 2-in. gauge, and afterwards measured by means of a microscope. Load–extension observations were made up to fracture in each test, and at regular increments of load the permanent elongation of the specimen was determined by removal of the load.

The load–extension and load–permanent elongation curves were plotted for each specimen, and from them an estimate was obtained of the permanent elongation at fracture. From the plotted observations the modulus of elasticity, the 0·1 per cent. proof stress, and the ratio of permanent elongation at fracture to the total extension at fracture, were determined. The elongation of each test-piece was also determined in the usual manner after fracture, and the diameter at fracture was measured.

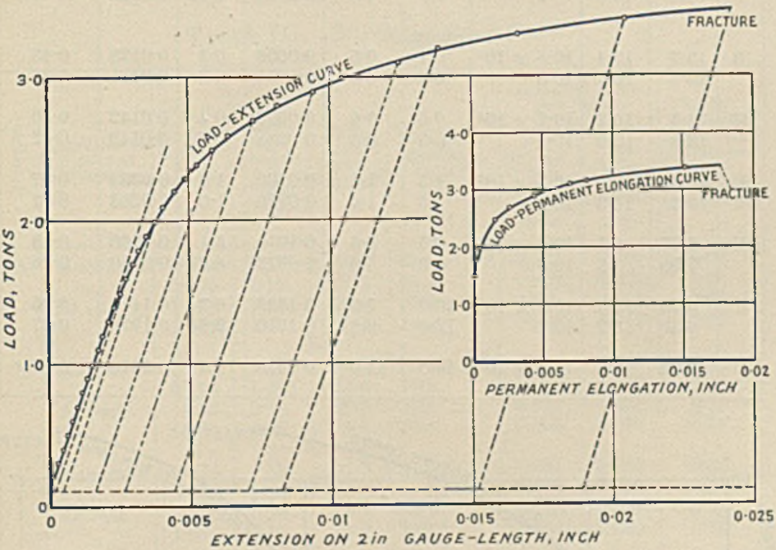

Fig. 1.—Tensile Test on Material D. Diameter of Specimen 0·564 in.

The tensile tests were made in duplicate on each material, except material G, and the results are given in Table II. Representative load–extension and load–permanent elongation curves are given in Fig. 1.

Bend Tests.

Transverse bend tests were made in duplicate on each material, except material G, in the form of bars unmachined, and bars machined to $\frac{7}{8}$ in. in diameter, the surface being finished by polishing with grade "00" emery cloth. The tests were carried out in a 5-ton multiple-lever, gear-driven testing machine at a constant rate of deflection of 0·013 in. per minute. Each specimen was centrally loaded on a 6-in. span; the supports had a radius of 0·75 in. and the load was applied

TABLE II.—*Results of Tensile Tests.*

Material.	0·1% Proof Stress, Tons/in.².	Ultimate Stress, Tons/in.².	Modulus of Elasticity, Lb./in.².	Approximate Reduction of Area at Fracture, Per Cent.	Elongation on 2-In. Gauge Length (from Specimen after Fracture), Per Cent.	From Load-Extension Curve.			Ratio: Permanent Elongation at Fracture/Total Extension at Fracture.
						Permanent Elongation at Fracture,		Total Extension at Fracture,	
						Inch.	Per Cent.	Inch.	
A	...	16·3	10·6 × 10⁶	VS	VS	0·0003	0·02	0·0072	0·04
	...	15·8	10·2	VS	VS	0·0003	0·02	0·0082	0·03
B	15·7	17·4	10·5 × 10⁶	about 0·1	0·5	0·0056	0·3	0·0128	0·43
	15·3	16·7	10·5	0·2	0·5	0·0051	0·3	0·0111	0·37
C	14·3	16·2	10·1 × 10⁶	0·5	0·6	0·0072	0·4	0·0142	0·50
	13·8	16·0	10·1	0·5	0·5	0·0082	0·4	0·0149	0·52
D	10·3	13·9	10·3 × 10⁶	1·5	1·3	0·0190	1·0	0·0239	0·77
	10·2	14·3	10·2	1·5	1·4	0·0190	1·0	0·0263	0·72
E	7·67	8·1	10·4 × 10⁶	6·5	5·5	0·1010	5·1	0·1060	0·95
	7·95	8·5	10·5	6·0	5·0	0·0912	4·6	0·0950	0·96
F	6·23	13·9	10·3 × 10⁶	10·0	7·5	0·1332	6·7	0·1402	0·95
	6·20	15·2	10·2	12·0	9·8	0·1910	9·6	0·1979	0·97
G	6·02	16·0	10·3 × 10⁶	13·0	12·0	0·2325	11·6	0·2374	0·98

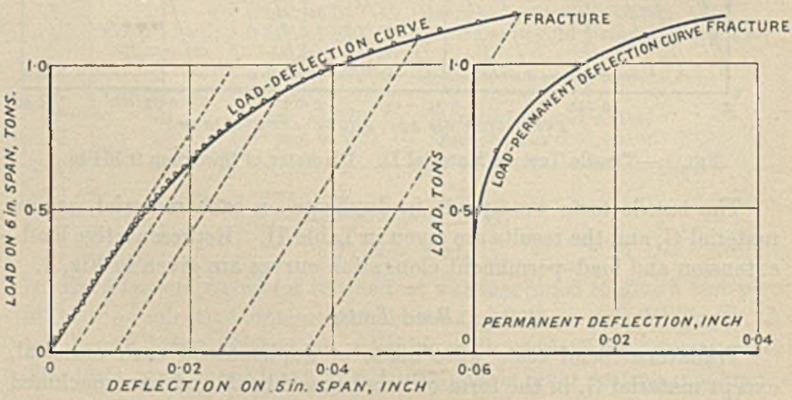

FIG. 2.—Bend Test on Material D (Machined). Central Load on 6-in. Span. Diameter of Specimen, 0·875 in.

through a 1·5-in. diameter steel rod. Deflection measurements were made on a central span of 5 in. by means of the instrument described below. In each test load-deflection observations were made up to fracture; at intervals of loading the permanent deflection was determined by removing the load.

The load–total deflection and load–permanent deflection curves were plotted, and from these an estimate was made of the permanent deflection of each specimen at fracture. The value of the modulus of elasticity was obtained from the plotted observations.

The results of the bend tests are given in Table III, and representative load–total deflection and load–permanent deflection curves of machined and unmachined specimens are given in Figs. 2 and 3, respectively.

TABLE III.—*Results of Bend Tests.*

Material.	Condition of Surface of Specimen.	Diameter of Specimen, Inch.	Maximum Load on 6-in. Span, Tons.	Modulus of Rupture, Tons/in.^{2}.	Modulus of Elasticity, Lb/in.^{2}.	From Load–Deflection Curve.		Ratio: Permanent Deflection at Fracture/Total Deflection at Fracture.
						Permanent Deflection at Fracture, Inch.	Total Deflection at Fracture, Inch.	
A	Machined	0·874	1·11	25·5	$10{\cdot}5 \times 10^6$	$0{\cdot}001_1$	0·029	0·04
	”	0·875	1·10	25·2	10·4	$0{\cdot}001_3$	0·028	0·05
	As cast	1·062	1·87	23·9	10·6	$0{\cdot}001_1$	0·022	0·05
	”	1·067	1·60	20·1	10·5	$0{\cdot}000_6$	0·019	0·03
B	Machined	0·875	1·235	28·2	$10{\cdot}6 \times 10^6$	$0{\cdot}007_8$	0·038	0·21
	”	0·874	1·295	29·6	10·5	$0{\cdot}009_8$	0·040	0·25
	As cast	1·066	2·10	26·5	10·3	$0{\cdot}004_5$	0·029	0·15
	”	1·064	2·02	25·6	10·3	0·005	0·030	0·17
C	Machined	0·875	1·39	31·7	$10{\cdot}5 \times 10^6$	0·021	0·059	0·36
	”	0·874	1·24	28·4	10·2	0·014	0·047	0·31
	As cast	1·066	2·25	28·4	10·3	0·010	0·036	0·28
	”	1·070	2·10	26·2	10·3	$0{\cdot}007_8$	0·033	0·24
D	Machined	0·874	1·16	26·7	$10{\cdot}3 \times 10^6$	0·041	0·080	0·52
	”	0·875	1·175	26·8	10·3	0·038	0·066	0·57
	As cast	1·070	2·17	27·0	10·3	0·036	0·061	0·59
	”	1·074	2·00	24·7	10·1	0·019	0·042	0·45
E	Machined	0·875	0·765	17·4	$10{\cdot}3 \times 10^6$	0·208	0·228	0·91
	”	0·875	0·835	19·0	10·3	0·246	0·265	0·93
	As cast	1·058	1·22	15·8	10·3	0·132	0·149	0·89
	”	1·060	1·33	17·1	10·4	0·175	0·191	0·92
F	Machined	0·876	1·50	34·1	$10{\cdot}3 \times 10^6$	0·550	0·575	0·96
	”	0·876	1·60	36·3	10·3	0·640	0·675	0·95
	As cast	1·062	2·37	30·2	10·3	0·233	0·260	0·90
	”	1·062	2·41	30·8	10·3	0·307	0·333	0·92
G	Machined	0·875	1·51	34·5	$10{\cdot}3 \times 10^6$	0·470	0·508	0·92
	As cast	1·063	2·49	31·6	10·6	0·314	0·341	0·92
	”	1·062	3·02	38·5	10·1	0·512	0·542	0·95

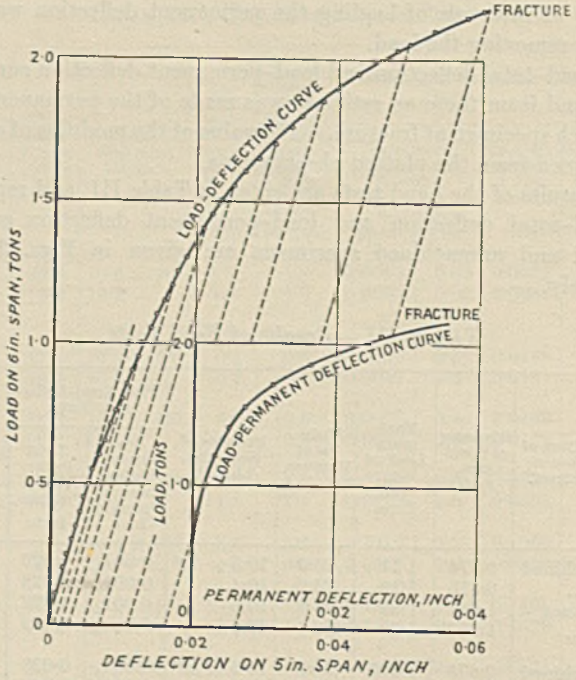

Fig. 3.—Bend Test on Material D (Unmachined). Central Load on 6-in. Span. Diameter of Specimen, 1·070 in.

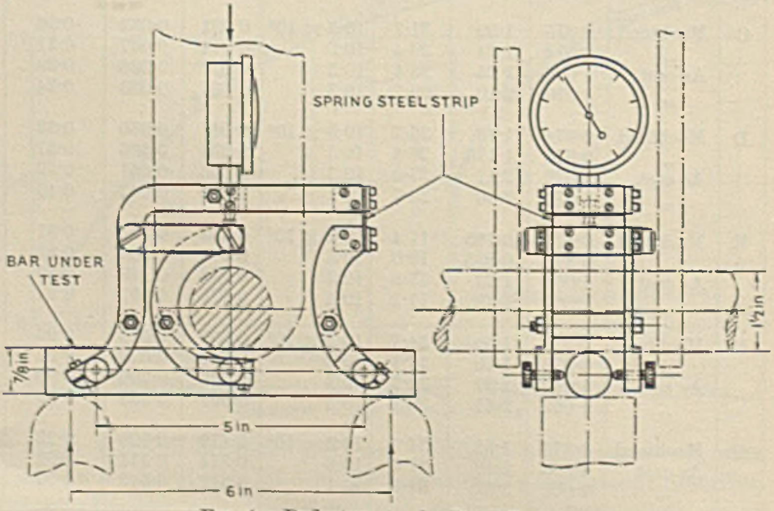

Fig. 4.—Deflectometer for Bend Tests.

In the case of the more ductile materials, errors were introduced into the load observations by the rounded supports of the testing apparatus shown in Fig. 4. At a deflection of 0·5 in, the loading span had decreased to about 5·5 in.; this undoubtedly gives large errors in the determinations of the maximum load and modulus of rupture of materials F and G, and probably accounts for the low values obtained for the ratio of permanent deflection to total deflection at fracture in the materials of high ductility.

A summary of the results of the tests is given in Table IV, and the

TABLE IV.—*Summary of Results.*

Material.	True Elongation on 2-in. Gauge Length in Tensile Tests (from Curve), Per Cent.	Tensile Tests (2-in. Gauge Length).			Bend Tests (6 in. Span).		
		Permanent Elongation at Fracture, Inch.	Total Extension at Fracture, Inch.	Ratio: Permanent Elongation at Fracture/Total Extension at Fracture.	Permanent Deflection at Fracture, Inch.	Total Deflection at Fracture, Inch.	Ratio: Permanent Deflection at Fracture/Total Deflection at Fracture.
A	0·02	0·0003	0·0072	0·04	0·001$_1$	0·029	0·04
	0·02	0·0003	0·0082	0·03	0·001$_3$	0·028	0·05
					0·001$_1$	0·022	0·05
					0·000$_6$	0·019	0·03
B	0·3	0·0056	0·0128	0·43	0·007$_8$	0·038	0·21
	0·3	0·0051	0·0111	0·37	0·009$_8$	0·040	0·25
					0·004$_5$	0·029	0·15
					0·005	0·030	0·17
C	0·4	0·0072	0·0142	0·50	0·021	0·059	0·36
	0·4	0·0082	0·0149	0·52	0·014	0·047	0·31
					0·010	0·036	0·28
					0·007$_8$	0·033	0·24
D	1·0	0·0190	0·0239	0·77	0·041	0·080	0·52
	1·0	0·0190	0·0263	0·72	0·038	0·066	0·57
					0·036	0·061	0·59
					0·019	0·042	0·45
E	5·1	0·1010	0·1060	0·95	0·208	0·228	0·91
	4·6	0·0912	0·0950	0·96	0·246	0·265	0·93
					0·132	0·149	0·89
					0·175	0·191	0·92
F	6·7	0·133	0·140	0·95	0·550	0·575	0·96
	9·6	0·191	0·198	0·97	0·640	0·675	0·95
					0·233	0·260	0·90
					0·307	0·333	0·92
G	11·6	0·233	0·237	0·98	0·470	0·508	0·92
					...	...	...
					0·314	0·341	0·92
					0·512	0·542	0·95

ratio of permanent deformation to total deformation at fracture is plotted against the elongation in tension for each method of test in Fig. 5.

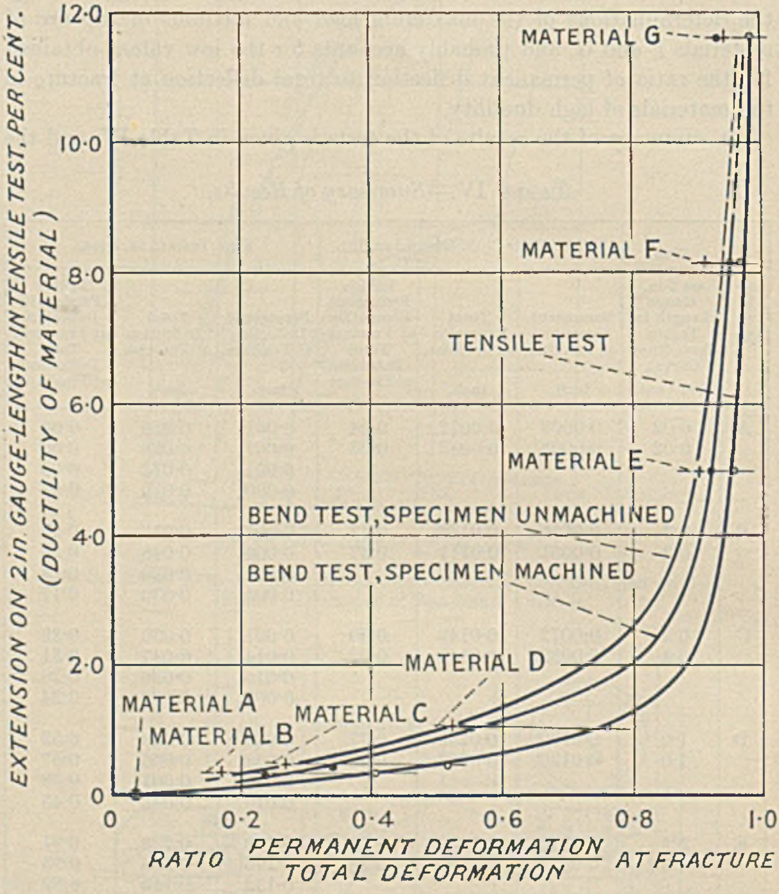

Fig. 5.—Curves Showing the Variation of the Ratio $\frac{\text{Permanent Deformation}}{\text{Total Deformation}}$ at Fracture with the Ductility of the Material as Measured in a Tensile Test.

Deflectometer Used in the Bend Tests.

The instrument used for determining the deflections of the specimens used in the transverse bend tests is shown diagrammatically in Fig. 4. It was designed at the Royal Aircraft Establishment, South Farnborough, and was constructed in the Engineering Department of the National Physical Laboratory.

The deflectometer incorporates an Ames dial indicator, calibrated in thousandths of an inch, and is arranged so that the specimen under test recedes from the indicator, thus obviating damage to the latter on fracture of the specimen. In use the instrument is lightly fixed to the specimen by three pairs of pointed screws; the deflection of the centre of a 5-in. span is recorded on the dial directly, without a multiplying device. Errors in the readings due to the deformation of the specimen at the points of loading and support are eliminated by mounting the deflectometer on the neutral plane of the specimen. The shape of the deflectometer is such that it can be used for central loading tests on a 6-in. span, and for four-point loading tests on a greater span, deflection measurements being made in each case on a 5-in. span. Over the range of deflections obtained in the tests made the errors due to the method of measurement were negligible.

Discussion of Results.

Tensile Tests.

Table II gives the mechanical properties determined by the tensile tests. The ratio of permanent elongation to total extension at fracture is plotted against percentage elongation in Fig. 5. The ratio is zero for completely non-ductile material and rises to unity in completely ductile material. The plotted curve consists of two nearly straight lines joined by a short portion of high curvature which corresponds with a permanent elongation of about 2–3 per cent. The values of elongation measured on the broken test-pieces are all definitely higher than those obtained from the load–extension curves.

Bend Tests.

Table III gives the mechanical properties determined by the bend tests on machined and unmachined bars. The ratio of permanent deflection to total deflection at fracture is plotted against percentage elongation from the tensile test in Fig. 5. The curves are of the same form as that obtained from the tensile tests. Very satisfactory agreement was obtained on tests made in duplicate on unmachined bars.

Comparison of the Two Methods.

In this investigation the permanent deformation measured on the tensile test-piece was, in general, approximately one-half of that measured on the bend test-piece. In the tensile tests measurements were made on a 2-in. gauge length; the bend tests involved measurements on a 5-in. span, the loading span being 6 in. There was thus little difference in the order of measurement between the two tests. With either method of test it is possible to compute, with a fair degree of accuracy, the plastic deformation from observations of breaking stress and total deformation immediately prior to fracture, if it is assumed that the ratio of the load to elastic strain is unaltered by the plastic deformation of the material. From the results obtained this assumption appears to be justified in the case of material of very low ductility.

The test-pieces of the dimensions employed in the investigation show the ratio of permanent deformation at fracture to the total deformation at fracture to be higher in the case of the tensile test than in the bend test, and for this reason the tensile test is superior to the bend test for the measurement of ductility. It is not possible to state, from the results obtained, that this ratio is independent of the dimensions of the test-pieces.

SUMMARY.

(1) So far as this investigation extends, the bend test applied to sand-cast aluminium alloy bars has yielded no information concerning ductility which is not obtained from the tensile test.

(2) On the test-pieces employed in this investigation the ratio of plastic deformation to total deformation of a test-piece loaded to the breaking point is higher in the tensile test than in the bend test, particularly when the plastic deformation is small. Consequently the tensile test is preferable to the bend test for the measurement of ductility.

(3) Bend tests on machined and unmachined bars have given very satisfactory agreement.

(4) Measurements of elongation on broken tensile test-pieces have given values higher than those obtained from complete load–extension curves.

ACKNOWLEDGMENTS.

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PAPER No. 659. 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 April 2, 1934. **659**

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THE CONSTITUTION OF COPPER–IRON–SILICON ALLOYS.*

By Professor D. HANSON,† D.Sc., Vice-President, and E. G. WEST,‡ Ph.D.

Synopsis.

The constitution has been examined of alloys containing up to 8 per cent. of iron and 8 per cent. of silicon. The solubility of iron in copper is decreased by the presence of silicon. Over the greater portion of the range of compositions examined, iron exists in the alloys as such, containing only a small amount of silicon and copper in solution; its solubility in the solid state decreases rapidly with fall of temperature and becomes very small below 700° C. Within certain ranges of composition, iron and silicon combine to form another constituent, probably FeSi, which forms a series of alloys with the α solid solution. FeSi also appears to form systems of alloys with the α, β, γ, δ, and ϵ constituents of the copper–silicon series. The shape of the liquidus and solidus curves has been determined and the changes occurring in the system during the process of cooling from the liquid state, have been indicated.

The constitution of the alloys suggests the possibility of modifying their mechanical properties by heat-treatment.

Introduction.

Copper-rich alloys containing metallic silicides have attracted attention recently on account of their capacity for heat-treatment, but very little has been published on the subject of the constitution of these alloys. The present paper deals with alloys of the system copper–iron–silicon.

Corson's [1] paper on the precipitation of silicides in copper-rich alloys gave only a few examples of copper–iron–silicon alloys, and the results tabulated are for physical properties only. It is evident from his photomicrographs that his alloys were not nearly in a state of equilibrium, but uniform solid solutions were said to be obtained at 930° C. in all alloys containing less than 1·0 per cent. of iron. He suggested that Fe_2Si was the effective silicide of the system with a solid solubility between 1·3 per cent. and 2·5 per cent. Ellinghaus [2] gave

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† Professor of Metallurgy, The University, Birmingham.

‡ Research Student, Metallurgical Department, The University, Birmingham.

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results for nine alloys of this system, principally mechanical and electrical properties. Annealing temperatures above 800° C. were not employed, but the softening temperatures after cold-working were obtained. The effective silicide was stated to be FeSi, and an alloy containing 2·38 per cent. of iron and 2·54 per cent. of silicon was stated to be a homogeneous solid solution when cast. His contention that the solubility limit of iron in copper is raised by addition of silicon does not seem to be in accordance with his photographs.

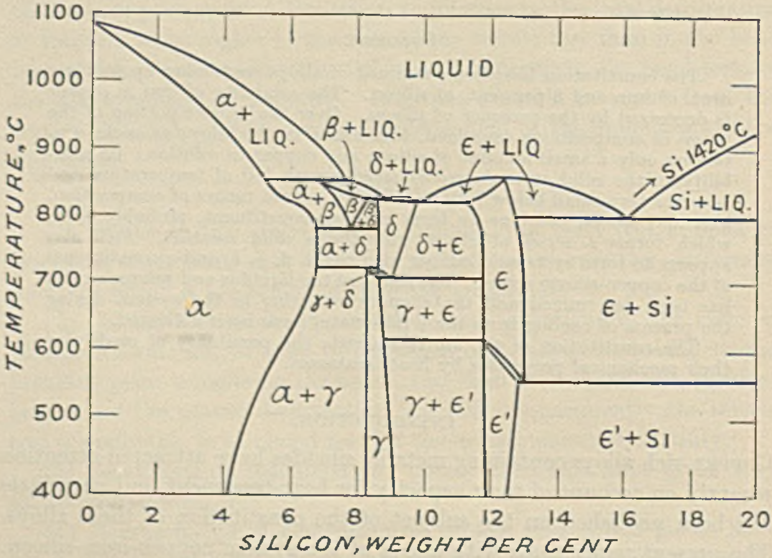

Fig. 1.—Copper–Silicon Alloys. (Smith.)

The Binary Systems.

These have all been investigated recently, and the equilibrium diagrams may be summarized as follows:

(i) *Copper–Silicon.* The reactions according to Smith[3] are given in Fig. 1, the chief points being the configuration of the α-phase boundary and the complexity of the reactions beyond this. The solid solubility of silicon in copper increases from 5·25 per cent. at 852° C. to 6·7 per cent. at 785° C., and remains at this figure until a temperature of 725° C. is reached; below this temperature, the solubility falls to 4·1 per cent. at 400° C. The photomicrographs given in this paper enabled the phases under review in the present research to be readily identified. Later work by Matuyama,[4] Iokibe,[5] and others, has not altered this part of the diagram.

(ii) *Copper–Iron.* The diagram of Ruer and Goerens,[6] taken in conjunction with the work of Hanson and Ford,[7] gives a complete survey of the system, which is shown in Fig. 2. The solubility of pure iron in solid copper decreases from 3·9 per cent. at 1100° C. to less than 0·2 per cent. at 750° C.

(iii) *Iron–Silicon.* Published diagrams vary in a number of details; that due to Haughton and Becker [8] is given in Fig. 3, this having been used in preference to others published. They state that two compounds are definitely present, and possibly a third. These are FeSi at approximately 33 per cent. of silicon, Fe_2Si_5 at 55 per cent., with Fe_3Si_2 at 26 per cent. of silicon as a possible solid solution of FeSi in the α phase.

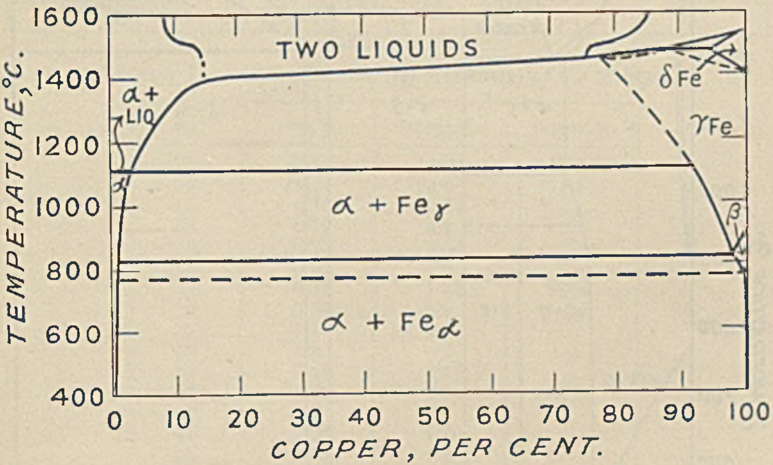

FIG. 2.—Iron–Copper Alloys. (Ruer and Goerens; Hanson and Ford.)

The present paper deals mainly with the α (copper-rich) solid solution range, but other parts of the ternary system have to be considered in the survey of the copper corner.

EXPERIMENTAL DETAILS.

The experimental methods are given in some detail, as the slight variations in procedure sometimes cause corresponding variations in the results obtained by different workers in researches of this nature.

(i) *Casting and Working.*

To facilitate alloying, which is rather difficult when the pure components are used, temper alloys were employed, and their compositions,

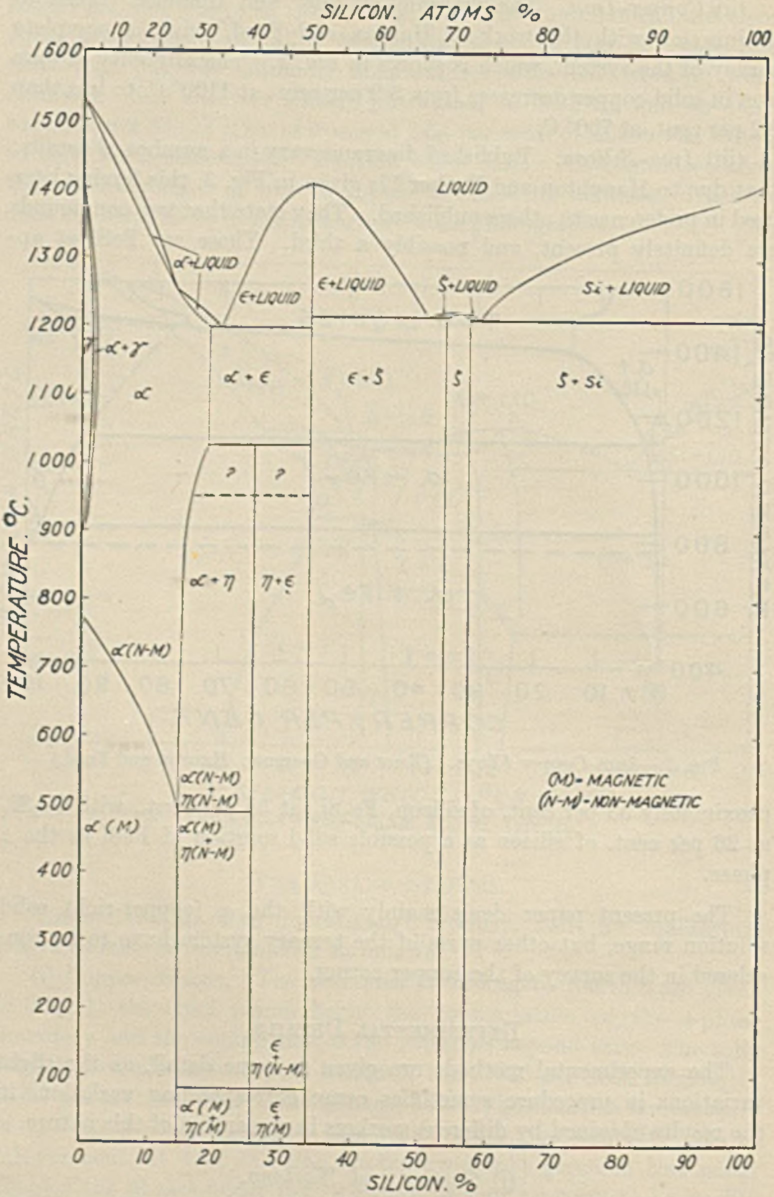

Fig. 3.—Iron-Silicon Alloys. (Haughton and Becker.)

together with the analyses of the original materials, are given in Table I.

TABLE I.

Material.	Copper, %.	Silicon, %.	Iron, %.	Carbon, %.	Other Elements, %.
American washed iron	...	...	96·1	3·8	0·10, max. impurity
Silicon	...	97·0	1·8	trace	1·0 Al, 0·2 Ca, trace Zn
Temper alloy 1	19·3	13·2	67·2	trace	...
Temper alloy 2	75·1	24·6	trace	...	trace Al
Temper alloy 40	48	18	34	trace	...

TABLE II.—*Compositions (by Analysis) of the Alloys.*

No.	Iron, %.	Silicon, %.	Copper, %.
1	67·2	13·2	19·3
2	trace	24·6	75·1
3	0·10	0·54	...
4	0·10	4·4	...
5	0·25	2·54	...
6	0·25	7·0	...
7	0·31	1·34	98·31
8	0·50	8·9	...
9	1·1	4·8	...
10	1·3	0·7	...
11	1·45	1·45	...
12	1·85	1·3	96·82
13	1·0	7·0	...
15	2·94	1·36	...
16	2·95	1·8	...
17	3·3	2·65	...
18	2·7	3·98	...
20	4·7	1·7	...
21	4·2	1·75	94·01
22	4·1	2·2	...
23	3·6	5·5	...
24	4·15	5·4	...
27	5·0	1·0	93·8
28	5·5	1·8	...
29	6·3	2·1	...
31	4·95	5·5	...
33	0·62	0·26	99·04
34	0·47	0·74	...
35	0·10	2·14	97·76
36	0·5	2·1	97·2
37	1·27	1·8	...
38	1·8	1·6	...
39	1·05	0·25	98·5
40	34·0	18·0	48·0
41	2·0	0·85	...
42	2·54	1·28	...
43	2·95	1·45	96·4
47	2·5	2·05	...
48	3·45	1·0	...

Traces of carbon and aluminium were found in the temper alloys, but these were eliminated in the making of the final alloys, in which neither carbon, aluminium, nor calcium could be detected.

The final alloys were made as follows: copper was melted under charcoal in a closed Salamander crucible in a gas-fired furnace and the required amount of temper alloy No. 1 added. The metal was well stirred and allowed to stand for a few minutes before alloy No. 2 was added. The melt was again well stirred and cast from 1200° C. into split chill moulds 1 in. in diameter. The bars were about 4 in. long and 12 oz. in weight.

The compositions of the alloys are given in Table II.

(ii) *Thermal Analysis.*

Cooling and heating curves of all alloys were obtained, a gradient furnace being used. The cooling curve was taken first, and the heating curve then obtained immediately, and the specimen allowed to cool in the air. The lid was kept on the crucible throughout, to prevent oxidation of the melt, and chemical analysis showed that the changes in composition were negligible, the maximum silicon loss being 0·05 per cent. Segregation had occurred in some cases, however. The rate of heating and cooling was about 20° C. per minute, readings being taken every 5° C. The couple was calibrated at intervals, the melting points of copper, silver, silver/copper eutectic, aluminium, zinc, and tin being used, and considering all possible errors due to calibration, e.m.f. measurement, and plotting, the maximum inaccuracy is approximately 10° C.

The results of the thermal analysis are given in Table III.

(iii) *Heat-Treatment.*

According to Smith * the rate of diffusion of silicon to the surface of copper–silicon alloys is extremely high, and preliminary experiments confirm this; to avoid oxidation losses, the alloys were annealed *in vacuo*. It was also apparent that the alloys were likely to require very long annealing periods to attain equilibrium, and the apparatus was devised with each of these points in view. Specimens approximately ½ × ¼ × ¼ in. were cut from the chill-castings and were cold-worked by hammering before treatment. They were cut longitudinally for examination in every case. Specimens were annealed in thick silica tubes, 18 in. long by ⅜ in. internal diameter, sealed at one end, six specimens being placed in this end. Four tubes were heated in a Nichrome wound furnace, giving a uniformly heated zone 4 to 6 in. long in the centre.

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* *Loc. cit.*

TABLE III.—*Data for the Liquidus and Solidus Surfaces.*

Alloy No.	Liquidus, ° C.	Second Stage, ° C.	Solidus, ° C.		
			Liquid.	No Liquid.	Solidus.
3	1077	...	...	...	...
4	987	...	905	895	900
5	1038	...	990	985	985
6	877	...	855	850	850
7	1064	...	1040	1035	1040
8	830	...	817	810	813
9	*	968	885	870	875
10	1075	...	1045	1030	1040
11	1060	...	1010	1000	1005
12	1062	...	1010	1000	1005
13	891	...	865	855	860
15	*	1067	1025	1015	1020
16	*	1055	1010	1000	1005
17	*	1037	970	965	965
18	*	1007	940	925	930
20	*	1067	1025	1015	1020
21	*	1058	1020	1000	1010
22	*	1045	1005	995	1000
23	*	985	920	910	915
24	*	973	920	910	915
27	*	1080	1045	1035	1040
28	*	1078	1040	1025	1032
29	*	1060	1030	1010	1020
31	*	980	935	925	930
33	1080	...	...	...	...
34	1072	...	1060	1040	1050
35	1052	...	...	...	...
36	1057	...	998	995	995
37	1050	...	1005	995	1000
38	1054	...	1005	995	1000
39	1083	...	...	...	...
41	1075	...	1040	1030	1035
42	1067	...	1010	1005	1010
43	*	1064	...	...	...
47	*	1045	990	990	990
48	*	1070	...	...	...

* The arrests at the liquidus were too small to be recorded with any certainty. The liquidus corresponding with the separation of iron crystals was determined roughly by observing the temperature at which crystals appeared at the clean surface of alloys melted in nitrogen and cooled slowly from above the liquidus temperature. The low density of the iron crystals facilitated their detection in this manner, and the method could probably be made very accurate. The following observations were obtained :

Iron, %.	Silicon, %.	Liquidus, ° C.
3·0	2·0	1126
4·0	2·0	1210
3·0	3·0	1235
2·0	4·0	1135
2·0	7·0	1158

The projecting ends of the tubes were stopped with air-tight bungs and connected to a pump through air-tight cocks. The pump was run daily for short intervals, and specimens were quite bright when removed. The temperature was controlled by a Haughton–Hanson thermostat and was measured by a Chromel–Alumel couple placed among the annealing tubes, and connected to a thread recorder. The annealing temperatures employed were 1025°, 970°, 925°, 870°, 800°, 750°, 675°, and 550° C., and the corresponding variations in the annealing period are given in the tabulated results. The annealing temperature never rose above the required figure, and the maximum fall did not exceed 10° C., even this being only momentary. Quenching was carried out as follows: all the cocks were closed, and one tube at a time was opened, withdrawn from the furnace, and inverted over a large bath of water at 15° C. The time taken to quench the specimens was about one second, and no appreciable cooling took place before they entered the water.

The results of the heat-treatments are given in Tables IV and V.

(iv) *Determination of the Solidus.*

The annealing temperatures were too far apart to give the solidus, and the gradient furnace was modified to allow specimens to be quenched rapidly from a known temperature. A metal quenching bath, 8 in. deep and 6 in. in diameter, was fitted round the pillar, *P*, wax being used to ensure a water-tight joint. The couple was placed inside the pillar, and the hot junction was bent at 90° at the top of the pillar.

Table IV.—*Microstructure of Annealed and Quenched Specimens.*

Temp., ° C.	870	830	800	750	675	550
Time, Hrs.	170	100	200	240	270	300
Alloy No.	Constituents present.					
4	α	...	α	α + Fe	α + Fe	α + Fe + γ
6	α + L	$\alpha + \beta$	$\alpha + \beta$	$\alpha + \delta$ + FeSi	α + FeSi + γ	α + FeSi + γ
9	α + Fe	...	α + Fe	α + Fe	α + Fe	α + Fe + γ
12	α + Fe	...	α + Fe	α + Fe	α + Fe	α + Fe
13	Liq.	$\alpha + \beta$ + FeSi	$\alpha + \delta$ + FeSi	α + FeSi + γ	α + FeSi + γ	α + FeSi + γ
15	α + Fe	...	α + Fe	α + Fe	α + Fe	α + Fe
16	α + Fe	...	α + Fe	α + Fe	α + Fe	α + Fe
17	α + Fe	...	α + Fe	α + Fe	α + Fe	α + Fe
18	α + Fe	...	α + Fe	α + Fe	α + Fe	α + Fe
20	α + Fe	...	α + Fe	α + Fe	α + Fe	α + Fe
21	α + Fe	...	α + Fe	α + Fe	α + Fe	α + Fe
22	α + Fe	...	α + Fe	α + Fe	α + Fe	α + Fe
27	α + Fe	...	α + Fe	α + Fe	α + Fe	α + Fe
28	α + Fe	...	α + Fe	α + Fe	α + Fe	α + Fe
38	α + Fe	...	α + Fe	α + Fe	α + Fe	α + Fe
43	α + Fe	...	α + Fe	α + Fe	α + Fe	α + Fe

TABLE V.—*Microstructure of Annealed and Quenched Specimens in the α Range.*

Temperature, ° C.			1025	970	925	870	800	750	675	550
Time, Hrs.			48	100	100	170	200	240	270	300
Alloy No.	Iron, %.	Silicon, %.			Constituents present (see note below).					
3	0·1	0·54	A	A	A	A	A	A *	B	B
4	0·1	4·4	L	C	C	A	A *	B	B	D
5	0·25	2·5	C	A	A	A *	B	B	B	B
7	0·31	1·34	A	A	A	A	B	B	B	B
9	1·1	4·8	L	L	C	B	B	B	B	D
10	1·3	0·7	A	A ?	B	B	B	B	B	B
11	1·45	1·45	C	B	B	B	B	B	B	B
12	1·85	1·3	C	B	B	B	B	B	B	B
33	0·62	0·26	A	A	A	A	B	B	B	B
34	0·47	0·74	A	A	A	A	B	B	B	B
35	0·10	2·14	C	A	A	A	A	B	B	B
36	0·5	2·1	C	A	A *	B	B	B	B	B
37	1·27	1·8	C	B	B	B	B	B	B	B
38	1·8	1·6	C	B	B	B	B	B	B	B
39	1·05	0·25	A	A	A	B	B	B	B	B
41	2·0	0·85	A	B	B	B	B	B	B	B

Note.—* indicates that the alloy was on the limit at this temperature.

A	homogeneous α.
B	α + iron.
C	α + liquid.
D	α + iron and traces of γ.
L	all liquid.

A small piece of Nichrome foil rested over the hot junction, and a silica tube was placed inside the pillar, projecting from the lower end. The details are given diagrammatically in Fig. 4.

The hot zone of the furnace was maintained at 1050° C. and the furnace calibrated, so that, by means of a scale fitted to the side, any required temperature was obtained by moving the furnace over the specimen. Small specimens about $\frac{1}{2} \times \frac{1}{4} \times \frac{1}{4}$ in., were coated with a wash of Alundum to prevent excessive oxidation and placed on the foil. The furnace was lowered and the temperature maintained for 15 minutes. The temperature was checked and the specimen dislodged by an upward thrust of the silica tube, so that a rapid quench was obtained. The bath was maintained at 15° C. Identical specimens were quenched at temperature intervals of 10° C.

(v) *Polishing and Etching.*

Specimens (other than silicon-rich alloys) polished in the usual manner on emery paper and finished on moist chamois leather with magnesia powder, exhibited large holes when viewed under the microscope. These were due to the removal of particles of an iron-rich constituent, and all specimens were therefore polished in the absence of water. Paraffin was used on the emery papers and alcohol on the chamois leather, when good surfaces free from holes were obtained. Alcoholic solutions were used for etching whenever possible. Ferric chloride solution in alcohol, chromic acid (Villellar's reagent), 10 per cent. hydrochloric acid in alcohol, and Smith's bichromate–chloride reagent were found satisfactory for etching the copper matrix and copper–silicon phases: hydrofluoric acid, preferably applied on a pad of cotton wool, darkened the iron constituents. Both types of reagent were usually applied to develop the structure of the same specimen.

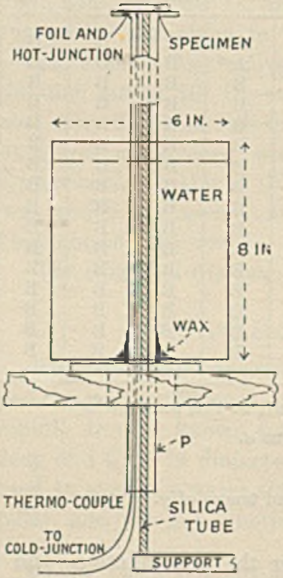

Fig. 4.

Identification of the Phases.

No new phases are introduced, within the range of alloys examined, beyond those belonging to the two binary systems. Near the copper–silicon side of the system, the α, β, γ, δ, and ϵ phases defined by Smith were readily detected, and could be identified by the etching methods which he used and the general characteristics of the phases which he has recorded. In addition to these phases, two other constituents were observed. One was identified with the iron constituent of the copper–iron series, and is essentially iron containing some dissolved copper and silicon. This constituent occurs in particles approximately globular in form, and is distributed fairly evenly throughout the alloys. The other constituent was hard and angular; it was distributed unequally in the matrix of the alloys, and showed a marked tendency to segregate at the top of the ingot, and it occurred in alloys containing more than about 5 per cent. of silicon and rather low iron contents.

Several methods were used to identify these constituents, the most fruitful being microscopical examination, chemical analysis, and hardness. The first constituent had all the micrographic characteristics of the α iron constituent of the copper–iron series, and a photograph is shown in Fig. 5 (Plate I), referring to an alloy containing 5·5 per cent. of iron and 1·8 per cent. of silicon. The second constituent is illustrated

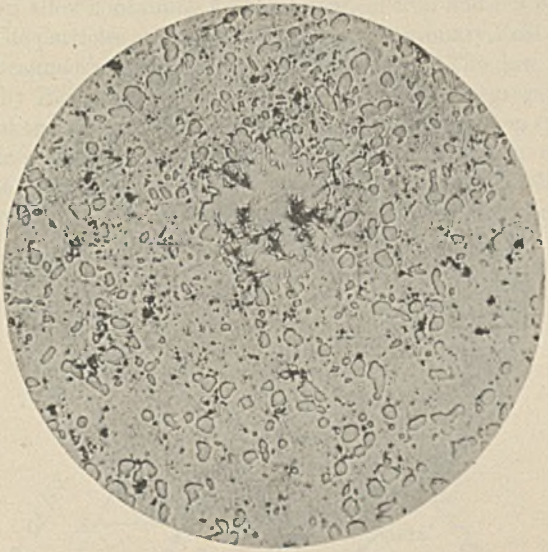

FIG. 5.—Iron 5·5%, Silicon 1·8%. Iron Crystals in a Matrix of a Solution. × 150.

FIG. 6.—Iron 4·34%, Silicon 8·9%. FeSi Crystals. × 500.

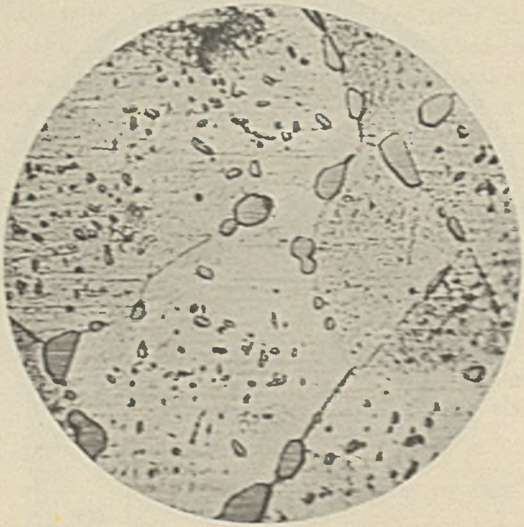

FIG. 17.—Silicon 5·0%, Iron 1%. α + Fe. × 500.

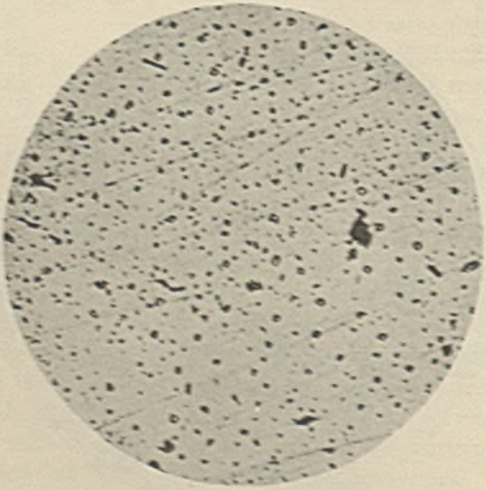

FIG. 18.—Silicon 0·7%, Iron 1·3%. Quenched from 970° C. Re-heated to 675° C. α + Fe. × 500.

in Fig. 6 in an alloy containing 4·34 per cent. of iron and 8·9 per cent. of silicon. The particles are similar in form to the primary FeSi crystals shown in Phragmén's paper [9] on the FeSi alloys. The low density (6·05) given by Phragmén would also account for their segregation.

In some of the alloys containing high iron with low silicon (particularly in certain samples outside the range of composition reported herein), some of the iron appeared to separate while the alloy was still wholly molten. The iron-rich portion had all the metallographic characteristics of the one micro-constituent. A small portion of this constituent was extracted from one of the alloys and was magnetic and brittle. It was crushed, and the adhering copper-rich matrix removed by solution in dilute nitric acid. An analysis of the residue gave the following result: iron 90·5; silicon 7·5; copper 2·0 per cent. This confirms that these particles are essentially a solid solution of silicon and copper in α iron. A similar method could not be used to identify the other constituents, since no particles sufficiently large to be extracted could be found. By comparing the analyses of the upper

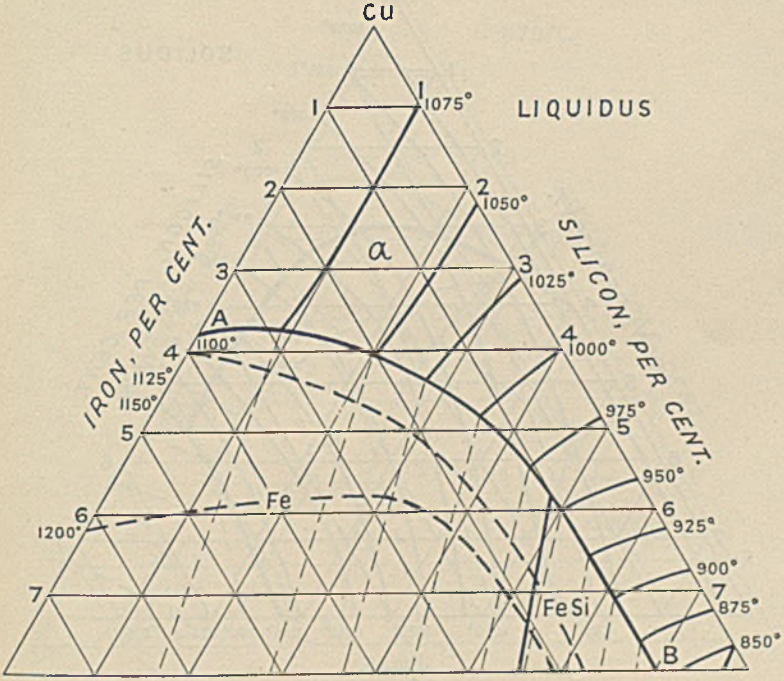

Fig. 7.

and lower halves of a slowly-cooled ingot in which this constituent was segregated to the top of the ingot, it was established that the iron and silicon in this constituent were present in proportions corresponding with the formula FeSi.

A series of hardness measurements was made by means of a sclerometer on specimens containing large particles of each of the two iron-rich constituents; a conical diamond under a load of 150 grm. was used. The results of the measurements are shown in Table VI. The large difference in hardness between the two constituents is definitely established, and the measurement of the scratch-hardness was found useful in identifying constituents during the microscopical examination of some of the alloys. For purposes of comparison, the corresponding constituents in pure iron–silicon alloys were also tested.

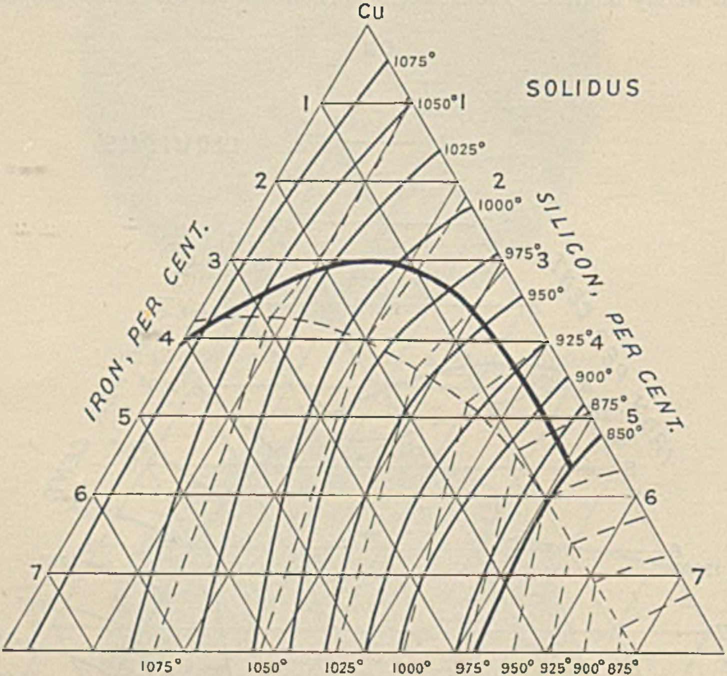

Fig. 8.

The Equilibrium Model.

The results of the thermal analysis and microscopical examination of the heat-treated specimens are given in detail in the Tables. From these data, an equilibrium model was constructed, the form of which is shown by Figs. 7–16.

The process of solidification is indicated in Figs. 7 and 8; in the former, the true shape of the liquidus surface is indicated by the heavy isothermal lines on which the temperatures are marked. The thin, dotted isothermal lines refer to the second stage in the solidification. The liquidus surface consists of three main sections, corresponding with the separation of primary crystals of α solid solution, iron crystals, and FeSi crystals; in the extreme right-hand corner, a small portion of the surface representing the separation of the β phase is also shown. The α liquidus shown in the diagram is practically complete, but the surfaces representing the separation of iron and FeSi extend very much further into the whole system, probably to the opposite face representing alloys of iron and silicon. The isothermal lines on the α liquidus are substantially correct, since the data from the cooling curves are sufficient to indicate this surface with fair accuracy. The form of the liquidus corresponding with the separation of iron and FeSi is shown by the

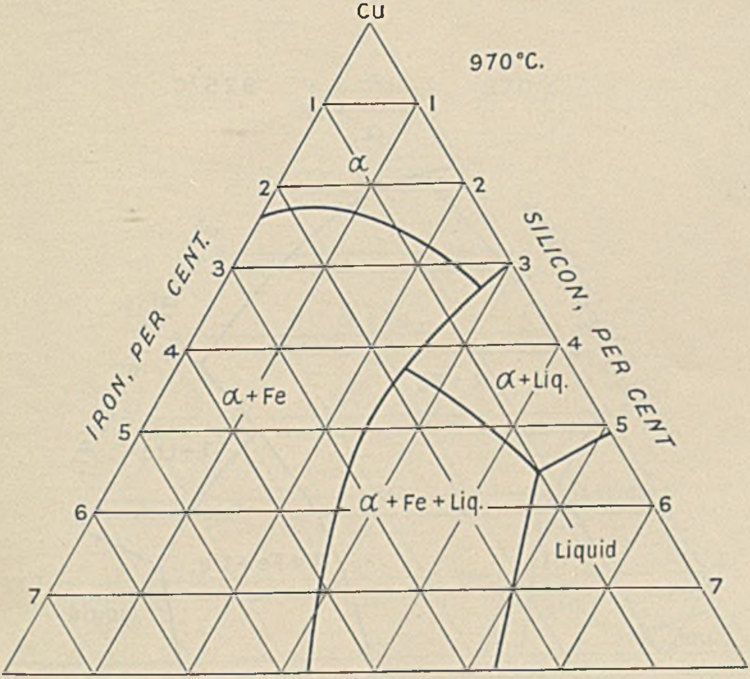

Fig. 9.

dotted, heavy lines, and is only approximate, since the arrests corresponding with this transformation were very small, on account of the small amount of iron-rich constituent involved. The general form of the curves is, however, probably correct.

Alloys the compositions of which fall within the limit of the α field do not separate a second phase except along a zone near the junction with the iron and FeSi fields, whilst those which fall within the iron

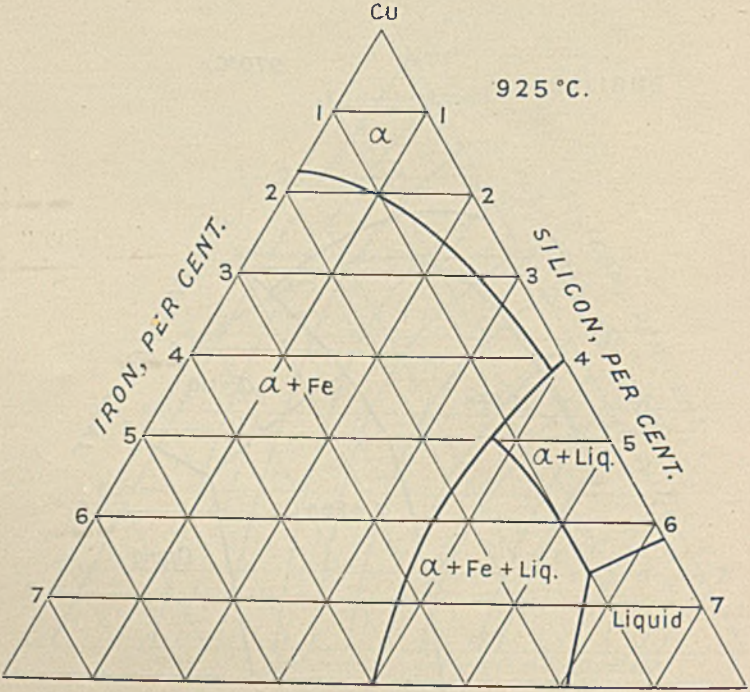

Fig. 10.

and FeSi fields complete their solidification by depositing copper-rich α solution, which deposition commences at the surface of secondary separation shown by the thin, dotted isothermal lines in Fig. 7.

The completion of the solidification process can be pictured by means of Fig. 8. In this diagram, the full lines represent the solidus of the system, whilst the dotted lines represent, over the α region, the liquidus surface, and over the iron and FeSi regions, the upper surface of secondary separation. The temperatures of the isothermal lines on the solidus surface are indicated on the copper–silicon face, and those on the other surfaces, on the base of the diagram.

The constitution at lower temperatures is indicated by the series of horizontal sections through the model shown in Figs. 9–15. The data from which these have been constructed are shown in the Tables. The phase fields are indicated on the diagrams, and require no further amplification. The boundaries of the α and α + Fe fields are probably fairly accurately indicated. In the extreme right-hand corner of the model the phase boundaries have not been closely determined, partly because insufficient alloys were prepared for the purpose, and partly because equilibrium was difficult to attain in this region of the diagram; they should be regarded as only tentative, and as being qualitative rather than quantitative.

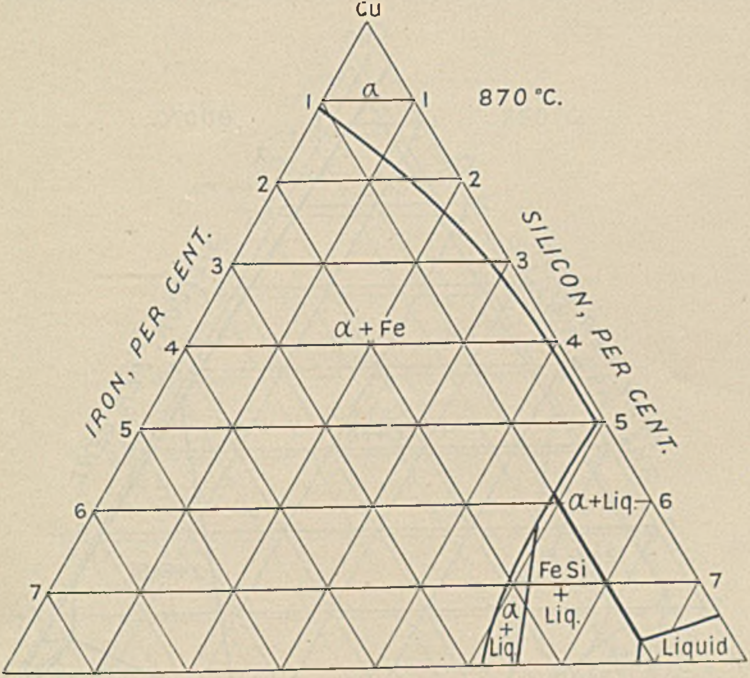

Fig. 11.

Fig. 16 shows the shape of the boundary of the phase field below the solidus line. The solubility of iron decreases rapidly below the solidus as the temperature falls, and becomes very low below about 700° C.; in addition, the solubility of iron, even at high temperatures, is decreased by the presence of silicon. These effects give rise to a somewhat complicated solubility surface, and the complication is increased by the fact that, close to the copper–silicon surface, the solubility of the γ-phase actually increases with fall of temperature between about 850° C. and 750° C.

General Nature of the Alloys.

The constitution of alloys of this ternary system appears to be one in which the constituents of the iron–silicon system combine with those of the copper–silicon system, as is indeed to be anticipated, since copper and iron themselves form no intermediate phases. The α solid solution (copper-rich) forms a series of alloys with iron (the α solution of Haughton and Becker's diagram) and with FeSi. The β, γ, δ, and ε constituents also form a series of alloys with FeSi, but not with iron; examples of alloys of this type were met with in the right-hand corner of the present system, and in the alloys outside the range of the present diagram, but this investigation is not more than enough to detect their existence.

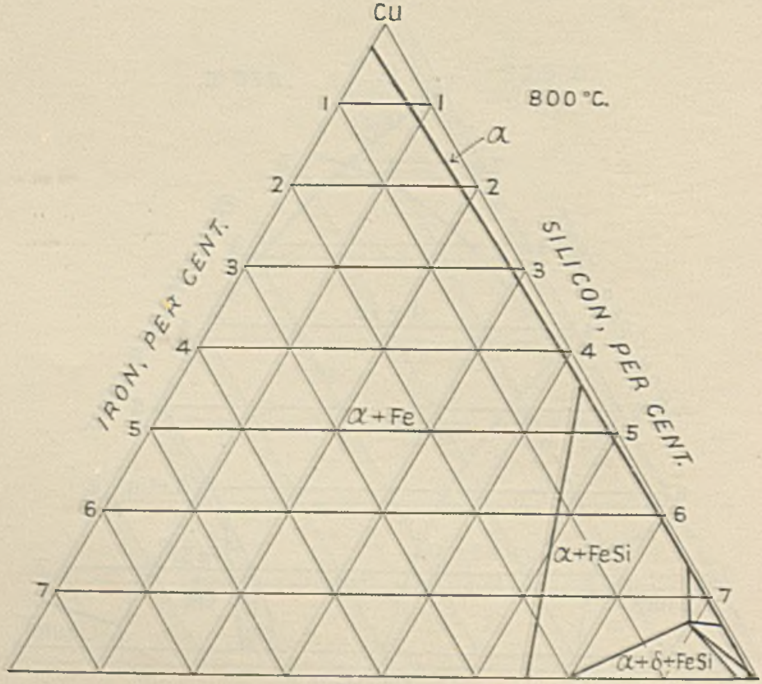

Fig. 12.

The diagrams enable one to picture fairly closely the nature of the reactions which occur during the cooling of alloys of this system. Copper-rich alloys within the α range solidify by depositing a copper-rich solid solution, whilst iron and silicon become concentrated in the residual liquid; except near the limits of the field, such alloys consist, when they are just solid, of a single phase. As cooling proceeds still further, iron is precipitated from solid-solution as indicated by the sloping surface in Fig. 16, from which it can be seen that only in a very narrow zone close to the copper–silicon face does iron remain in solid solution; the amount in this case being very small. Alloys the compositions of which fall outside the α range commence to solidify by depositing iron or FeSi. In that case, the liquid becomes rapidly impoverished in iron, until its composition reaches that indicated by the boundary between the α and the Fe or FeSi fields (*AB* in Fig. 7). When this point is reached, the stage of secondary separation commences, the liquid composition changing with temperature, as indicated by this boundary line, in such a manner that it becomes enriched

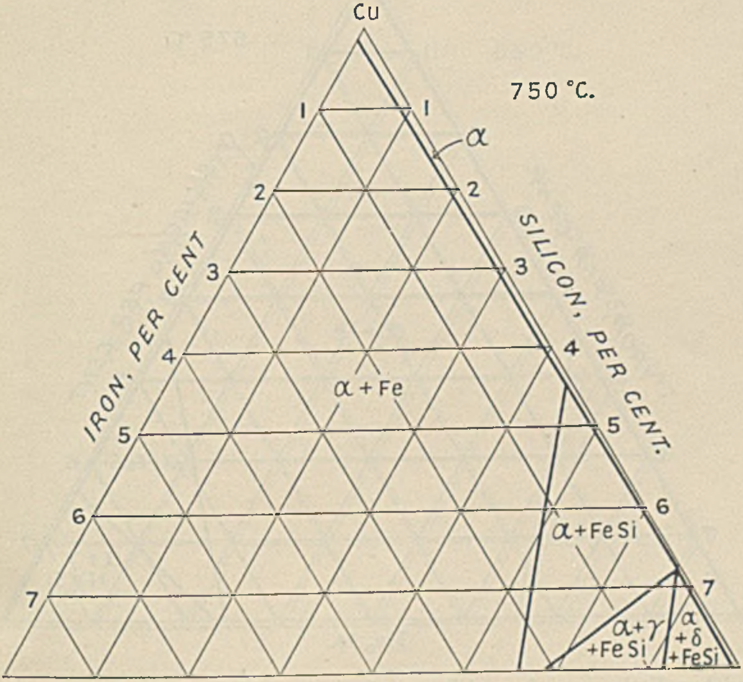

FIG. 13.

with silicon, but still further impoverished in iron. Thus we see that in such alloys the liquid phase loses iron in the first portion of the solidification process, without much change in the silicon content, and loses copper during the second portion of the solidification process while the silicon content of the residue mounts rapidly. The iron-rich constituents are deposited first, then the α solid solution together with a little more iron-rich constituent are formed, and finally, the silicon-rich phases during the final stage in the solidification. In all alloys, precipitation of iron from the α solid solution occurs with fall of temperature, and in alloys close to the copper–silicon face some precipitation of the γ-phase was also observed below 600° C.

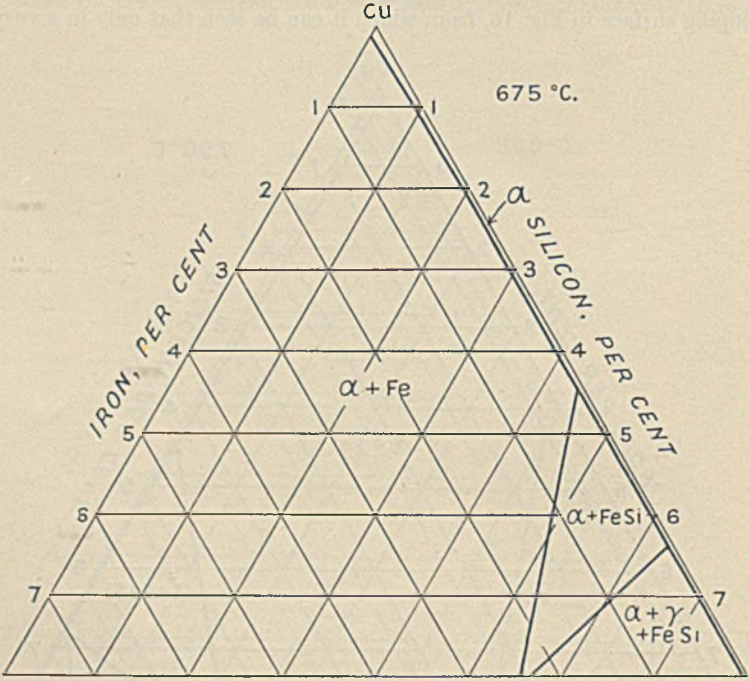

Fig. 14.

Two typical photomicrographs are shown in Figs. 17 and 18 (Plate II).

Precipitation-Hardening.

The wide range of composition over which precipitation of the iron constituents occurs on cooling suggests that the alloys of this system should be amenable to heat-treatment. Corson has already reported increases in hardness in copper alloys containing iron and silicon as a result of quenching followed by re-heating, but the improvement in strength which he obtained was not very great. A further examination of the possibilities in this direction appears to be justified in the light of the results now obtained, since alloys of this system possess the type

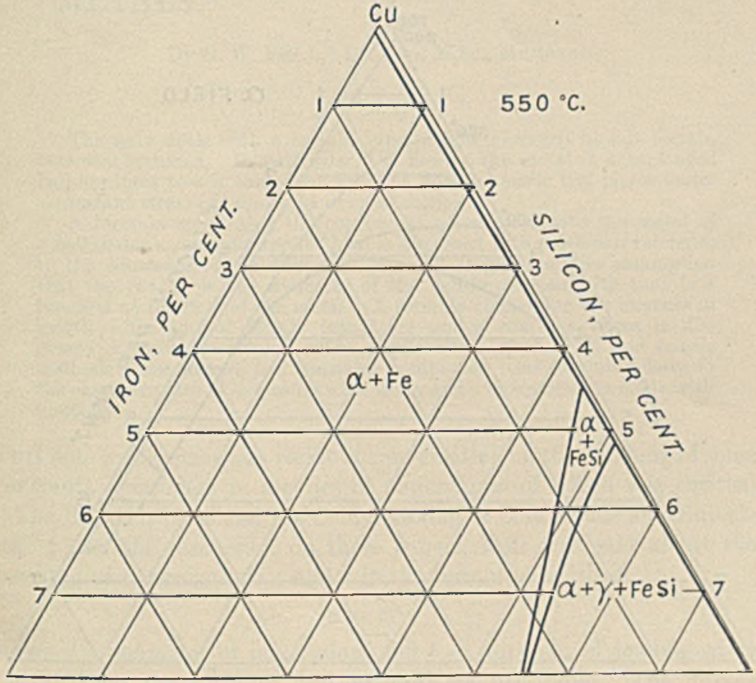

FIG. 15.

TABLE VI.—*Scratch Hardness Results for the Iron-Rich Phases.*

Description.	Mean Scratch, Widths, Inch.			Mean.
	1st Scratch.	2nd Scratch.	3rd Scratch.	
FeSi in alloy 26 . . .	0·051	0·060	0·056	0·056
FeSi in iron–silicon alloy .	0·049	0·056	0·051	0·052
Globule in alloy 28 . .	0·087	0·092	0·085	0·088
Globule in alloy 20 . .	0·085	0·087	0·085	0·086
Globule in alloy 23 . .	0·076	0·080	0·083	0·079
Globule in alloy 24 . .	0·076	0·080	0·069	0·075
6·5% iron–silicon alloy . .	0·086	0·085	0·085	0·085

of constitution associated with hardening by heat-treatment. The authors have made a few preliminary experiments, the results of which were disappointing since the increases in hardness obtained were not very great, and this is in keeping with the experience of Hanson and Ford on copper–iron alloys. Nevertheless, the possibilities have not yet been fully explored.

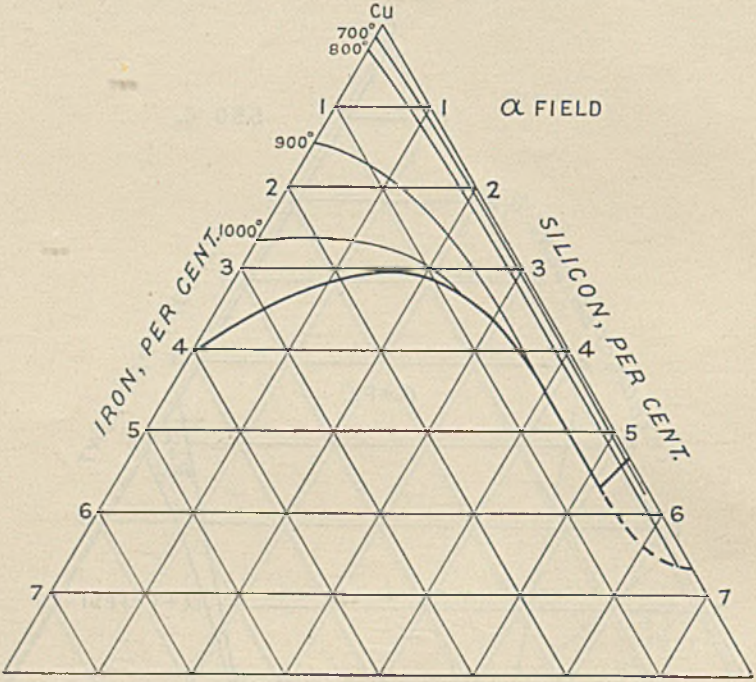

Fig. 16.

Bibliography.

[1] Corson, *Proc. Inst. Met. Div., Amer. Inst. Min. Met. Eng.*, **1927**, 435–450: *Iron Age*, 1927, 353–356; *Rev. Mét.*, **1930**, Feb.–May (especially pp. 202–205).

[2] Ellinghaus, *Abhand. Inst. Metallhütt. u. Elektromet. K. Tech. Hochschule, Aachen, B.I.*, **1921**, 5–23.

[3] C. S. Smith, *J. Inst. Metals*, 1928, **40**, 359–373; *Amer. Inst. Min. Met. Eng., Tech. Paper* No. **142**, 1928; *Trans. Amer. Inst. Min. Met. Eng., Inst. Metals Div.*, **1930**, 164–193.

[4] Matuyama, *Sci. Rep. Tohôku Imp. Univ.*, 1928, [i], **17**, 665.

[5] Iokibe, *Kinzoku no Kenkyu*, 1931, **8**, 433–456.

[6] Ruer and Goerens, *Ferrum*, 1917, **14**, 49.

[7] Hanson and Ford, *J. Inst. Metals*, 1924, **32**, 335-360.

[8] Haughton and Becker, *J. Iron Steel Inst.*, 1930, **121**, 315-332.

[9] Phragmén, *J. Iron Steel Inst.*, 1926, **114**, 397–403.

PAPER No. 660. 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 April 2, 1934.

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

A NOTE ON SOME FORMULÆ CONCERNING VISCOUS AND PLASTIC FLOW IN SOFT METALS.*

By E. W. FELL,† Dr.-Ing., M.Sc., MEMBER.

SYNOPSIS.

The note deals with a certain type of flow observed in soft metals, eutectics included. In particular, the flow of the metal in a prolonged ball-hardness test is compared with the flow in tensile test-pieces under a constant stress per unit area of cross-section.

A formula concerning the continuous penetration into the metal of a ball under a constant applied load is discussed with particular reference to the constants in the formula. A result is given of the assumption that the change in the diameter of the ball-impression with time is a function of the flow of the metal. A formula concerning the increase in length with time of tensile test-pieces under constant stress is discussed regarding constants. The applicability of the ball and tensile methods is considered, and constants compared. One formula relates to the change in rate of extension with stress and a comparison is made with viscosity.

THIS note was written as a result of conversation on the meaning of some constants mentioned in a series of papers, one of which was entitled "The Ball-Hardness and the Cold-Working of Soft Metals and Eutectics."‡ In the discussion on these papers, little was said about the meaning of the constants c and s in the formula described,

$$d = ct^s \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (1)$$

where $d =$ diameter of impression, and $t =$ duration of loading after the load on the machine had reached its maximum. The values obtained for these constants varied according to the state of the metal and the mode of carrying out the test. It is hoped that this note may be of value in attempting to discuss the meaning of these constants and in comparing them with some recent work concerning a similar type of flow in metal at room temperatures.

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* Manuscript received December 29, 1933.

† Recently at St. John's College, Cambridge.

‡ F. Hargreaves, *J. Inst. Metals*, 1928, **39**, 301–327; further papers, *ibid.*, 1928, **40**, 41–54; 1929, **41**, 257–283; 1930, **44**, 149–167.

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).

Formula (1) fits the interesting experimental results which were obtained,[*] since the points representing a single set of observations lie near a straight line when plotted with $\log t$ as abscissa and $\log d$ as ordinate. It is seen from the formula that at a specified time, the diameter of the impression is dependent on the coefficient c and the index s. The value of $\log c$ is the " additive constant " in the equation of the $\log t$–$\log d$ curve, and s is the gradient. c and s are found to be constants for a particular metal in a definite state and for prescribed conditions of testing.

It will be noted that formula (1) is determined for a constant load only. Strictly, therefore, it does not seem clear why the rate of application of the load should have little effect on the results obtained when s has a negligible value (see p. 308 of Hargreaves's paper), or that its effect will vary at different stages of the operation of loading when s is not constant for different loads (*ibid.*, p. 309). In passing, it may be noted that the formula does not hold in an interval of time including $t = 0$ and values of t above $t = 0$: there is little to show when d begins to fit the formula. It is possible that, contrary to the formula, the diameter of the impression is not equal to c when $t = 1$. The diameter of the impression when $t = 0$ depends on the metal and on the conditions of testing prior to this time.

The formula shows that the diameter of the impression, which is indirectly a measure of the ease with which the ball penetrates the metal, is dependent on both c and s. For, suppose that the change in the diameter of the impression with time is a function of the flow of the metal, then the increase in d in a small interval of time, δt, is from formula (1) found to be $cst^{s-1} . \delta t$, to the first order. Thus the increase in d is partly dependent on c and s, or, briefly, on the constant (cs). Both c and s appear to vary differently in the experiments, and the influence of c is considerable, as is shown by taking, for example, the lead–tin eutectic, worked, referred to on p. 322 of Hargreaves's paper, Table X, as Material No. 8, where approximately $c = 1\cdot92$, $s = 0\cdot143$.

t.	t^s.	ct^s.
30	1·62	3·11
270	2·23	4·28
540	2·46	4·72

In a further paper,[†] mention is made of the " creep factor s," but since

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[*] F. Hargreaves, *loc. cit.*

[†] *J. Inst. Metals*, 1930, 44, 151.

c should be taken into account, this term would not appear permissible. Meyer's formula,

$$L = ad^n \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (2)$$

where L = maximum load on the ball, d = diameter of impression after a standard time, and a and n are constants, scarcely shows what is taking place as the load is increased from zero to maximum in a test, since strictly the time required for this to happen is generally less than the standard time employed.

The author of the present paper is indebted to Mr. C. E. Pearson, M.Met., for kindly supplying details of a paper on "The Viscous Properties of Extruded Eutectic Alloys of Lead–Tin and Bismuth–Tin."* In this paper, rates of extension in tensile tests at constant stress per unit area of cross-section are given. Provided sufficient time after extrusion was allowed for, rate of extension was found to be uniform; Table IV shows the change in original gauge-length with time at constant stress (in passing, it may be mentioned that the relation $\log_{10}$ (time)–$\log_{10}$ (length) is not linear for the two cases described). In the formula mentioned,

$$l = l_0 e^{kt} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (3)$$

where l = length after time t, l_0 = original gauge-length, the constant k will be found in Table IV to have the following approximate values in in./minute: for lead–tin eutectic, 24 hrs. after extrusion and stressed at 1000 lb./in.^{2}, $k = 0{\cdot}0140$; for lead–tin eutectic, annealed 5 hrs. at 100° C., and stressed at 400 lb./in.^{2}, $k = 0{\cdot}00044$.

It is interesting to compare, as far as is possible, the results of Hargreaves and Pearson with regard to the flow of the metal. The lead–tin eutectic, 75 per cent. reduction by hammering, in Table XVI of Hargreaves's paper, may be compared with the lead–tin eutectic, severely worked by extrusion at room temperatures, in Table V of Pearson's paper. On differentiating in (3) with regard to the time and putting $l_0 = 1$, $t = 0$, the rate of extension $\left(\frac{dl}{dt}\right)$ will be found to be k. Results for k, together with the values for c and s taken from Table XVI, are given in Fig. 1. It will be seen that only c varies in accordance with the curve representing k, whilst s has practically the same value for the three determinations made in the first four days of ageing after working. From these few results it may be deduced that k and s are not comparable.

Why should not the ball method be convenient for measuring this type of flow, provided the metal be more or less isotropic and the points of support of the specimen be at such a distance that reaction effects

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* (*Monthly*) *J. Inst. Metals*, 1933, Dec., cci–ccxv.

thereat have negligible influence in the neighbourhood of the ball? It might be expected that the two methods should give comparable values for these constants in homogeneous materials like pitch. Comparable values for the flow in metals may not be obtainable, because they are not in this sense homogeneous, in addition to the alteration of their properties on working. In the ball method the material is pushed away by the penetrating ball, in the tensile method it is pulled out.

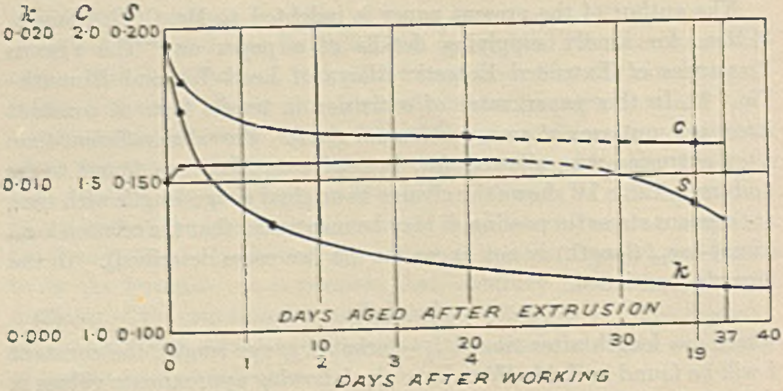

FIG. 1.—Lead–Tin Eutectic. Comparison of the Constants k, c, and s (k for 1000 lb./in.^{2}, c and s for 6·35 mm. ball/40·3 kg.).

In the first method, the contact pressure at a fixed point on the ball varies in magnitude and possibly also in direction with time; in the second method, the pull across a transverse section within the gauge-length may be visualized as constant in magnitude and direction with the passage of time. The experimental conditions are thus simpler in the second method. Such differences as these may account for any variation of results between the two methods, assuming that the metal is initially in the same condition.

Table V has also been used to examine the relationship between the applied stress and the rate of extension k, and Fig. 2 shows log (stress)–log k curves for extruded lead–tin eutectic in the four states mentioned in the table. The curves are not straight lines. They cease to be straight above a stress of about 600 lb./in.^{2}, and in the absence of systematic experimental error this may suggest that a change occurs in the mode of flow as the stress is increased.

Accordingly, in the range 200–600 lb./in.^{2}, let

$$k = b^{-1}p^{m} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \qquad (4)$$

where k = rate of extension, p = stress, b and m are constants. b will be seen to depend on the state of the metal and possibly on the kind of metal, whilst m (= 2·72 in c.g.s. units) has the same value for the four curves, since they are parallel, as shown in Fig. 2, and is practically unaffected by the different states of the metal considered in the figure.

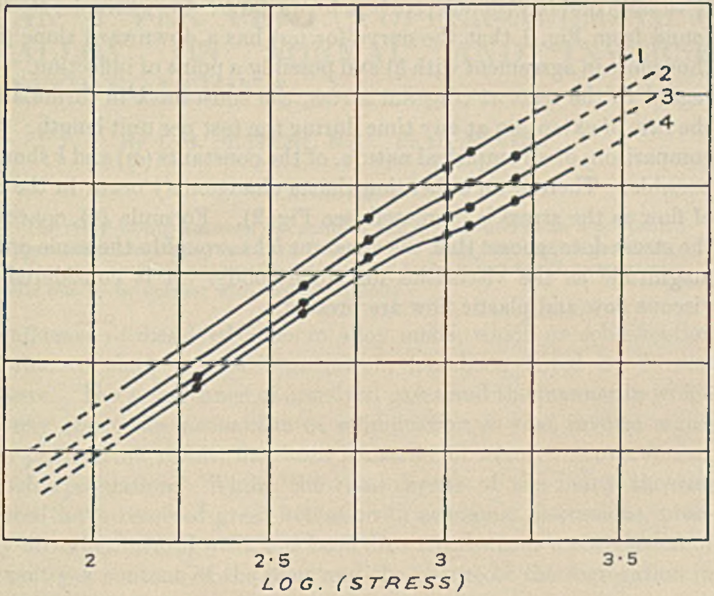

FIG. 2.—Extruded Lead–Tin Eutectic. Variation of k with Stress. (1) Aged 1 Day after Extrusion; (2) Aged 7 Days after Extrusion; (3) Annealed 5 Hrs. at 100° C.; (4) Aged 37 Days after Extrusion.

It will be found in this range that for the extruded lead–tin eutectic the following values for b are obtained :

Aged 1 day after extrusion . . . $b = 4{\cdot}46 \times 10^{16}$ c.g.s. units
Aged 7 days after extrusion . . . $b = 7{\cdot}94 \times 10^{16}$,, ,,
Annealed 5 hrs. at 100° C. . . . $b = 1{\cdot}41 \times 10^{17}$,, ,,
Aged 37 days after extrusion . . . $b = 2{\cdot}24 \times 10^{17}$ approx.

The tests were made at 21° C. ± 2°. In the figure, the curves have therefore been assumed to consist each of two straight portions, for a lower and a higher range of stress, which have been extended by drawing in the broken lines. For the higher range of stress above about 1000 lb./in.^{2}, the values for b and m behave as above, being somewhat smaller in magnitude. The only reason for introducing formula (4) is to show that b is roughly of the same order of magnitude as the viscosities for some solids.

CONCLUSION.

The constants c and s require careful use; complex conditions—for example, in the ball method—have been mentioned. It is suggested that the use of the product cs would remove some irregularities, in that it would combine the effect of each constant: for example, it will be found from Fig. 1 that the curve for (cs) has a downward slope (being thus more in agreement with k) and possibly a point of inflection. With regard to the tests at constant stress, the constant k in formula (3) is the rate of extension at any time during the test per unit length. Some comparison, of an empirical nature, of the constants (cs) and k should be possible. There is an indication that a change may occur in the mode of flow as the stress is increased (see Fig. 2). Formula (4), concerning the stress data, shows that the constant b has roughly the same order of magnitude as the viscosities for some solids. It is considered that viscous flow and plastic flow are present.

PAPER No. 661. 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 April 2, 1934.

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NOTE ON THE INFLUENCE OF GASES IN AN 8 PER CENT. COPPER–ALUMINIUM ALLOY ON NORMAL AND INVERSE SEGREGATION.*

By I. G. SLATER†, M.Sc., Ph.D., MEMBER.

SYNOPSIS.

The relationship between gas content and segregation in an 8 per cent. copper–aluminium alloy has been determined. In a sand-cast ingot, 3-in. in diameter by 3 in., segregation was found to be inverse with very gassy melts but to be normal with degassed melts.

THE influence of dissolved gases in alloy melts, which on solidification are liable to show inverse segregation, has been noted by several observers. The significance of dissolved gases and the manner in which they may affect the mechanism of solidification so that inverse segregation phenomena result, has been a matter of keen controversy and of much speculation. Whilst the rival merits of the many theories advanced have received great attention in academic discussions, practically no experimental work has been directed towards a correlation of the exact gas content of the melt and the nature of the segregation in the resulting ingots.

Studies made during recent years, of gas equilibria in solid and liquid metals, have established the necessary technique for the production of melts having controlled gas contents. The relationship, if such exists, between gas content and segregation can therefore be determined. A few experiments which have been made in this connection with an 8 per cent. copper–aluminium alloy, are reported on in this paper.

EXPERIMENTAL.

A series of " 3L11 " aluminium–copper alloy ingots having various gas contents was examined. The ingots were all from the same batch of metal with the exception of No. 1, which had a lower copper content.

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* Manuscript received December 27, 1933.

† The University, Birmingham.

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 gas content of the ingots ranged from a maximum, obtained by thoroughly saturating the melt by poling with damp green wood, to a minimum produced by various de-gassing processes. In each case, the melt was cast at 700° C. into a skin-dried green-sand mould, 3 in. in diameter by 3 in., with an open top and without subsequent feeding. During solidification, large quantities of gas were given off from No. 1 ingot; No. 2 ingot showed little gas, and the others remained quite tranquil. Sections of the five ingots were examined for the visual appearance of pinholes, and these are recorded in Table I.

Two sets of drillings for analysis were taken from each block; from the outer circumference and from the "heat centre," that is, the area at which the last portions solidify. For purpose of comparison of gas content, the total volume of cavities in each ingot has been calculated from density determinations:

$$\text{volume of cavities, per cent.} = \left[1 - \frac{\rho'}{\rho''}\right] 100$$

where ρ' = observed density of ingot, and
ρ'' = optimum density of gas-free metal.

The value of ρ'' for ingots Nos. 2–5 was taken as 2·870, the optimum density recorded on a portion of a sand-cast block, 3 in. by 3 in. in diameter, which had been poured from a completely de-gassed melt. For ingot No. 1, ρ'' was 2·850. The total volume of cavities is not exactly equal to the volume of gas retained in the ingot, since the pressure of the gas in the pinholes is unknown and there is a slight effect due to liquid shrinkage (ingot No. 5 showed traces of shrinkage at the "heat centre"); the comparison requires a relative modification in each instance.

The observations made are summarized in Table I.

TABLE I.

Ingot No.	Density.	Visual Appearance of Polished Half-Section.	Volume of Cavities, Per Cent.	Copper, Per Cent.	
				Edge.	Centre.
1	2·758	Very many pinholes	3·3	7·6	7·0
2	2·802	Moderate number of pinholes	2·4	8·3	8·1
3	2·819	Few pinholes	1·8	8·0	8·1
4	2·842	Sound	1·0	8·0	8·5
5	2·861	No pinholes, trace shrinkage at the centre	0·3	7·7	8·7

The relationship between the percentage volume of cavities and the type and amount of segregation is shown graphically in Fig. 1.

In the experimental conditions employed, it is seen that the amount of gas present in the melt determines the character of segregation in the ingot. The influence of this factor in determining the segregation with other rates of solidification, remains to be established.

A further ingot (No. 6) having the same gas content as No. 2 was prepared by allowing the melt to solidify under a pressure of nitrogen at 200 lb./in.^{2}. This ingot had a density of 2·866 and was quite free from pinholes. Determinations of the copper content were made as before, and the results were identical with those obtained for the No. 2 ingot. An external gaseous pressure therefore does not influence the extent of segregation to which the alloy is normally liable.

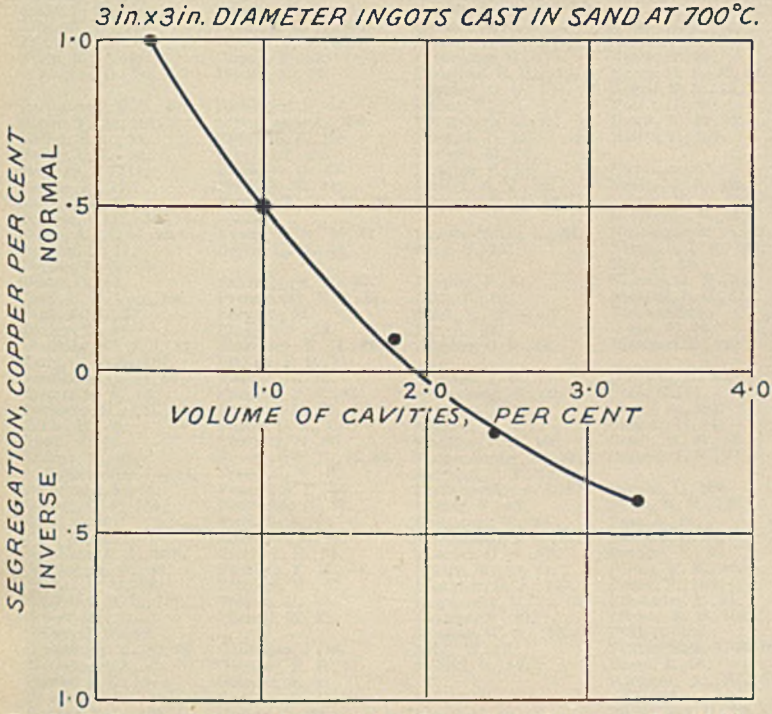

Fig. 1.—Influence of Gas on Segregation of Copper in an 8 per cent. Cu : Al Alloy.

A discussion of the results now obtained in the light of the several theories of inverse segregation current will not be attempted. It is intended that they should indicate a very profitable line of investigation.

In the experimental conditions employed it is seen that the amount of gas present is [illegible] determining the character of segregation [illegible]. The influence of [illegible] in determining the segregation with other rates of solidification, remains to be established.

When the copper [illegible] the same gas-content as [illegible] was [illegible] by allowing the melt to solidify under a pressure of [illegible] at [illegible]. The ingot had a density of 2·93 and was quite free

Fig. 2.—Influence of Gas on Segregation of Copper in an 4 per cent. Cu-Al Alloy.

from pinholes. Determinations of the copper content were made as before, and the results were identical with those obtained for the [illegible] ingot. An external gaseous pressure, therefore, does not influence the extent of segregation to which the alloy is normally liable.

A discussion of the results now obtained in the light of the general theory of inverse segregation will not be attempted. It is intended that they should indicate [illegible] investigation.

AUTHOR INDEX TO ABSTRACTS

Author Index to Abstracts

METALLURGICAL ABSTRACTS

(GENERAL AND NON-FERROUS)

Volume 1 FEBRUARY 1934 Part 2

I.—PROPERTIES OF METALS

(Continued from pp. 2–6.)

Aluminium: Resistance to Corrosion and Use of the Metal in the Chemical Industry. Am. Matagrin (*Rev. Chim. Ind.*, 1933, **42**, 66–72, 99–102, 128–132).—A review, discussing corrosion-resistance, foundry practice, rolling, soldering, drawing, uses in the dairy, brewing, rubber and chemical industries, and protection by anodic oxidation.—E. S. H.

†**Has Aluminium a Transformation Point?** O. Tiedemann (*Metallwirtschaft*, 1933, **12**, 669–671).—T. has previously described (see *J. Inst. Metals*, 1926, **35**, 540) phenomena in aluminium which point to the existence of a transformation point; up to the present no satisfactory explanation of these has been advanced, nor have they been contradicted. The fact that the temperature curve for a number of properties shows no inflection is no indication of the absence of a transformation. The literature on transformations in zinc and cadmium is discussed.—v. G.

†**On Investigations of the Alleged Allotropy of Aluminium.** A. Schulze (*Metallwirtschaft*, 1933, **12**, 667–669).—A review of articles published on this subject to date leads to the conclusion that aluminium has no transformation point and that observed irregularities in the temperature curves of various properties are due to the effects of impurities.—v. G.

Amorphous–Crystalline Transformation of Arsenic and Antimony. G. R. Levi and D. Ghiron (*Atti R. Accad. Lincei Rend.*, 1933, [vi], **17**, 565–569; *Chem. Zentr.*, 1933, **104**, II, 3082).—The conversion of amorphous antimony into the crystalline form is accelerated by such catalysts as hydrochloric acid and hydriodic acid; there is no definite transformation temperature, but the change can occur at 180° C., although 270° C. was previously thought to be the minimum temperature. Reduction of antimony chloride to metal invariably yields the amorphous form, whereas reduction of other salts in the absence of chlorides yields the crystalline form. Rapid heating of the amorphous form causes the change to occur explosively, but explosion may be avoided by prolonged heating at low temperatures.—A. R. P.

***On a Polymorphic Transformation of Calcium.** A. Schulze and H. Schulte-Overberg (*Metallwirtschaft*, 1933, **12**, 633–635).—Thermal, electrical, and dilatometric tests on calcium containing 4·6% of impurities, including carbon, oxygen, a trace of iron, and 1·7% nitrogen, indicate the existence of a transformation at 430°–450° C. accompanied by a heat evolution of $2·3 \pm 0·3$ cal./grm.—v. G.

***X-Ray Investigations on Calcium at High Temperatures.** L. Graf (*Metallwirtschaft*, 1933, **12**, 649–653).—X-ray examination of the calcium used by Schulze and Schulte-Overberg (cf. preceding abstract) showed that the metal is face-centred cubic at low temperatures ($a = 5·56$ A. at 20° C.) and body-centred cubic above 450° C. ($a = 4·43$ A. at 480° C.). The recrystallization temperature of cold-worked calcium is about 350° C.—v. G.

***Measurements on Contact Potential Difference between Different Faces of Copper Single Crystals.** Bernhard A. Rose (*Phys. Rev.*, 1933, [ii], **44**, 585–588)—Cf. *J. Inst. Metals*, 1933, **53**, 482. The contact p.d. between (111)

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* Denotes a paper describing the results of original research.

† Denotes a first-class critical review.

and (100) faces of single crystals of copper has been measured at different stages of a thorough outgassing treatment. The first effect of outgassing is to reduce the surface gas layer to a thickness at which it has a definite crystal structure related to that of the underlying copper. Although further treatment removes the residual gas, it also produces new crystal facets by evaporation of copper, so that a true final state cannot be obtained. The results indicate that the contact p.d. between the above two faces is at least 0·384 v., and is probably greater than 0·463 v. These values are much greater than was expected for a symmetrical cubic crystal. For polycrystalline copper the contact p.d. between the plates falls to only 0·01 v. after outgassing. —W. H.-R.

The Formation of Oxide Films on Gold and Iron. William James Shutt and Arthur Walton (*Trans. Faraday Soc.*, 1933, **29**, 1209–1216).—The passivation of gold by treatment with alkalis is explained, on the basis of the oxide film theory of passivity, by the interaction of the gold with the solution to form a layer of gold oxide which can be rendered fully passive by subsequent anodic treatment. The chemical reaction by which the oxide film is formed results in the liberation of hydrogen which is adsorbed on the gold; when the passivated metal is treated with dilute hydrochloric acid, the oxide film dissolves, but the hydrogen remains adsorbed and, if sufficient is present, prevents further action of alkalis. If oxidizing agents, such as hypochlorite, are added to solutions in which the oxide film is formed, no hydrogen is adsorbed, and the loss in weight on treating the passive metal with hydrochloric acid corresponds closely with that expected by the formation of a monomolecular layer of gold oxide. No film can be detected in solutions of low hydroxyl-ion concentration containing oxidizing agents, such as concentrated nitric acid or acidified permanganate solution, probably owing to the removal of adsorbed hydrogen and the slowness of the formation of gold oxide. In acid solutions the potential of an electrode containing adsorbed hydrogen falls with increasing p_H more rapidly than that of an electrode from which the hydrogen has been removed by chlorine, but in alkaline solution the potentials are the same, since more adsorbed hydrogen is readily produced.—A. R. P.

***Study of the Electrical Properties of Thin Films of Platinum Obtained by Cathodic Pulverization in Simple Gases.** André Féry (*J. Phys. Radium*, 1933, [vii], **4**, 301–315).—Films of platinum formed by cathodic discharge in helium, oxygen, nitrogen, and hydrogen are not characterized by definite properties. They absorb the gas present in the discharge tube. At room temperature the electrical resistance of the films diminishes after their formation; it decreases further on heating, and gas is evolved simultaneously. Ordinary platinum is not obtained even after heating at 500° C.—E. S. H.

***On the Nature of the Spontaneous Separation of Polonium on Silver in Various Acids.** Otto Erbacher (*Z. physikal. Chem.*, 1933, [A], **165**, 421–426).—The phenomena associated with the spontaneous separation of polonium on silver can be explained by the following two assumptions: (*a*) an electrochemical exchange of the silver atoms with the more noble polonium ions, (*b*) formation of a solid solution of polonium in the silver peroxide film produced by the ozone formed by the action of the α-rays emitted from the polonium. —B. Bl.

Some Properties and Uses of Rhenium (Dvi-Manganese). J. G. F. Druce (*Indust. Chemist*, 1933, **9**, 244).—A review of published work.—E. S. H.

The Atomic Mass of Sodium. II.—The Sodium Chloride–Silver Ratio. Clyde R. Johnson (*J. Phys. Chem.*, 1933, **37**, 923–933).—Five determinations of the sodium chloride : silver chloride ratio gave the value 22·994 for the atomic mass of sodium.—J. S. G. T.

***Mechanical Properties of Electrolytic Zinc Sheets.** O. Bauer and J. Weerts [with F. Beck] (*Metallwirtschaft*, 1933, **12**, 615–618).—Tensile and bending tests have been made on various types of zinc sheet at temperatures between − 80° C. and + 220° C. The sheets are anisotropic, the tensile strength in the direction of rolling being about 10% less, and the elongation and bending strength about 30–50% greater than in the transverse direction. The elongation falls rapidly below 20° C. and the bending strength below 40° C. Up to 0·06% of impurity (lead, iron, copper, cadmium) found in commercial electrolytic zinc have no appreciable effect on the mechanical properties of hot-rolled sheet. A grade of zinc with 0·9% lead showed a tensile strength about 25% greater than that of electrolytic zinc, but the elongation and bending strength were much lower; the effect of temperature on this material was similar to that on the other grades of zinc tested.—v. G.

†**Impurities in Commercial Zinc.** Werner Fröhlich (*Met. Ind.* (*Lond.*), 1933, **43**, 559–560, 589–590).—The chief impurities in commercial brands of primary zinc are cadmium, lead, and iron, whilst tin, copper, antimony, arsenic, and aluminium may also be present in remelted zinc. Cadmium causes considerable increase in hardness, brittleness, and hot shortness; the maximum permissible amount is 0·25% for rolling and 0·1–0·75% for galvanizing, according to whether much or little bending is to be imposed. Cadmium is sometimes added to improve the fluidity of the bath. Lead is relatively harmless, and tends to increase the softness and ductility of coatings and to neutralize the effect of cadmium; rolling zinc may contain 1·25 and galvanizing zinc 0·3–0·5%. It also increases the weathering resistance of zinc. More than 0·015% of iron makes zinc too hard and brittle for rolling; large amounts increase the amount of dross and ashes in the galvanizing bath and lower the acid corrosion-resistance of zinc. Tin is rarely present, but up to 0·75% tends to produce brighter and smoother coatings. Rolling zinc should not contain more than 0·15% of copper and galvanizing zinc not more than 0·2%, larger amounts in the latter causing a yellow sheen. All kinds of zinc should contain as little arsenic and antimony as possible (not more than 0·1%), and galvanizing zinc not more than 0·01% of aluminium.—J. H. W.

Creep of Metals. J. Neill Greenwood (*Modern Eng.*, 1933, **7**, 322–324).—A brief survey of creep phenomena and their investigation.—H. W. G. H.

Modern Researches on the Properties of Engineering Materials. J. Neill Greenwood (*Modern Eng.*, 1933, **7**, 243–248 and 277–281).—A review of present knowledge of the fatigue, corrosion-fatigue, and creep properties of materials, steels in particular, is followed by a discussion of its application to the problem of design. Reference is made principally to the work of Gough, Haigh, and McAdam.—H. W. G. H.

Thermal Effects in Elastic and Plastic Deformation. M. F. Sayre (*Proc. Amer. Soc. Test. Mat.*, 1932, **32**, (II), 584–592; discussion, 593–606).—See *J. Inst. Metals*, 1932, **50**, 468. The discussion, in which *A. Nadai*, *L. B. Tuckerman*, and *M. F. Sayre* took part, deals chiefly with the testing of steel proving rings for thermal creep.—A. R. P.

Elasticity, Plasticity, Toughness, Brittleness, and Hardness. M. Roš and A. Eichinger (*Assoc. Internat. Essai Mat., Congrès de Zürich*, **1932**, (II), 530–543).—[In German.] See *J. Inst. Metals*, 1931, **47**, 473.—S. G.

Relations between Elasticity and Plasticity, Toughness and Brittleness. Practical Means of Characterizing Them. P. Regnauld (*Assoc. Internat. Essai Mat., Congrès de Zürich*, **1932**, (II), 544–547).—[In French.] See *J. Inst. Metals*, 1931, **47**, 473.—S. G.

Elasticity and Plasticity, Tenacity and Fragility. G. Sachs (*Assoc. Internat. Essai Mat., Congrès de Zürich*, **1932**, (II), 548–554).—[In German.] See *J. Inst. Metals*, 1931, **47**, 473.—S. G.

Ideal and Practical (Test) Relation between Elasticity, Plasticity, Tenacity, and Brittleness. F. B. Seely (*Assoc. Internat. Essai Mat., Congrès de Zürich*, 1932, (II), 555–559).—[In English.] See *J. Inst. Metals*, 1931, **47**, 474.—S. G.

Fundamental and Practical (Test) Connection between Elasticity and Plasticity, Tenacity and Brittleness. A. Schob (*Assoc. Internat. Essai Mat., Congrès de Zürich*, 1932, (II), 560–566).—[In German.] See *J. Inst. Metals*, 1931, **47**, 474.—S. G.

On the Relation Existing between Elasticity, Plasticity, Tenacity, and Brittleness. Suggestion in Regard to a Measurement for Tenacity under a Static Load. Ph. Theodorides (*Assoc. Internat. Essai Mat., Congrès de Zürich*, 1932, (II), 567–570).—[In German.] Standard definitions of the terms elasticity, plasticity, tenacity, and brittleness are suggested and discussed. It is proposed that the determination of elastic limit be replaced by the determination of the lower limit of plasticity. Tenacity should be defined as the capacity of a material for plastic deformation under increasing forces and should be measured by determining the ratio of two work-values under a static load. —A. R. P.

Discussion [on Elasticity, Plasticity, &c.] M. Spindel. W. Rutgers. J. Basta. M. Roš. P. Santo Rini. W. Rosenhain. H. Fromm. H. Rabozée. A. Mesnager. W. Tafel (*Assoc. Internat. Essai Mat., Congrès de Zürich*, 1932, (II), 574–584).—[In English, French, or German.] The discussion deals with the necessity of standardizing the methods of determining the various plastic and elastic properties of metals and with the need for internationally accepted definitions of these properties.—A. R. P.

Remarks on a Theorem of Conservation in the Theory of Metals. F. Bloch (*J. Phys. Radium*, 1933, [vii], **4**, 486–491).—Theoretical.—E. S. H.

†**Metallurgical Problems in Handling Hydrogen under High Pressures and Temperatures.** John L. Cox (*Trans. Amer. Inst. Chem. Eng.*, 1933, **29**, 43–87).—The first part of the paper discusses published work on creep, particularly in respect of alloy steels. Reference is made to the active effect of chromium in raising creep strength. A *bibliography*, containing references to 220 papers on creep, including non-ferrous metals and alloys, is given. The second part reviews published work on the corrosion and embrittling of metals and alloys (mainly alloy steels) at high temperatures by hydrogen. —E. S. H.

***Researches on Metal Electric Arcs.** T. Toniszewski and T. Maciejewski (*Acta Phys. Polon.*, 1933, **2**, 67–74).—The static characteristics of arcs between plane and hemispherical metal electrodes are given for all possible combinations of iron, copper, molybdenum, tungsten, and brass. The Ayrton constants of the systems copper–copper, molybdenum–molybdenum, and tungsten–tungsten have been determined: with the second pair these constants are the same for all current densities, whereas with the other pairs there are two current-density ranges wherein these constants vary.—A. R. P.

***Theory of the Dependence of the Electrical Conductivity of Metals on Pressure.** Wolfgang Kroll (*Z. Physik*, 1933, **85**, 398–402).—The effect of pressure on the electrical conductivity of metals is discussed along the lines of Bloch's theory. The effect is correctly interpreted if Fermi's expression for the potential at a lattice point is used in the theory.—J. S. G. T.

***Magnetic Interaction of Metallic Electrons. Criticism of Frenkel's Theory of Super-Conductivity.** H. Bethe and H. Fröhlich (*Z. Physik*, 1933, **85**, 389–397).—Frenkel's theory of super-conduction, attributing the phenomenon to magnetic forces called into play between the electrons, is considered to be untenable. Such forces, it is shown, can in no way affect the value of the conductivity, and are revealed, macroscopically only, in the phenomenon of self-induction. The work is entirely mathematical in character.—J. S. G. T.

II.—PROPERTIES OF ALLOYS

(Continued from pp. 7–11.)

***Studies of the Ternary System Aluminium–Antimony–Magnesium.** W. Guertler and A. Bergmann (*Light Metals Research*, 1933, 2, (39), 1–14).—A full, illustrated translation from *Z. Metallkunde*, 1933, 25, 81, 111. See *J. Inst. Metals*, 1933, 53, 343.—J. C. C.

***Thermal Measurements on Hardenable Aluminium Alloys.** W. Fraenkel (*Metallwirtschaft*, 1933, 12, 583–585).—Heating curves have been taken by a sensitive differential method on aluminium alloys with (*a*) 4% copper, (*b*) 4% copper and 0·5% magnesium, and (*c*) 4% copper, 0·5% magnesium, and 0·5% manganese. In all cases an absorption of heat occurs before true precipitation commences, and precipitation itself is accompanied by an evolution of heat which for quenched and aged specimens is as great as, or greater than, that for freshly quenched specimens. Ageing is therefore not associated with precipitation.—v. G.

***Heat Evolution and Mechanism of Transformation of Hardenable Aluminium Alloys.** H. Röhrig (*Metallwirtschaft*, 1933, 12, 671).—Cf. preceding abstract. In this connection attention is directed to the work of Kokubo and Honda (*J. Inst. Metals*, 1931, 47, 266) in which similar results were obtained.—v. G.

On the Mechanical and Chemical Properties of Alloys of Aluminium with Cr, Fe, Mg, Mn, Ti, V. H. Bohner (*Light Metals Research*, 1933, 2, (29), 1–23; and *Met. Ind.* (*Lond.*), 1933, 43, 27–30, 56–58).—Translated in full from *Metallwirtschaft*, 1933, 12, 251–255, 265–267. See *J. Inst. Metals*, 1933, 53, 694.—J. C. C.

***The " Precipitation Heat-Treatment " Effects in Copper–Aluminium Alloys.** W. Stenzel and J. Weerts (*Light Metals Research*, 1933, 2, (37), 2–25).—A full translation, illustrated by sketches, from *Metallwirtschaft*, 1933, 12, 353, 369. See *J. Inst. Metals*, 1933, 53, 694.—J. C. C.

†Nickel in the Light Alloys. J. Cournot (*Rev. Nickel*, 1933, 4, 137–142).—Of these alloys Duralumin is the oldest and the modern process of precipitation-hardening has brought its use to a better understanding. It is, however, corrodible. Addition of 2% cadmium, and the juxtaposition of aluminium and Duralumin sheets have been suggested as remedies in certain special alloys. Usually, however, these materials require delicate handling. Increasing the quantity of nickel in this type of alloy gives a fine structure and better physical properties. Addition of small quantities of chromium reinforces the effect of nickel, giving material possessing homogeneity, stability, and inoxidizability.—W. A. C. N.

The Aluminium Alloy Anticorodal. A. I. A. G. (*Schweiz. Tech. Z.*, 1933, 236–239).—Anticorodal is used exclusively for decorative work. Its physical properties are tabulated. Some of its many applications are illustrated.—W. N.

***The System Iron–Cobalt–Aluminium.** Werner Köster (*Arch. Eisenhüttenwesen*, 1933, 7, 263–264).—The space model of the solid state of iron–cobalt–aluminium alloys differs from that of the corresponding metal system (see Koster, *Met. Abs.*, this vol., p. 71) only in the size of the various fields; this is due to the similarity in the nickel–aluminium and cobalt–aluminium systems. Observations on the magnetic transformation have afforded similar, as yet unexplained, results to those observed in the nickel system.—J. W.

***The System Iron–Cobalt–Manganese.** Werner Köster and Winfried Schmidt (*Arch. Eisenhüttenwesen*, 1933, 7, 121–126).—The γ–ε boundary in the cobalt–manganese system has been established and the variation of the lattice constants of the two phases with the composition determined. The temperature of the γ–ε transformation and of the magnetic transformation of cobalt are so quickly reduced by addition of manganese that they reach room temperature at 30% and 38% manganese, respectively. The ternary system iron–cobalt–manganese up to 50% manganese has been studied by dilatometric, X-ray, and micrographic methods. Below 1400° C. homogeneous γ is formed which is converted at lower temperatures to α in alloys containing up to 18% manganese and 80% cobalt. The degree of hysteresis of this reaction increases with increase in the manganese content. Between 18 and 30% manganese the γ-phase is converted partly or wholly into ε. The γ–ε transformation in the iron–manganese system is completely analogous to the corresponding transformation in pure cobalt and in the ternary system these transformations are joined together by a plane of equilibrium. With a constant manganese content the lattice parameters of the ternary γ- and ε-phases decrease, at first linearly, then more rapidly as the iron is replaced by cobalt; with a constant iron or cobalt content, however, they increase linearly with increasing manganese content. The change from the ferro- to the para-magnetic state does not appreciably affect the dependence of the parameters on the concentration, but the lattice of the ferromagnetic phases are larger than those of the paramagnetic.—J. W.

A New Corrosion-Resistant Copper Alloy. [Corrix.] Anon. (*Metallwirtschaft*, 1933, **12**, 622).—Corrix is an alloy of copper 86, aluminium 10, and iron 4% made from specially purified metals. It can be cast and worked readily, and towards many reagents is as resistant to corrosion as the austenitic chromium–nickel steels.—v. G.

Copper Alloys that Have the Strength of Steel. Anon. (*Machinery (N.Y.)*, 1933, **40**, 104–105).—The characteristics and uses of silicon–bronze and beryllium–copper alloys are briefly reviewed.—J. C. C.

†**The Aluminium–"Bronzes."** E. C. J. Marsh and E. Mills (*Aircraft Eng.*, 1933, **5**, 251–255, 286–288).—A general survey of the subject with reference to the usual commercial forms, methods of manufacture, working properties, heat-treatment, micro-structure, corrosion-resistance, &c.—H. S.

Investigation on the Transformations in the Solid State in the System Copper–Gold. Günter Wehner (*Thesis: Univ. Leipzig*, 1931, 78 pp.).—See *J. Inst. Metals*, 1932, **50**, 730.—I. M.

***The Modulus of Elasticity of Annealed α-Bronzes.** Léon Guillet, Jr. (*Compt. rend.*, 1933, **197**, 1320–1321).—The kind of elastic deformation imposed on a body is important. Torsion and bending are heterogeneous deformations. On the other hand, if the test-piece is long relative to its cross-sectional area, the stress imposed by tension is the same in all parts of the section, *i.e.* the deformation is homogeneous; it is, however, relatively very small, and pure tension is difficult to apply. Elongations have been measured to $\frac{1}{1000}$ mm. with a Martens' elasticimeter, loads of about 30 grm./mm.^{2} being applied with an Amsler machine with the help of wedges, at constant speed with increasing and decreasing loads. The values of Young's modulus are tabulated below, and will be seen to diminish as the tin content increases in an approximately linear relationship. This agrees perfectly with Chevenard and Portevin's results for the modulus of torsion of certain alloys (brass, cupro-nickel, copper, &c.):

Tin, %.	Copper, %.	Young's Modulus, Mean Value.
1·92	97·97	12,600
3·81	96·10	12,300
6·05	93·85	11,970
8·02	91·92	11,650
9·90	90·05	11,260

—J. H. W.

Notes on Volvit Bronze. Anon. (*Metallwirtschaft*, 1933, **12**, 674).—Volvit bronze contains 0% tin and considerable amounts of phosphorus. By careful supervision of the casting and working operations, cold-rolled tubes and rods can be made of this alloy. It has a Brinell hardness of 230 in the drawn state, whilst the annealed metal has a tensile strength of 40 kg./mm.^{2} and an elongation of 70%. The alloy is suitable for making all types of bearing boxes.—v. G.

***Influence of Temperature on the Mechanical Properties of Brasses.—I.–II.** W. Broniewski and K. Wesolowski (*Rev. Mét.*, 1933, **30**, 396–401, 453–457).—[I.—] Tests included tensile tests on thin sheets (5 mm.) at elevated temperatures, thin sheets being chosen to obviate serious cooling of the test-length by conduction of heat to the testing-machine. Hardness tests were made at elevated temperatures, the ball and mounting used to determine the hardness being heated to temperature with the specimen. In making impact tests at elevated temperatures the test-piece was heated on the hammer itself. Three brasses were used containing: (1) zinc 33%; (2) zinc 40%; and (3) zinc 40, lead 1·3%. The results of tests made at temperatures in the range − 200° to 700° C. are given as graphs and are compared by B. and W. with the results of tests published by other investigators. [II.—] In brasses containing 33% of zinc the effect of cold-work is no longer observed in the mechanical properties above 400° C. In pure brasses of 40% zinc the effect of cold-work is more persistent, and does not disappear from the diagram of notched-bar values until 600° C. is exceeded. The introduction of lead into brass seems to lower that limit to about 500° C. For the three brasses studied, the curves of tensile strength, elastic limit, and hardness are of similar form, having a rapid descent at a fairly low temperature in the zone of recrystallization with ranges of less rapid change on each side.—H. S.

P.M.G. Alloy. Anon. (*Machinery* (*Lond.*), 1933, **42**, 770–771).—The properties in the cast and forged conditions of 18 copper alloys made up with P.M.G. hardener alloy in various proportions, with or without zinc, are tabulated. Some typical applications are quoted.—J. C. C.

Tellurium–Lead. W. Singleton (*Plumbing Trade J.*, 1934, **13**, 242–243).—A lecture to the Institute of Plumbers on the properties of tellurium–lead and its applicability to plumbing.—E. S. H.

***On Zinc in Lead Bearing Metals.** K. L. Ackermann (*Metallwirtschaft*, 1933, **12**, 618–619).—If there is sufficient antimony in lead–antimony–zinc alloys, the zinc forms a compound which crystallizes in long, brittle crystals which make the alloy hard but brittle. If tin is also present, it combines with part of the antimony, and some of the zinc is set free. Zinc produces difficulties in casting, especially when heavy metals such as copper, iron, and nickel, are also present, and must therefore be considered as an undesirable constituent of lead bearing metals.—v. G.

Mechanical Properties of White-Metal Bearing Alloys at Different Temperatures. H. K. Herschman and J. L. Basil (*Proc. Amer. Soc. Test. Mat.*, 1932, **32**, (II), 536–555; discussion, 556–557).—See *J. Inst. Metals*, 1932, **50**, 429.—S. G.

***Study of the Ultra-Light Alloys of Magnesium, Aluminium, and Copper.—I.** Paul Bastien (*Rev. Mét.*, 1933, **30**, 478–501).—See *J. Inst. Metals*, 1933, **53**, 623.—H. S.

***The System Iron–Nickel–Aluminium.** Werner Köster (*Arch. Eisenhüttenwesen*, 1933, **7**, 257–262).—The system has been examined thermally and micrographically up to 30% aluminium. Since the compound NiAl forms a continuous series of solid solutions with α-iron within the range tested, the alloys contain only the α- and γ-phases. The $(\alpha + \gamma)$-field is divided into 2 parts, the first forms a narrow wedge extending out from the scythe-shaped $(\alpha + \gamma)$-field of the iron–aluminium system, and the second a broader wedge extending to room temperature from the nickel–aluminium system down to a very low nickel content and broadening with decreasing temperature. The magnetic transformation point of iron–aluminium alloys is first raised by addition of nickel; for alloys with a high content of nickel and aluminium, however, it occurs at a considerably lower temperature after quenching from a high temperature than after cooling slowly from a medium temperature. The α-phase is ferromagnetic up to a content of 70% nickel and about 20% aluminium.—J. W.

Stainless Nickel–Chromium Alloy. [Inconel.] Anon. (*Indust. Australian*, 1933, **88**, 269).—See *J. Inst. Metals*, 1933, **53**, 437.—P. M. C. R.

†**Chromium–Nickel as a Corrosion-Resistant Alloy.** Robert J. McKay (*Metals and Alloys*, 1933, **4**, 177–180, 202–204).—A review of the properties, uses, and resistance to corrosion of nickel–chromium alloys, especially Inconel (chromium 12–14, iron 5–6%, remainder nickel).—A. R. P.

Chromium–Nickel Resistance Alloys. Anon. (*Arch. tech. Messen*, 1933, **3**, (29), F30).—An account of certain proprietary resistance alloys, including Megapyr. Their analyses and physical properties are tabulated, and permissible working temperatures and special applications are indicated.—P. R.

Symposium on Electric Resistance Alloys. Anon. (*Japan Nickel Rev.*, 1933, **1**, 376).—[In English and Japanese.] A very brief summary of the proceedings.—W. A. C. N.

Resistance Alloys for Heating, and Their Testing. W. Hessenbruch (*Arch. tech. Messen*, 1933, **3**, (29), T155–T156).—The analyses, relevant physical properties, and approximate working ranges of a number of resistance alloys are tabulated, and comparative curves show the effect of temperature on the specific resistance of typical alloys. Mechanical properties at room temperature are quoted, and curves show the limits of creep of certain materials at high temperatures. Methods of durability testing are discussed, and the influence of temperature on durability is shown graphically. The importance of surface loading, frequency and duration of run, furnace atmosphere, and of certain constituents of specific alloys are briefly discussed, results being tabulated in some cases.—P. M. C. R.

***An Investigation on the Nickel–Chromium Alloys.** Yonosuke Matsunaga (*Japan Nickel Rev.*, 1933, **1**, 347–363).—[In English and Japanese.] Specimens were melted in an hydrogen atmosphere in an electric furnace. The specimens for thermal analysis were heated in hydrogen in thick-walled quartz tubes. For samples containing more than 70% chromium, however, interpolation methods had to be employed. Variations in solid solubility were traced by microscopic study. A new equilibrium diagram has been developed. A eutectic containing 51% chromium is formed at 1346° C. The α-phase is soluble to the extent of 47% copper at 1346° C. and 44% copper at room temperature. The corresponding figures for the β-phase are 37 and 7% nickel respectively. Oxidation, hardness, and electric resistivity measurements indicate that alloys containing 15–35% copper are best for heat-resistivity purposes. In any case, the chromium should be less than 50% of the alloy.—W. A. C. N.

Equilibrium Diagram of Nickel and Chromium. S. Nishigori and M. Hamazumi (*Japan Nickel Rev.*, 1933, **1**, 391).—[In English and Japanese.] Abstracted from *Sci. Rep. Tôhoku Imp. Univ.*, 1929, [i], **18**, 491–502. See *J. Inst. Metals*, 1930, **43**, 477.—W. A. C. N.

Study of the Life of Electric Heating Wires. M. Horioka (*Japan Nickel Rev.*, 1933, **1**, 292–310).—[In English and Japanese.] An investigation of various methods for conducting forced life tests on resistance wires for electric heating. In ideal tests of this nature the following factors would be altered simultaneously—oxidation, protection by oxide film, change of internal structure, heterogeneity of material, and strength at high temperature. As this, however, cannot be done easily the tests preferred were—forced oxidation test in oxygen, measurement of oxidation by thermo-balance, measurement of the weight of oxidized matter peeled off from the surface, brine test, microscopic study, measurement of cracking and peeling-off sound in the cooling. The experimental results are given in tabular and graphical form. It is stated that there is a definite relation between the life of resistance wire and the absolute temperature at which the wire is put into service. The breakdown hrs. in air can be lengthened by 4 or 5 times when the running temp. is lowered by 100° C. in the range between 800° and 1300° C. The breakdown of wires tested in air frequently occurs before the temperature or watt consumption decreases to 80% of the initial values. The life of the wire can be regarded as approximately proportional to the diameter of the wire. Owing to the greater solubility of the chromium of the alloys than that of the other elements in brine solution, the brine test is of little use in determining the life of wires. The peeling-off of the oxidized film is useful only in the higher ranges of temperatures. The oxygen gas test shortens the time of testing by $\frac{1}{30}$ or more of that of the air test. It is suggested that the cracking sound test is worthy of further study.—W. A. C. N.

Research on Electric Heating Elements. Isamu Asaki (*Japan Nickel Rev.*, 1933, 1, 311–321).—[In English and Japanese.] The quality of a heating wire depends greatly on its chemical composition and the melting process used in producing the alloy. The deleterious effect of low-grade raw materials is emphasized. The compositions of the commercial alloys are given. The mechanical working—drawing—is receiving increasing attention at the present time, in order to attain still greater uniformity of the wires. With good-quality wires the oxide film formed on the surfaces of heating wires is principally Cr_2O_3 which is difficult to scrape off. Forced heating is considered the most effective and practical method for the quality test. The causes affecting the life of heating wire are discussed. Photomicrographs show the growth of the intergranular oxide films.—W. A. C. N.

Forced Life Test of Heating Wires. Shinji Togō (*Japan Nickel Rev.*, 1933, 1, 322–341).—[In English and Japanese.] A study of the physical properties of electric heating wires as applied to various heating utensils and for sundry purposes. As no single property is alone responsible for the differing lives of wires, a modified life test under stringent conditions is the only possible one for determining the comparative qualities of the elements. The useful life, *i.e.* when the filament becomes incapable of standard heating temperature and current consumption, is not an important consideration at low heating temperature ranges, but the breakdown life, *i.e.* the life before actual failure, is extremely important. The higher the temperature the more the useful life factor enters into the question. From the results of his tests T. concludes (1) the life of a wire is affected considerably by any non-uniformity in its diameter; (2) the stronger the adhesion of the oxide films the longer the life; (3) the life depends on the rate of oxidation and also on the uniformity of the inner physical structure. See also *J. Illuminating Eng. Soc. Japan*, 1928, 12, 386, and (abstracts) *Japan Nickel Rev.*, 1933, 1, 380; *J. Inst. Metals*, 1933, 53, 347.—W. A. C. N.

Testing the Life of an Electric Heating Wire. Yasuyuki Toba (*Japan Nickel Rev.*, 1933, 1, 342–346).—[In English and Japanese.] Two classes of wires are under consideration: (1) nickel 80, chromium 20%; (2) nickel 60, chromium 15, and iron 25%. The lives of the wires have been determined by the time which elapses up to the point of breakdown by heating to a high temperature and then cooling them alternately at a certain time interval. The apparatus and technique employed are described and discussed.—W. A. C. N.

Design of Electric Heating Devices. Isamu Asaki (*Japan Nickel Rev.*, 1933, 1, 364–373).—[In English and Japanese.] A discussion which embraces the mechanical and electrical properties of the materials for the heating elements, electric heaters, heating elements under service conditions, connecting parts, calculations in the design of electric heaters.—W. A. C. N.

Oxidation Tests of Heating Wires at High Temperatures. S. Togō (*Japan Nickel Rev.*, 1933, 1, 379–380).—[In English and Japanese.] Summary from *J. Illuminating Eng. Soc. Japan*, 1928, 12, 354–362, which was published in Japanese. See *J. Inst. Metals*, 1933, 53, 347.—W. A. C. N.

Coefficient of Thermal Expansion of Heating Wires. S. Togō (*Japan Nickel Rev.*, 1933, 1, 381–382).—[In English and Japanese.] Summary from *J. Illuminating Eng. Soc. Japan*, 1928, 12, 243, which was published in Japanese. See *J. Inst. Metals*, 1933, 53, 347.—W. A. C. N.

Electrical Resistance of Heating Wires. S. Togō (*Japan Nickel Rev.*, 1933, 1, 383–385).—[In English and Japanese.] Summary from *J. Illuminating Eng. Soc. Japan*, 1928, 12, 590–605, which was published in Japanese. See *J. Inst. Metals*, 1933, 53, 347.—W. A. C. N.

Machinable Metal. P. W. Rauschert (*Canning Age*, 1933, 14, 447).—Describes the properties of "Illinois" nickel alloy and its use in handling foodstuffs in the canning and dairy industries.—E. S. H.

Catalogues [Nichrome]. Anon. (*Japan Nickel Rev.*, 1933, 1, 392–394).—[In English and Japanese.] Particulars of physical, chemical, and electrical properties of the most important Nichrome alloys passing under proprietary names are given.—W. A. C. N.

***Liquation or Segregation of the Constituents of Silver Coinage Alloys.** S. W. Smith (*Sixty-Third Rep. Royal Mint (Lond.)*, 1932, 55–57).—It has already been shown (*Sixty-First Rep. Royal Mint (Lond.)*, 1930, 55–60) that in the 50 : 50 silver–copper alloy the copper primaries which form at temperatures between the liquidus and the solidus are free to move in the molten matrix, and do so move under the influence of gravity if allowed sufficient time. In order to demonstrate micrographically the movements which occur in casting, copper primaries were concentrated under the influence of gravity at the top of a molten cylindrical specimen of this alloy by "soaking" at a suitable temperature, and sudden chilling was then applied in their vicinity. Both micrographic and analytical evidence showed that the copper primaries had been scattered by the chilling surface and had moved away from it in strict accordance with the well-known effect of casting alloys of this composition in chill moulds under ordinary conditions. These observations were extended to other silver coinage alloys both on the copper-rich and on the silver-rich sides of the eutectic.—J. H. W.

Chemical Studies of Ancient Chinese Coins.—II. Tsurumatsu Dōno (*J. Chem. Soc. Japan*, 1932, 53, 100–109; *C. Abs.*, 1933, 27, 5).—[In Japanese.] Assay of ancient coins can be made with accuracy by means of combined chemical and microscopic tests. True ancient coins showed more lead than less ancient or imitation coins and the lead appeared in a more segregated black mass of metal under the microscope.—S. G.

Silver–Copper Alloys Containing Phosphorus.—III. K. W. Fröhlich (*Mitt. Forschungsinst. Edelmetalle*, 1933, 7, 91–96).—See *J. Inst. Metals*, 1933, 53, 696. With increasing phosphorus content the tensile strength of annealed 50 : 50 copper–silver alloy decreases to a minimum with 0·1% phosphorus and remains fairly steady up to 1% phosphorus after which it slowly increases reaching 30 kg./mm.^{2} with 2·5% phosphorus; the elongation rises sharply to 0·1% phosphorus then more slowly to a maximum at 1%. Phosphorus increases the rate of grain-growth on annealing, hence alloys containing this element can be annealed at lower temperatures or for shorter periods than phosphorus-free alloys. The hardness of the alloys is scarcely affected by the phosphorus content, but falls appreciably with increase in annealing temperature from 520° to 700° C.; the Erichsen value reaches a maximum with 0·1% phosphorus, the precipitation-hardening effects are unaltered, but the rate of corrosion in acetic acid is decreased slightly. Phosphorus has a similar effect on 80 : 20 and 83 : 17 silver–copper alloys.—A. R. P.

***Structure of Silver Amalgam.** A. Weryha (*Z. Krist.*, 1933, 86, 335–339).—Examination by the X-ray method of silver amalgam, produced by immersing a silver wire in mercury for some time, shows the presence of the compound Ag_3Hg_4.—E. S. H.

***Solidification Diagram of Alloys Formed by Two Alkali Metals: Sodium–Rubidium Alloys.** E. Rinck (*Compt. rend.*, 1933, 197, 1404–1406).—The rubidium for these experiments was prepared partly from the chloride by the calcium reaction (Hackspill method) and partly aluminothermally from the carbonate, and then purified by fractional distillation. The solidification diagram does not resemble that of the sodium–potassium alloys, and no evidence of the compound Na_2Rb was found. A eutectic occurs at 75 atomic-% of rubidium at − 4·5° C. The curve tends to become horizontal in the vicinity of the composition of a possible compound $NaRb_2$, and it was supposed that for alloys of this composition the 2 metals would be mutually miscible at temperatures above the temperature of the beginning of crystallization. The alloys were shown experimentally to exhibit no sign of segregation when soaked for 5 hrs. at temperatures between 80° and 200° C. inclusive. The results indicate that only the study of another property of the liquid alloys will explain the particular shape of the liquidus.—J. H. W.

***[Effect of] Precipitation from Supersaturated Solid Solutions after Cold-Work in the Heat Expansion Diagram.** Franz Bollenrath (*Metallwirtschaft*, 1933, 12, 569–573).—The temperature at which precipitation commences in aged Elektron, Lautal, and especially Duralumin has been determined from dilatometric curves, as well as the effect of cold-work on the shape of the curves. The actual precipitation is preceded by a process of rearrangement of the atoms in the lattice which is characterized by a rise in the coeff. of expansion. This coeff. is $22·8 \times 10^{-6}$ for unworked Duralumin at 20° C., and falls to $21·9 \times 10^{-6}$ after a reduction of 20% by cold-rolling. The temperature of the beginning and ending of the precipitation is reduced 30° C. by a 20% reduction, and is only slightly more after a more severe reduction. The precipitation of $CuAl_2$ and of Mg_2Si can be recognized as separate reactions.—v. G.

Influence of Recrystallization Temperature and Grain-Size on the Creep Characteristics of Non-Ferrous Alloys. C. L. Clark and A. E. White (*Proc. Amer. Soc. Test. Mat.*, 1932, 32, (II), 492–506; discussion, 507–516).—See *J. Inst. Metals*, 1932, 50, 432. In the discussion *Howard Scott* pointed out, from a review of the work done by other investigators, that the recrystallization temperature of pure metals is a constant function of the relaxation temperature; thus the former is about 0·5 times, and the latter about 0·47 times, the melting point in ° abs. From C. and W.'s work $(T_1 + 273)/(T_2 + 273) = 0·95$ for Monel metal and various copper–zinc alloys where T_1 is the temperature at which the creep rate is 0·001% per hr. at a load of 10,000 lb./in.^{2}, and T_2 is the temperature of maximum softening rate on annealing alloys cold-rolled to 80–85% reduction for 15 minutes. From this relation it is suggested that more significant information on the strength of metals at high temperature will be obtained by making creep tests at the recrystallization temperature or some predetermined fraction thereof. *Arthur McCutchan* has subjected the curves (on a log–log basis) given in the paper to mathematical analysis, and points out that the parabola determined from these curves and plotted on ordinary paper gives a clearer picture of the relation of stress to creep and makes a fairly reliable distinction between the creep characteristics of material below and above the recrystallization temperature.—A. R. P.

***Investigations on Segregation.** G. Masing and E. Scheuer (*Light Metals Research*, 1933, 2, (35), 12–29).—A full translation, including sketches, from *Z. Metallkunde*, 1933, 25, 173. See *J. Inst. Metals*, 1933, 53, 698.—J. C. C.

***Volume-Magnetostriction Exhibited by Poly- and Single-Crystals.** O. v. Auwers (*Physikal. Z.*, 1933, 34, 824–827).—Read at the IX Deutschen Physikertag, September, 1933. [*Note by Abstractor:* By volume-magnetostriction of a substance is to be understood the relative change of volume ($\Delta V/V$) accompanying the production of a magnetic field, H, in the region of a sample of material of initial volume V.] Investigation of the phenomenon in the case of single crystals of iron–nickel and iron–cobalt alloys shows that: (1) below technical saturation point the effect is, to a first approximation, negligible; (2) above saturation point the magnitude of the effect is directly proportional to the strength, (H) of the external magnetic field, and the law of proportionality is independent of the orientation of the crystal lattice with respect to the direction of the magnetic field; (3) the abscissa, H_0, on the H axis, corresponding with the point of intersection of the straight lines giving the relation of $\Delta V/V$ to H is smaller in proportion as the direction of magnetization corresponds more exactly with the direction of easiest magnetization in the crystal lattice; (4) the inclination of these straight lines to the H axis depends on the composition of the crystal lattice. The effect in the case of Perminvar multi-crystalline alloys is small and there is considerable resemblance between the volume-magnetostriction composition diagram and the composition–structure diagrams.—J. S. G. T.

III.—STRUCTURE

(Metallography; Macrography; Crystal Structure.)

(Continued from pp. 12–14.)

Metallographic Grinding with Paraffin [Wax] Impregnated with Abrasives. R. L. Dowdell and M. J. Wahll (*Metals and Alloys*, 1933, 4, 181–182).—The use of French emery papers in preparing metallographic sections may be obviated by finishing the polishing, after the coarse emery treatment, on rotating steel discs coated with a mixture of paraffin wax and abrasive. Two discs are used, the first being coated with wax and 150-mesh Carborundum, and the second with wax and 400-mesh Alundum. The steel discs are rotated vertically, and the specimen is held by hand flat against the side; in this way no abrasive is worked into the surface of soft metals, the metals do not become hot, and no surface flow occurs, since the wax acts as lubricant. Aluminium, magnesium, and copper can be polished in ½ the usual time with less residual scratch. An automatic apparatus for polishing 4 specimens simultaneously is described.—A. R. P.

Method of Preparation of Lead and Lead Alloy Cable Sheath for Microscopic Examination. W. H. Bassett, Jr., and C. J. Snyder (*Proc. Amer. Soc. Test. Mat.*, 1932, 32, (II), 558–568; discussion, 569–575).—See *J. Inst. Metals*, 1932, 50, 485. In the discussion *E. E. Schumacher* and *G. M. Bouton* detailed the procedure for preparing sections of lead alloys for micrographic work used in the Bell Telephone Labs. The section should be cut with a microtome from a specimen which is so clamped that the knife cuts diagonally. Rough grinding is done on a No. 1 French emery paper and the finishing on a "00" paper; finally the section is given a few strokes on a leather strip. Etching is done with 75% acetic acid containing hydrogen peroxide. Lead–antimony alloys are washed in strong sodium hydroxide solution, then rinsed in a dilute soap solution and dried in a current of air; in this way a transparent film is formed which prevents tarnishing. Some characteristic micrographs of various lead alloys are shown.—A. R. P.

***Etching Method for the Micrographic Examination of Platinum Metal Alloys.** F. Beck (*Metallwirtschaft*, 1933, **12**, 636–637).—Alloys of platinum with rhenium, rhodium, and iridium can be etched by immersion in a fused sodium chloride bath at 860° C. in a graphite crucible, a current of 3 amp./cm.^{2} at 2·5 v. being passed between the alloy as anode and the crucible as cathode for 5–45 seconds. The specimens are then quenched in distilled water.—v. G.

***Sub-Microscopic Differences between Cast and Recrystallization Conditions in Metals.** U. Dehlinger (*Physikal. Z.*, 1933, **34**, 836–838).—Read at IX Deutschen Physikertag, September, 1933. D. has already suggested that differences occurring in the cast and recrystallization conditions of certain alloys is probably attributable to the development of a mosaic structure in the latter. Tensile tests carried out on cast and recrystallized single crystals of aluminium (99·5–99·8% purity) show that the crystal grain in the case of the latter is characterized by a considerably more marked mosaic structure than is the case with the cast material.—J. S. G. T.

***The *L* X-Ray Spectrum of Solid Aluminium.** T. H. Osgood (*Phys. Rev.*, 1933, [ii], **44**, 517–519).—The *L* X-ray spectrum of solid aluminium shows a wide continuous band between approximately 170 and 200 A. This indicates that the conduction electrons are spread over a range of energy levels in agreement with the Sommerfeld theory.—W. H.-R.

***Crystal Structure and Electrical Properties. II.—Lattice Structure and [Electrical] Conductivity of Bismuth Single Crystals Subjected to Transverse Magnetization.** O. Stierstadt (*Z. Physik*, 1933, **85**, 310–331).—The crystal lattice structure of bismuth single crystals is revealed by measurements of the electrical resistance of the crystal oriented at various inclinations to the crystal axes.—J. S. G. T.

***Soft X-Rays from (100) and (111) Faces of Single Copper Crystals.** Morgan L. Williams (*Phys. Rev.*, 1933, [ii], **44**, 610–617).—Between 90 and 220 v., 14 critical potentials have been found in the emission of soft X-rays from the (100) and (111) faces of single crystals of copper, the values for the two faces agreeing within 1·5 v. These may be explained by Kronig's theory (*Z. Physik*, 1932, **75**, 191) which is based on Bloch's theory of metals.—W. H.-R.

On Lithium Alloys. II.—X-Ray Analysis of the System Lithium–Cadmium. A. Baroni (*Atti R. Accad. Lincei Rend.*, 1933, [vi], **18**, 41–44; *Chem. Zentr.*, 1933, **104**, II, 3526).—Cf. *J. Inst. Metals*, 1933, **53**, 437. Thermal analysis of the lithium–cadmium system has confirmed the existence of LiCd, $LiCd_3$, and Li_3Cd. X-ray examination shows that LiCd has a lattice of the cæsium chloride type, $a = 3·32$ A., with 1 molecule in the unit cell; the calculated density is 5·336, the experimental 5·123. $LiCd_3$ has the same type of lattice with $a = 8·62$ and 8 molecules in the unit cell, $d_{\text{calc.}} = 7·136$, d_{actual} 6·925. The compound Li_3Cd could not be detected by X-rays.—A. R. P.

†**Lattice Constants, 1933.** M. C. Neuburger (*Z. Krist.*, 1933, **86**, 395–422).—Values for the atomic number, atomic weight, density (calculated from X-ray data), space lattice, space group, lattice type, lattice parameter, shortest distance between atoms, atomic radius, atomic space, packing density, volume of the elementary cell, volume per atom, and atomic volume are tabulated for a number of elements, including 43 metals.—E. S. H.

***Magnetic Dipole Fields in Unsaturated Cubic Crystals.** L. W. McKeehan (*Phys. Rev.*, 1933, [ii], **44**, 582–584).—The mean values of the randomly-directed local magnetic field at a lattice point of body-centred and face-centred cubic arrays of equal magnetic dipoles have been calculated by assuming that (*a*) the orientation of neighbouring dipoles is independent, (*b*) the direction of each dipole axis is one of the directions of easy magnetization of iron and nickel which have the above lattice types, and (*c*) the mean magnetization in a large group (2000) of dipoles has definite fractions of the saturation value. The results indicate that, if local constraints prevent parallel alignment of adjacent magnetic elements, the high intensity of local magnetic fields may be an important cause of high coercive force.—W. H.-R.

***A Contribution to the Theory of Heteropolar Crystals.** H. M. Evjen (*Phys. Rev.*, 1933, [ii], **44**, 501–509).—Although the details of this paper refer to salts, it should be noted as giving a development of the theory of the solid state, and a discussion of the evidence in favour of the existence of secondary structure of crystals.—W. H.-R.

***Electron Diffraction and Structure of Thin Metallic Layers.** J. A. Prins (*Z. Krist.*, 1933, **86**, 301–303).—Tin showed a diagram corresponding with the tetragonal modification. Calcium showed the presence of hydroxide, whilst magnesium did not give a hexagonal pattern corresponding with the metal, but the diagram resembled that of magnesium oxide.—E. S. H.

***Experimental Determination of the Distribution of Conduction Electrons in Metals.** H. M. O'Bryan and H. W. B. Skinner (*Phys. Rev.*, 1933, [ii], **44**, 602–603).—A note. Measurements have been made of the intensity distribution in the X-ray bands from solid lithium, beryllium, carbon, sodium, magnesium, aluminium, and silicon. In contrast to the previous work of Houston (*Phys. Rev.*, 1931, [ii], **38**, 1797), the results are in better agreement with the electron distribution predicted by the simple Sommerfeld electron theory of metals than with that expected from the more complex theories of the Bloch type.—W. H.-R.

IV.—CORROSION

(Continued from pp. 15–18.)

***On Corrosion of Welded Aluminium Cables.** O. Scarpa (*Alluminio*, 1933, **2**, 327–328).—In a short note, are discussed the results of some interesting experiments which show the very good resistance to corrosion of welds made with an alloy of the following composition: zinc 45, aluminium 35, tin 15%. —G. G.

***Corrosion at Riveted Joints of Duralumin Structure.** G. W. Akimov (*Light Metals Research*, 1933, **2**, (36), 13–15).—Translated from *Korrosion u. Metallschutz*, 1932, **8**, 309. See *J. Inst. Metals*, 1933, **53**, 355.—J. C. C.

***Corrosion of Light Alloys.** G. Guzzoni (*Alluminio*, 1933, **2**, 329–336).—In this first part of the article G. discusses the principal rules governing the mechanism of the corrosion of light alloys, and the methods of preventing it, especially the use of anodic polarization.—G. G.

Copper in Architecture. W. H. J. Vernon (*Plumbing Trade J.*, 1933, **13**, 176).—From a lecture delivered to the Association of Architects, Surveyors, and Technical Assistants. The paper refers especially to the green patina which forms on weathered copper and its reproduction by artificial methods. —E. S. H.

On the Action of Acetylene of Petroleum Cracking Gas on Copper and Brass. J. S. Zalkind and B. A. Vovsi (*Zhurnal Prikladnoi Khimii* (*Journal of Applied Chemistry*), 1933, [B], **6**, (4), 677–680).—[In Russian, with German summary.] Since acetylene is present in products obtained by cracking petroleum its effect on copper and brass has been investigated. Two gases were examined: the primary gas, direct from the cracker, and the residual gas remaining after compression and cooling of the primary; they contained respectively 0·9–1% and 1·68% of acetylene. Since only traces of copper acetylide were produced in tests at 20°, 55°, and 80° C., even under a pressure of 35 atmospheres, it is concluded that there is no danger in employing copper and brass plant under the above conditions.—M. Z.

The Action of Corrosive Media on Admiralty Metal. Sydney Born and W. L. Nelson (*Nat. Petrol. News*, 1933, **25**, 27–31; *Chem. Zentr.*, 1933, **104**, II, 3750).—Copper alloys such as brass, bronze, nickel–brass, silicon–bronze, and especially Admiralty gun-metal are rapidly corroded by even very dilute solutions of ammonia and hydrochloric acid. Gun-metal is, however, only very slightly affected by hard water, dilute sodium hydroxide solution, and dilute hydrogen sulphide water or gas. Addition of sodium hydroxide as a neutralizer to acid liquors to be brought into contact with gun-metal is recommended.—A. R. P.

Corrosion in Sulphonators. Anon. (*Chem. and Met. Eng.*, 1933, **40**, 409).—The following results of corrosion tests of metals in sulphonators under actual operating conditions, were obtained at the plant of the Endicott Johnson Corporation in co-operation with the International Nickel Company.

Metal.	Corrosion-Rate, mg./dm.², per Batch.	
	Sulphonated Neatsfoot Oil.	Sulphonated Castor Oil.
Lead	127	165
18–8 Chrome–nickel iron . .	425	22
Nickel	30	25
Monel metal	34	11
Ni-Resist	90	29
Plain cast iron	10,000	120

—F. J.

Increased Acidity Inhibits Corrosion. Application to Canning Prunes. E. F. Kohman and N. H. Sanborn (*Indust. and Eng. Chem.*, 1933, **25**, 920–922).—It is shown that the addition of citric acid (obtained from lemon juice) in the canning of prunes lessens their corrosive action on the tinplate can. This is consistent with the principles of the electro-chemical theory of corrosion.—F. J.

Effect of Metals on the Colour of Raspberries and Strawberries. J. M. Bryan and T. N. Morris (*Canning Trade J.*, 1933, **3**, 252).—From the Report of the Food Investigation Board for 1932. Amounts up to 40 parts per million of aluminium, copper, nickel, chromium, zinc, lead, or silver had no immediate effect on the colour of the fruits. 10 parts per million of iron produced discolouration of raspberries, 2 parts were sufficient to discolour strawberries, but iron had no effect on black currants. Discolouration by tin was most marked with black currants, 2 parts per million being sufficient to impart a bluish tint, although after heating, the discolouration almost disappeared. Raspberries after heating are discoloured by 40 parts per million of tin, whilst black currants are not affected by 100 parts per million.—E. S. H.

Methods for Preventing Corrosion in Ice-Producing Plant. A. Freundlich (*Z. ges. Kälte-Ind.*, 1933, **40**, 147–148; *Chem. Zentr.*, 1933, **104**, II, 3612).—For parts which come into contact with brine, lead-coated steel should be used and for other parts lead-coated steel further coated with zinc.—A. R. P.

Corrosion in Gearing. J. R. Kammel (*Commonwealth Eng.*, 1933, **21**, 75–76).—Describes experiments carried out by W. Rosenhain at the National Physical Laboratory and discusses the conclusions that have been reached therefrom.—J. H. W.

The Stability of Trichlorethylene. Investigations of Its Corrosive Action on Metals. Anon. (*Chem. Trade J.*, 1933, **93**, 227–229).—Under the influence of actinic light (*e.g.* sunlight) trichlorethylene decomposes into carbonyl chloride and hydrogen chloride or into diacetyl chloride which further decomposes into hydrogen chloride and dichloracetic acid; these acid decomposition products are liable to produce corrosion in degreasing plants, but experiments have shown that their development can be prevented by adding organic amines or diphenylguanidine to the trichlorethylene. After this treatment only zinc, cast iron, and mild steel are attacked by the degreaser, and then only very slightly. Carbon tetrachloride, on the other hand, is inert only to aluminium, Staybrite steel, and Monel metal.—A. R. P.

†**On the Question of the Protection from Corrosion and Corrosion Stability of Binary Solid Solutions.** L. Graf (*Metallwirtschaft*, 1933, **12**, 585–587, 602–603).—A review of theoretical and practical work on Tammann's theory of resistance limits.—v. G.

†**Corrosion and Protection of Metals.** U. R. Evans (*Rev. Mét.*, 1933, **30**, 502–508; and (abstract) *Industrie chimique*, 1933, **20**, 809–810).—A good survey of the subject with special reference to recent research work. Corrosion is discussed under the headings—direct oxidation, places susceptible to corrosion, electrochemical corrosion, corrosion by a drop on a horizontal surface, corrosion of a vertical plate. Protection against corrosion is dealt with under the headings—materials resistant to corrosion, treatment of water, metallic coatings, and paints. A *bibliography* is appended.—H. S.

***Comparative Results of the Measurement of Corrosion.** Jean Cournot and Henri Fournier (*Compt. rend.*, 1933, **197**, 1409–1411).—Siebel and Pomp's cupping test, the Persoz test, and the loss-of-weight method have been used to measure the effects of corrosion on a number of alloys, which were tested before and after 2 months' corrosion in a salt mist. If σ is the percentage loss in weight or diminution of the property measured, a factor σ' is used to show the sensitiveness of the measurement, so that in the loss of weight method, σ' is the quotient of σ by half the maximum variation of the results as a percentage of the mean value, and in the cupping tests, σ' is calculated as

Character of Corrosion.	Loss of Weight, %.	Siebel and Pomp Test.			Persoz Test.	
		Breaking Stress.	Elongation, %.	Deflection.	Load.	Deflection.
Armco Iron.						
Diminution %, σ	10	9·9	25·8	15	18·2	6
Sensitivity, σ' .	1·10	0·11	0·28	0·18	0·17	0·13
18% Chromium, 8% Nickel Austenitic Steel.						
Diminution %, σ	0·07	−0·5	−2·2	−1·10	2·8	−2·9
Sensitivity, σ' .	0·00	0·00	0·00	0·00	0·00	0·00
Austenitic Ferro–Nickel, containing 34% Nickel.						
Diminution %, σ	0·09	6·09	−10·5	−1·4	10	10·4
Sensitivity, σ' .	0·00	0·04	0·02	0·00	0·07	0·09
Duralumin.						
Diminution %, σ	0·06	53·2	54·9	32·9	17·9	16·9
Sensitivity, σ' .	0·001	1·18	0·79	0·64	0·16	0·19
Monel Metal.						
Diminution %, σ	0·09	1·32	11·8	4·7	7·9	9·5
Sensitivity, σ' .	0·008	0·00	0·05	0·02	0·15	0·23
67 : 33 Brass.						
Diminution %, σ	0·07	0·37	14·06	9·8	0·32	4·12
Sensitivity, σ' .	0·00	0·00	0·11	0·08	0·00	0·03

the quotient of σ from the expression : $\frac{d\sigma}{\sigma} = \frac{dI}{I} \cdot \frac{I}{I-F} + \frac{dF}{F} \cdot \frac{F}{I-F} + \frac{dI}{I}$, where I = the initial and F = the final value. The results are tabulated as shown at foot of previous page.

For certain types of alloys, the Siebel and Pomp test is considered superior for the measurement of corrosion.—J. H. W.

***Tests of a Method of Continuous Measurement of Slight Corrosion Accompanied by Evolution of Gas.** A. Portevin, E. Prétet, and L. Guitton (*Rev. Mét.*, 1933, **30**, 362–365).—A method is developed for the study of slow corrosion of steels of the corrosion-resisting types in dilute acids, the specimen being suspended from the arm of a balance during immersion in the corroding medium. Gas bubbles which become detached are caught in a bell attached to the suspension above the specimen.—H. S.

Salt-Spray Tests. L. Richard (*Galvano*, **1933**, (20), 15–16).—The construction of a suitable apparatus is described.—E. S. H.

Controlled Data from an Immersion Test. R. F. Passano (*Proc. Amer. Soc. Test. Mat.*, 1932, **32**, (II), 468–474; discussion, 475–476; and *Amer. Soc. Mech. Eng. Preprint*, **1932**).—See *J. Inst. Metals*, 1932, **50**, 480.—A. R. P.

The Problem of Corrosion-Fatigue of Metals. August Thum and Heinrich Ochs (*Forschungen u. Fortschritte*, **1933**, **9**, 478–479).—A short review of the problem of corrosion-fatigue.—J. W.

V.—PROTECTION

(Other than Electrodeposition.)

(Continued from pp. 18–20.)

†**Electrolytic Oxidation of Aluminium.** E. Herrmann (*Schweiz. Tech. Z.*, **1933**, (19), 285–291; and (translations in abstract) *Light Metals Research*, 1933, **2**, (33), 13–20; *Aluminium Broadcast*, 1933, **4**, (12), 13–20).—A general introductory review of the methods—chemical and electrolytic—that are used in forming the oxide protective layer on aluminium. The Alumilite process is particularly described. The others mentioned are the Bengough and the Eloxal processes. In the Alumilite process, the objects, after thorough cleansing in organic and alkali solvents, are immersed as anodes in a bath of dilute sulphuric acid to which small quantities of addition agents may be added. The cathode is of lead. The chemical nature, and the thickness, of the oxide layer produced under differing conditions are discussed. When the basis material is pure, clean aluminium the layer is colourless and transparent. With aluminium–silicon alloys it is grey. The oxide layer may be coloured in a great variety of tones by immersion in certain organic dyes. More recently, in order to obtain more permanent colouration under exposed conditions, the oxide layer is impregnated with inorganic electrolytes, which are then caused to absorb mineral colouring matters by the use of specific physical or chemical means. Iron and silver salts, sodium bichromate and potassium ferrocyanide solutions have been used in this connection.
—W. A. C. N.

†**Gas for Modern Calorizing.** Anon. (*Gas World* (*Industrial Gas Suppt.*), 1933, **5**, (12), 11).—The art of calorizing, *i.e.* protecting iron and steel against corrosion by the application of a coating of aluminium, is described. Town's gas is the fuel used.—J. S. G. T.

The Manufacture of Tinplate. Wilhelm Krämer (*Stahl u. Eisen*, 1933, **53**, 1237–1240).—A review.—J. W.

The Effect of Insufficient Pickling on Subsequent Galvanizing. V. A. Wardell (*Indust. Chemist*, 1933, **9**, 233–234).—Pickling in sulphuric acid, using glue as an inhibitor, is affected by the grain size of the sheet. This is shown by simultaneous pickling of sheets of the same composition in the same cradle, differing in annealing treatment. The softer, fully annealed sheet gave a typical "skinned" coating when galvanized, whilst the harder sheet gave a good spangle and smooth surface. Pickling removes the scale from hard sheets with a minimum loss of iron, although soft annealed sheets lose a considerable quantity of iron before pickling is satisfactory.—E. S. H.

Embrittlement of Hot-Galvanized Structural Steel. Samuel Epstein (*Proc. Amer. Soc. Test. Mat.*, 1932, **32**, (II), 293–374, discussion, 375–379).—The problem of embrittlement in galvanized structural steel angles for electrical transmission towers is discussed and methods of quantitative testing for such embrittlement are described. Data from a large number of tests on 170 heats of various steels in the rolled, pickled, and galvanized conditions with punched and drilled holes are tabulated; they show that in all cases embrittlement is confined to the largest-sized punched angles, and that punching is the principal factor in producing it, pickling, galvanizing, and the nature of the steel being of only minor importance. In the discussion *V. L. Glover* stated that his experience showed hydrogen absorption in pickling to be an important fact in producing embrittlement of galvanized wires; pickling in 0·5% nitric acid entirely eliminated the brittleness.—A. R. P.

Effect of Zinc Coatings on the Endurance Properties of Steel. W. H. Swanger and R. D. France (*Proc. Amer. Soc. Test. Mat.*, 1932, **32**, (II), 430–448, discussion, 449–452; and *Amer. Soc. Mech. Eng. Preprint*, **1932**).—See *J. Inst. Metals*, 1932, **50**, 482. In the discussion *Robert Job* stated that the corrosion-fatigue strength of steel staybolts was not improved by cadmium plating, probably owing to the cracking of the deposit. *H. S. Rawdon* confirmed the superiority of zinc-plated over hot-galvanized wires, but *W. M. Peirce* pointed out that if a thin coat is applied by hot-galvanizing immediately after drawing, so that pickling is reduced to a minimum, the endurance properties are as good as those of plated wires. *W. H. Swanger* was of opinion that hydrogen embrittlement caused by pickling played only a minor part in determining the endurance strength.—A. R. P.

Some Factors Affecting the Preece Test for Zinc Coatings. H. H. Walkup and E. C. Groesbeck (*Proc. Amer. Soc. Test. Mat.*, 1932, **32**, (II), 453–463, discussion, 464–467; and *Amer. Soc. Mech. Eng. Preprint*, **1932**).—See *J. Inst. Metals*, 1932, **50**, 481. In the discussion *A. R. Small* stated that his work had shown that the Preece test was satisfactory for works routine; immersion for 1 minute was the equivalent of 0·1 oz./ft.^{2}, and about the equivalent of exposure for 1 year in the Chicago atmosphere. *W. H. Finkeldey* said that the number of dips a given weight of coating would normally stand was frequently doubled by the presence of smooth, adherent zinc corrosion products. *F. F. Farnsworth* considered that the test was satisfactory only for determining the uniformity of the coating, and *H. S. Rawdon* considered that the test was not suitable for all types of zinc coating.—A. R. P.

Neo-Sherardizing. Rustproofing by the Sherardizing Process. Anon. (*Met. Ind.* (*Lond.*), 1933, **43**, 630).—An improved sherardizing process is said to produce a brighter and more uniform coating and to permit of thicker coats. Chrome sherardizing consists of directly plating chromium on to a polished sherardized article. Copper and brass sherardizing are used for decorative purposes. Sherardizing with aluminium powder instead of with zinc allows the metal to be used at a bright red heat without scaling, but it is more expensive, as a higher temperature and preferably a reducing atmosphere are required for the process.—J. H. W.

Protecting Underground Pipe Lines Against Soil Action. K. H. Logan (*Chem. and Met. Eng.*, 1933, **40**, 514–516).—Based on a paper read before the Electrochemical Society. See *J. Inst. Metals*, 1933, **53**, 638.—F. J.

Metallic Coatings. Anon. (*Commonwealth Eng.*, 1933, 21, 91–92).—Brief review of the various methods available for coating iron and steel with protective non-ferrous metals.—J. H. W.

Metallization. Anon. (*Soudeur-Coupeur*, 1933, 12, (10), 1–5).—Applications to steel structures, cisterns, coils, and vessels are described and illustrated. The advantages of the modern Schoop pistol, using wire, are explained.—H. W. G. H.

Rubber Coatings for Abrasion and Corrosion. Leonard Church (*Chem. and Met. Eng.*, 1933, 40, 467–469).—Corrosion-resistance, wear, and abrasion resistance, and insulation against electricity, heat, sound, or vibration are all possible through the rubber coating of metallic parts by electro-deposition. Zinc can be used as readily as any other metal and, since zinc hydroxide and zinc oxide are not only not detrimental to the rubber, but are useful for cure, zinc is usually chosen, being readily and cheaply applied as a light coating to other metals. The process of depositing the rubber and the properties of the rubber coatings are described.—F. J.

Corrosion Protection and Ennoblement of Metals. Walter Savelsberg (*Chem.-Zeit.*, 1933, 57, 883–884).—The mechanism of corrosion and protection is discussed and methods of protecting metals from corrosion by paints, enamels, and electrodeposits of other metals are briefly described.—A. R. P.

Permeability of Paint Films to Moisture. Robert I. Wray and A. R. Van Vorst (*Indust. and Eng. Chem.*, 1933, 25, 842–846).—Various methods for determining permeability of paint films to moisture are discussed and results obtained by three methods given. In general, aluminium paint coatings show greater resistance to the passage of moisture than other pigments in the same vehicles. The aluminium powder concentration in the vehicle and the grade of powder used also have a marked effect on the permeability of the paint. Higher powder content, within limits, and finer grades of powder make more impermeable paint films.—F. J.

Protective Painting is more than Surface Covering. S. C. Britton and U. R. Evans (*Food Ind.*, 1933, 5, 392–393).—The general principles of protecting metal work by paint are reviewed.—E. S. H.

VI.—ELECTRODEPOSITION

(Continued from pp. 20–22.)

Some New Organic Addition Agents for Cadmium Electroplating. R. A. Claussen and H. L. Olin (*Trans. Electrochem. Soc.*, 1933, 63, 87–94; discussion, 94–97).—For abstract of the paper see *J. Inst. Metals*, 1933, 53, 249. In the discussion *Gustaf Soderberg* maintained that an ideal addition agent must not react chemically with the solution or be oxidized at the anode or reduced at the cathode to form ineffective compounds, must be equally effective over a wide range of concentrations, and must not be included in the deposit. On this basis he criticizes work on the effect of adding waste products as recommended by C. and O., since these products contain a wide variety of compounds only some of which may be effective; he also suggests that light may be thrown on the reason why some substances are active and others not by a study of cathode potentials. *L. Addicks*, on the other hand, states that an addition agent is destroyed as it is used up for the effect desired, and therefore recommends that these agents be added continuously drop by drop from a mechanical device. *Leon R. Westbrook*, in reply to questions by *U. C. Tainton*, said that small amounts of lead, tin, and arsenic in the bath darken the deposit, but their effect is overcome to some extent by adding a nickel salt as a brightener. Aqueous or alkali extracts of various organic substances, *e.g.* wood, or sulphonated castor oil, and some sulphonated derivatives of naphthalene, can also be used as brighteners in cadmium plating baths. *U. C. Tainton* stated that colloidal silicic acid is used as an addition agent in zinc deposition from sulphate electrolytes in preference to organic compound; it is not included in the deposit, but travels towards the anode. —A. R. P.

Cadmium Plating Instead of Galvanizing. Anon. (*Z.V. d. Kupferschmied.*, 1933, **45**, 181–182).—Cf. *J. Inst. Metals*, 1933, **53**, 136, 445. Short note describing the electrodeposition of cadmium.—M. H.

Chromium Plating. Anon. (*Automobile Eng.*, 1933, **23**, 507).—See *Met. Abs.*, this volume, p. 20. A description of a portable plating outfit which comprises two cases, one containing the electrical equipment necessary for plating, and the other the plating solutions, plating pads, and cleaning and polishing materials. A portable buffer also forms part of the outfit. It is stated that satisfactory and uniform deposits are obtained with this equipment, and that quicker deposition of both chromium and nickel is possible than in the vat process.—J. W. D.

Information for the User about Chromium Plate. Marvin J. Udy (*Metal Progress*, 1933, **24**, (6), 24–27, 62).—Many failures of chromium-plating in practice are due to neglect of one or more of the following factors: appropriate thickness of coating for a given purpose, nature and quality of basis metal, nature and finish of undercoating. The significance of certain characteristic properties of chromium plate on industrial applications is discussed.—P. R.

A New Bath for the Direct Nickeling of Zinc. George W. Nichols (*Met. Ind.* (*Lond.*), 1933, **43**, 566–568).—Paper read before the Electrochemical Society. See *J. Inst. Metals*, 1933, **53**, 559.—J. H. W.

On the Platinizing of Noble and Base Metals. Edmund R. Thews and Ralph W. Harbison (*Chem.-Zeit.*, 1933, **57**, 980–981).—The following are discussed: economics of the process, stability of the plate, old and new plating baths, their preparation, maintenance, and operation.—A. R. P.

Some Notes on Silver Plating. Anon. (*Galvano*, **1933**, (20), 13–14).—A brief discussion of the process, in which it is claimed that the principal causes of failure are excess or insufficiency of cyanide, or excess of carbonate. —E. S. H.

***The Use of the Microscope in the Study and Control of Electrodeposits.** A. Portevin and M. Cymboliste (*Rev. Mét.*, 1933, **30**, 323–348).—A study of the technique of examining electrodeposits microscopically, of the qualities and defects of electrodeposits in relation to properties, and the factors affecting structure. Protection of electrodeposits by supplementary electrodeposits of other metals, *e.g.* copper or nickel, and chromium when the original deposit is a delicate one, before sections are cut for microscopical examination, is recommended. The protective or supplementary electrodeposit should not be one vigorously attacked by the etching medium. Attention is paid to thickness, inequalities, porosity, pin-holes, cracks, excrescences, colour, lustre, adhesion, flaking or peeling, corrosion-resistance, and structure of electrodeposits, and 74 photographs illustrating the structures of deposits are given. —H. S.

Theories of Addition Agent Action. Robert Taft (*Trans. Electrochem. Soc.*, 1933, **63**, 75–82; discussion, 82–85).—For abstract of the paper see *J. Inst. Metals*, 1933, **53**, 255. In the discussion, *P. Jacquet* gave details of tests made on the deposition of copper from sulphate solutions containing various colloids; gelatin and pure serum albumin modified the stress in the deposit considerably, gum arabic slightly, and dextrin not at all. With gelatin the stress of the deposit is closely connected with the method of preparation and age of the colloidal solution and with its "gold number," which appears to confirm the theory that some colloids are included in electrodeposits by adsorption. This theory is further confirmed by observations made on the adherence of electrodeposits to copper sheet which has first been dipped in colloidal solutions and washed before placing in the electrolytic bath; with solutions containing proteins or peptones, especially serum albumin, no adherence of the deposit is obtained, whereas with gum or dextrin solution good adherence is obtained. The colloid layer in the first case is produced in a few seconds, and cannot be removed by washing even in boiling water, hence it appears that colloids may stick to metals by adsorption independently of the electric current; with the current they are subject to cataphoresis, and are thus responsible for the variations of concentration in the neighbourhood of the cathode which modify the adsorption equilibria. *Lawrence Addicks* stated that in the early days of copper refining, smooth deposits were obtained by adding, to the electrolyte, oil or the solution obtained by boiling wood chips with water. Glue size was also used in nickel plating solutions to obtain smooth deposits. R. T., in reply, stated that at low temperatures gum arabic produces a profound effect on the form of electrodeposited copper.—A. R. P.

Control of Electrodeposits. Anon. (*Galvano*, 1933, (14), 23–25, (15), 23–26).—Translated from *Machinery* (*Lond.*), 1932, **39**, 581–585. See *J. Inst. Metals*, 1932, **50**, 683.—E. S. H.

VII.—ELECTROMETALLURGY AND ELECTROCHEMISTRY

(Other than Electrodeposition and Electro-Refining.)

(Continued from pp. 23–24.)

***The Electrolysis of Metallic Salt Solutions with a Cathode of Rarified Gas.** N. Thon (*Compt. rend.*, 1933, **197**, 1114–1117).—Experiments were undertaken in depositing different metals using a rarified gas cathode and varying the distance between the cathode and the surface of the liquid. With a.c., the system electrolyte/rarified gas/platinum becomes a sensitive detector, the positive rectified current going to the surface of the liquid towards the metal. An applied potential difference of 1000 v. was used. It was established (1) that the electrolysis of salts of metals less noble than hydrogen (zinc, cadmium, lead, nickel) does not form a metallic deposit, but results only in an evolution of hydrogen; (2) that copper and mercury, although more noble than hydrogen do not form deposits from their salts, copper sulphate, and mercurous nitrate, respectively; (3) that a deposition of the metals is obtained with solutions of the simple salts, silver nitrate, gold chloride, and lead chloride. In the case of silver, a deposit is obtained even if the polarity of the electrodes is reversed. The statement relating to copper sulphate is in contradiction to Corbino's results, and a number of observations are made in support of that statement.—J. H. W.

The Hydrogen Overvoltages of Iron–Chromium Alloys in Potassium Hydroxide Solution. M. de Kay Thompson and D. M. Fleming (*Electrochem. Soc. Preprint*, 1934, April, 73–77).—The hydrogen overvoltage of iron–chromium alloys in *M*-potassium hydroxide solution at 25° C. is constant between 0 and 60% chromium, after which it rises gradually to that of chromium in a concave curve.—A. R. P.

The Conductivity of Electrolytes Measured by the Resistance of Palladium Wire Containing Hydrogen. Notes on a Similarly Named Paper by C. A. Knorr and E. E. Schwartz. Donald P. Smith (*Z. Elektrochem.*, 1933, **39**, 743–744).—Both quantitative and qualitative arguments are raised against explanations put forward by K. and S. See *J. Inst. Metals*, 1933, **53**, 363.
—J. H. W.

IX.—ANALYSIS

(Continued from pp. 25–27.)

***Analysis with Wedge Spectra : Its Recent Application to Zinc on a Quantitative Basis.** Morris Slavin (*Eng. and Min. J.*, 1933, **134**, (12), 509–513).—The spectroscopic determination of Co, Fe, Cu, Cd, Tl, Ge, and Pb in $ZnSO_4$ solutions, and of Fe, Cu, Cd, and Pb in metallic Zn is described. A suggested improvement consists in separating the metals into groups as in qualitative analysis, adding prior to precipitation, a known amount of a metal which acts as a collector during the separation, and as the base material while spectrographing. From measurements of the comparative intensities of the lines of this metal and those of the unknown metal the percentage of the latter in the original sample can be calculated.—R. Gr.

***Quantitative Rapid Micro-Analysis of Pure Aluminium.** F. Pavelka and Hermine Morth (*Mikrochemie*, 1933, **13**, 305–312).—The metal (0·1 grm.) is dissolved in 50% H_2SO_4 and the solution is oxidized with 1 drop of H_2O_2 and diluted to 10 c.c. in a graduated flask; 3 c.c. of the solution are used for the colorimetric determination of Fe with $K_4Fe(CN)_6$, a further 2 c.c. for the determination of Cu by measuring the time taken for the catalytic reduction of $Fe(CNS)_3$ with $Na_2S_2O_3$ under standardized conditions, and 2–3 c.c. for the determination of Mn by a modified persulphate method. —A. R. P.

Methods of Analysis for Brass and Bronze. Anon. (*Schweiz. Tech. Z.*, **1933**, (24), 375–377).—The standard methods adopted by the U.S.M. Normal bureau are described.—W. A. C. N.

Method of Analyzing Antifriction Alloys. P. Foerster (*Ann. Chim. Analyt.*, 1933, [ii], **15**, 441–446).—Modifications of the usual procedure are recommended. The Sn and Sb oxides which remain insoluble after treatment of the alloy with HNO_3 are evaporated with $Na_2S,9H_2O$ and a little S until a thick syrup is obtained. This is diluted and the insoluble PbS and CuS are collected, dissolved in HNO_3, and added to the main filtrate. The solution containing SnS_2 and Sb_2S_3 is divided and aliquot parts taken for Sn determination by I_2 titration, and Sb determination by $KMnO_4$ titration. Cu and Pb are determined by electrolysis of the HNO_3 solution and the spent electrolyte is used for determination of Zn and Fe.—A. R. P.

***Detection of Alkaline Earth Metals.** A. J. Scheinkmann and A. B. Politzschuck (*Z. anal. Chem.*, 1933, **94**, 192–193).—The carbonate precipitate obtained with $(NH_4)_2CO_3$ in the usual way is dissolved by gentle warming with $CH_3{\cdot}COONH_4$ solution. To test for Ca, 10 drops of this solution are boiled with 3 drops of NH_4OH, a few crystals of NH_4Cl, and 10 drops of saturated $K_4Fe(CN)_6$ solution; a white precipitate of $Ca(NH_4)_2Fe(CN)_6$, insoluble in $CH_3{\cdot}COOH$, indicates Ca. To test for Ba, a few drops of the acetate solution are treated with dilute H_2SO_4, when an immediate white precipitate indicates Ba; on boiling the filtrate a white precipitate indicates Sr.—A. R. P.

***Picrolonic Acid as a Reagent for the Alkali Metals.** Y. Volmar and M. Leber (*J. Pharm. Chim.*, 1933, [viii], **17**, 427–431; *Chem. Zentr.*, 1933, **104**, II, 2426–2427).—K is detected and separated by precipitation with (*a*) picric acid, (*b*) H_2PtCl_6 and C_2H_5OH, or (*c*) Carnot's reagent (CaS_2O_3 being substituted for $Na_2S_2O_3$). In the filtrate from (*a*) Na gives an immediate precipitate with 0·02 *N*-picrolonic acid. To test for Na in the filtrate from (*b*) the C_2H_5OH must be removed and the Pt precipitated before applying the picrolonic acid test. Similarly, in method (*c*) C_2H_5OH must be boiled off, Bi precipitated with H_2S and Ca with $(NH_4)_2CO_3$, and NH_4 salts expelled by evaporation and heating before testing for Na.—A. R. P.

On the Detection of Minute Amounts of Arsenic by the Gutzeit Method. G. Lockemann and B. Fr. von Bülow (*Z. anal. Chem.*, 1933, **94**, 322–330).—Modifications of the method to improve its sensitivity are described in detail. —A. R. P.

***A New Way of Detecting Barium, Strontium, and Calcium in the Systematic Course of Analysis.** Johanna Brintzinger and H. Brintzinger (*Z. anal. Chem.*, 1933, **94**, 166–170).—In microchemical analysis Ca may be identified as $CaSO_4,2H_2O$,Ba as $BaSiF_6$, and Sr as $Sr(IO_3)_2$ which give characteristic crystals on a microscope slide.—A. R. P.

***Microchemical Identification of Sodium with the Aid of Picric Acid** Georges Denigès (*Bull. Trav. Soc. pharm. Bordeaux,* 1933, **71**, 191–195; *Chem. Zentr.*, 1933, **104**, II, 2427).—In spite of its relatively great solubility (10–12%) in H_2O, Na picrate can serve for the identification of Na. The solution is evaporated and the dry residue (1 mg.) treated with 1 drop of 1% picric acid solution; in the presence of Na characteristic clusters of needles are formed. K, Rb, and Cs may be previously removed with $HClO_4$. —A. R. P.

***On the Use of 5 : 7-dibromo-*o*-(8)-Hydroxyquinoline as a Specific Reagent for Vanadium.** G. Gutzeit and R. Monnier (*Helv. Chim. Acta,* 1933, **16**, 239–240).—Tervalent V may be detected by the brown precipitate (or colouration at high dilutions) given with 5 : 7-dibromo-*o*-(8)-hydroxyquinoline. Fe must first be removed by boiling with 3*N*-NaOH; the filtrate is acidified with HNO_3 and the reagent added.—E. S. H.

***The Behaviour of Zirconium, Thorium, and Some Rare Earths Towards Quinalizarin.** A. S. Komarowsky and I. M. Korenmann (*Z. anal. Chem.*, 1933, **94**, 247–249).—On adding a few drops of alcoholic quinalizarin solution to a neutral chloride solution of Zr, Th, or the rare earths, and then making the solution feebly alkaline with NaOH, a blue colour, eventually flocculating to a blue precipitate, is obtained. The limits of sensitivity in p.p.m. are Nd 0·5, Pr 1·08, Ce 1·15, La 2·0, Zr 6·25, Th 6·67.—A. R. P.

On the Colorimetric Estimation of Antimony in Copper. A. A. Vassiliev and M. E. Schub (*Zhurnal Prikladnoi Khimii* (*Journal of Applied Chemistry*), 1933, [B], **6**, (3), 560–462).—[In Russian, with German summary.] Clark's method is critically examined. A sharper comparison is obtained by extracting the coloured C_5H_5N–KI–Sb complex with an organic solvent, *e.g.* $C_5H_{11}\cdot OH$. Satisfactory results are obtained with 0·001–0·004% Sb, but certain difficulties exist which render further work desirable.—M. Z.

A Volumetric Method for the Determination of Barium and Sulphates. J. C. Giblin (*Analyst*, 1933, **58**, 752–753).—The feebly HCl solution of Ba is titrated with H_2SO_4 using Na rhodizonate paper as indicator; the titration is finished when a drop of the solution no longer gives a red spot on the paper. —A. R. P.

On the Use of Rhodizonic Acid as an Indicator in the Volumetric Determination of Barium. A. Friedrich and S. Rapoport (*Mikrochemie*, 1933, **14**, 41–48).—Tests under varying conditions failed to give good results, since Ba rhodizonate forms an almost insoluble colloidal suspension which reacts only slowly with sulphate ions (cf. preceding abstract).—A. R. P.

***Colorimetric Determination of Bismuth.** C. Mahr (*Z. anal. Chem.*, 1933, **94**, 161–166).—In 4–6% HNO_3 Bi produces a yellow colour with an excess of $CS(NH_2)_2$, whereas Cu and Pb are precipitated as crystalline compounds. The yellow colour of the filtered solution is compared in a Dubosq colorimeter with that produced by a standard Bi solution under similar conditions. In the presence of Sb, KF is added to prevent interference; $Fe^{\cdot\cdot\cdot}$ must be reduced to $Fe^{\cdot\cdot}$ by treatment with N_2H_4 solution. The method gives good results with as little as 0·15 mg. of Bi in the presence of 1·5 grm. of Cu or 3 grm. of Pb.—A. R. P.

***Determination of Chromium by the Mercurimetric Method.** Al. Ionescu-Matiu and S. Herscovici (*Bull. Soc. chim. France*, 1933, **53**, 1032–1038).—The solution containing the Cr as CrO_4 and free from Cl' and SO_4'' is treated with an excess of $HgNO_3$ and the Hg_2CrO_4 removed. The filtrate is oxidized with $KMnO_4$ and the resulting $Hg(NO_3)_2$ titrated with NaCl after addition of Na nitroprusside until the turbidity disappears.—A. R. P.

The Application of the Mercurithiocyanate Precipitation of Copper to Its Colorimetric Determination. J. Golse (*Bull. Trav. Soc. pharm. Bordeaux*, 1933, **71**, 16–24; *Chem. Zentr.*, 1933, **104**, II, 2427–2428).—The Cu is precipitated together with a known quantity of Zn by addition of an excess of $(NH_4)_2Hg(SCN)_4$, and the colour of the precipitate is compared with that obtained in a series of standards containing the same amount of Zn but variable amounts of Cu. As little as 0·001 mg. of Cu is sufficient to impart a violet tint to the $ZnHg(SCN)_4$ precipitate.—A. R. P.

A Contribution to the Colorimetric Determination of Sodium. F. Alten and H. Weiland (*Z. Pflanzenernährg. Düng. Bodenkunde*, 1933, [A], **31**, 252–255; *Chem. Zentr.*, 1933, **104**, II, 2427).—The method depends on the precipitation of the Na as the triple acetate of Na, UO_2, and Mg and the colorimetric determination of the UO_2 with $K_4Fe(CN)_6$.—A. R. P.

Nephelometric Determination of Small Quantities of Bismuth [in Copper]. Luigi Malossi (*Rend. Accad. Sci. fisich. mat. Napoli*, 1932, [iv], **2**, 83–90; *Chem. Zentr.*, 1933, **104**, II, 2298).—The Bi is separated from the HNO_3 solution of the Cu by precipitation with $(NH_4)_2CO_3$, the precipitate dissolved in the minimum of HCl and the solution treated with a 0·5% suspension of agar-agar and with an alkaline solution of Na_2SnO_2 whereby colloidal bismuth is formed the colour of which is compared with that produced similarly in a standard Bi solution.—A. R. P.

The Determination of Small Amounts of Bismuth in Copper. L. C. Nickolls (*Analyst*, 1933, **58**, 684).—Cf. *J. Inst. Metals* (Monthly Issue), 1933, July, p. xcvi. The method recommended by the Technical Sub-Committee of the Fiscal Policy Committee of the Brass and Copper Industries gives good results, but the use of SO_2 for reducing the $Fe^{\cdot\cdot\cdot}$ to $Fe^{\cdot\cdot}$ is bad. A much better reducing agent is obtained by dissolving 10 grm. of Sn in 100 c.c. of $6N$-H_2SO_4: a few drops of this $SnSO_4$ solution rapidly reduces the Fe and has no effect on the Bi colour, nor does it cause liberation of I_2 from the KI used.—A. R. P.

The Electrolytic Determination of Bismuth, Tin, Lead, and Antimony without Mechanical Stirring. Th. Grosset (*Bull. Soc. chim. Belg.*, 1933, **42**, 269–280).—Bi is deposited from a boiling HNO_3-tartaric acid solution using 0·5 amp. at 1·32 v., Sb from a boiling HCl solution containing $NH_2OH{\cdot}HCl$ and tartaric acid using 3·2 amp. at 2 v., Pb from a boiling nitrate solution using 3 amp. at 2·1–1·5 v., and Sn from a boiling HCl solution containing NaCl, KCl, NH_4Cl, and $(NH_4)_2S_2O_8$ using 3·2 amp. at 2·1 v. and a Ni-plated Pt cathode.—A. R. P.

***The Determination of Cadmium in the Presence of Zinc in Spelter and in Zinc Ores.** A. Pass and A. M. Ward (*Analyst*, 1933, **58**, 667–672).—The metal is dissolved in $2N$-H_2SO_4 and the solution boiled with Fe nails to remove Cu, Bi, As, and Sb as metals and Pb as $PbSO_4$. The filtrate is treated with 5 grm. of Rochelle salt, a few drops of SO_2 water, 40–50 c.c. of $0{\cdot}2N$-KI, and sufficient of a 2·5% solution of β-naphthaquinoline in $0{\cdot}5N$-H_2SO_4 to give an excess of 5–6 c.c. The complex Cd precipitate is collected on an asbestos layer in a porous glass crucible, washed with a dilute solution of the precipitant and rubbed up with $2N$-NH_4OH. The asbestos, &c., is filtered off, and the filtrate treated with HCl until N with respect to this acid, then with 5 c.c. of 10% KCN and a little starch solution, and titrated with $M/40$-KIO_3

(1 c.c. = 1·405 mg. of Cd). In the NH_4OH extraction only the I_2 in the precipitate is removed; the titration is based on the action: $2HI + HIO_3 + 3HCN = 3ICN + 3H_2O$. Phenyltrimethylammonium iodide may also be used as precipitant for the Cd.—A. R. P.

***The Use of Potential-Forming Systems Metal/Metal-Anion for Potentiometric Analysis. I.—The Precipitation Potentiometric Titration of Chromate, Molybdate, and Tungstate Ions as well as a Series of Metal Ions by the Use of Chromium, Molybdenum, and Tungsten as Indicator Electrodes.** H. Brintzinger and E. Jahn (*Z. anal. Chem.*, 1933, **94**, 396–403).—W, Cr, and Mo in the form of R_2MO_4 salts (R = an alkali metal or NH_4) can be titrated potentiometrically with $BaCl_2$ at 95° C. using an indicator electrode of the corresponding metal. By titration at 95° C. with Na_2MoO_4, using a Mo electrode, Ba, Sr, Pb, and Cd may be determined in neutral solution, and at 20° C. Cu and Mn may be determined similarly; C_2H_5OH must be added for Mn and Sr and $CH_3 \cdot COONH_4$ for Cu. Ba may also be titrated at 95° C. with Na_2WO_4 (W electrode) or Na_2CrO_4 (Cr-plated steel electrode).—A. R. P.

The Determination of Copper by the Salicylaldoxime Method. S. Astin and H. L. Riley (*J. Chem. Soc.*, **1933**, 314–315).—A note on the method.—S. V. W.

The Separation and Determination of Copper and Nickel by Salicylaldoxime. H. L. Riley (*J. Chem. Soc.*, **1933**, 895).—A note on the method.—S. V. W.

Solubility of Lead Chromate. Application to the Volumetric Determination of Lead. H. Huybrechts and Ch. Degard (*Bull. Soc. chim. Belg.*, 1933, **42**, 331–346).—$CH_3 \cdot COOH$ and $CH_3 \cdot COONH_4$ separately augment the solubility of $PbCrO_4$ in high concentrations, but together their effect is less marked; the presence of $Ca(NO_3)_2$ assists flocculation of the $PbCrO_4$. In the volumetric determination of Pb by the chromate method the solution should contain a minimum amount of acetates and 0·6–1 g. of $Ca(NO_3)_2$ per 100 c.c.; K_2CrO_4 should be added to the cold solution and the excess determined in the usual way after removal of the $PbCrO_4$ precipitate.—A. R. P.

Determination of Magnesium by Means of 8-Hydroxyquinoline. H. Fredholm (*Ann. Brass. Dist.*, 1933, **31**, 43–44).—From *Svensk Kem. Tidskr.*, 1932, **44**, 79. To the solution containing 25 mg. of Mg in 100 c.c. at 75° C. are added 2–3 grm. of NH_4Cl and 2 c.c. of $3N$-NH_3 aq., then drop by drop a slight excess of a 2% alcoholic solution of 8-hydroxyquinoline. After boiling for 3–4 minutes, the precipitate is collected and dissolved in $2N$-HCl; $N/10$-$KBrO_3$ is added until a yellow colouration is produced, and the excess of $KBrO_3$ titrated with $Na_2S_2O_3$, using starch as indicator.—E. S. H.

†Detection and Determination of Small Quantities of Mercury. Friedrich Cucuel (*Mikrochemie*, 1933, **13**, 321–364).—A review of recent work.—A. R. P.

A Rapid Method of Estimating Phosphorus in Copper and Copper–Zinc Alloys. A. A. Vassiliev and Z. W. Tchurilima (*Zhurnal Prikladnoi Khimii* (*Journal of Applied Chemistry*), 1933, [B], **6**, (3), 563–566).—[In Russian, with German summary.] A modification of the molybdate methods of Lorenz and of Finkener is described by which complete precipitation of up to 0·1% P can be obtained in 1 hr.—M. Z.

Drop Method for the Approximate Quantitative Determination of Platinum. N. A. Tananaeff and G. T. Michaltschischin (*Z. anal. Chem.*, 1933, **94**, 188–192).—The method depends on the orange colour produced by adding 1 drop of $SnCl_2$ solution to a drop of H_2PtCl_6 solution and a drop of TlCl solution on a piece of filter paper. The depth of colour is compared with that produced by a standard Pt solution under similar conditions. The results are accurate to 2–12% for quantities of Pt of the order of 0·1 mg.—A. R. P.

Determination of Potassium by the Cobaltinitrite Method. O. M. Kosman (*Zhurnal Prikladnoi Khimii* (*Journal of Applied Chemistry*, 1933, [B], **6**, (2), 362–366).—[In Russian, with German summary.] The merits of the method are discussed and a new technique described.—M. Z.

***On the Quantitative Determination of Tin by Precipitation as Stannous Sulphide.** Benedikt Linke and Heinrich Preissecker (*Z. anal. Chem.*, 1933, **94**, 238–239).—The solution containing the tin as $SnCl_2$ and 4 c.c. of HCl (*d* 1·19) per 100 c.c. is treated with a rapid stream of H_2S on the water-bath. The black precipitate of SnS yields SnO_2 for weighing after ignition at a gentle heat, than at full redness. If the original solution contains the Sn as $SnCl_4$, it must first be reduced with Mg in a flask fitted with a Bunsen valve.
—A. R. P.

[Contribution] to the Knowledge of the Dithizone Reaction. Remarks on the Work of H. Wölbling and B. Steiger. Hellmut Fischer (*Angew. Chem.*, 1933, **46**, 517).—Cf. *J. Inst. Metals*, 1933, **53**, 563. Oxidizing agents interfere in the Hg reaction, but their effect can be overcome by addition of 1% KCN solution. The Ag reaction is not affected by acids; by shaking the CCl_4 extract of the Ag test with 1% KCN the Ag colour changes to green, whereas that due to Hg persists unchanged. The Cu reaction is prevented by KCN in neutral or alkaline solution, so that traces of Pb in Cu may be detected by the test if KCN is added. The Hg reaction is also prevented by KCN, so that the method does not distinguish between the two metals.—A. R. P.

Application of Mercurimetry to the Determination of Silver. J. V. Dubský and J. Totílek (*Chem. Obzor.*, 1933, **8**, 86–88).—See *J. Inst. Metals*, 1933, **54**, 649.—A. R. P.

†Wulff's Foil Colorimeter for Determining p_H Values. W. Kordatzki (*Arch. tech. Messen*, 1933, **3**, (28), T135).—The indicator consists of a membrane, penetrable by water and aqueous solutions and containing adsorbed colouring matter; its application to the determination of p_H values, especially of turbid or viscous media is described. In special adaptations of the indicator for high dilutions, and as a substitute for litmus paper, the p_H value is indicated by the shade assumed by the foil, approximate values being quoted. An extensive *bibliography* covers industrial applications, including galvanizing.
—P. M. C. R.

X.—LABORATORY APPARATUS, INSTRUMENTS, &c.

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

(Continued from pp. 27–28.)

***Manipulation of the Research Microscope. [Mechanical Stage Device for Microscopes.]** Ralph Wichterman (*Science*, 1933, **78**, (2021), 266–267).—Large areas may be examined under high magnification by moving the specimen in one direction on a mechanical stage, but difficulties exist in shifting the specimen by steps in a direction at right angles to the motion, so that the successive bands which are examined just overlap. A device made by the Spencer Lens Co., Buffalo, New York, enables the specimen to be moved over the required distance by one turn of a knob.—W. H.-R.

Advances in Microscopy. F. F. Lucas (*Assoc. Internat. Essai Mat., Congrès de Zürich*, **1932**, (I), 422–444).—[In English.] See *J. Inst. Metals*, 1932, **47**, 96.—S. G.

Progress of Metallography. J. L. Haughton (*Assoc. Internat. Essai Mat., Congrès de Zürich*, **1932**, (I), 457–468).—[In English.] See *J. Inst. Metals*, 1931, **47**, 87.—S. G.

Recent Development in Research on the Constitution of Alloys. W. Guertler (*Assoc. Internat. Essai Mat., Congrès de Zürich*, **1932**, (I), 469–483).—[In German.] See *J. Inst. Metals*, 1931, **47**, 527.—S. G.

X-Ray Investigations of the Constitution of Alloys. A. Westgren (*Assoc. Internat. Essai Mat., Congrès de Zürich*, **1932**, (I), 484–499).—[In English.] See *J. Inst. Metals*, 1931, **47**, 536.—S. G.

Discussion [on Metallography]. J. L. Haughton. W. Rosenhain. C. Benedicks. A. Portevin. O. Chlebus. A. Schimmel. G. Masing. F. F. Lucas (*Assoc. Internat. Essai Mat., Congrès de Zürich*, **1932**, (I), 501–507).—[In English, French, or German.] The discussion centred chiefly on the optical theory of microscopic resolution, on the nature of transformations in steel, and of the β–β′ transformation in brass, and on the need for using very pure metals for the study of equilibria in alloy systems.—A. R. P.

On the Use of Polarized Light in the Examination of Metal Sections. (Frhr.) M. v. Schwarz (*Assoc. Internat. Essai Mat., Congrès de Zürich*, **1932**, (I), 508–517).—[In German.] This paper has been published in full with colour photomicrographs in *Z. Metallkunde*, 1932, **24**, 97, and in *Metallurgia*, 1931, **4**, 180 (see *J. Inst. Metals*, 1931, **47**, 659; 1932, **50**, 744).—A. R. P.

***The Attainment of Very Low Temperatures by Compression of Liquid Helium.** W. Meissner (*Wiss. Abhandl. Physikal.-Tech. Reichsanst.*, 1933, **17**, 88–93).—Reprint from *Z. Physik*, 1933, **81**, 832–837; see *J. Inst. Metals*, 1933, **53**, 516.—M. H.

The Inspection of Interiors. P. Nettmann (*Automobiltech. Z.*, 1933, **36**, (23), 597).—A portable apparatus for the visual examination of hollow objects is described. The optical system can be adjusted to give a general view of the interior, or to show any desired portion of the walls.—P. M. C. R.

Magnetic Apparatus for the Measurement of Thicknesses. P. Bricant (*Technique moderne*, 1933, **25**, (10), 360)—Abstract of a note to the Académie des Sciences, March 6, 1933. The continuous and automatic measurement of the thickness of thin sheets, and the diameters of fine wires is made by measuring electrically the variation in the reluctance of an air gap in a transformer core caused by variations in the sheet thickness. The method can be used even when the magnetic permeability of the material is nearly equal to that of air, and it is particularly applicable to the measurement of small displacements of moving pieces such as in the dilatation of solids or the variations in thickness of a manometric capsule.—R. B. D.

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

(Continued from pp. 28–30.)

***Investigations on the Depth of Penetration of [Metal] Sheets in the Erichsen Test.** Fr. Dörge (*Z. Metallkunde*, 1933, **25**, 165–168, 210–214).—An experimental and mathematical investigation has shown that the Erichsen test is merely a mechanical breaking process similar to the tensile test. The Erichsen number does not give information concerning the deep drawing capacity of a sheet. The experiments were carried out with 0·5 and 1·5 mm. sheets of aluminium, copper, 72 : 28 brass, 63 : 37 brass, and 93 : 7 copper–tin alloy.—M. H.

†Fatigue-Testing Machine for Metals. Anon. (*Schweiz. Tech. Z.*, **1933**, 197–204).—A historical survey of fatigue-testing is first given and this is followed by descriptions of many types of machines in current use.—W. A. C. N.

Endurance. P. Ludwik (*Assoc. Internat. Essai Mat., Congrès de Zürich*, **1932**, (I), 190–206).—[In German.] See *J. Inst. Metals*, 1931, **47**, 472.—S. G.

The Present State of Knowledge of Fatigue of Metals. H. J. Gough (*Assoc. Internat. Essai Mat., Congrès de Zürich*, **1932**, (I), 207–227).—[In English.] See *J. Inst. Metals*, 1931, **47**, 472.—S. G.

Stress Corrosion of Metals. D. J. McAdam (*Assoc. Internat. Essai Mat., Congrès de Zürich*, **1932**, (I), 228–246).—[In English.] See *J. Inst. Metals*, 1931, **47**, 531.—S. G.

The Development of Fatigue-Testing in Germany. E. H. Schulz and H. Buchholtz (*Assoc. Internat. Essai Mat., Congrès de Zürich*, **1932**, (I), 278–303).—[In German.] See *J. Inst. Metals*, 1931, **47**, 492.—S. G.

Discussion [on Fatigue]. R. Kühnel. (Sir) Henry Fowler. B. Kounovsky. H. F. Moore. F. Bacon. T. Ver. O. Chlebus. F. N. Speller. C. Benedicks. A. Umlauf. M. Füchsel. W. Fahrenhorst. A. Gessner. H. A. Dickie. P. Ludwik. W. Rosenhain (*Assoc. Internat. Essai Mat., Congrès de Zürich*, **1932**, (I), 305–328).—[In English or German.] The whole of the discussion deals with fatigue phenomena in steel.—A. R. P.

The Davos Fatigue-Testing Machine. Anon. (*Machinery* (*Lond.*), 1933, **43**, 15–16).—A rotating-beam type of fatigue machine using 4-point loading is described. Special chucks are provided which obviate the necessity for tapping holes in the test-piece.—J. C. C.

The Endurance Strength of Structural Materials for Aircraft and Aero Engines. Kurt Matthaes (*Z. Flugtech. u. Motor.*, 1933, **24**, (21), 593–598; (22), 620–626).—[I.—] Adequate endurance testing must allow for constant static stress as well as for variable stresses arising in service from vibration and other causes. Endurance curves derived from alternate stress tests are given for 6 materials, and characteristic fractures are illustrated. Further curves show the influence of frequency on resistance to vibration in the cases of annealed copper, rolled aluminium, and mild steel. Tables show the influence of previous static stresses on 3 steels, on an alloy of the Duralumin class, and on a magnesium alloy. The relation between endurance strength and static strength is shown in comparative curves for steels and for aluminium and magnesium alloys, with analyses and tensile strengths. [II.—] Endurance strengths and the effects of corrosion are given for a variety of ferrous and non-ferrous semi-finished materials, which are further discussed with reference to special forms. The effect of stress concentrations at points where there are abrupt variations in cross-section is discussed, and is tabulated for certain common cases and materials. The influence of boring, notching, threading, riveting, and welding is considered in relation to the endurance strength of finished pieces. An appended note discusses the work of R. E. Peterson on Model Testing (*Applied Mechanics*, 1933, **1**, (2), 79).—P. M. C. R.

The Inter-Relationship of the Rockwell, Brinell, and Shore Hardness Numbers. W. E. J. Beeching (*Met. Ind.* (*Lond.*), 1933, **43**, 641).—Equations which give the inter-relationship of Rockwell, Brinell, and Shore hardness numbers within ± 10% are as follows:

Brinell number

$$= \frac{K}{130 - \text{Rockwell Ball number}} = \frac{C}{(100 - \text{Rockwell Cone number})^2}.$$

Shore number

$$= \tfrac{1}{10}\,(\text{Brinell number}) + 10 = \frac{K_1}{130 - \text{Rockwell Ball number}} + 10,$$

where K, K_1, and C are constants.—J. H. W.

The Notched-Bar Impact Test Problem in Germany. M. Moser (*Assoc. Internat. Essai Mat., Congrès de Zürich*, **1932**, (I), 342–355).—[In German.] See *J. Inst. Metals*, 1931, **47**, 492.—S. G.

Impact Tests on Notched-Bars. R. Zoja (*Assoc. Internat. Essai Mat., Congrès de Zürich*, **1932**, (I), 356–364).—[In French.] See *J. Inst. Metals*, 1931, **47**, 492.—S. G.

Impact Tests—Standard Test-Pieces. M. Schmidt (*Assoc. Internat. Essai Mat., Congrès de Zürich*, **1932**, (I), 365–371).—[In German.] See *J. Inst. Metals*, 1931, **47**, 493.—S. G.

Meaning of the Notched-Bar Impact Test for Investigation and for Acceptance Test Purposes. R. H. Greaves (*Assoc. Internat. Essai Mat., Congrès de Zürich*, **1932**, (I), 372–378).—[In English.] See *J. Inst. Metals*, 1933, **47**, 493.—S. G.

The Notched-Bar Impact Test as an Acceptance Test. A. Steccanella (*Assoc. Internat. Essai Mat., Congrès de Zürich*, **1932**, (I), 379–387).—[In French.] See *J. Inst. Metals*, 1931, **47**, 493.—S. G.

Discussion [on Resilience]. F. Körber. V. Jareš. A. Hasch. M. Moser. A. Steccanella. (Sir) Henry Fowler. G. Stratilesco. Fr. P. Fischer. J. F. Cellerier. E. Dupuy. O. Hönigsberg. W. Rosenhain. H. Moore (*Assoc. Internat. Essai Mat., Congrès de Zürich*, **1932**, (I), 394–405).—[In English, French, or German.] The discussion ranges round the adoption of a standard test-piece for determining the notched-bar impact strength of metals, particularly steel.—A. R. P.

Note on the Convenience and Ease of the Notched-Bar Test for Testing Welds. H. Dustin and D. Rosenthal (*Assoc. Internat. Essai Mat., Congrès de Zürich*, **1932**, (I), 409–411).—[In French.] From experiments on welds in steel it is concluded that the notched-bar impact test is a suitable rapid method for the works testing of welds.—A. R. P.

Hardness Testing. E. E. Halls (*Machinery* (*Lond.*), 1933, **43**, 121–124; 375–378; *correspondence*, 356–357).—The characteristics, advantages, and limitations of the following machines are critically discussed:—Shore scleroscope, Duroskop, Brinell, Baby Brinell, Firth Hardometer, Rockwell, Vickers diamond, Monotron, Rockwell superficial hardness tester, Herbert pendulum, Cloudburst tester, and Losenhausenwerk "New-type" tester. The relationship between various hardness scales is considered in some detail. The empirical nature of any relationship between rebound and indentation test results is pointed out. Such factors as machine accuracy, the flattening of Brinell balls, and the relation between hardness and tensile strength are discussed. The pyramid diamond test is considered to offer greatest promise for the future.—J. C. C.

The Drop-Hardness Tester. M. von Schwarz (*Werkstatt u. Betrieb*, 1934, **67**, (1/2), 4–6).—An illustrated account, with *bibliography*, of a hardness test by combined indentation and impact methods. A standard weight falling through a standard height down a vertical tube strikes a ball of known size resting on the test-piece; the impression produced is measured, and conversion curves to Brinell figures are given. The method is applicable to metals and alloys of all types.—P. M. C. R.

Extensometers for Strip Steel. E. Skerry (*Aircraft Eng.*, 1933, **5**, 239–240).—The Gerard and Lindley extensometers are described. Both instruments are designed for commercial testing of metals or alloys when observations of the proof stress values are desired.—H. S.

Metals at High Temperatures. J. Galibourg (*Assoc. Internat. Essai Mat., Congrès de Zürich*, **1932**, (I), 134–142).—[In French.] See *J. Inst. Metals*, 1931, **47**, 490.—S. G.

Materials at High Temperatures. R. G. Batson and H. J. Tapsell (*Assoc. Internat. Essai Mat., Congrès de Zürich*, **1932**, (I), 160–167).—[In English.] See *J. Inst. Metals*, 1931, **47**, 489.—S. G.

Discussion [on Papers on Materials at High Temperatures]. F. Körber. H. Dustin. C. J. van Nieuwenburg. R. Grandmaitre. (Sir) Henry Fowler. A. Pomp. H. J. Gough. O. Chlebus. W. Rosenhain (*Assoc. Internat. Essai Mat., Congrès de Zürich*, **1932**, (I), 169–176).—[In English, French, or German.] Cf. preceding abstracts. Most of the discussion refers to the behaviour of steels at high temperature and to the relative merits of the short time creep test of Pomp and the more prolonged test of the National Physical Laboratory. *C. J. van N.* raised an interesting question by his statement that under high pressures metals may volatilize at relatively low temperature, thus when a copper tube is heated at 400°–425° C. in steam at 300–350 atm. minute octahedral crystals of copper condense in the cool parts, and a similar behaviour is shown by silver. Under these conditions too, zinc is rapidly removed from brass leaving sponge copper, and silicon from steel boiler plate. *O. C.* quoted examples of fatigue failure of locomotive staybolts, and said that the endurance of metals at high temperature should be tested under bending and torsional loads as well as under static loads.—A. R. P.

The Behaviour of Metallic Materials at Temperatures at which Recrystallization Occurs even after Small Deformation. W. Rohn (*Assoc. Internat. Essai Mat., Congrès de Zürich*, **1932**, (I), 177–182).—[In German.] At temperatures above which recrystallization occurs even after small deformation large differences are found in the creep limit according to whether this is determined by approach from a high or a low temperature, the limiting creep stress being much greater in the second case than in the first. Again, similar differences in the results occur according to whether the load is applied to the test before heating or after the testing temperature is reached, or at an intermediate temperature. These facts are illustrated by curves obtained for an alloy of nickel with 15% chromium, 15% iron, and 7% molybdenum. This alloy appears to be stronger at temperatures above 700° C. than any commercial alloy on a chromium–nickel–iron basis, but its limiting creep stress is only 0·8 kg./mm.^{2} at 900° C. and 0·3 kg./mm.^{2} at 1000° C. A peculiar feature of this alloy is that annealing at 1250° C. induces a higher creep limit at 1000° C., but a much lower yield point at room temperature than does annealing at 1050° C. or lower; similar effects of high annealing temperature have been observed with nickel and iron.—A. R. P.

Apparatus for the Determination of Rate of Creep and Limiting Creep Stress. W. Rohn (*Assoc. Internat. Essai Mat., Congrès de Zürich*, **1932**, (I), 183–186).—[In German.] See *J. Inst. Metals*, 1930, **44**, 597.—A. R. P.

***On an Improved Apparatus for the Static Determination of the Torsion Modulus of Crystal Rods and Its Application to Single Crystals of Zinc.** E. Goens (*Wiss. Abhandl. Physikal.-Tech. Reichsanst.*, **1933**, **17**, 69–85).—Reprint from *Ann. Physik*, **1933**, [v], **16**, 793–809; see *J. Inst. Metals*, 1933, **53**, 653.—M. H.

The Calibration of Testing Machines. H. F. Moore (*Assoc. Internat. Essai Mat., Congrès de Zürich*, **1932**, (II), 482–491).—[In English.] See *J. Inst. Metals*, 1931, **47**, 214.—S. G.

Accuracy of Measurement and Variability of Test Results. F. C. Lea (*Assoc. Internat. Essai Mat., Congrès de Zürich*, **1932**, (II), 492–498).—[In English.] See *J. Inst. Metals*, 1931, **47**, 215.—S. G.

Calibration and Accuracy of Testing Machines. W. Ermlich (*Assoc. Internat. Essai Mat., Congrès de Zürich*, **1932**, (II), 499–514).—[In German.] See *J. Inst. Metals*, 1931, **47**, 214.—S. G.

Discussion [on Calibration and Accuracy of Testing Machines]. F. Rinagl. A. Photiades. H. F. Moore. P. Santo Rini. —— von Bohuszewicz. J. Basta. C. C. Teodorescu (*Assoc. Internat. Essai Mat., Congrès de Zürich*, **1932**, (II), 515–527).—[In German, English, or French.] The discussion revealed the necessity for defining precisely the characteristics of testing machines, especially sensitiveness, accuracy, and reliability, and for drawing up a set of rules for the calibration of such machines.—A. R. P.

Theory and Experiments in Regard to Grain-Size and Fineness. A. H. M. Andreasen (*Assoc. Internat. Essai Mat., Congrès de Zürich*, **1932**, (II), 437–442).—[In German.] See *J. Inst. Metals*, 1931, **47**, 218.—S. G.

Present Status of Particle Size Measurement. L. Work (*Assoc. Internat. Essai Mat., Congrès de Zürich*, **1932**, (II), 443–457).—[In English.] See *J. Inst. Metals*, 1933, **47**, 219.—S. G.

On the Size Determination of Free Grains. H. W. Gonell (*Assoc. Internat. Essai Mat., Congrès de Zürich*, **1932**, (II), 458–468).—[In German.] An air elutriator for grading powders of sub-sieve size is described and an account given of some results on various materials obtained by its use. The apparatus separates grains of 60 μ down to 2 μ in diameter according to the sp. gr. Among the materials tested was tungsten powder, and photographs are given of grains of this material of diameter < 2 μ, 2–5 μ, and 5–10 μ.—A. R. P.

Discussion [on Grain-Size in Loose Materials]. M. Roš. K. Sandera. C. J. van Nieuwenburg. A. H. M. Andreasen. J. Basta. M. Spindel. G. von Kazinczy. O. Stern. E. Suenson. G. Haegermann. R. Meldau (*Assoc. Internat. Essai Mat., Congrès de Zürich*, **1932**, (II), 471–479).—[In French or German.] The discussion showed the diversity of methods used in various countries and the need for unification. Collaboration is recommended to determine the accuracy of the various methods, the limits of the methods, and the relationship between the results obtained by the different methods.—A. R. P.

RADIOLOGY

X-Ray Diagnosis in Welding Technology. H. Kochendörffer (*Autogene Metallbearbeitung*, 1933, **26**, 230–235).—The importance of X-ray investigation in development research on welding is emphasized. Three important applications are suggested, *viz.*, examination of the quality of welding rods, control testing of operators, and control testing of work in progress, in conjunction with bend tests. The last application is considered of great value; the test-piece is radiographed before and after bending and the nature of the cracks produced in bending is carefully noted. Examples of radiographed welds in steel are illustrated.—H. W. G. H.

X-Ray Testing of Welds. Ancel St. John (*Welding J.*, 1933, **30**, 52–53).—A brief review of radiography applied to welds is given. The great importance of proper technique is emphasized and the use of a thickness gauge to ensure correct penetration is explained. The location of defects by double exposure with reference markers is described.—H. W. G. H.

X-Ray Pictures of Weld Seams. H. Halberstadt (*Autogene Metallbearbeitung*, 1933, **26**, 225–230).—An apparatus ("Metalix") is described, which fulfils the necessary conditions for industrial X-ray equipment, *viz.*, complete insulation of high-voltage connections, efficient screening, ease of transport, and simplicity of manipulation. The principles of interpretation of radiographs are explained and typical faults in weld seams are illustrated.—H. H.

X-Ray Examination of Welded Copper Vats. Anon. (*Brewers' J.*, 1933, **69**, 617–618).—The methods used for radiographing welds are briefly explained and it is suggested that the application to large copper vats used for brewing is to be recommended.—H. W. G. H.

XII.—TEMPERATURE MEASUREMENT AND CONTROL

(Continued from pp. 30–32.)

†**On Temperature Measurements.** W. Liesegang (*Oesterr. Chem.-Zeit.*, 1933, **36**, 60–61; discussion, 61).—Methods of measuring furnace temperatures with thermocouples and radiation pyrometers are described and discussed. For the protection of precious metal couples at temperatures up to 1700° C. the use of "Sinterkorund" (crystalline alumina) tubes is recommended. *L. Hecht* stated in the discussion that platinum metal couples are rapidly destroyed when used without adequate protection in electric furnaces heated by Silit rod resistance elements, owing to the carbon monoxide generated by oxidation of the Silit or to vaporization of silicon therefrom; both of these factors produce serious embrittlement of the couple wires.—A. R. P.

Temperature Measurements with Tungsten–Molybdenum Thermocouples. Bernhard Osann, Jr., and Ernst Schröder (*Arch. Eisenhüttenwesen*, 1933, 7, 89–94).—Experiences with tungsten–molybdenum couples in various types of sheath are described.—J. W.

Resistance Thermometers. Georg Keinath (*Arch. tech. Messen*, 1933, 2, (19), T8–T9).—The principle of the resistance thermometer is described. The application is mainly to the measurement of temperatures below 800° C., and especially of very low temperatures. Factors influencing the choice of conductor are enumerated and discussed. Metallic conductors are of most service. The temperature coefficients of 19 metals are given. Certain electrolytic resistance thermometers are described. A *bibliography* is appended.—P. M. C. R.

XIII.—FOUNDRY PRACTICE AND APPLIANCES

(Continued from pp. 32–34.)

The World Foundry Congress, Paris, September, 1932.—V. F. Renaud (*Rev. Mét.*, 1933, 30, 382–395).—See also *J. Inst. Metals*, 1933, 53, 521. Summaries of papers by Rowe and Gingerich on improvements in quality in castings in aluminium alloys, by Hanson on defects in aluminium alloys, by Cazaud on fatigue properties of castings in aluminium-rich alloys, by Sonnino on melting of aluminium in electric or combustion furnaces, by Ballay and Thomas on silicon in cupro-nickel, by Renaud on precious alloys of gold, silver, and nickel, and others are given.—H. S.

†**Deoxidizers and Fluxes.** G. L. Bailey (*Met. Ind.* (*Lond.*), 1933, 43, 561–564, 583–587; discussion, 587–588 and 592).—Paper read before the Midland Metallurgical Societies. A description is given of the action of deoxidizers and their affinity for oxygen, the removal of the resulting oxide, the action of phosphorus on tin and zinc alloys, and the formation of phosphate slag, the function of manganese as a deoxidizer, and the use of hydrogen and of carbon monoxide (Reitmeister's method) in the deoxidation of copper. The use of salt mixtures as fluxes for non-ferrous melting have a wide variety of uses. For high melting-point metals, glass is frequently used, and this may have a deoxidizing as well as a protective action. The use of degasifiers is discussed, and fluxes for aluminium and magnesium and of special fluxes, such as Thermit, are described; 22 references are given. In the discussion, the use of borax and a charcoal cover were advocated and the reaction of copper with phosphorus was discussed. B. replied.—J. H. W.

Aluminium Melting Losses. William Ashcroft (*Metallurgia*, 1933, 9, 42, 52).—The most important factors with regard to their influence on dross losses in the melting of aluminium and its alloys include the type of furnace employed; the melting temperature; the length of time required for melting and superheating to the pouring temperature; the length of time the metal is allowed to remain in the furnace after reaching the pouring temperature; the constitution of the furnace atmosphere in contact with the metal, method of firing and fuel used; and the volume of air and products of combustion passing over the metal in unit time. These factors are considered, and special attention is given to selection of melting furnaces, and the various types of furnaces suitable for melting for repigging or casting into rolling ingots; for general foundry practice; for modern die-casting practice, and for the melting of scrap and borings are considered with a view to the reduction of melting losses in practice.—J. W. D.

Silumin Chill-Castings.—Die-Castings. [A.] v. Zeerleder (*Schweiz Tech. Z.*, 1933, 233–236).—Cast-iron and Silumin chill- and sand-castings are compared as regards cost and ultimate weight. Macroscopical examination of ordinary and modified Silumin is described and illustrations of typical samples are given. The physical properties of ordinary, modified, β, γ, and modified γ-Silumin are tabulated. Die-casting machines are illustrated. —W. A. C. N.

What is the Effect of Phosphorus as a Deoxidizer in Copper Alloys? E. T. Richards (*Z. ges. Giesserei-Praxis: Das Metall*, 1933, **54**, 454–455, 471–473).—The difficulties occasionally attending the use of phosphorus or phosphor–copper as a deoxidizer are discussed with reference to a number of specific examples of copper alloy castings in which the failures or flaws are shown to be due to insufficient or excess phosphorus in the castings or to its being incorrectly added or given insufficient time to take effect. To guard against possible ill effects, the casting should contain between a trace and, at the most, 0·02% of phosphorus. Above this amount, the phosphorus becomes an addition element to the alloy, and exerts a favourable effect only in certain alloys and for specific technical purposes.—J. H. W.

[Bells] Music in the Air. Anon. (*Tin*, **1933**, Nov., 10–11).—A brief description of the composition, casting, and tuning of bells is given.—J. H. W.

Casting and Recasting Bearings and Bushes. Erich Becker (*Z. ges. Giesserei-Praxis: Das Metall*, 1933, **54**, 491–493, 512–513).—The manufacture of cast bearings and bushes free from cold shot, porosity, blisters, and cracks, and made from iron, steel, brass, and white metal is described. Failures are usually due to lack of care in the preparations for the casting.—J. H. W.

***Contribution to the Knowledge of Inverse Segregation in [Bronze] Ingots.** F. Höhne (*Giesserei*, 1933, **30**, 523–525).—Ingots of 10%-tin bronze were prepared by melting the metals in neutral, oxidizing, and reducing atmospheres, and the distribution of the tin in the ingot was determined by analysis. In metal melted in an oxidizing atmosphere little inverse segregation occurred, maximum differences of only 0·4% tin in various parts of the ingot being found. In metal melted in a neutral or reducing atmosphere inverse segregation was severe, differences of up to 1·5% tin being found between the outer and inner portions of the ingot. A high moisture content in the melting atmosphere increases the amount of inverse segregation, hence, by preventing hydrocarbons and moisture from access to the melt inverse segregation may be reduced to a minimum; this may be effected by using solid fuel or electricity and by keeping a feebly oxidizing atmosphere above the molten metal. The density of ingots melted in a reducing atmosphere is less than that of ingots melted in an oxidizing atmosphere; this difference is shown to be due to gas absorption, probably hydrogen. It is suggested that this hydrogen produces inverse segregation by forcing the still fluid metal in the inner part of the casting through the dendritic crystals first formed.—A. R. P.

The Manufacture of Hollander Strips of Phosphor–Bronze. Anon. (*Z. ges. Giesserei-Praxis: Das Metall*, 1933, **54**, 511–512).—Hollanders used for pulping in the manufacture of paper are made from zinc- and iron-free phosphor–bronze with about 93% of copper and 7% of tin. The zinc and iron must be absent, otherwise the sensitive pulp may be discoloured. The strip is best cast in sand, and then compacted and hardened in a cold-roll; chill-casting is not recommended. Rolling beyond 2 mm. (from 5 to 15 mm.) only increases the cost without improving the metal. Segregation, piping, and the formation of stannic acid are difficulties to be contended with in sand-castings. The moulding and the casting of the metal is described. —J. H. W.

Factors Affecting the Physical Properties of Cast Red Brass (85 Cu, 5 Zn, 5 Sn, 5 Pb). H. B. Gardner and C. M. Saeger, Jr. (*Proc. Amer. Soc. Test. Mat.*, 1932, **32**, (II), 517–534; discussion, 535).—See *J. Inst. Metals*, 1932, **50**, 427. In the discussion *H. M. St. John* agreed that a coarse crystalline structure results in low tensile strength but pointed out that other factors than a high casting temperature can produce such a structure, *e.g.* the presence of aluminium, magnesium, or silicon. The presence of nickel or sulphur tends to counteract the effect of these impurities by producing a close-grained structure.—A. R. P.

Brass Pressure-Castings as Produced Economically. William W. Serg (*Iron Age*, 1933, 132, 16–19).—The Polak die-casting machine is worked by hydraulic pressure of between 3000 and 6000 lb./in.^{2}. When the die is closed, the brass, in a semi-molten or plastic condition, is ladled into the compression chamber and forced into the die cavity, usually at 1575° F. (860° C.). The remnant is rejected and the die at once opened hydraulically, all cones being pulled automatically. The composition of the brass recommended by S. is copper 60, lead 0·75, tin 0·50, and zinc 38·75%. The mean physical properties of 9 such bars cast in this manner were: tensile strength 58,400 lb./in.^{2}, elastic limit 36,417 lb./in.^{2}, reduction of area 7·6%, elongation 6·7%, Rockwell hardness 45·2 at the surface, and 35·8 on the section. The castings are liable to be porous and to contain blow-holes, especially in heavy sections. The surface finish is not so good as that of a forging, but better than that of a sand casting. The processes of forging and of pressure casting brass and the properties and structures of the resulting products are compared. —J. H. W.

Tough, Strong, Permanent Die-Castings. D. L. Colwell (*Metal Progress*, 1933, **24**, (6), 19–23).—The results of exposure tests carried out by the American Society for Testing Materials are summarized, the analyses of the 9 zinc-base alloys concerned being given. The importance of using zinc of high purity is emphasized by reference to these results. A table gives the composition and properties of A.S.T.M. alloys Nos. 21 and 23; the results of mechanical testing show that Alloy 23 possesses greatly increased resistance to the combined effects of heat and moisture, as well as improved permanence of dimension, as compared with earlier developments.—P. M. C. R.

Die-Casting Metals Set New Standards. Anon. (*Machinery* (*N.Y.*), 1933, **40**, 101–103).—A general review of the properties of the alloys used in die-casting.—J. C. C.

Electrolytic Process for the Fabrication of Metal Models. [C. O. Herb] (*Galvano*, 1933, (20), 23–24).—Translated from *Machinery* (*Lond.*), 1932, **39**, 677; see *J. Inst. Metals*, 1932, **50**, 712.—E. S. H.

European Synthetic Moulding Sands. C. W. Briggs and R. A. Gezelius (*J. Amer. Soc. Naval Eng.*, 1933, **45**, 462–485).—Synthetic sands, such as chamotte which is essentially a highly-aluminous clay suitably treated; German Industrial Extra, which is comprised mostly of quartz and chalcedony grains; and Cement Bond Sands, which contain silica sand and a good-grade cement, are compared with Downer sand, which is a naturally bonded American sand. The composition of these various sands and their physical properties of permeability, compression, shear, tensile, and sintering point, when made up with varying water contents into green- and dry-sand moulds, are discussed, and consideration is also give to their grain distribution and to their thermal conductivity.—J. W. D.

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

***Removal of Non-Ferrous Metal (Copper–Zinc Alloy) Layer from Plated Iron Waste.** W. A. Heifetz (*Zhurnal Prikladnoi Khimii* (*J. Applied Chemistry*), 1933, [B], **6**, (4), 653–664).—[In Russian, with German summary.] Owing to the shortage of non-ferrous metals in Russia the use of bimetal (plated iron) has been greatly developed. Since in various manufacturing processes a high percentage (30–50%) of scrap is produced, the problem of recovering the non-ferrous metal (in the present case copper from a 10% zinc–copper alloy) has been investigated. An electrolytic method has been developed in which the bimetal is the anode, sheet copper the cathode, and a neutral copper nitrate solution the electrolyte. The iron portion of the bimetal becomes passive, and its potential is raised to 2·12 v.; the film is, however, destroyed by heating above 65° C. The electrolyte has a minimum resistance at molar concentration and its resistance is independent of the cation, so that no change occurs as the copper is replaced by zinc provided that the copper content does not fall below a certain minimum (35 grm./litre). Starting with 160 grm. of copper per litre, about 1 kg. of copper can be obtained per litre of solution, the energy required being directly proportional to the current density. The spent electrolyte is diluted to precipitate the iron as hydroxide, and treated with zinc oxide to precipitate the copper as hydroxide which is redissolved in nitric acid to produce new electrolyte. The zinc nitrate solution is treated with sodium carbonate, to produce zinc carbonate and sodium nitrate.—M. Z.

XV.—FURNACES AND FUELS

The Design of Town Gas Fired Furnaces. F. L. Atkin (*Gas World* (*Industrial Gas Supplement*), 1933, 5, (11), 8–13; discussion, 13–14).—The following are briefly discussed: types and sizes of furnaces, heat loss to flue, heat required to maintain a definite temperature, total heat transfer, thermal conductivity of firebricks, efficiency of recuperation, heat required to raise temperature of furnace, maximum heat input and combustion chamber design, burner design, and furnace construction.—J. S. G. T.

The Performance of Thermostats on Gas[-Heated] Appliances. Harry W. Smith, Jr. (*Amer. Gas J.*, **1933**, (3719), 7–10, and 12).—Classes of thermostats and their operating characteristics are briefly discussed.—J. T.

[Annealing Furnaces.] H. W. L. Evans (*Sixty-Third Rep. Royal Mint* (*Lond.*), **1932**, 48–49).—In the Bates and Peard annealing furnace, the charge is drawn through a water-sealed heating chamber on a chain, the bars of which are found to bend away from the direction of travel. This has been corrected by reversing the direction of travel of the chain daily, and by driving the chain wheels at both ends of the furnace simultaneously, so as to equalize the tension on the chain.—J. H. W.

Industrial Furnace with Resistances of Molybdenum. F. Lauster (*Elektrotech. Z.*, 1933, **54**, 662).—Abstract from *Elektrowärme*, 1933, 2, 103. The molybdenum resistance wires are enclosed in highly refractory tubes through which a protective gas is conducted, *e.g.* a mixture of nitrogen and hydrogen or the vapours obtained by thermal decomposition of methyl alcohol. A heating chamber 25 × 25 × 60 cm. in size requires 800 c.c. of methyl alcohol per hr. or 30 l. of nitrogen–hydrogen mixture per day.—B. Bl.

Construction and Operation of a Coreless Vacuum Induction Furnace. Werner Bottenberg (*Arch. Eisenhüttenwesen*, 1933, 7, 233–236).—From *Mitt K.W.-Inst. Eisenforschung*, 1933, **15**, 55–58; cf. *J. Inst. Metals*, 1933, **53**, 575.—J. W.

Determination of the Maximum Carrying Capacity of Furnace Electrodes. Bruce L. Bailey and Raymond R. Ridgway (*Trans. Electrochem. Soc.*, 1933, **63**, 283–298; discussion, 298–300).—For abstract of the paper see *J. Inst. Metals*, 1933, **53**, 383. In the discussion *E. C. Sprague*, *R. M. Hunter*, *R. R. Ridgway*, and *Colin G. Fink* discussed the power losses at joints and the rate of oxidation of graphite electrodes under various operating conditions.
—A. R. P.

Electric Heat-Treatment. Oskar Ney (*Werkstatt u. Betrieb*, 1933, **66**, 393–395).—The electric furnace is stated to be cheaper in operation and more closely controllable than fuel-heated types; the proportion of rejections is reduced by the even distribution of heat. The following types of electric furnace are described and illustrated: (1) a 6-fold quenching and tempering furnace for continuous operation, with interchangeable and rapidly removable heating units; (2) a tilting furnace for the hardening and quenching of small parts; (3) a furnace for the rapid but controlled heating of pieces prior to forging.—P. M. C. R.

†**Heat-Resisting Chromium–Nickel–Iron Alloys for Furnace Construction.** L. J. Stanbery (*Metals and Alloys*, 1933, 4, 127–135, 159–164).—A comprehensive and useful review of the preparation, properties, and uses of non-scaling and distortion-free alloys of nickel, chromium, and iron for use in high-temperature work.—A. R. P.

Canadian Electric Furnace Industry. Alfred Stansfield (*Trans. Electrochem. Soc.*, 1933, **63**, 259–281).—See *J. Inst. Metals*, 1933, **53**, 383.—S. G.

The Electric Furnace and Its Products in the U.S.S.R. C. H. Vom Baur (*Trans. Electrochem. Soc.*, 1933, **63**, 305–308).—See *J. Inst. Metals*, 1933, **53**, 524.—S. G.

FUELS

Low-Grade Town's Gas. Anon. (*Fuel Economist*, 1933, **9**, 113).—Facts with regard to the distribution of low-grade town's gas (cal. val. 200 B.Th.U/ft.^{3}) are briefly referred to.—J. S. G. T.

Application of Gas Analysis to Industrial Problems. Morton Bermann (*Gas Age-Record*, 1933, **72**, 211–214).—Charts for determining excess air, ultimate carbon dioxide, and potential heat due to the combustion of mixtures of coke-oven gas and carburetted water-gas of known composition are discussed.—J. S. G. T.

Recent Progress in Use of Pulverized Fuel. John Rogers (*Fuel Economist*, 1933, **9**, (97), 36–41).—General lines of progress are outlined. In metallurgical furnaces, about 40,000 tons of pulverized fuel are used per annum in the United Kingdom. Descriptions of coal employed, cost of grinding, burner development, and application to metallurgical purposes are briefly discussed.
—J. S. G. T.

Pulverized Fuel Firing and the Grid Burner. P. Howden (*Fuel Economist*, 1933, **9**, (97), 46–49).—The technique of burning pulverized fuel is briefly discussed and the design and application of the "Grid" burner developed by the Department of Scientific and Industrial Research for the combustion of pulverized fuel are described. It is claimed that the "Grid" burner requires less refractory and a smaller combustion space than any other pulverized fuel burner for the same fuel consumption. Further, on most industrial furnace applications, a combustion chamber extension is unnecessary. The burner is available in sizes consuming from 30–3500 lb. of fuel per hr.
—J. S. G. T.

Determination of the Resistance of Coal to Pulverization. F. Mathieu (*Assoc. Internat. Essai Mat., Congrès de Zürich*, **1932**, (II), 419–420).—[In French.] The method of G. B. Gould (*Power*, 1930, **72**, 886–889) is outlined and briefly discussed.—A. R. P.

Reactions of Pulverized Coal Burners. C. Campbell (*Colliery Guardian*, 1933, **147**, 525–526).—The size of particle influences the properties of the coal cloud, to which the ordinary gas laws do not in general apply: the regulation of the ignition point, and of the maximum temperature point, is considered. The coal cloud, though entailing a great loss of heat in the combustion chamber, has valuable insulating effects in certain liquation processes; its elimination in other cases is discussed. Observations of the flow and velocity of the cloud, and the composition of gases, at the point of combustion and subsequently, should be regularly recorded; methods are indicated. Other desirable forms of record are outlined, together with some principles of economical working.—P. M. C. R.

Sampling of Coal, Coke and other Fuels, and of Clinker and Ash. K. Bunte (*Assoc. Internat. Essai Mat., Congrès de Zürich*, **1932**, (II), 304–316).—[In German.] The precautions to be taken in obtaining an accurate sample of this type of material are enumerated and discussed at length.—A. R. P.

Sampling Coal. W. A. Selvig (*Assoc. Internat. Essai Mat., Congrès de Zürich*, **1932**, (II), 349–357).—[In English.] The methods of the A.S.T.M. are briefly described.—A. R. P.

XVI.—REFRACTORIES AND FURNACE MATERIALS

(Continued from p. 35.)

Tercod—A New Refractory Brick for Electric Furnaces. G. S. Diamond (*Trans. Electrochem. Soc.*, 1933, **63**, 301–304; discussion, 304).—For abstract of the paper see *J. Inst. Metals*, 1933, **53**, 524. In the discussion *Frank W. Godsey* pointed out that the resistance of silicon carbide bonded with a small amount of carbon falls with an increase in the voltage impressed so that with very high voltages large currents will flow through the material. —A. R. P.

***Influence of Fireclay Dust on the Chemical and Thermal Properties of Firebricks.** P. P. Budnikov and E. L. Mandelgrin (*Zhurnal Prikladnoi Khimii* (*Journal of Applied Chemistry*), 1933, [B], **6**, (1), 1–11).—[In Russian, with German summary.] The influence of grain-size of the fireclay on the properties of firebricks was investigated. Large grain-size increases the porosity and thus lowers the mechanical strength and increases its thermal resistance. With a large proportion of fine material (less than 0·2 mm.) deterioration in the resistance to heat changes, slagging and deformation occur. Tests with fireclay made from Tchasoviar clay containing silica 53·96, alumina 32·45, iron oxide 0·85, titania 1·01, lime 0·31%, magnesia traces, alkalis 2·56, loss on ignition 8·86%, showed that increase of dust (less than 0·2 mm.) content raises the water requirements, which thus become directly proportional to the dust content. Contraction in volume on burning increases up to 30% dust, but falls thereafter. The density increases, whilst specific porosity and water absorption power decrease with increase of dust content. Mechanical strength increases with dust content, refractory properties and deformation under load remain unaltered, whilst resistance to thermal changes falls progressively. No relation could be established between dust content and resistance to slagging. 20% appeared to be the optimum figure for the fireclay in question. Linear expansion of the bricks is inversely dependent on this volume contraction.—M. Z.

On the Testing of Refractories for Industrial Fire Hearths. Georg Ising (*Tonind. Zeit.*, 1933, **57**, 812–813).—A test-piece made up of several bricks is subjected to the direct flame of a blast furnace.—B. Bl.

The Use of Standard Firebricks in Furnace Construction. Ernst Maase (*Stahl u. Eisen*, 1933, **53**, 1156–1161).—J. W.

The Manufacture of Slag-Resistant Crucibles for High-Frequency Induction Furnaces. Heinz Siegel (*Arch. Eisenhüttenwesen*, 1933, **7**, 21–23).—J. W.

On Protective Coats for Furnace Repairing. Paul Müller (*Tonind. Zeit.*, 1933, **57**, 602–604).—The conditions under which refractory coats provide protection to the brickwork of furnaces are discussed.—B. Bl.

Silica Furnace Lining for the Burning of Big Silica Bricks. Gustav Oetzel (*Tonind. Zeit.*, 1933, **57**, 249–250).—Fireclay and silica brick linings for furnaces used in burning large silica bricks are compared.—B. Bl.

XVII.—HEAT-TREATMENT

(Continued from p. 35.)

Improved Salt Baths for Duralumin. Anon. (*Aircraft Eng.*, 1933, **5**, 242).—The containers are made in mild steel with welded joints, the corners being rounded. Calorizing is applied in order to render the steel resistant to oxidation. Specially prepared paints which undergo distinct colour changes at definite temperatures are applied to different parts of the container to indicate the temperature.—H. S.

Salt Baths for Duralumin. Chas. E. Foster (*Aircraft Eng.*, 1933, **5**, 265).—A letter criticizing the use of paints which undergo colour changes at definite temperatures to indicate the temperatures of salt-baths on the grounds that the walls of the bath above the salt will have temperature gradients and the temperature indicated will not necessarily be that of the salt. It is also contended that a pyrometer having a pointer moving over a temperature scale gives information of much greater value. Cf. preceding abstract.—H. S.

***The Heat Treatment of Aluminium-Coated [Light] Alloys.** G. Guidi (*Alluminio*, 1933, **2**, 323–326).—The outer coatings of aluminium-clad light alloys of high mechanical strength may be affected in various ways by heat-treatment. Thus in the case of Alclad 17 ST, a high temperature, or prolonged heating before quenching, may change the mechanical properties or the resistance to corrosion owing to diffusion of $CuAl_2$ into the aluminium coating. Optimum conditions for heat-treating Alclad are given.—G. G.

XVIII.—WORKING

(Continued from pp. 35–37.)

Some Faults in the Working of Gold Alloys.—I. [Effect of Phosphorus and Oxides.] E. Raub (*Mitt. Forschungsinst. Edelmetalle*, 1933, **7**, 104–108).—In gold alloys, especially palladium white gold alloys, the presence of phosphorus results in the formation of copper phosphide; the cast alloys can be readily worked cold, but break up badly on hot-rolling, and the sheet usually breaks into small pieces when quenched after annealing. These troubles are attributed to segregation of the phosphide or a eutectic thereof along the grain boundaries. When low-carat gold alloys are melted under non-reducing conditions, oxides of some of the base metals are liable to be included in the casting either in solution in the constituents or as minute inclusions; in the former case brittleness is usually produced, and in the latter case imperfections due to scaling or opening-up of the sheet during rolling or annealing may occur, especially with zinc or nickel oxide.—A. R. P.

Note on the Working of Lead-Base Antifriction Metal Having High Copper Content. A. Ricard and H. Ackermann (*Cuivre et Laiton*, 1933, **6**, 471–473).—A description of the theoretical functions of these alloys and of the special tools necessary in their transformation into bearings, &c., in order not to diminish their antifrictional properties.—W. A. C. N.

Effect of a Backward Pull Upon the Tension Required to Draw Wire. F. C. Thompson (*Wire and Wire Products*, 1933, **8**, 400–401).—Abstract of a paper read before the Iron and Steel Institute. See *J. Inst. Metals*, 1933, **53**, 667.—J. H. W.

Forming Aluminium and Brass Products by the Extrusion Process. J. B. Nealey (*Machinery* (*N.Y.*), 1933, **40**, 140–142).—A brief account is given of the operation and construction of a 4000-ton extrusion press, taking billets 12–16 in. in diam. and having an hourly capacity of 11 tons of aluminium alloy or 20 tons of brass. Billets are heated to 875° F. (466° C.) for aluminium alloy, or 1400° F. (760° C.) for brass in gas furnaces fitted with automatic temperature control. Special arrangements are provided for easy removal of the metal left in the pressure chamber after extrusion.—J. C. C.

Forming and Fabrication of Metals in the Construction of Aircraft. Harold Crary (*Metal Stampings*, 1933, **6**, 244–246).—A general description is given of the equipment and processes employed in the forming and manufacture of aluminium and steel parts used in the construction of all-metal aircraft. —J. H. W.

†**Pressing of Non-Ferrous Metals: The Extrusion Press.** W. Brunnckow (*Maschinenbau*, 1933, **12**, 539–542).—A review.—v. G.

A New Form of Edge for Coins. H. W. L. Evans (*Sixty-Third Rep. Royal Mint* (*Lond.*), **1932**, 51).—Although in this country the amount of counterfeiting is very small, it is more serious in the East. Trial blanks have therefore been made with a deep groove in the edge in which round beads are pressed up in relief. The blank was then struck up in a coining press in the ordinary way, using a milled collar. The effect of coining is to close up the groove slightly so that the beads are protected, whilst it is impossible to take a satisfactory mould of the edge of the piece by the usual methods for the purpose of making a cast replica.—J. H. W.

The Machining of Aluminium and Its Alloys. A. von Zeerleder (*Schweiz. Tech. Z.*, **1933**, 225–230).—A discussion of the special methods which have to be adopted in machining, by a variety of processes, aluminium and its alloys. The cutting angle and rake of the tools employed in turning are particularly described, and the many different types of work which have to be performed reviewed critically. The conditions necessary for certain special alloys are tabulated.—W. A. C. N.

Behaviour of Metals During Cutting Investigated at Length. Friedrich Schwerd (*Iron Age*, 1933, **132**, 31; and *Mech. World*, 1933, **94**, 890).—Abstracts of a paper read before the American Society for Testing Materials and the American Society of Mechanical Engineers. See *J. Inst. Metals*, 1933, **53**, 668.—J. H. W.

Getting Best Results from Chromium-Plated Cutting Tools. Charles F. Bonnet (*Machinery* (*N.Y.*), 1933, **40**, 212–214; and (editorial) *Machinery* (*Lond.*), 1933, **43**, 248).—The chromium plating of cutting tools is advantageous, not in producing a hard cutting edge, but in providing behind the edge a hard, self-lubricating surface to which chips do not "seize." Details of the practice followed in chromium plating various types of tools are given. Reamers which are undersize may be reclaimed by a heavy deposit of chromium.—J. C. C.

XIX.—CLEANING AND FINISHING

(Continued from p. 37.)

The Cleaning of Metals. III.—Theory of Alkaline Cleaner (ctd.). IV.—Some Practical Aspects of Alkaline Cleaning. V.—The Electrolytic Cleaner. S. Wernick (*Indust. Chemist*, 1933, **9**, 275–277, 308–311, 345–348).—(III.—) The degreasing of metals in alkaline solutions is discussed from the point of view of interfacial tension and peptization. (IV.—) After showing how the best procedure for a given application depends on the nature of the metal, the treatment it has undergone, and the purpose of the cleaning, W. discusses the practical features of caustic soda, soda ash, sodium silicate, trisodium phosphate, caustic potash, potassium carbonate, trichlorethylene, and carbon tetrachloride. (V.—) Existing practice in the application of acid and alkaline electrolytic cleaners is described.—E. S. H.

XX.—JOINING

(Continued from pp. 37–45.)

***Soldering and Brazing.** Arthur S. Newman and R. S. Clay (*J. Sci. Instruments*, 1933, **10**, 333–338).—A general description of the processes of soldering and brazing with many useful practical hints. The use of the different fluxes, the making of cylindrical or conical tubes, and the hard soldering of Manganin wires are dealt with in detail. The construction of (*a*) a special tool for making "stitches" to hold the edges of sheet metal together, (*b*) a Bunsen burner giving a high temperature, and (*c*) various clamps for holding pieces together is described and illustrated.—W. H.-R.

The Production of Solder. Anon. (*Machinery* (*Lond.*), 1933, **43**, 73).—A note on the melting and casting of lead–tin solders.—J. C. C.

†Silver Solders (Hard Solders). W. Stein (*Mitt. Forschungsinst. Edelmetalle*, 1933, **7**, 80–87, 97–103).—Recent patent and journal literature on silver solders is reviewed, and the composition, melting point, and working properties of numerous types of silver solder, including standard German, English, and American solders, are tabulated.—A. R. P.

†On the Use of Silver Solders in the Chemical Industry. Robert J. Snelling and Edmund Richard Thews (*Chem. Fabrik*, 1933, **6**, 443–444).—The composition and physical properties of 17 ternary copper–zinc–silver alloys are tabulated. These solders may be divided into two classes, *viz.*, silver brasses and zinciferous copper–silver alloys. The melting point is determined in the first place by the zinc content. With a constant zinc : copper ratio the melting point is reduced by increasing the silver content. Alloys with 70% silver have a minimum melting point (750°–760° C.) when the zinc : copper ratio is 1 : 2, and alloys with 65% silver when the ratio is 4 : 3 (720° C.). Substitution of part or all of the zinc by cadmium has very little effect on the melting point, whilst addition of tin reduces the malleability. Addition of nickel to ternary alloys increases the strength and hardness and improves the resistance to corrosion without producing embrittlement. Iron and lead should never be present. Details are given of methods of using the solders with various metals and alloys.—A. R. P.

The Electric Arc-Welding of Aluminium. L. Anastasiadis (*Elektroschweissung*, 1933, **4**, 166–168).—The main difficulties in arc-welding aluminium are the great heat conductivity, the instability of the arc, and the rapid formation of alumina. These are overcome by preheating the parent metal and using electrodes with a suitable flux coating. The last is of great importance; it must be mechanically strong, produce a stable arc, and give a slag which will dissolve alumina and have a lower sp. gr. than the weld metal. The electrode should be connected to the positive pole and should be of slightly greater diameter than the thickness of the sheet to be welded. The current used varies from 60–100 amp. for 2 mm. sheet to 250–300 amp. for 7-mm. sheet, and the arc voltage is 20–28 v. Typical test figures are given in the article.—H. W. G. H.

Gas Welding of Aluminium and Its Alloys. Herbert Herrman (*Welding Ind.*, 1933, **1**, 303–306, 347–350).—A detailed description of good practice in welding sheet and castings.—H. W. G. H.

Aluminium Welding Technique. Anon. (*Automotive Ind.*, 1933, **69**, 705–706).—A summary of recommended practice for torch, arc, butt, and spot welding.—P. M. C. R.

Welding the Aluminium Alloys. G. O. Hoglund (*Welding Eng.*, 1933, **18**, (9), 28–31).—Practical information is given on oxy-acetylene, metallic arc, and resistance welding. For welding purposes, the wrought alloys are divided into two groups—"cold-worked" and "heat-treatable." For the former, pure aluminium is used as welding rod, and, for the latter, a 5% silicon alloy rod is recommended. For spot-welding the modern methods of control—" shot-welding " or thyratron valve—are considered essential in most cases.—H. W. G. H.

Welding High-Chromium Alloys. Anon. (*Machinery* (*Lond.*), 1933, **43**, 266).—A note. The use of a neutral flame and a flux of 3 parts of borax fused with 1 of silica is recommended.—J. C. C.

Welding Copper by the " Long-Arc " Method. W. J. Chaffee (*Welding Eng.*, 1933, **18**, (9), 20–23).—This newly developed method of carbon-arc " welding " requires a special filler rod, called " Hobronze," which contains tin and phosphorus. High welding speeds, minimum distortion, and low cost are claimed. Welding machines capable of delivering full amperage with a long arc of high voltage (up to 50 v.). Typical jobs are described. The process has been successfully applied to " bronze " welding and for welding copper to steel.—H. W. G. H.

Welding Copper Piping for Process Industries. Anon. (*Welding*, 1933, **4**, 468).—Three types of joint are used, according to the temperature conditions—welded, bronze-welded, and silver soldered.—H. W. G. H.

Welded Joints in Copper and Copper Alloy. Ira T. Hook (*Machinist* (*Eur. Edn.*), 1933, **77**, 720–724).—The difficulties in welding copper are loss in strength of the metal near the weld, the redistribution of cuprous oxide in the weld, and the high heat conductivity of the copper. The more commonly used welding rods are copper deoxidized with silicon or phosphorus, phosphor-bronze, or Everdur. The method of welding with the last is set out in detail, the carbon arc being preferred to the oxy-acetylene torch. The properties and the structures of the different types of weld produced are described.
—J. H. W.

An Oxwelded Copper Tank. Anon. (*Oxy-Acetylene Tips*, 1933, **12**, 227–228).—A vessel for acetic acid storage is described. It is 20 ft. high × 10 ft. diam., and is fabricated from ½ in. thick deoxidized copper, by oxy-acetylene welding. The importance of using deoxidized material is explained.—H. H.

Small Welded Everdur Tanks. Ira T. Hook (*J. Amer. Weld. Soc.*, 1933, **12**, (10), 14–21).—Domestic hot-water tanks were formerly made of cold-rolled copper with soldered or brazed seams. Modern conditions of heavy duty make welded seams essential. Since, in copper, the strength of a weld is less than that of the cold-rolled material, the use of Everdur is recommended, and detailed instructions are given for welding it by oxy-acetylene, metallic arc, carbon arc, and resistance methods.—H. W. G. H.

Re-Surfacing Parts Subject to Wear with Manganese-Bronze. Anon. (*Soudeur-Coupeur*, 1933, **12**, (10), 8).—Such parts as the heads of Diesel engine pistons, distributing valves of petrol pumps, &c., may be repaired by applying a layer of manganese-bronze by means of the blowpipe. Two examples are illustrated.—H. W. G. H.

Welding of Commercial Yellow Brass Pipe. Anon. (*Oxy-Acetylene Tips*, 1933, **12**, 245–248).—Detailed instructions are given for welding alpha brass pipe of 4-in. bore. A butt joint with a 90° vee is recommended and a special bronze welding rod is used with a slightly oxidizing flame. Test and cost data are given and the article is illustrated by photographs, showing the technique adopted, and by photomicrographs showing the structure of the welds obtained.
—H. W. G. H.

Oxy-Acetylene Welding of Brass and Bronze Sheets. Herbert Herrman (*Welding Ind.*, 1933, **1**, 207–210).—Also published in *Met. Ind.* (*Lond.*), 1933, **43**, 145–148. See *J. Inst. Metals*, 1933, **53**, 587.—H. W. G. H.

Welding of Nickel-Chromium Wires and Tapes. Anon. (*Japan Nickel Rev.*, 1933, **1**, 374–375).—[In English and Japanese.] A list of the chief difficulties met with in welding operations of this nature, and suggestions as to the means for overcoming them in the most efficient way. Conditions for arc welding and for oxy-acetylene welding are summarized.—W. A. C. N.

XXI.—INDUSTRIAL USES AND APPLICATIONS

(Continued from pp. 45–52.)

Aluminium, the Metal of the Present and the Future. Anon. (*Machinery (N.Y.)*, 1933, 40, 81–84).—Typical applications of aluminium, including its use in railroad stock construction, dragline excavators, and structural work are described and illustrated.—J. C. C.

Light Alloys in Commercial-Vehicle Diesel Engines. Anon. (*Nickel Bull.*, 1933, 6, 153–154).—A brief account is given of the applications of R.R. and Y alloys in the construction of commercial-vehicle Diesel engines.—J. H. W.

Aluminium Cylinder Heads. F. F. Kishline (*Automobile Eng.*, 1933, 23, 209–210).—A paper presented to the Society of Automotive Engineers (U.S.A.). See *J. Inst. Metals*, 1933, 53, 530.—J. W. D.

The Use of Aluminium in Shipbuilding. (Sir) Westcott Abell (*Shipping World*, 1933, Aug. 16, 23; *Aluminium Broadcast*, 1933, 4, (15), 13–20).—The application of aluminium alloys in ship construction is reviewed, with particular reference to the elimination of fire hazard, weight reduction, corrosion-resistance, and the construction of furniture and ships' equipment. —J. C. C.

Aluminium Radiators—The New Heating Units for Central Heating. A. Eigenmann (*Schweiz. Tech. Z.*, 1933, (17), 245–249).—The theoretical considerations involved in the transfer of heat from the primary heating medium through the material of the radiators to the outer air are discussed. The relative advantages and disadvantages of iron, steel, copper, and aluminium radiator elements are critically reviewed. In the newest designs of aluminium construction the heating elements are placed within the wall, usually below window level. Minimum loss of heat and correct directional distribution of heat are claimed for this arrangement.—W. A. C. N.

Aluminium and Chemical Industry Material. E. De la Rozière (*Rev. Aluminium*, 1933, 10, 2219–2227).—The properties of aluminium which render it especially suitable for use as a constructional material in the chemical industry are described. Of these properties, those especially considered are the passivity of the metal and its alloys and the enhancement of the passivity by such processes as the M.B.V., and the behaviour of aluminium in the presence of hydrogen sulphide. The use of aluminium in machinery dealing with fatty products, and painting with aluminium powder are described. —J. H. W.

The Application of Duralumin in Vehicle Construction. —— Arntzen (*Automobiltech. Z.*, 1933, 36, 628–629).—Abstract *in extenso* of a paper read before the Automobil- und Flugtechnische Gesellschaft, Berlin, Nov., 1933. The composition, cost, and applications of Duralumin are considered. Certain problems arise from its use, whether in engines, body, or superstructure; the economics effected depend, at the present high price of the alloy, on the readjustments by which these difficulties have been met.—P. M. C. R.

Effectiveness of Paints in Retarding Moisture Absorption by Wood. F. L. Browne (*Indust. and Eng. Chem.*, 1933, 25, 835–842).—The protection against moisture absorption afforded to wood by coatings of primers and paints was studied by the Forest Products Laboratory method. Coatings of ordinary paint applied over an aluminium paint primer are more effective than those applied over a granular pigment primer. Primers highly effective against moisture movement can be made with aluminium powder provided that a finely-divided grade of powder be used in a special varnish vehicle.—F. J.

XXIII.—BIBLIOGRAPHY

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

(Continued from pp. 54–59.)

***American Society for Testing Materials.** *Book of A.S.T.M. Tentative Standards.* Issued annually. 1933. Med. 8vo. Pp. xxviii + 1136. Philadelphia, Pa.: American Society for Testing Materials, 260 S. Broad St. (Paper, $7.00; cloth, $8·00.)

[The term "tentative" is applied to a proposed standard which is to be published and distributed in order to elicit comments and criticisms for all who are interested. Because of their careful development by the A.S.T.M. committees and critical examination by the Society prior to publication, these tentative standards have important applications and are widely used in industry. The volume contains tentative specifications, methods of test, and definitions of terms covering engineering materials and the allied testing field. There are 223 tentative standards in this edition of which 34 deal with persons and 21 with non-ferrous materials; those of non-ferrous interest published during 1933 for the first time deal with zinc-coating (hot-dip) on hardware and fastenings, and magnesium ingot and stick for remelting. New tentative test methods include impact testing of metallic materials, short-time high-temperature tension tests, and "creep" tests. Previously issued tentative standards for the following, among others, have been revised: Aluminium-base sand-casting alloys in ingot form; aluminium-base alloy sand-castings; aluminium alloy (Duralumin) bars, rods and shapes (aluminium–copper–magnesium–manganese); aluminium sheet and plate; aluminium alloy (Duralumin) sheet and plate (aluminium–copper–magnesium–manganese); aluminium–manganese alloy sheet and plate; chemical analysis of aluminium and light aluminium alloys; determination of phosphorus in copper-base alloys in ingot form for sand-castings; aluminium-base alloy die-castings; zinc-base alloy die-castings; chemical analysis of metallic materials for electrical heating; compression testing of metallic materials; Rockwell hardness testing of metallic materials; verification of testing machines.]

***American Society for Testing Materials.** *Index to A.S.T.M. Standards and Tentative Standards.* Med. 8vo. Pp. 124. 1933. Philadelphia, Pa.: 260 S. Broad St. (Gratis.)

[This very useful index has been completely revised, and, while the method of indexing is essentially the same, the subject matter has been rearranged to enable references to be located even more quickly than heretofore.]

Bachmetew, E. F., A. A. Botschvar, G. S. Shdanow, and J. S. Umanski. *The Recrystallization of Metals.* [In Russian.] Pp. 351. 1933. Moscow and Leningrad: Gosmaschmetisdat. (Rbl. 8.)

***Bacon, F.** *Fatigue and Corrosion-Fatigue, with Special Reference to Service Breakages,* with a Summary of Discussion by the South Wales Branch and Written Communications. Demy 8vo. Pp. 32 + 685–736, illustrated. 1933. Newcastle-on-Tyne: Institution of Mechanical Engineers, North-Eastern Branch.

[This paper has been printed in the *Proc. Inst. Mech. Eng.*, which, however, does not contain the valuable discussion here published at the expense of the North-Eastern Branch of the Institution.]

***de Belin, G. A., and E. E. Bradbury.** *Key Words to the Metallurgy of Steel.* Post 8vo. Pp. 24, with 1 figure. [1934.] Sheffield: Greenup and Thompson, Ltd. (6*d.*)

***British Aluminium Company, Limited.** *Aluminium Sheet Metal Work.* (No. 357; superseding No. 296.) 7 × 9 in. Pp. 68, illustrated. 1933. London: The British Aluminium Co., Ltd., Adelaide House, King William St., E.C.4.

***Childs, W. H. J.** *Physical Constants: Selected for Students.* Post 8vo. Pp. viii + 77. 1934. London: Methuen and Co., Ltd. (2*s.* 6*d.* net.)

***Dammer, Otto.** Begründet und in erster Auflage herausgegeben von. *Chemische Technologie der Neuzeit.* In zweiter, erweiterter Auflage, bearbeitet und herausgegeben von **Franz Peters** und **Herm. Grossmann.** Unter Mitwirkung von — Alexander, — Arndt, — Baudrexel, — Baumhauer, — Beck, — Berdel, — Bergander, — Bertelsmann, — Börnstein, — Brecht, — Bresser, — Brieger, — Brisker, — Brode, — Bujard, — Classen, — Cohn, O. Dammer, — Davidsohn, — Durst, — Eger, — Endell, — Engelhardt, — Evers, — Eyer, — Faust, — Ferenczi, E. J. Fischer, (Reg. Rat. Dr.) — Fischer, — Friedrich (Biebrich), — Friedrich (Stassfurt), — Geibel, — Gerhardt, — Geuther, — Goehring, — Graefe, — Haegermann, v. Hagen, — Heiduschka, — Henkel, — Herzfeld-Hoffmann, — Herzfeld-Wuesthoff, R. Hoffmann, — Jaeckel, — Junkmann, — Kast, — Kausch, — Kissling, — Knigge, — Kolb, — Koschmieder, — Kreth, — Krifka, — Kühle, — Kuttenkeuler, — Leitner, — Lohmann, — Luhmann, — Meyer, Jakob Meyer, Alfred R. Meyer, — Muth, — Napthali, P. Neumann, — Perndanner, — Rammstedt, — Riemann, — Ristenpart, — Rocha-Schmidt, — Rübencamp, — Rüdiger, — Sander, — Savelsberg, — Schall, — Schauwecker, Erich Schmidt, Max Schmidt, — Schmitz-Dumont, — Schnegg, — Schrauth, v. Schwarz, — Sembach, — Serger, — Springer, — Stahl, — Stephan, — Stooff, — Valenta, — Willstaedt, — Wipfler, H. Wolff, — Wulff, und — Wüstenfeld. Fünf Bände. II Band, 2 Teil. 4to. Pp. xvi + 888, with 343 illustrations. 1933. Stuttgart: Ferdinand Enke. (Geh., R.M. 93; geb., R.M. 98.)

***Department of Scientific and Industrial Research.** *Report for the Year* 1932–1933. Presented by the Lord President of the Council to Parliament by Command of His Majesty, December, 1933. (Cmd. 4483.) Med. 8vo. Pp. iv + 189. 1934. London: H.M. Stationery Office. (3*s*. net.)

***Engineer, The.** *The Engineer Directory and Buyer's Guide*, 1934–1935. Pp. 248. London: " The Engineer," 28 Essex St., W.C.2.

***Ephraim, Fritz.** *A Text-Book of Inorganic Chemistry.* English edition by **P. C. L. Thorne.** Second edition, revised and enlarged. Roy. 8vo. Pp. xii + 873, with 85 illustrations. 1934. London and Edinburgh: Gurney and Jackson. (28*s*. net.)

***Glasstone, Samuel.** *Electrometric Methods in Physical and Analytical Chemistry.* Demy 8vo. Pp. 39, with 10 illustrations. 1934. London: Institute of Chemistry of Great Britain and Ireland, 30 Russell Sq., W.C.1.

***Kroenig, W. O.,** and **G. A. Kostylew.** *Corrosion of Magnesium Alloys.* Part II.—*Corrosion of Cast Magnesium Alloys.* [In Russian, with English summary.] (U.S.S.R. The People's Commissariat for Heavy Industry United Aircraft Industries; Transactions of the Research Institute for Aircraft Materials, No. 4.) Sup. Roy. 8vo. Pp. 60, with 15 illustrations. 1933. Moscow and Leningrad: State Technical Bookshop. (Rbl. 1 20 k.)

***Kroenig, W. O.,** and **G. A. Kostylew.** *Corrosion of Magnesium Alloys.* Part III.—*Influence of Heat-Treatment on the Corrosion of Cast Magnesium Alloys.* [In Russian, with English summary.] (U.S.S.R. The People's Commissariat for Heavy Industry United Aircraft Industries; Transactions of the Research Institute for Aircraft Materials, No. 5.) Sup. Roy. 8vo. Pp. 31, with 55 illustrations. 1933. Moscow and Leningrad: State Technical Bookshop. (60 k.)

***Kroenig, W. O.,** and **G. A. Kostylew.** *Corrosion of Magnesium Alloys.* Part IV.—*The Corrosion of Magnesium and Elektron in Contact with Other Metals.* [In Russian, with English summary.] (U.S.S.R.

The People's Commissariat for Heavy Industry United Aircraft Industries; Transactions of the Research Institute for Aircraft Materials, No. 7.) Super Roy. 8vo. Pp. 25, with 17 illustrations. 1933. Moscow and Leningrad: State Technical Bookshop. (60 k.)

***Levinstein, Herbert.** *The Chemist as a Directing Force in Industry.* The Fifth S. M. Gluckstein Memorial Lecture, 1933. Demy 8vo. Pp. 22. 1934. London: Institute of Chemistry of Great Britain and Ireland, 30 Russell Sq., W.C.1.

***Lundquist, Eugene E.** *Strength Tests of Thin-Walled Duralumin Cylinders in Pure Bending.* (Technical Notes, National Advisory Committee for Aeronautics, No. 479.) [Mimeographed.] 4to. Pp. 10, with 7 figures. 1933. Washington: National Advisory Committee for Aeronautics.

***Panseri, Carlo.** *La Fonderia d'Alluminio.* Metallografia e Tecnologia delle Leghe Leggere da Fonderia. Roy. 8vo. Pp. xvi + 582, with 311 illustrations. 1934. Milano: Ulrico Hoepli. (L. 65.)

***Pilcher, Richard B.** *Alchemists in Art and Literature.* Demy 8vo. Pp. 54, illustrated. 1933. London: Institute of Chemistry of Great Britain and Ireland, 30 Russell Sq., W.C.1.

***Pohl, Ernst.** *Hilfsbuch für Einkauf und Abnahme metallischer Werkstoffe.* Demy 8vo. Pp. viii + 143, with 88 illustrations. 1933. Berlin: VDI-Verlag G.m.b.H. (R.M. 8; VDI-Members, R.M. 7.20.)

***Whittick, G. Clement.** *Roman Mining in Great Britain.* (Excerpt from *Transactions of the Newcomen Society,* Vol. XII, 1931–1932.) 4to. Pp. 28, with 2 plates. Newcomen Society.

***v. Zeerleder, Alfred.** *Technologie des Aluminiums und seiner Leichtlegierungen.* Med. 8vo. Pp. ix + 289, with 204 illustrations. 1934. Leipzig: Akademische Verlagsgesellschaft m.b.H. (Br., R.M. 12.60; geb., R.M. 14.)

THESES.

***Boss, Arno.** *Die deutsche Hüttenindustrie der Metallegierungen.* Entwicklung und volkswirtschaftliche Bedeutung der Industrie der Aufbereitung von Altmetallen und Rückständen von Kupfer, Zinn, Zink, Blei und deren Legierungen. Inaugural-Dissertation zur Erlangung der Doktorwürde genehmigt von der Philosophischen Fakultät der Friedrich-Wilhelms-Universität zu Berlin. Med. 8vo. Pp. 83. 1931. Berlin: Bibliothek der Friedrich-Wilhelms-Universität.

***Parks, Margaret Merriman.** *A Gravimetric Method for the Quantitative Determination of Vanadium.* Dissertation submitted in Partial Fulfilment of the Requirements for the Degree of Doctor of Philosophy in the Faculty of Pure Science, Columbia University. Med. 8vo. Pp. 23. New York: Columbia University.

***Rosenberg, Ernst.** *Untersuchungen über Elektrolytische Metallabscheidung.* Inaugural-Dissertation zur Erlangung der Doktorwürde genehmigt von der Philosophischen Fakultät der Friedrich-Wilhelms-Universität zu Berlin. Demy 8vo. Pp. 31, with 18 illustrations. 1932. Berlin: Bibliothek der Friedrich-Wilhelms-Universität.

NEW PERIODICAL.

Wire Industry. Vol. I, No. 1 (Jan., 1934). 5 Fetter Lane, London, E.C.4. Published every second Thursday in each month (£1 1*s.* per annum, post free).

XXIV.—BOOK REVIEWS

(Continued from pp. 60–64.)

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

This important and welcome publication gives a survey of a vast amount of available information on melting and casting metals and the properties of castings. The treatment of the subject has been planned to make the book of service to those engaged in the technical field.

The author, who is well known for his own scientific work in metallurgy, shows an exceptional acquaintance with English and American publications on these subjects, and the numerous references to original papers add greatly to the value of the book.

The first main section (pp. 1–110) deals fully with the processes of melting and solidification, assembles the data on the properties of molten metals, and clearly indicates the rôle they play in the manipulation and subsequent solidification of the cast metal. Frequent indications occur throughout the book of the limitations of existing knowledge, which should be stimulating to further work in this branch of metallurgy, for many years too much neglected.

The second section (25 pp.) treats of ingots and the moulds in which they are cast, but even allowing for the limitation of the work to non-ferrous metallurgy, rather fuller treatment would have been welcome.

The third section (about 130 pp.) is concerned with finished castings and their production. Here the following, amongst other matters, are dealt with: casting processes, casting properties of alloys, cracks and stresses in castings, dependence of strength on casting conditions, testing of castings. Finally, five plates give the constitution of the more important non-ferrous alloys.

All who are concerned with the control of commercial production should share with research metallurgists the advantage which they can gain by reading and using this book. Many engaged in the working of metals are already alive to the value of knowledge on the subjects here dealt with, but far too few of those who produce finished castings appear to be concerned with these fundamental data, on which improvement of their products so much depends. The publishers have succeeded in fixing a price which shows a welcome reduction on some of their recent achievements.

Metallurgical Analysis by the Spectrograph, being Some Experiences of the Application of the Spectrograph to the Analysis of Non-Ferrous Metals and Alloys. By D. M. Smith. With a Foreword by H. W. Brownsdon. Roy. 8vo. Pp. xi + 114, with 8 illustrations in the text, and 10 plates. 1933. London: British Non-Ferrous Metals Research Association, Regnart Buildings, Euston St., N.W.1. (10*s.* 6*d.*)

This is the first book about spectrographic analysis written primarily for the metallurgical worker; it is very welcome. It opens with an admirably concise statement of the principles and methods of spectrum analysis, and a cautious statement of what the method may be expected to do. The technique of various methods is then clearly described; the author wisely concentrates on methods which have proved their value in routine work, to the neglect of a few more complicated and specialized methods. All the essential facts and formulæ are given, and there are ample references to the methods of other workers.

The main part of the book deals with quantitative analysis, and includes many tables of spectrum lines for the analysis of the common metals, together with reproductions of spectra which help in the identification of the lines.

To test the utility of these tables the book was put in the hands of a beginner in spectrum analysis, an experienced chemist who has been using a spectrograph for a short time. He was asked to analyse a sample of commercially impure tin by the spark method, and one of fire-box copper by the arc. In the first case his results were disappointing, in the second they were satisfactory, and the criticisms which follow are partly based on observation of his work.

The section on technique for spark spectra would be improved by the inclusion of a short list of the more prominent lines due to air usually found in the spark spectra of metals, as these are often difficult to identify.

In selecting pairs of lines for quantitative comparison the author has occasionally not been critical enough. There are some pairs of lines which appear equal when photographed with one spectrograph but cannot be made to appear equal when photographed (under the same conditions) with a spectrograph of different dispersion. Such lines are troublesome to identify, but they are even more troublesome to use, and some of the difficulties arising in the analysis of tin may be traced to this cause. Also pairs of lines are sometimes included which are so far separated in the spectrum that the choice of a different photographic plate by the analyst may lead to amazingly large errors. The table for lead in zinc is the worst in this respect, those for copper in tin, tin and cadmium in lead, also contain dangerous lines.

A warning footnote might have been appended to the tables as to this point, and also the the tables for cadmium and tin in lead, iron in copper, which include some pairs of lines of which one is an arc line, one a spark line. Deductions from such lines are reliable only if the operator has been lucky as well as careful in controlling conditions.

The tables have occasional notes warning users of possible coincidences between lines of different metals, but directions are not given for detecting whether these coincidences have occurred, which is usually possible by reference to other lines in the spectrum.

On the whole, the tables are excellent, clear, and easy to use, and contain only one misprint. The table for bismuth in lead is remarkable in that it gives instruction for differentiating between 0·085 and 0·09 per cent. of bismuth; elsewhere the accuracy to be expected is of the order of 25 per cent.

An adequate bibliography and index complete the book, the detailed information and ample illustrations of which make one grateful to the publishers as well as the author for a most valuable work.—E. VAN SOMEREN.

Praktikum der chemischen Analyse mit Röntgenstrahlen. Von G. v. Hevesy und E. Alexander. Pp. iv + 80, with 17 illustrations. 1933. Leipzig: Akademische Verlagsgesellschaft m.b.H. (M. 4.80.)

New methods of supplementing chemical analysis by physical means appear from time to time, and the use of X-ray spectra, although discovered later than that of optical spectra, has already reached an equally advanced stage of development. This more rapid development is partly due to the fact that in the application of X-rays to analysis practice has marched hand in hand with theory, instead of preceding it by many years, as with optical spectra; also the field covered by the X-ray method is more restricted.

This booklet is essentially a manual for the actual user of X-ray methods; it wisely assumes little previous knowledge on the reader's part, and opens with a clear outline of the principles of X-ray emission, and its application to analysis. Then follow chapters on qualitative analysis, and on quantitative analysis. The materials dealt with include most of the metals, usually as compounds in powder form.

Half the book deals with apparatus and experimental technique; it gives complete instructions for carrying out an analysis, and many valuable tables. Besides the tables of wavelengths of lines and absorption-edges due to the elements, the authors give a table of the most useful line pairs for comparison in quantitative work. This is followed by a most instructive table setting out all the coincidences or overlappings which are likely to occur, and which may lead to errors or render certain analyses impossible.

Some text-books are like guide-books, others are like maps, essential to the traveller in their field, but less interesting to the general reader. This book and that on spectrum analysis by Mr. Smith are in the map class.—E. VAN SOMEREN.

Traité de Photo-métallographie. Par Louis Villemaire. Demy 8vo. Pp. 125, with 25 illustrations. 1932. Paris: J. Danguin. (21 francs.)

The title of the book might suggest that it would be of interest to metallographers and metallurgists generally. It is, however, concerned with the subject of photographic process reproduction, and while apparently a very useful and practical treatise, it is written for that industry, and its metallurgical aspect is confined to the use of the zinc plates in the processes described.—O. F. HUDSON.

Technique of Modern Welding. By P. Bardtke. Authorized Translation from the Second German Edition, with Additions and Revision by Prof. Bardtke, by Harold Kenney. Med. 8vo. Pp. xi + 299, illustrated. 1933. London and Glasgow: Blackie and Son, Ltd. (15*s*.)

The German edition was reviewed in *J. Inst. Metals*, 1933, 53, 429. The comments then made are applicable, almost *in toto*, to this excellent translation. It must still be considered a German text-book, and the defects of the sections on non-ferrous welding remain. It is to be regretted that the translator could not give of his own knowledge in that sphere of welding. Nevertheless, it cannot be denied that, as he claims in his preface, " the book will remain of valuable assistance to the student, engineer, draughtsman, and operative for many years to come." The book is well produced and an adequate index is provided.

—H. W. G. HIGNETT.

The Use of Copper in Plumbing. By A. C. Martin. Post 8vo. Pp. vi + 121 + xiii, with 41 illustrations. Manchester: Plumbing Trade Journal Co., Ltd., 9 Albert Sq. (2*s*. 8*d*., post free.)

The use of copper for water services is now so extensive that this little book, which has been produced for the benefit of plumbers, should meet a very real need.

After a brief review of the properties of copper in relation to its application in water services, the jointing of copper tubes, the welding and technique of welding, and the bending of copper tubes are dealt with and illustrated adequately, and in a practical manner. The book concludes with chapters devoted to the use of copper in cold-water service, in hot-water service, and in sanitary service.

The book is written in a clear and simple style and should prove a very useful little handbook.—O. F. Hudson.

Les Bases Scientifiques de la Soudure Autogène. Par Albert Portevin. Conférence fait à la Société des Ingénieurs Soudeurs, le 27 Avril, 1933. Med. 8vo. Pp. 32, with 3 illustrations. 1933. Paris: Institut de Soudure Autogène, 32 Boulevard de la Chapelle.

This is a fascinating paper by one of the greatest of all metallurgical philosophers. One cannot usefully comment upon it; one can only recommend all to read it. It will profit even those who have no practical interest whatever in welding.

M. Portevin considers, in very great detail, the phenomena of welding, applying to each the known laws of metallurgy and illustrating each application. Autogenous welding is defined as a process by which local fusion, and usually addition of identical or similar metal, produces metallic continuity in a joint, in such a way as to realize, as far as possible, complete homogeneity of the useful properties of the material. The local fusion has three effects—the "casting" of the weld metal, the heat-treatment of the neighbouring parent metal, and metallurgical reactions with surrounding media (atmosphere, slag, &c.). The influence of these effects on chemical composition, physico-chemical constitution, structure, and internal stress, is discussed in order to arrive at a definition of weldability. An expression, $C \times H$, is deduced for the coefficient of weldability, where C is a function of the soundness of the joint, and H is a function of its homogeneity.—H. W. G. Hignett.

Handbook of Chemistry and Physics. A Ready-Reference Book of Chemical and Physical Data. Edited by Charles D. Hodgman. Eighteenth edition. Fcap. 8vo. Pp. xiii + 1818. 1933. Cleveland, O.: Chemical Rubber Publishing Co., West 112th St. and Locust Avenue. ($6.00.)

The eighteenth edition of this very useful handbook of chemical and physical data appears as the book reaches its twentieth year of existence. As in previous editions, considerable revision of much of the data has taken place and new features have been incorporated. The most important revision is that of the table of physical constants of inorganic compounds. This table, in addition to the revision of the data concerning the substances previously included, is extended by the addition of nearly one thousand fresh compounds. The metallic derivatives of organic compounds have been brought together in a separate table (pp. 398–433). The descriptive matter concerning the elements has been revised and rewritten. All the radioactive elements and the newly discovered elements have been included. New tables are introduced on (i) the volumetric primary standards, (ii) the efficiency of drying agents, (iii) liquids for the measurement of refractive index by the immersion method, (iv) density of solutions of hydrofluosilicic acid. The research of the current year on isotopes is included in a table which gives the characteristics of all the known isotopes.

The present edition of the handbook is, if this is possible, an improvement on the preceding edition; it is a work of reference which should be in the hands of all engaged in the study or practice of chemistry, physics, and engineering. The book may be whole-heartedly recommended.—James F. Spencer.

Chemical Guide-Book. Ninth Edition. Pp. 600. 1933. New York: Chemical Markets Incorporated. (Price $2.00.)

The book is divided into five parts: I, a catalogue of leading American chemical firms arranged alphabetically; II, an alphabetical list of chemical and allied products with brief notes of their properties and uses and a list of American suppliers; III, a geographical directory arranged alphabetically by state and town; IV, a buyer's guide for containers, packing and shipping supplies; and V, chemical statistics showing comparative prices of important heavy and fine chemicals, intermediates, and allied products. The American purchaser will find herein all the information he requires on where to purchase a chemical product, how it is shipped, the various grades available, and tariff data.—A. R. Powell.


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INSTITUTE OF METALS EDUCATIONAL TOUR

The first Educational Tour of the Institute of Metals—to metallurgical establishments in Belgium—will take place from Sunday, April 8, to Saturday, April 14, 1934 (both inclusive), *if sufficient junior members of the Institute signify to the Secretary, by Monday, March 12, their intention to participate.*

At the request of the Council, the National Union of Students has kindly made the following arrangements.

The party will leave London (Victoria) at 10 a.m. on Sunday, April 8, for Liége, travelling via Dover, Ostend, and Brussels.

Monday, April 9, and Tuesday, April 10, will be spent in Liége and district, where the following visits have been arranged:—

(1) Sté. Ame. John Cockerill;
(2) Sté. Ame. d'Ougrée-Marihaye;
(3) Sté. Ame. des Mines et Fonderies de Zinc de la Vielle-Montagne;
(4) Fabrique Nationale d'Armes de Guerre.

On Tuesday evening, or Wednesday morning, April 11, the party will travel to Charleroi where visits will be paid to:—

(1) Ateliers de Constructions Électriques de Charleroi;
(2) Sté. Ame. des Laminoirs, Hauts Fourneaux, Forges, Fonderies et Usines de la Providence.

On Thursday morning, April 12, the party will leave Charleroi for Brussels, where the day will be spent, mainly in seeing the Belgian capital. It is hoped, however, that a visit to the University will be arranged.

On Friday, April 13, the party will travel to Bruges, which, of all Belgian cities, has best preserved the characteristics of a mediæval town.

On Saturday morning, April 14, the party will return to London, which will be reached at 4.42 p.m.

The cost per head will be £6 10s. The price quoted will include third-class rail travel (second class on the steamer between Dover and Ostend); accommodation in hotels; three meals per day (continental breakfast, lunch and dinner); service, tips and taxes; conveyance between stations and hotels and local journeys to the works, &c., visited.

Extras are baths, afternoon tea, passports, and purely personal expenses. Visas are not required in Belgium by British subjects.

Junior and student members intending to participate are requested to communicate with the Secretary as soon as possible so that adequate arrangements can be made in good time. *Remittances* may accompany the notification of participation, but in any case *these must reach the Secretary by March* 12.

Further details, including place of meeting, will be communicated to those taking part.

Members of staffs of Universities and Colleges will help if they will bring this announcement to the notice of their students and of others likely to benefit from the Tour.

G. SHAW SCOTT,
Secretary and Editor.

The Institute of Metals,
36 *Victoria Street, London, S.W.*1.