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P. 100!36



Part 2



Vol. 3

The Monthly Journal of the
**INSTITUTE OF
METALS**
and
METALLURGICAL ABSTRACTS

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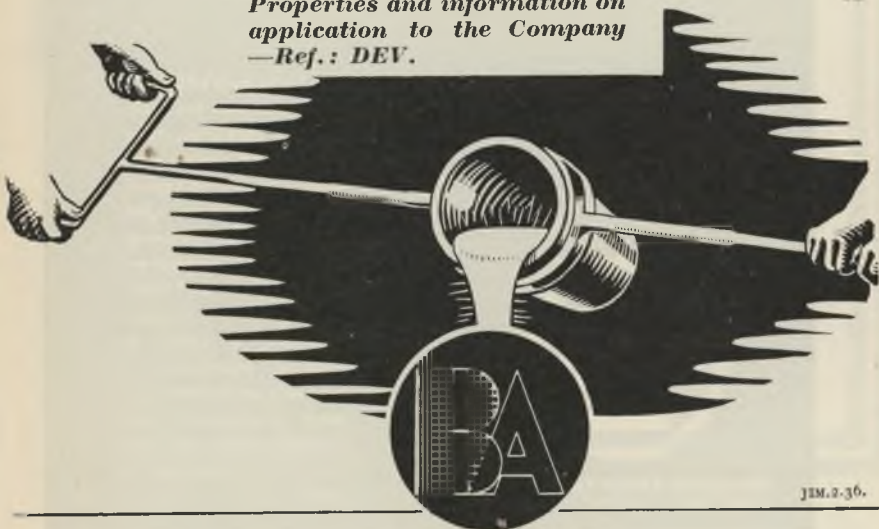
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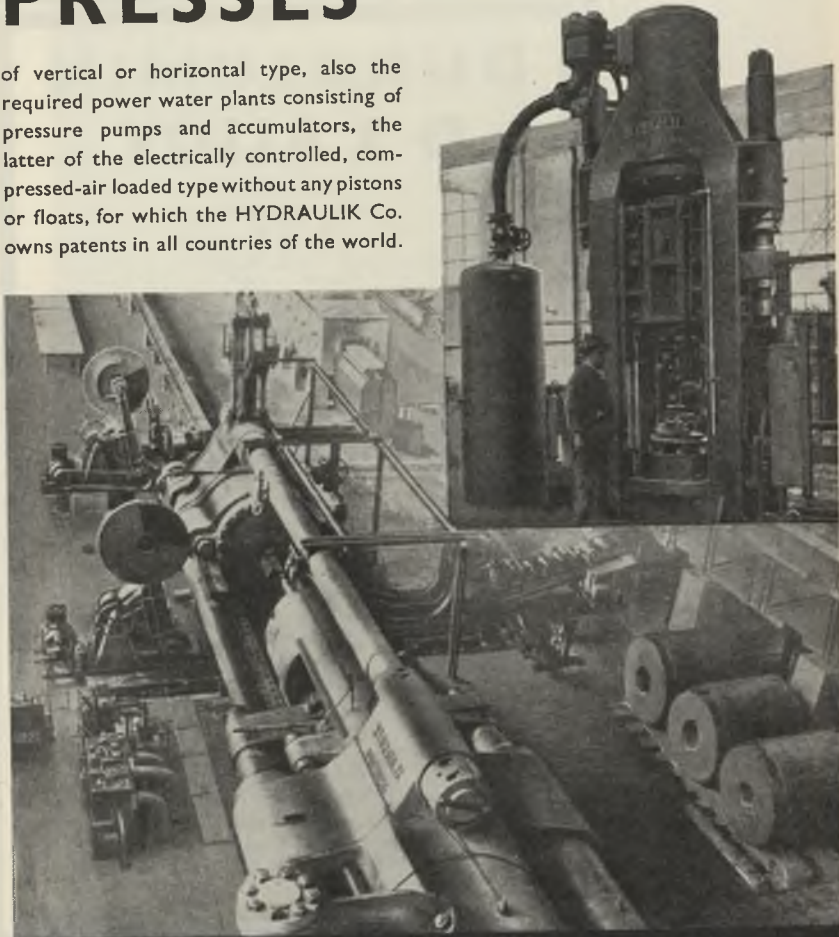
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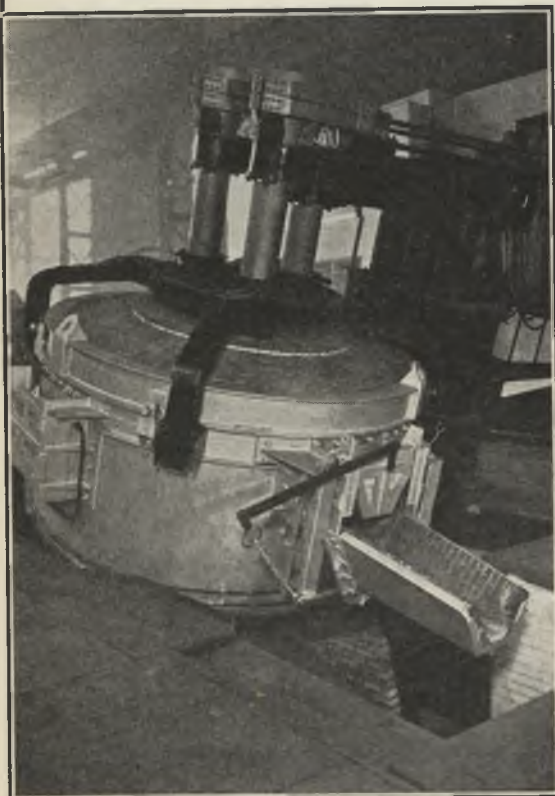
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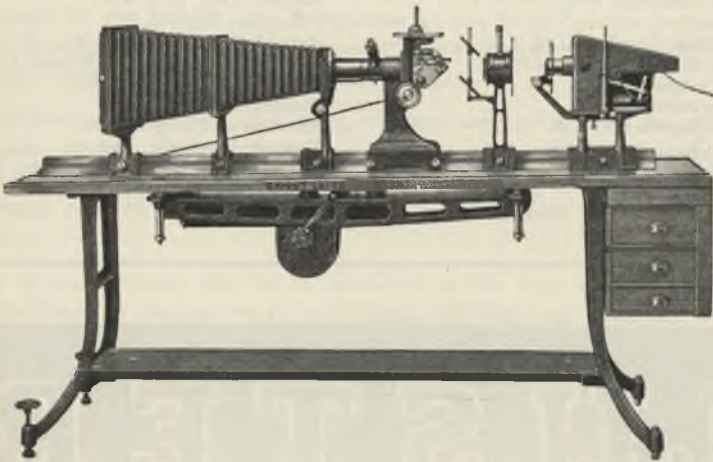
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Monthly Journal of the

INSTITUTE OF METALS

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THE MEMBERSHIP OF THE COUNCIL

It has been felt for some time that many members who might serve on the Council to the advantage of the Institute, are not given the opportunity of doing so under the present system of election. While the experience of those who have given long service as Members of Council is undoubtedly valuable, the benefit to be gained by drawing on a wider circle of our membership, and especially by including in the Council a larger proportion of younger members, may well be of no less value. By fixing a reasonable limit to continuous service an increased rate of accession of new members to the Council can be secured and better representation given, over a period of years, to the varied interests included in the Institute's membership. Closer contact between the Council and the general body of members should follow, and the flow of fresh ideas should stimulate the work of the Council and its Committees.

Other scientific and technical institutions, faced with the problem of a tendency to permanent membership of the Council, have adopted various solutions such as requiring that a retiring Member of Council shall not be eligible for immediate re-election, or nominating more candidates than vacancies, thus ensuring a ballot.

Under our present Articles of Association, a Member of Council retires after a given period (usually 3 years) from the date of his election. He is, however, immediately eligible for re-election, and it has become customary to re-elect retiring members willing to serve again.

The Council of the Institute has had the question under consideration for many months and has decided to recommend a change in procedure, the essence of which is to limit the maximum period of continuous service on the Council. This will apply to all Members of Council without exception, but the total period will naturally be longer in the case of those who pass from ordinary membership of Council to higher office. It is hoped in this way to secure a

satisfactory balance between the experience gained by fairly long (but not unlimited) service on the Council and the fresher outlook of members who serve for a shorter period. Previous service on the Council will not be a bar to re-election provided that at least one year has elapsed since retirement.

An important feature of the proposals is the inclusion in the Council of all Chairmen of Local Sections, for the period of their Chairmanship. The Council regards the work of the Local Sections as an essential part of the life of the Institute and hopes that this step will strengthen the tie between the Local Sections and the Council. Even where, owing to distance, the Chairman of a Local Section cannot attend Council meetings regularly, he and his local Committee would be kept in touch with the activities of the Council and its Committees, and his views, conveyed in any appropriate way, would always receive sympathetic consideration at Council meetings.

Amendment of such of the Articles of Association as define the constitution of the Council is necessary to bring the proposed changes into effect. The Articles can be amended only by resolution passed by the requisite majority at a General Meeting of members of the Institute. An Extraordinary General Meeting of members will be held at 5.30 p.m. on March 10, 1936 (the day preceding the Annual General Meeting, in the evening of which the Discussion on Metallic Wear in the Presence of Lubricants will take place), to consider the Council's proposals. The terms of the special Resolution to be moved have already been circulated to all members with the notice convening the meeting. Opportunity will be given for adequate discussion. An important change of the kind indicated should only be carried through with the full approval of a thoroughly representative body of members, and it is hoped by the Council that as many members as can do so will attend this meeting.

LETTERS TO THE EDITOR

The Death of King George V.

I wish to express to the British Institute of Metals, membership of which I have always considered a great honour, my sympathy at the death of His Majesty King George V.

The sincerity and heartiness of the expressions of sympathy which English people have received from the German nation and from German individuals is due partly to an understanding of the great love and honour which they bear to their King and Emperor and partly to the personal esteem and affection which we feel for the dead King who, in Germany, has always been regarded as a lovable and noble personality.

WILLI CLAUS.

Berlin.

I have just heard the sad news of the decease of His Majesty King George the Fifth. During my stay in England, I realized very well the high sense of respect and esteem which English people felt towards their King; everywhere I noticed signs of deep love and veneration to the old King, and on this account I have fully understood the great sorrow of your country. Please accept my sincere condolence on this sad occasion. Let us hope that the new reign will be as prosperous as the preceding; this is my sincerest wish.

JOAQUIN ORLAND.

Liège.

INSTITUTE NEWS AND ANNOUNCEMENTS

Annual General Meeting, London.

As announced in the *Monthly Journal* for January, the Annual General Meeting will be held in the Hall of the Institution of Mechanical Engineers, Storey's Gate, Westminster, S.W.1, on Wednesday and Thursday, March 11 and 12, the meeting being preceded, on Tuesday, March 10, by an Extraordinary General Meeting, to be followed by a Discussion on **Metallic Wear in the Presence of Lubricants**. A detailed programme of the Annual General Meeting was posted to each member on January 31, together with a form intended to be used to apply for tickets for the Annual Dinner on March 11, for visits that have been arranged for the afternoon of March 12, and for luncheons on March 11 and 12.

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):

AUSTIN, G. Wesley: "The Effect of Molten Solder on Some Stressed Materials."

BANNISTER, C. O., and R. RIGBY: "The Influence of Light on Electrode Potential and Corrosion Phenomena of Certain Non-Ferrous Metals."

BLAZEY, C.: "Experiments on the Electrical Resistance of Copper and Some Copper Alloy Wires."

BRITTON, S. C.: "An Electrolytic Test for Zinc Coatings on Wire."

COOK, M.: "The Physical Properties and Annealing Characteristics of Standard Nickel Silver Alloys."

JONES, W. D.: "Influence of Surface Cuprous Oxide Inclusions on the Porosity of Hot-Tinned Coatings on Copper."

DANIELS, E. J.: "The Hot-Tinning of Copper: The Attack on the Basis Metal and Its Effects."

Institute News and Announcements

GWYER, A. G. C., and P. C. VARLEY :
"A Deep-Drawing Test for Aluminium."

TEED, P. L. : "Plastic Age-Hardening of Duralumin."

All the above-mentioned papers have been published in recent issues of the *Monthly Journal*, beginning with that dated October 1935. Members should bring to the meeting copies of the *Monthly Journal* containing papers in which they are interested. No separate copies of the papers will be available, except to members who have paid a special subscription of 5s. per annum for separate copies.

Members who are unable to attend the meeting are invited to discuss the papers above listed—and others that have been published in the *Monthly Journal* since September—by correspondence. Such written discussions should be received by the Secretary not later than the date mentioned at the head of each paper.

Annual Dinner.

It is hoped that as many members as can possibly do so will attend the meetings, visits, and Dinner. The Dance previously announced will not take place owing to the national mourning for the late King George V. After the Dinner there will be an informal social gathering of members and their friends; music will be discoursed by a string band. Tickets for the Dinner are now obtainable from the Secretary, price 12s. 6d. each. Application may be conveniently made on the previously circulated reply form.

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, to which attention is directed in the following Report of Council and Treasurer's Report. Intending members might usefully be advised that if they join the Institute now their first subscription covers the extended period ending June 30, 1937, instead of the usual twelve months; whilst it brings a corresponding extra number of *Journals*. Nominations should be addressed to the Secretary. The

next election is due to take place on April 2, 1936.

Beilby Memorial Awards.

From the interest derived from the invested capital of the Sir George Beilby Memorial Fund, at intervals to be determined by the administrators representing the Institute of Chemistry, the Society of Chemical Industry, and the Institute of Metals, awards are made to British investigators in science to mark appreciation of records of distinguished original work, preference being given to investigations relating to the special interests of Sir George Beilby, including problems connected with fuel economy, chemical engineering, and metallurgy.

Awards are made, not on the result of any competition, but in recognition of continuous work of exceptional merit, bearing evidence of distinct advancement in knowledge and practice.

The administrators of the Fund are the Presidents, the Honorary Treasurers, and the Secretaries of the three participating Institutions, who will be glad to have their attention directed to outstanding work of the nature indicated. Correspondence on this subject should be addressed to the Convener, Sir George Beilby Memorial Fund, Institute of Chemistry, 30 Russell Square, London, W.C.1.

Membership Additions.

The following were elected on January 16, 1936 :

As Members.

ALLEN, Reginald J., Birmingham.
BALLAY, Marcel, Dr.-es.-Sci., Paris.
FLETCHER, Louis, Birmingham.
FREESTONE, Wheaton T., Peterborough.
KILBEY, Alfred John, Orpington.
LARCOMBE, Samuel, Birmingham.
LISLE, Arthur Battershill, Wembley.
MCCARROLL, R. H., B.Ch.E., Dearborn, Mich., U.S.A.
MEYERSBERG, Heinz, Dr.-Ing., Wembley.
MOORE, John Eric, Guiseley.
MURPHY, Maurice, London.
NETTMANN, Paul H. R., Dr.-Ing., Berlin-Charlottenburg, Germany.

Local Sections News

PARKER, Theodore Henry George,
B.Sc., A.C.G.I., London.
SHAUER, Julius, Moscow.
SMITH, Philip George, B.Sc.,
A.R.S.M., London.
SPOONER, E. C. R., M.Sc., B.E.,
Avonmouth.
TANN, Jiff P., Birmingham.

As Student Member.

COUND, Thomas Edwin, B.Sc., Swan-
sea.

PERSONAL NOTES

PROFESSOR P. A. J. CHEVENARD and PROFESSOR A. M. PORTEVIN have been elected foreign corresponding members of the Academy of Technical Sciences of Warsaw.

MR. L. G. MARTELL, B.Sc., has accepted the position of Metallurgist with the Telegraph Construction and Maintenance Company, Ltd., Greenwich.

LOCAL SECTIONS NEWS

SYNOPSIS OF PAPERS TO BE READ AT COMING MEETINGS.*

London Section.

The Patenting of Metals and Alloys. By G. S. W. Marlow, B.Sc. (*March 5.*)

The nature of the British patent monopoly; definition of an invention; new methods of winning or working a metal; new alloy or new method of making an old alloy; patentable utility; invention by "selecting" a particular alloy having special properties from a known class; and British procedure will be discussed. The talk will be illustrated by the facts of relevant decided cases.

North-East Coast Section.

Foundry Costing. S. G. Homfray, B.A., and R. A. Balderston. (*March 17.*)

The object of costs in the iron foundry and brass foundry; how far subdivision of departments should be carried; the relative importance of the items which make up the cost; the method of checking and allocation; metal cost, value of direct and indirect scraps, loss and costs of melting; foundry tackle and sundry materials; and the effect of rejections on the cost will be discussed.

Scottish Section.

The Centrifugal Casting of Non-Ferrous Metals. By F. W. Rowe, B.Sc. (*March 9.*)

The author will give a short *résumé* of the objects of centrifugal casting, detailing the deficiencies generally found in sand-cast non-ferrous metals and alloys, and a brief historical outline of centrifugal casting as applied to non-ferrous metals indicating the limitations and advantages of the various methods and types of moulds. A detailed examination will be made of the variations in structure which are obtained in centrifugal castings and the related physical properties and their effect on the subsequent behaviour of the parts in service. A general survey will be given of the application in industry of centrifugal castings, the applicability of various alloys to centrifugal casting, and the improvement in physical properties which can be expected.

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

Subject to revision. Not to be published, wholly or in part, until presented at the Annual General Meeting of the Institute of Metals to be held on March 11, 1936, 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, 1935.

THE Council has pleasure in submitting its report on the activities of the Institute during the twenty-eighth year of its existence.

ROLL OF THE INSTITUTE.

The number of members on the Roll of the Institute on December 31 in the past five years is shown in the following table:

	Dec. 31, 1931.	Dec. 31, 1932.	Dec. 31, 1933.	Dec. 31, 1934.	Dec. 31, 1935.
Honorary Members	5	5	5	5	4
Fellows	7	8	8	7	7
Ordinary Members	2146	2073	2038	1992	1987
Student Members .	74	79	80	85	69
	2232	2165	2131	2089	2067

The Council regrets that the industrial improvement is not yet reflected in an increase in the Institute's membership. In order that the services offered to members may be maintained at their present level it is important that the numerical strength of the Institute—in which there was a net increment of approximately 100 in each of the years from 1920 to 1930—should not remain below the 1931 total, which was the highest reached since the foundation of the Institute. A membership of 2500 should be possible and would enable the Council to conduct the affairs of the Institute with less financial anxiety than is at present the case. The Council is impressed by the disparity between the number of subscribing members and the far greater number of those who, in one way or another, derive benefit from the Institute's work, and is convinced that there are many in the latter class who ought to share in the cost (and not only in the benefits as at present) to the small extent involved in joining the Institute as members.

OBITUARY.

The deaths of the following members were notified to the Secretary: Professor N. N. Baraboshkin; Dr. A. Bramley; C. W. Bryant; A. Citroën; Professor W. R. E. Hodgkinson; G. C. Klug; P. H. Langdon; E. Le Bas; Dr. A. D. Little; Captain W. H. Upton Marshall; Lieut.-Colonel S. H. Pollen; Professor A. Sapojnikoff; and L. P. Sidney.

In addition the Council record with regret the death of Sir Richard Glazebrook, who was one of the few Honorary Members, a distinction that he had enjoyed since 1910.

CONSTITUTION OF THE COUNCIL.

At several meetings of the Council held during the past year consideration was given to proposals for securing more frequent change in the constitution of the Council and including on the Council the chairmen of all the Local Sections. The essence of the scheme is a limitation of the maximum period of continuous service on the Council. To give effect to the proposals will necessitate

Report of Council

certain alterations in the Institute's Articles of Association, and the necessary steps have been taken to enable members to vote on the changes proposed at an Extraordinary General Meeting to be held on the day preceding the Annual General Meeting at which this Report is due for presentation.

MEETINGS OF THE INSTITUTE.

The Annual General Meeting in London on March 8 and 9, 1935, was preceded on March 7 by a Joint Meeting with several other institutions to discuss the subject of "Cold-Pressing and Drawing." The usual Annual Dinner and Dance was held on March 8, and a visit was paid to the Battersea Power Station on March 9.

The May Lecture was delivered in London, on May 8, by Professor W. L. Bragg, F.R.S., on "Atomic Arrangements in Metals and Alloys."

Newcastle-upon-Tyne was the scene of a successful Autumn Meeting from September 9 to 12. This was the Institute's first visit to Newcastle since 1911. The Autumn Lecture was given by Dr. H. W. Brownsdon on "Metal Melting—Its Effect on Quality," and was followed by a general discussion of the subject in which various aspects were dealt with by different authorities. After the discussion of papers on the two following days members visited works and other places of interest in and around Newcastle.

A visit took place on September 19 to the Shipbuilding and Engineering Exhibition at Olympia, where members were entertained to tea by the courtesy of the Exhibition Managers.

PUBLICATIONS.

The past year saw the issue of a familiar Institute publication in a new guise. *Metallurgical Abstracts*, published under this title since January 1931 and issued monthly in the Institute's *Monthly Journal*, was bound as a part of the *Journal* series prior to 1934. The Abstracts volumes are now quite independent of the half-yearly *Journal* and have their own volume numbering. The bound Volume 1 (1934) of *Metallurgical Abstracts* was issued to members in 1935; Volume 2 is in course of completion. Members should find it an advantage to have on their shelves the Abstracts volumes in a form that at once differentiates them from the *Journal* volumes.

The *Monthly Journal* during 1935 has contained, in addition to the *Metallurgical Abstracts* supplement, all the papers accepted by the Institute, lectures, addresses, news of the Local Sections, and Letters to the Editor, as well as official announcements and editorial matter dealing with the activities of the Institute, and lists of meetings of other societies. Members are invited to make greater use of the *Monthly Journal* for discussing matters of common interest in the Correspondence columns. Two volumes of the *Journal*, Vols. LVI and LVII, were issued as usual during the year.

A change in the practice of presenting papers offered to the Institute was made during the year. Previously every paper accepted was formally presented at a General Meeting, being either discussed or taken as read. After the September Meeting the Council announced that, in future, papers would be accepted for publication in the *Journal* and not necessarily for presentation at any meeting. Papers for presentation and oral discussion at a meeting will be selected, as on the occasion of the meeting at which this report is presented, from those previously published in the *Monthly Journal*. The first papers to be issued under the new arrangement were those contained in the October issue of the *Monthly Journal*. Written discussion is still invited on all papers published.

An important decision of the past year is intended to widen the field covered

Report of Council

by papers published in the *Journal*. Although the Council has always been glad to receive papers of all classes that would, to quote the Memorandum of Association, "promote the science and practice of non-ferrous metallurgy in all its branches," most of the papers presented have reported the results of original research. Whilst it is intended that this class of matter shall still form the greater part of the *Journal*, the Council desires to encourage, in addition, papers covering a wider field and will be glad, therefore, to consider for publication papers in any of the following classes :

- (a) Papers recording the results of original research ;
- (b) First-class reviews of, or accounts of, progress in a particular field ;
- (c) Papers descriptive of works' methods, or recent developments in metallurgical plant and practice.

For the convenience of members attending the Institute's General Meetings, the Council authorized the supply of loose prints of papers published in the *Monthly Journal*. This service, the existence of which does not appear to be widely known, is available at a cost of 5s. per annum.

The preparation was actively continued of a General Index to the *Journal* and *Metallurgical Abstracts*, Vol. XXVI (1921) to Vol. LV (1934), on the receipt of a first indication from members that about 400 copies would be required. It is expected that 1000 copies will be sold at the advance subscription price of 25s. for two volumes: Names Index and Subject Index, though either volume can be purchased separately at 15s. The Names Index is expected to be ready for issue in the spring of 1936.

LOCAL SECTIONS.

Meetings were held during the winter months by each of the six Local Sections of the Institute. A list of the papers read is included in an Appendix to this Report. The Scottish Local Section varied its programme by including an evening works' visit, which was well attended.

The second Supper-Dance took place at Thames House, Millbank, London, S.W.1, on November 27, this being arranged jointly by the London Local Section and the Institute of Metals. The function was again well attended by members and friends, and is likely to become an annual gathering.

The Council entered into an arrangement with the Council of the Manchester Metallurgical Society whereby all members of the Institute resident in Lancashire and Cheshire have the privilege of joining the society (subject to the approval of its Committee), without the payment of further subscription, the Institute paying the current subscription for each such member. The new arrangement came into force at the beginning of the session 1935-1936. As a result, the programme of the Manchester Metallurgical Society was printed with the programmes of the Institute's six Local Sections in the green folder issued to all British members in September, and synopses of the Manchester Society's papers appear in the Institute's *Monthly Journal*.

LIBRARY.

In the past year 109 text-books have been added to the Library and more than 2000 books and periodicals have been borrowed by members. The number of personal visits paid to the Library since February, when a record was first begun, was 224, a total that includes visitors from the United States, France, Germany, Australia, Egypt, India, and Japan. As in previous years, the services of the Science Library at South Kensington have been largely utilized, and the Council desires to thank the Director, Brigadier C. E. B. Mackintosh, D.S.O., R.E., and his staff for their valuable assistance.

Report of Council

There has been a tendency for members to make more use of the photostat service than formerly. Photostat copies can be obtained at a moderate cost and are particularly valuable to overseas members. The conditions on which they can be supplied are set out in the *Journal*, Vol. XLII, p. 387.

Authors of books, papers, or technical articles of direct or indirect interest to the science or practice of non-ferrous metallurgy are invited by the Council to forward copies to the Institute where they will be of service both in the Library and in the preparation of abstracts.

EDUCATIONAL TOUR.

Following the success of the Institute's first Educational Tour to Belgium in 1934, the Council arranged in the spring of 1935 a similar journey to Germany for the benefit of student members. A party numbering 40 left London on April 6, returning on April 15, after a very profitable stay in the Rhineland. German members of the Institute were exceedingly kind to the young men, throwing their works and institutions open to inspection, and offering generous hospitality.

THE SILVER JUBILEE OF KING GEORGE V.

The Council co-operated, in conjunction with other scientific institutions, in the preparation and presentation of an Address of Congratulation to His Majesty on the occasion of the Silver Jubilee of his Accession to the Throne. A reply was received stating that "His Majesty much appreciates this expression of loyalty and devotion in which the President, Officers, and Members of the Institute of Metals have joined."

COMMITTEES.

The following Committees were appointed for the year 1935-1936 :

Finance and General Purposes Committee.

Barclay, W. R.
Charles, Lieut.-General Sir Ronald.
Clarke, H. W.
Dixon, Engineer Vice-Admiral Sir Robert (*Chair*).
Lancaster, H. C.
Morcom, E. L. (*Vice-Chairman*).
Munday, A. H.
Preston, The Hon. R. M.
Smout, A. J. G.
Turner, Professor T.

Ex-officio :

The President.
Ex-President.
Hon. Treasurer.
Chairman, Publication Committee.

Local Sections Committee.

Andrew, Professor J. H.
Barclay, W. R. (*Chair*).
Brownsdon, Dr. H. W.
Gray, Kenneth.
Greer, H. H. A.
Griffiths, W. T.

Hanson, Professor D.
Haughton, Dr. J. L.
Munday, A. H.
Thompson, Professor F. C.

Ex-officio :

The President.
Ex-President.
Hon. Treasurer.
Local Reception Committee's Representative.
Chairman and Secretary of :
Birmingham Local Section.
London Local Section.
North-East Coast Local Section.
Scottish Local Section.
Sheffield Local Section.
Swansea Local Section.

Meeting: Committee.

Andrew, Professor J. H.
Barclay, W. R.
Brownsdon, Dr. H. W. (*Chair*).
Gwyer, Dr. A. G. C.
Hanson, Professor D.
Haughton, Dr. J. L.
Weeks, H. B.

Report of Council

Ex-officio :

The President.
Chairman, Publication Committee.

Membership Committee.

Andrew, Professor J. H.
Barclay, W. R. (*Chair*).
Brown, Engineer Vice-Admiral Sir
Harold A.
Charles, Lieut.-General Sir Ronald.
Genders, Dr. R.
Gray, Kenneth.
Lancaster, H. C.
Morcom, E. L.
Mundey, A. H.
Seligman, Dr. R.
Weeks, H. B.

Ex-officio :

The President.
Local Sections' Committee Representative.

Publication Committee.

Brownsdon, Dr. H. W.
Desch, Dr. C. H.
Genders, Dr. R.
Gwyer, Dr. A. G. C.
Hanson, Professor D.
Haughton, Dr. J. L.
Hutton, Professor R. S.
Murphy, A. J.
Seligman, Dr. R.
Smith, Dr. S. W.
Smithells, Dr. C. J. (*Chair*).
Sutton, H.
Thompson, Professor F. C.
Turner, Professor T.

Ex-officio :

The President.
Chairman, Finance and General Purposes Committee.

In addition to the above, several special committees and sub-committees were appointed to deal with matters of occasional importance.

REPRESENTATIVES.

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

AMERICAN SOCIETY FOR TESTING MATERIALS (Committee on Die-Cast Metals and Alloys): Mr. A. H. Mundey.

ASSOCIATION OF SCIENTIFIC AND TECHNICAL INSTITUTIONS: Dr. Richard Seligman.

BRITISH NON-FERROUS METALS RESEARCH ASSOCIATION SPECIAL RESEARCH SUB-COMMITTEE (Institute of Metals Corrosion Committee): Professor Sir Harold Carpenter, Dr. Richard Seligman, and Mr. H. B. Weeks.

BRITISH STANDARDS INSTITUTION (Technical Committee IS/8, Creep Properties): Dr. C. H. Desch.

BRITISH STANDARDS INSTITUTION (Non-Ferrous Metallurgy Industry Committee): Sir Henry Fowler, Dr. H. Moore, Dr. Richard Seligman, Mr. H. B. Weeks, and Mr. G. Shaw Scott.

BRITISH STANDARDS INSTITUTION, TECHNICAL COMMITTEE (Standardization of Lead Alloys for Cable-Sheathing): Mr. H. C. Lancaster.

BRITISH STANDARDS INSTITUTION (Standardization of Plated Finishes for Fittings and Equipment): Professor R. S. Hutton.

BRITISH STANDARDS INSTITUTION (Standardization of Silver Deposits): Professor R. S. Hutton.

BRITISH STANDARDS INSTITUTION (Technical Committee AC/16, Copper Alloys): Mr. F. Tomlinson.

CHEMICAL ENGINEERING CONFERENCE, 1935: Dr. Richard Seligman.

CITY AND GUILDS INSTITUTE (Advisory Committee on Metallurgy): Professor T. Turner.

CONFERENCE FOR THE STUDY OF MATERIALS OF CONSTRUCTION AND THEIR TESTING: Mr. W. R. Barclay and Dr. H. Moore.

CONGRESS OF INDUSTRIAL CHEMISTRY, BRUSSELS, 1935: Dr. Richard Seligman.

Report of Council

CONSTANTINE TECHNICAL COLLEGE, MIDDLESBROUGH (Foundry Advisory Committee): Professor J. H. Andrew and Mr. G. Mortimer.

INTERNATIONAL CONGRESS OF MINING, METALLURGY, AND APPLIED GEOLOGY, 1935: Dr. H. Moore and Dr. Richard Seligman.

MANCHESTER METALLURGICAL SOCIETY: Professor F. C. Thompson.

NORTH-EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS JUBILEE CELEBRATIONS: Dr. H. Moore.

PARLIAMENTARY SCIENCE COMMITTEE: Dr. H. Moore and Mr. G. Shaw Scott.

PROFESSIONAL CLASSES AID COUNCIL: Mr. H. B. Weeks.

CORRESPONDING MEMBERS TO THE COUNCIL.

The Council again desires to 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 (*Sweden*); Professor P. A. J. Chevenard (*France*); Mr. W. M. Corse, S.B. (*United States of America*); Professor J. Neill Greenwood (*Australia*); Dr.-Ing. Max Haas (*Germany*); Mr. J. Hamburger, Jazn. (*Holland*); Professor Dr. E. Honegger (*Switzerland*); Mr. R. Mather, B.Met. (*India*); Dott. C. Sonnino (*Italy*); Professor G. H. Stanley, D.Sc., A.R.S.M. (*South Africa*); Professor A. Stansfield, D.Sc., A.R.S.M., F.R.S.C. (*Canada*); and Professor K. Tawara, D.Eng. (*Japan*).

Signed on behalf of the Council,

H. MOORE, *President.*

W. R. BARCLAY, *Vice-President.*

January 16, 1936.

APPENDIX.

LOCAL SECTIONS' PROGRAMMES, 1935-1936.

BIRMINGHAM LOCAL SECTION.

Chairman: M. COOK, Ph.D., M.Sc. *Hon. Secretary*: J. W. JENKIN, Ph.D., B.Sc., Messrs. Bromford Tube Company, Ltd., Erdington, Birmingham.

1935.

PROGRAMME.

- Oct. 3. Professor J. H. ANDREW, D.Sc. "Gaseous and Solid Impurities in Ingots."
Oct. 24. FRANCIS W. ROWE, B.Sc. "The Production and Control of Bronze Castings."
Nov. 7. Open Discussion: "The Hot Rolling of Sheets."
Dec. 5. Joint Meeting with the LOCAL SECTION OF THE INSTITUTE OF PHYSICS.
Dec. 17. CHRISTOPHER E. MOORE. "Recent Developments in Refractories." 1936.
Jan. 2. J. W. JENKIN, Ph.D., B.Sc. "Some Aspects of a Study of Steel Tubes."
Jan. 14. HAROLD G. WARRINGTON. "Light Alloys."
Jan. 30. E. J. DOBBS. "The Polishing of Metals."
Feb. 21. Open Discussion: "The Fabrication of Metal Structures."
Mar. 5. F. T. LONGMAN. "Methods of Analysis for Impurities in Copper, &c."
Mar. 17. Professor D. HANSON, D.Sc. "Recent Developments in Metallurgy."

Report of Council

- Mar. 31. MAURICE COOK, Ph.D., M.Sc. Chairman's Address: ANNUAL MEETING.
- Apr. 2. A. H. MUNDEY. "Recent Developments in the Casting of High-Strength Zinc-Base Alloys."

All meetings will be held in the James Watt Memorial Institute, Birmingham, at 7 P.M.

LONDON LOCAL SECTION.

Chairman: C. J. SMITHELLS, M.C., D.Sc. Hon. Secretary: S. V. WILLIAMS, B.Sc. Research Laboratories of the General Electric Co., Ltd., Wembley, Middlesex.

1935. PROGRAMME.

- Oct. 10. C. J. SMITHELLS, M.C., D.Sc. Chairman's Address: "Gases and Metals."
- Nov. 7. E. N. DA C. ANDRADE, D.Sc., Ph.D. "The Ultimate Strength of Metals." (Meeting held at the Royal School of Mines, South Kensington, S.W.7, at 8 P.M.)
- Nov. 27. Supper-Dance. (Thames House, Millbank, 7.30 P.M.)
- Dec. 12. N. D. G. ROBERTSON. "Die-Casting of Non-Ferrous Alloys." (Joint Meeting with the London Branch of the Institute of British Foundrymen.)

1936.

- Jan. 9. R. H. ATKINSON, M.A. "Metals of the Platinum Group."
- Feb. 6. H. W. CREMER, M.Sc. "The Applications of Metals in Chemical Engineering."
- Mar. 5. G. S. W. MARLOW, B.Sc. "Patent Law—With Special Reference to Non-Ferrous Metals."
- Apr. 2. 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, London, S.W.1 (unless otherwise stated), at 7.30 P.M.

MANCHESTER METALLURGICAL SOCIETY

(in association with the Institute of Metals).

President: L. E. BENSON, M.Sc. Hon. Secretary: J. A. TOD, B.Sc., Messrs. The Broughton Copper Co., Ltd., Manchester.

1935. PROGRAMME.

- Oct. 16. L. E. BENSON, M.Sc. Presidential Address.
- Nov. 6. Joint Meeting with the INSTITUTE OF METALS.
- Dec. 4. J. G. DOCHERTY, D.Sc. "Notch Brittleness in Metals."

1936.

- Jan. 15. J. H. G. MONYPENNY. "Recent Developments in Alloy Steels."
- Feb. 5. Major F. A. FREETH, O.B.E., Ph.D., D.Sc., F.R.S. "Trends of Metallurgical Developments."
- Feb. 19. N. L. EVANS, B.Sc. "Refining of Metals by Sodium Carbonate." (Meeting held in the Manchester College of Technology.)
- Mar. 4. S. F. DOREY, D.Sc., Wh.Ex. "Fusion-Welded Pressure Vessels."
- Mar. 18. Open Discussion led by R. W. COLBECK, M.A. "Materials and Maintenance of Lifting Gear." Preceded by ANNUAL MEETING.

The Meetings are held in the Engineers' Club, Albert Square, Manchester (unless otherwise stated), at 7 P.M.

Report of Council

NORTH-EAST COAST LOCAL SECTION.

Chairman : S. G. HOMFRAY, B.A. Hon. Secretary : C. E. PEARSON,
M.Met., Armstrong College, New-
castle-upon-Tyne, 2.

1935.

PROGRAMME.

- Nov. 12. STANLEY ROBSON, M.Sc. "The Manufacture of Zinc." (Joint Meeting with Newcastle branches of Society of Chemical Industry and Institute of Chemistry.)
Dec. 10. J. C. CHASTON, B.Sc., A.R.S.M. "The Manufacture and Uses of Powdered Metals."

1936.

- Jan. 14. J. WILLIS BEARD. "Hot Pressings in Brass and other Metals."
Feb. 11. W. T. GRIFFITHS, M.Sc. "Some Recent Developments in the Improvement of Non-Ferrous Alloys by Heat-Treatment."
Mar. 17. S. G. HOMFRAY, B.A., and R. A. BALDERSTON. "Foundry Costing." (Joint Meeting with the Newcastle Branch of the Institute of British Foundrymen.)
Apl. 7. Demonstration of High-Frequency Induction Furnace. ANNUAL GENERAL MEETING.

The Meetings are held in the Electrical Engineering Lecture Theatre, Armstrong College, Newcastle-upon-Tyne, at 7.30 P.M.

SCOTTISH LOCAL SECTION.

Chairman : J. W. DONALDSON, Hon. Secretary : H. BULL, Messrs.
D.Sc. Bull's Metal & Melloid Co., Ltd.,
Yoker, Glasgow.

1935.

PROGRAMME.

- Oct. 14. Works' Visit. Messrs. Henry Wiggin & Co., Ltd., Zenith Works, Thornliebank, Glasgow.
Nov. 11. J. W. DONALDSON, D.Sc. Chairman's Address.
Dec. 16. J. E. HURST. "The Addition of Non-Ferrous Metals to Cast Iron."

1936.

- Jan. 13. Capt. L. W. JOHNSON, M.C., M.Met. "Fatigue in Relation to Automobile Engineering." (Joint Meeting with the Institution of Automobile Engineers, Scottish Centre.)
Feb. 10. F. HUDSON. "Corrosion of Metals by Industrial Waters."
Mar. 9. FRANCIS W. ROWE, B.Sc. "The Centrifugal Casting of Non-Ferrous Metals."

All Meetings, except opening meeting, 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 : KENNETH GRAY. Hon. Secretary : H. P. GADSBY,
Assoc.Met., 193 Sandford Grove
Road, Sheffield, 7.

1935.

PROGRAMME.

- Nov. 8. E. A. SMITH, A.R.S.M. "Rolled Gold and Its Industrial Applications."
Dec. 13. A. W. HOTHERSALL, M.Sc.Tech. "The Adhesion of Electro-deposited Nickel."

Report of Council

1936.

- Jan. 17. C. J. SMITHELLS, M.C., D.Sc. "Diffusion of Gases through Metals."
Feb. 14. R. S. HILL. "Engine-Turning and Enamelling."
Mar. 13. ANNUAL GENERAL MEETING.

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 : ROOSEVELT GRIFFITHS, M.Sc. *Hon. Secretary and Treasurer* : A. E. W. SMITH, Ph.D., Metallurgical Department, University College, Singleton Park, Swansea.

1935.

PROGRAMME.

- Nov. 12. ROOSEVELT GRIFFITHS, M.Sc. Chairman's Address.
Dec. 10. L. C. PERCIVAL, B.Sc. "Welding."

1936.

- Jan. 21. A. L. NORBURY, D.Sc. "Modification of Alloys."
Feb. 11. J. H. G. MONYPENNY. "Some Modern Developments in Stainless Steels."
Mar. 17. A. J. MURPHY, M.Sc. "Metallurgical Control and the Bronze Foundry." ANNUAL GENERAL MEETING.

All Meetings are held at the Y.M.C.A., Swansea, at 6.30 P.M.

Report of Council

REPORT OF THE HONORARY TREASURER

(MR. JOHN FRY)

For the Financial Year ended June 30, 1935.

After passing through three or four difficult years it is encouraging to be able to report to members a definite improvement in the finances of the Institute. There has been an increase in income of £101 and a saving in expenditure of £424, the total improvement being £525 as compared with last year, which, I trust, means that we are leaving further behind us the depression which had such an adverse effect on the Institute and its finances.

The Council is greatly indebted to the Publication Committee for the way in which it has assisted in re-establishing the Institute's finances on a more satisfactory basis.

The chief factors which have contributed towards the improved position are an increase in subscriptions of £79 and a saving of £378 in the *Journal* Account, together with minor economies in many of the domestic expenses, mostly too small to require reference in this Report. The saving on the *Journal* has been effected principally as a result of publishing less matter than was provided for in the annual allotment to the Publication Committee. In the hope that more money will be available for publications in future the Council has allocated a considerably higher amount for the year 1935-1936 than was spent in 1934-1935.

The advertisement revenue is showing a steady increase and should be helpful to the Institute's finances in the near future.

In his letter to the Council the Auditor writes: "In my opinion the whole crux of the financial success of the Institute depends on a steady annual increase in the subscription income and every effort should be made to that end." The Council, too, feels that this is the right method of improving our finances. A considerable increase in the Institute's membership would entail only a very slight increase in the cost of the Institute's publications and other services, whilst the resulting extra revenue would enable the Institute to give still better value to members in exchange for their subscriptions and would permit of reserves being increased.

Entrance Fees amounting to over £231 have again been funded and carried direct to the Balance Sheet. This fund now stands at £1,770 5s. 5d. To-day there is also a hidden reserve in our investment in War Loan of about £300. Owing to the present method of dealing with Entrance Fees and the fact that the valuable stock of *Journals* is standing in the accounts at £1, and with an improving income and expenditure account, the finances of the Institute are, I feel, again in a more satisfactory position. It is advisable, however, for more reserves to be created, as and when the opportunities occur, so that, should we again meet difficult times, the Institute may be in a stronger position to weather the storm.

Report of Council

INCOME AND EXPENDITURE ACCOUNT FOR THE YEAR ENDED JUNE 30, 1935.

	30.6.1934.		30.6.1934.		30.6.1934.
	£	s.	d.	£	s.
To Salaries	2,103	115	0	2,115	0
" Wages and National Insurance	936	964	16	964	16
" <i>Journal</i> Account	1,607	829	7	1,221	9
" Rent, Telephone, Lighting, and Insurance	828	211	5	9	9
" Printing and Stationery	170	153	18	1	5
" Postages, Travelling and Sundry Expenses	410	375	4	2	2
" Library Expenses	74	67	15	8	8
" Subscriptions and Grants to Local Sections	148	162	18	6	6
" Expenses of Meetings	95	91	9	10	10
" Repairs and Renewals	41	20	8	5	5
" Bank Charges	13	7	17	10	10
" Audit Fee	56	26	5	0	0
" Excess of Income over Expenditure		165	17	3	3
	£6,451	192	3	192	3

JOURNAL ACCOUNT FOR THE YEAR ENDED JUNE 30, 1935.

	£	s.	d.	£	s.	d.
To Stock of <i>Journals</i> at June 30, 1934.						
" Cost of Production and Abstracts	3,547	0	10	1,063	2	1
" Fees, Payments made during year	867	772	19	2	1	576
" Amounts owing at June 30, 1935				74	6	3
	4,414	5,870	19	1,137	8	4
Less Amount owing at June 30, 1934	1,144	806	17	75	9	2
	3,270	3,004	2	1,061	19	2
		£3,005	2	£3,071	2	7

"HOUSE FUND" ACCOUNT FOR THE YEAR ENDED JUNE 30, 1935.

£	35	To Rent paid to the Institute of Metals	£	s.	d.
	1,050	" Balance as at June 30, 1935		35	0
				1,049	19
				8	8
	£1,085			£1,084	19

THE WOODHOUSE BENEVOLENT FUND

£13	By Balance at June 30, 1935	£13	s.	d.
			8	6

THE SILVER JUBILEE FUND

£672	By Balance at June 30, 1935	£672	s.	d.
			5	0



Report of Council

THE INSTITUTE OF METALS BALANCE SHEET AS AT JUNE 30, 1935.

LIABILITIES.		ASSETS.	
£	s. d.	£	s. d.
30.6.1934.		30.6.1934.	
Creditors:		Office Furniture:	
121	111 5 4	Balance at June 30, 1934	200 0 0
567	789 12 1	<i>Library Books, etc.</i>	100 0 0
772	796 14 7	Balance at June 30, 1934	16 16 0
1,760	1,697 12 0	<i>For Entrance Fees</i>	387 5 0
Cash:		<i>Journal Accounts (Sales and Ad- vertisements)</i>	272 6 3
558	157 1 4	<i>Less Reserve for Doubtful Subscrip- tions</i>	676 7 3
5	4 12 6	148 1 0	528 6 3
553	152 8 10	Stock of Journals:	
543	14 15 11	At Nominal Valuation	1 0 0
1,314	1,538 8 7	Investments:	4,410 14 10
224	231 16 10	£438 16s. 8d. 31% War Loan at Cost	13 8 6
1,538	1,770 5 5	<i>Woodhouse Fund:</i>	1,049 19 8
Industrial Fund Subscriptions Account:		Balance at Lloyds Bank	5 0 7
Contributions during year		<i>House Fund:</i>	1,049 19 8
Woodhouse Fund:		Balance at June 30, 1935	672 5 0
73	21 0 0	Balance at June 30, 1935	1,447 13 0
1,050	13 8 6	<i>Excess of Assets over Liabilities:</i>	165 17 3
672	1,049 19 8	Balance at June 30, 1934	1,613 10 9
Excess of Assets over Liabilities:		Balance at June 30, 1934	£6,975 14 3
1,808	1,447 13 0	442 Excess of Income over Expendi- ture for the year to June 30, 1935	£7,024
360	165 17 3	Balance at June 30, 1935	£6,975 14 2
1,448	1,613 10 9		
£7,024	£6,975 14 3		

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, 1935, according to the best of our information and from the explanations given to us and as shown by the books of the Institute.

December 24, 1935.

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

THE CONSTITUTION OF THE TIN-RICH ANTIMONY-TIN ALLOYS.*

By PROFESSOR D. HANSON,† D.Sc. (VICE-PRESIDENT), and W. T. PELL-WALPOLE,‡ B.Sc. (STUDENT MEMBER).

SYNOPSIS.

The constitution of the tin-rich alloys of the system antimony-tin was investigated by means of thermal analysis, microscopical examination, and electrical resistivity measurements. The liquidus and solidus of the tin-rich phase and the temperature of the peritectic reaction are in general agreement with the results obtained by Iwasé, Aoki, and Ōsawa. The solubility of antimony in tin is shown to decrease from 10.5 per cent. at 246° C. to 3.5 per cent. at 100° C.

PREVIOUS WORK.

THE system antimony-tin has been studied by many investigators, who are in general agreement that the liquidus consists of three branches corresponding to the separation of three solid solutions, though their results differ considerably in detail. The earliest diagrams include those determined by Reinders,¹ Stead,² Gallagher,³ and Williams.⁴ Gallagher³ employed thermal and microscopical methods; according to his diagram three peritectic horizontals exist at 430°, 319°, and 243° C., but that at 319° C. is not accompanied by a change of slope of the liquidus, and is attributed to a polymorphic transformation in the intermediate phase which is formed by the peritectic reaction at 430° C. Williams found two peritectics only, at 420° and 243° C., and considered that the phase formed at 420° C. is the intermetallic compound SbSn.

Konstantinow and Smirnow⁶ measured the electrical resistance and its temperature coefficient for these alloys, and found two breaks corresponding to the compounds SbSn and Sb_2Sn_3 . Guertler⁵ considered that Sb_2Sn_3 is formed at the peritectic reaction at 319° C.

All of these workers give the solubility of antimony in tin as 8-10 per cent., but none of them carried out a detailed investigation of this part of the system.

Gurevitch and Hromatko⁷ determined the liquidus curve for alloys

* Manuscript received December 20, 1935.

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‡ Research Student, Metallurgy Department, 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. LVIII, 1936. Reference should accordingly be as follows: *J. Inst. Metals*, 1936, 58 (Advance copy).

containing 0.05–10 per cent. antimony in tin (Fig. 1). The slight decrease of the freezing point of tin to 231.5°C . by addition of 0.1 per cent. antimony had not been noted in any previous work and, as Cowan ⁷ (in a discussion) pointed out, if such a eutectic does exist, the eutectic arrest would have been recorded on the cooling curves of the other alloys examined. The arrest point for the 10 per cent. alloy given as 246°C . is probably not due to the liquidus arrest but to the peritectic reaction.

Broniewski and Sliwowski ⁸ found the limit of lowest branch of the liquidus at 6 per cent. of antimony at 247°C .; the solid solubility

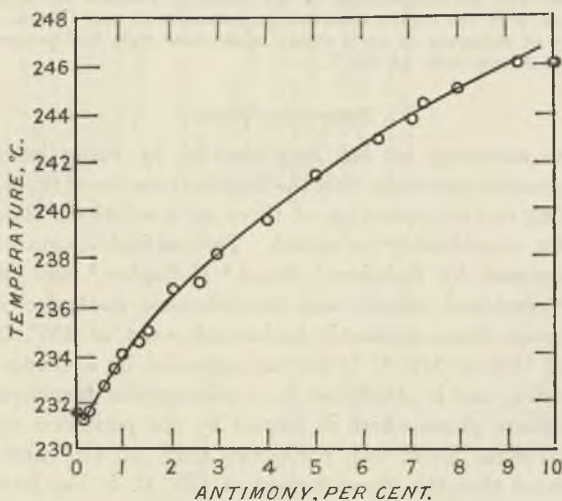


FIG. 1.—Liquidus Curve. (Gurevitch and Hromatko.)

of antimony in tin is stated to be 14 per cent. at 247°C ., decreasing to 8 per cent. at room temperature. They considered that the cubic phase is a solid solution of antimony in the compound Sb_2Sn_3 .

Bowen and Morris-Jones ⁹ measured the lattice-parameters of a series of these alloys, and showed that at room temperatures there is only one intermediate phase, the compound SbSn , capable of dissolving 6 per cent. of tin or 4 per cent. of antimony. They stated that the saturated tin-rich solid solution contains 9 per cent. of antimony at room temperature.

The most recent investigation of the whole system was carried out by Iwasé, Aoki, and Ôsawa,¹⁰ whose diagram is given in Fig. 2. They found that the peritectic reaction $\text{SbSn} + \text{liquid} \rightarrow \alpha$ occurs at 246°C ., and that the solubility of antimony in tin at 220°C . is 8 per cent.

The Constitution of Tin-Rich Antimony-Tin Alloys

They considered that the transition at 320°–325° C. is a polymorphic transformation in the β (SbSn) phase.

EXPERIMENTAL WORK.

(1) Preparation of Alloys.

The materials used in this research were Chempur tin (99.992 per cent. purity) and pure antimony (99.7 per cent.).

A temper alloy containing 50 per cent. of antimony, and approximating to the composition of the brittle SbSn phase, was prepared by adding antimony in small pieces to molten tin which was maintained

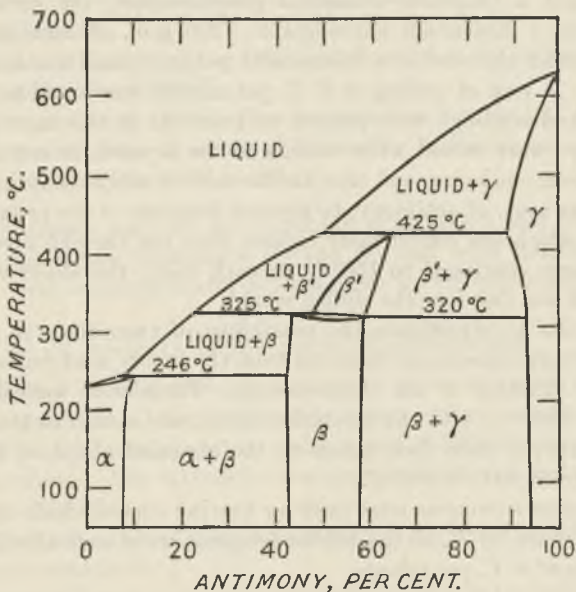


FIG. 2.—Antimony-Tin System. (Iwasé, Aoki, and Ôsawa.)

at 600° C. under a covering of charcoal. The antimony floats on the molten tin, so that vigorous stirring is necessary to effect solution without appreciable loss by oxidation.

Alloys containing 2–14 per cent. antimony were prepared by melting the tin under charcoal and adding the temper alloy, which dissolves quite rapidly at 300° C. The alloys were chill-cast into a $\frac{1}{2}$ -in. diameter cylindrical chill mould which was previously heated to 100° C.

The compositions of the temper alloy and of several experimental alloys were checked by chemical analysis. The results are shown in Table I.

Hanson and Pell-Walpole :

TABLE I.—*Analyses of Selected Alloys.*

Intended Composition, Antimony, Per Cent.	Analysis, Antimony, Per Cent.	
	50 (temper alloy)	49.8
10	9.89	9.91
4	4.05	4.08
8	7.9	7.95

(2) *Thermal Analysis.*

Inverse-rate cooling curves were taken, using an iron-Constantan couple and a Carpenter-Stansfield potentiometer, the curves being plotted on a Rosenhain chronograph. 200 gm. of each alloy were melted under charcoal in a Salamander pot in a small vertical electric furnace. A rate of cooling of 2° C. per minute was found to be satisfactory and readings were plotted at intervals of 0.5 m.v. (0.9° C.). The alloys were stirred while cooling to the liquidus to reduce undercooling to a minimum, and also, in the case of alloys containing more than 9 per cent. of antimony, to prevent flotation of the primary SbSn crystals which are considerably lighter than the tin-rich liquid. The curves were continued to 150° C. in each case; the alloys were then re-melted and cast into the chilled mould.

In order to investigate the possibility of transitions in the solid alloys, 30 gm. specimens were cut from the ingots, and drilled to take the bare junction of the thermocouple. These were annealed for 4 weeks at 190° C., with thermostatic control, and cooled in the furnace. Cooling curves were then taken on the annealed alloys at 2° C. per minute, from 200° to 100° C.

The same specimens were used for heating curves which were taken similarly, from 50° C. to the solidus temperature of each alloy, at a rate of heating of 4° C. per minute.

(3) *Microscopical Analysis.*

The alloys were prepared for microscopical examination by the methods developed by the authors for cadmium-tin alloys, described in a previous paper.¹¹

Several etching reagents were tried, but those which earlier workers had used for these alloys, including hydrochloric acid and acidified ferric chloride, were found to be unsatisfactory for detailed examination of the tin-rich matrix. The authors found that a 2 per cent. solution of nitric acid in alcohol gave the best results. This reagent deposits a smooth dark coating on the tin-rich solid solution, leaving the SbSn phase white whether it is present as the primary cuboids or in a finely

The Constitution of Tin-Rich Antimony-Tin Alloys

dispersed state as precipitated from solid solution. Hydrochloric acid has a similar effect, but attacks the matrix so vigorously that the fine precipitate is not easily discernible. The deposit produced by the alcoholic nitric acid etch tends to hide the grain boundaries of the tin-rich phase; these are revealed if the etched specimen is rubbed lightly on Selvyt cloth so as to reduce the intensity of the deposit, but this reduces the contrast between the two phases.

Traces of a hard blue-grey constituent were found in several alloys, but these were attributed to the presence of an insoluble impurity in the antimony, probably a sulphide.

Alloys were examined after the following treatments :

- (1) As chill-cast ;
- (2) Annealed for 4 weeks at 190° C. and cooled in the furnace ;
- (3) Quenched from 190° C. ;
- (4) Quenched from 190° C., then tempered for 1 hr. at 100° C. ;
- (5) Quenched from a series of increasing temperatures at 5° C. intervals from 190° to 245° C.

The specimens used for all quenching experiments had previously undergone treatments (1) and (2), and were maintained at each temperature for at least 8 hrs. before quenching.

ELECTRICAL CONDUCTIVITY MEASUREMENTS.

Specimens 1 in. long were taken from the chill-cast ingots, the outer skin was removed in a lathe, and each specimen was extruded at 200° C. through a die 0.1 in. in diameter, under a load of 3500 kg. on an Avery Brinell machine. The extruded wires were straightened and annealed for 14 days at 200° C.

The resistivity of each alloy was measured against a similar wire of pure tin as a standard.

A current of 1 amp. was passed through the alloy to be measured and through the standard in series. The decrease in potential over a length of 10 cm. in each case, was measured on a Carpenter-Stansfield potentiometer. The direction of the current in the series circuit was then reversed and measurements were repeated.

The value $\frac{P_x}{P_s}$ (where P_x , P_s represent the decrease in potential over equal lengths of an alloy and the standard, respectively) was plotted against composition, but it was found to be necessary to make corrections for the slight variations in the diameters of the wires.

Measurements were carried out (at 18° C.) after the following heat-treatments :

Hanson and Pell-Walpole :

- (1) All specimens were annealed for 14 days at 200° C., cooled in the furnace, then tempered at 100° C., and quenched ;
- (2) Quenched from 190° C. ;
- (3) Measurements carried out at 190° C., $\pm 1^\circ$ C. in an oil-bath ;
- (4) Quenched from 214° C. ;
- (5) Quenched from 235° C.

Specimens were annealed for at least 1 day at each temperature before quenching. After quenching from 235° C., it was found that alloys containing less than 5 per cent. of antimony had been partly or completely liquid at that temperature.

RESULTS OF THERMAL ANALYSIS.

The first series of cooling curves, taken over the freezing range, gave single arrests only for alloys containing 9 per cent. antimony or less. These points represent the liquidus of the tin-rich phase and agree quite well with Gurevitch's results for the same alloys. At 9 per cent. antimony and 246° C., there is a marked inflection in the liquidus curve (Fig. 3) which becomes much steeper, corresponding to the separation of primary δ (cuboid) phase, and alloys along this branch of the liquidus curve give a second arrest at 246° C., corresponding to the peritectic reaction between the liquid and the cuboid phase.

The cooling curves for annealed solid alloys gave no arrests at any composition. The results of heating curves for annealed alloys give a smooth curve for the solidus of the tin alloys up to 9 per cent. of antimony, the freezing range being very narrow (Fig. 3). Alloys containing 10–14 per cent. of antimony give arrests at 241°–242° C., whereas cooling curves gave arrests at 246° C. The authors believe that 246° C. is the true temperature of the transition, and an explanation of the low figures obtained on heating curves is advanced later.

MICROSTRUCTURES.

Chill-cast alloys containing up to 4 per cent. of antimony consist of the primary tin-rich phase showing coring (Fig. 4, Plate I). Alloys with 4–10 per cent. of antimony contain, in addition to the primary cored α phase (tin-rich), increasing amounts of a fine precipitate which appears white in an etched section (Figs. 5 and 6, Plate I). With 10 per cent. or more of antimony the primary separation is the cuboid phase, surrounded in each case by cored α with traces of the white precipitate. The precipitate is very similar in appearance to the cuboids and is the same or a very similar phase (Fig. 7, Plate I).

Annealing at 190° C. causes the coring to disappear completely after about 14 days, but the white precipitate increases in quantity

AS CHILL-CAST, ETCHED 2% HNO_3 IN ALCOHOL.

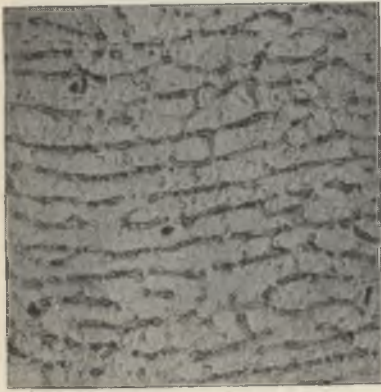


FIG. 4.—2% Antimony. Cored α .
 $\times 250$.

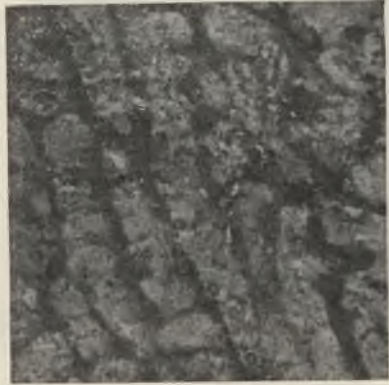


FIG. 5.—4% Antimony. Precipitate of δ
 (white) in Cored Primary α . $\times 1000$.

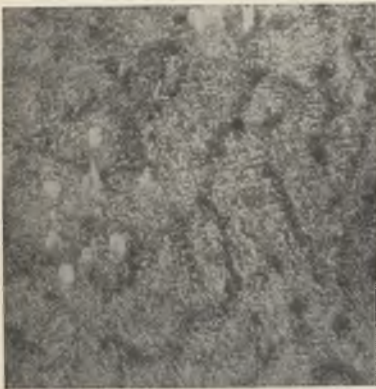


FIG. 6.—10% Antimony. Remains of
 Primary δ (light) in Cored α with
 δ Precipitate. $\times 200$.

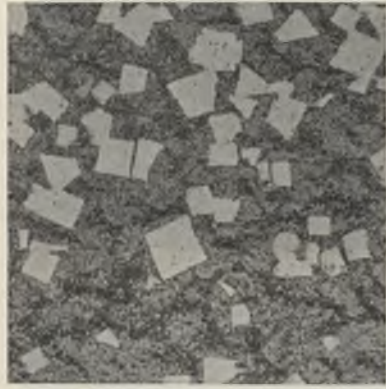


FIG. 7.—14% Antimony. Primary δ
 Cuboids, Cored α (dark), δ Precipitate.
 $\times 200$.



ETCHED 2% HNO₃ IN ALCOHOL.

FIG. 8.—7% Antimony. Annealed at 190° C. White Precipitate of δ in Dark α . $\times 300$.

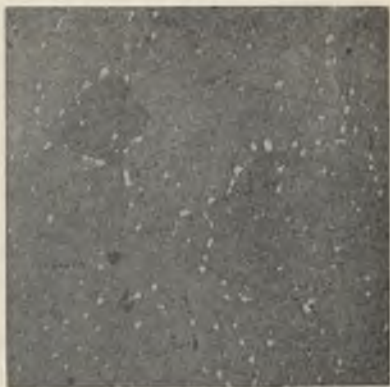


FIG. 9.—9% Antimony. Quenched from 190° C. White δ Precipitate, Chiefly Along α Grain-Boundaries. $\times 200$.

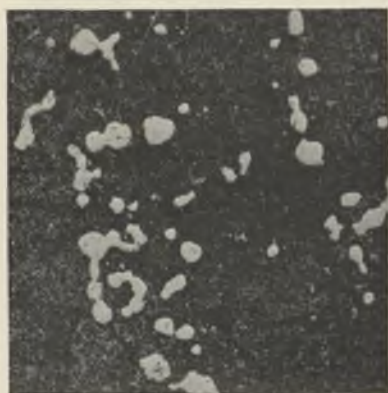


FIG. 10.—14% Antimony. Ann. 190° C. Showing Effect of Annealing on the δ Cuboids (see Fig. 7). $\times 200$.



FIG. 11.—3.5% Antimony. Quenched from 190° C. Tempered at 100° C.



FIG. 12.—8% Antimony. Quenched from 230° C. α . $\times 50$.

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and tends to coalesce, in all alloys containing more than 4 per cent. antimony (Figs. 8 and 9, Plate II). The primary δ cuboids (SbSn) tend to lose their angularity (Fig. 10, Plate II).

The results of annealing the alloys for 1 month at 190° C., followed by cooling in the furnace, show that all alloys with 3.5 per cent. anti-

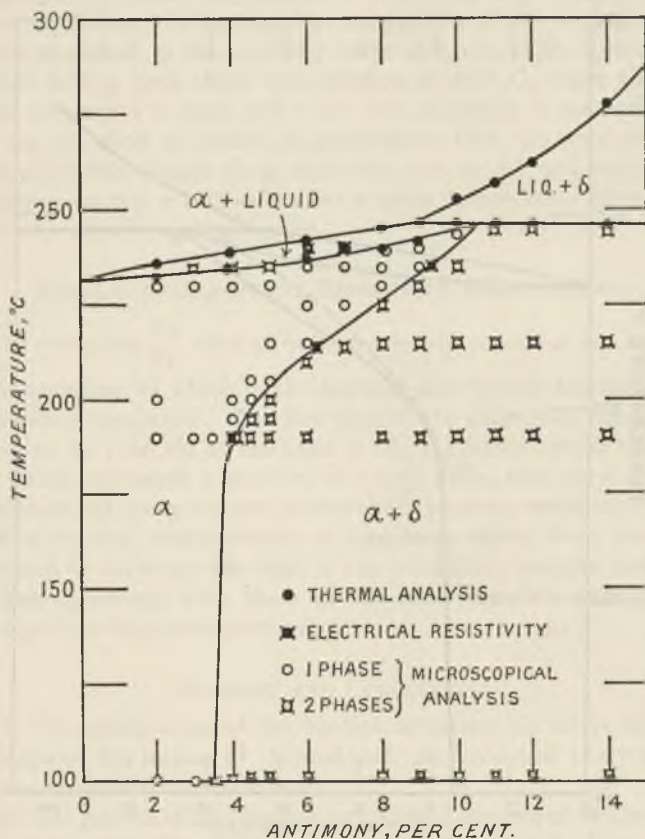


FIG. 3.—Antimony-Tin System. (By Authors.)

mony or more, contain the δ (SbSn) phase, but when quenched from 190° C. the 3.5 per cent. alloy is homogeneous α , whilst the 4 per cent. alloy contains traces of the δ precipitate.

On re-heating the quenched specimens in boiling water for 1 hr., the δ constituent reappears in the 3.5 per cent. alloy and increases considerably in quantity in the 4 per cent. alloy, principally in the grain boundaries (Fig. 11, Plate II). Thus the change of solubility

of antimony in tin from room temperature to 190°C . is not greater than 0.5 per cent.

The results of quenchings from higher temperatures show that there is a rapid increase of solubility from 4 per cent. at 190°C . to 9 per cent. at 235°C . and 10 per cent. antimony in tin at 245°C . The

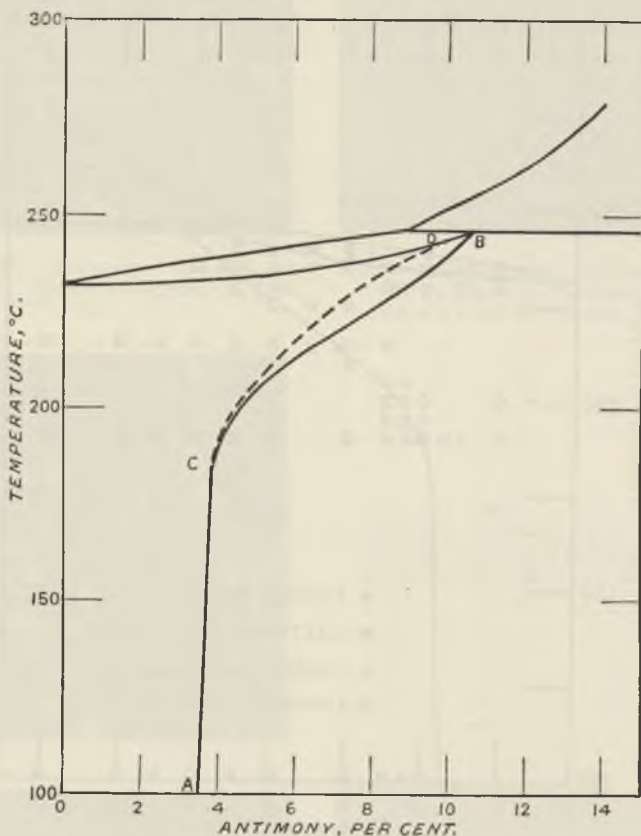


FIG. 13.

tin-rich phase shows considerable grain-growth at temperatures above 200°C . (Fig. 12, Plate II).

The α solidus was determined by quenching experiments, and the results confirm the figures obtained from heating curves, but in the case of alloys containing primary δ the liquid phase does not appear until the annealing is carried out at 246°C ., when the alloys appear to become completely liquid. At 245°C . the 10 per cent. alloy consists

The Constitution of Tin-Rich Antimony-Tin Alloys

entirely of the phase α whilst the 11 per cent. alloy contains traces of δ . Thus these results confirm the conclusions derived from cooling curves that the peritectic reaction occurs at 246° C. The lower figures obtained on heating curves may be explained by the form of the solubility curve (Fig. 13). Consider the alloy containing 11 per cent. antimony. At room temperatures it consists of α of composition A , plus some $SbSn$. On heating, the composition of the α phase should change according to the solubility curve AB , the whole of the δ precipitate having been taken into solution at 246° C. where the alloy should commence to melt, but if the rate of heating is not sufficiently slow for the alloy to remain in equilibrium, then the composition of the α phase will change along some line such as AD and melting will commence on the α solidus, *i.e.* at a lower temperature than would pertain for equilibrium conditions.

RESULTS OF ELECTRICAL RESISTIVITY MEASUREMENTS.

The curves for $\frac{Px}{Ps}$, after all heat-treatments, consist of two branches the intersection of which is the limit of the tin-rich solution at the temperature concerned. The first part of the curve rises steeply from the value for pure tin to the limit of the α solution, whilst the other part which represents a mixture of α with $SbSn$, rises very slowly to the highest antimony content measured (18 per cent. antimony).

Microscopical examinations of specimens taken from the wires confirmed in each case the limit of the α solution, and the results are in close agreement with those of the more complete microscopical investigations discussed previously.

SUMMARY AND CONCLUSIONS.

(1) The constitution of the tin-rich antimony-tin alloys has been investigated by means of thermal and microscopical analyses, and electrical resistivity measurements.

(2) The portion of the liquidus investigated consists of two branches, the first corresponding to the separation of the tin-rich phase (α) and the second to the separation of the cuboid phase δ . A peritectic reaction occurs at 246° C., between the cuboid δ and liquid containing 9 per cent. antimony, to form α containing 10.5 per cent. antimony.

(3) The solidus of the tin-rich phase has been determined by thermal and microscopical methods.

(4) The solubility of antimony in tin is shown to decrease from 10.5 per cent. at 246° C. to 4 per cent. at 190° C., and to 3.5 per cent. at 100° C. The form of the solubility curve suggests that the mechanical

The Constitution of Tin-Rich Antimony-Tin Alloys

properties of these alloys which form the base of tin-rich bearing metals might be sensitive to heat-treatment and the authors are carrying out an investigation in this direction.

ACKNOWLEDGMENTS.

The research described in this paper has been carried out with the aid of a grant from the International Tin Research and Development Council. The authors wish to express their thanks to the Council and to Mr. D. J. Macnaughtan for his interest in the work.

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THE INFLUENCE OF LIGHT ON ELECTRODE POTENTIAL AND CORROSION PHENOMENA OF CERTAIN NON-FERROUS METALS.*

By PROFESSOR C. O. BANNISTER, M.Eng., A.R.S.M., MEMBER, and
R. RIGBY, B.Eng., Ph.D.

SYNOPSIS.

A review is given of previous work on the effect of light on the corrosion of non-ferrous metals. A simple apparatus is described for the examination of the effects of light on zinc, lead, &c., under corroding conditions in conjunction with which a continuous record of changes in e.m.f. is made by the use of a thread-recorder. The influence is shown to be considerable in the case of lead and zinc, but only in the presence of oxygen, the aerated and illuminated electrode becoming more markedly cathodic. A more elaborate apparatus is then described arranged to allow perfect control over the oxygen supply to the metals under examination, and very marked response to illumination is shown in the case of zinc and aluminium. In the case of the latter metal records showing activity over 5 days are given. The maximum effect is obtained with light in the violet and near ultra-violet region, and the mechanism of the action suggested is the catalysis of the formation of protective oxide films.

THE result of work previously published on the influence of light on corrosion phenomena has been of a somewhat scrappy nature and has consisted less of organized investigation than of references to phenomena observed incidentally during the course of research in other directions. This is surprising since as early as 1818 Theodor von Grothaus¹ published a paper on "The Chemical Action of Light and Electricity," in which the electrochemical theory of light was first proposed. This work was dealt with in a paper by W. D. Bancroft,⁴ on "The Electro-Chemistry of Light," in which he directed attention to it, and quoted from it the two laws of von Grothaus which are of particular interest, as follows: (1) only those rays which are absorbed can produce chemical action; (2) the action of a ray of light is analogous to that of a voltaic cell.

E. Becquerel² carried out work on "The Influence of Light on Metals Immersed in Solutions," the results of which were published in

* Manuscript received December 30, 1935.

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

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1839. He obtained results showing differences of potential on illumination, and his work stood alone until 1897 when a paper was published by H. Rigollot,³ who placed more or less oxidized plates of silver and copper in solutions of their salts and measured the response obtained on illumination of one of the electrodes. The object of this work was to obtain some reliable form of photo-cell, and the potentials he obtained varied from solution to solution, the e.m.f. generated varying from 5 to 200×10^{-5} v.

In an important paper on "A Copper Oxide Photo-Electric Cell," published in 1917, T. W. Case⁶ reported that a number of electrolytes deposit upon copper a light-sensitive coating which shows signs of fatigue on prolonged exposure to light. He advanced a theory of this action based on the original coating being cuprous oxide, which is oxidized to cupric oxide by the action of light and that this cupric oxide dissolves electrochemically and sets up a current in an external circuit.

G. D. Bengough and O. F. Hudson⁷ in the Fourth Report to the Corrosion Committee of the Institute of Metals, in 1919, stated, in connection with the corrosion of copper in distilled water, that "in all cases the sides most directly exposed to the light tarnished most quickly." During 1919 W. H. J. Vernon⁹ also noted that "in the corrosion of brass rods in acid solutions (pickling bath), anodic and cathodic areas make their appearance coinciding with areas of maximum and minimum illumination."

The following appears in a paper published in 1920 by J. F. Liverseege and A. W. Knapp¹⁰: "The action of light is to increase the amount of action of water on lead. Ten samples of untreated water gave an average of 16.8 (pts. per 100,000) of lead when the tubes were exposed to daylight and 11.9 when the tubes were kept in a dark cupboard during the day of the experiment."

R. Audubert,¹¹ in 1923, gave the following details: When plates of the same metal are immersed in an electrolyte and one is illuminated by an arc lamp, an e.m.f. of $6-50 \times 10^{-6}$ v. is observed. The illuminated electrode is the anode with platinum, copper, or mercury and cathode with gold or silver.

U. R. Evans¹³ in his book states that "the action of light is a matter which cannot be disregarded in studying the corrosion of copper."

G. Athanasiu¹⁶ in 1925 stated that changes in e.m.f. which occur when mercury, lead, platinum, silver, copper, cadmium, and zinc are immersed in solutions of their salts and exposed to light can be explained by assuming (1) a chemical change on the surface of the metal, a quick change, and (2) a change due to the heat energy of the radiation employed, a slow change.

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In a paper on the corrosion of polished metal surfaces by W. W. Coblenz¹² it is stated that the atmospheric corrosion of certain polished surfaces is accelerated by the action of ultra-violet light. The portions exposed to the radiation become tarnished. The chief effect is due to radiations of wave-length less than 3000 Å. The author neglects to state what metals were examined.

An anonymous writer¹⁴ stated that moisture condenses more readily on surfaces of metals exposed to ultra-violet light and that corrosion is accelerated.

R. Audubert,¹⁵ in another paper, reported that the e.m.f. was very small and irregular and of the order 10^{-7} to 50×10^{-6} v. when he used a 20–25 amp. arc at 110 v. He found the illuminated surface to be the cathode for gold and silver, and based his theory of this effect on a result of photo electron-emission.

C. C. Palit and N. L. Dhar¹⁷ noted that the action of nitric acid on copper and mercury is accelerated by light.

F. Goldman and E. Rupp¹⁸ exposed silver and copper in air to ultra-violet light and produced passive films on these metals.

In a paper on "The Fogging of Nickel," Vernon¹⁹ showed quantitatively that fogging was reduced by approximately one-half by the exclusion of light.

The photoelectric effect with the wet and dry types of copper-cuprous oxide cell was discussed by W. E. Meserve,²⁰ who suggested that the action is the same in both types.

Although this paper deals with the corrosion of non-ferrous metals only, the results of correlated work on mild steel are being presented to the Iron and Steel Institute for its 1936 May Meeting, and the following is given merely as a summary of previous work carried out on the effect of light on the corrosion of ferrous metals.

C. H. Cribb and F. W. F. Arnaud²¹ found that iron specimens in water and various solutions exposed to diffused sunlight corroded more than similar specimens kept in the dark.

J. N. Friend^{22, 24} and also J. N. Friend, W. West, and J. Lloyd Bentley²³ found greater loss of weight in iron specimens in water exposed to light than in similar specimens kept in the dark.

G. M. Enos²⁵ and also W. P. Wood²⁶ found an accelerating effect of light on the corrosion of iron and steel.

C. Benedicks and R. Sundberg²⁷ have reported that the e.m.f.s of stainless irons and steels are displaced 10–15 millivolts by light, and H. Endo and S. H. Sekiguchi²⁸ have found the loss in weight of iron specimens in aqueous nitric and acetic acids and ferric chloride to be greater in diffused light than in the dark.

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FIRST SERIES OF EXPERIMENTS.

The investigation described in this paper was undertaken as a result of certain irregular effects obtained during some simple experiments

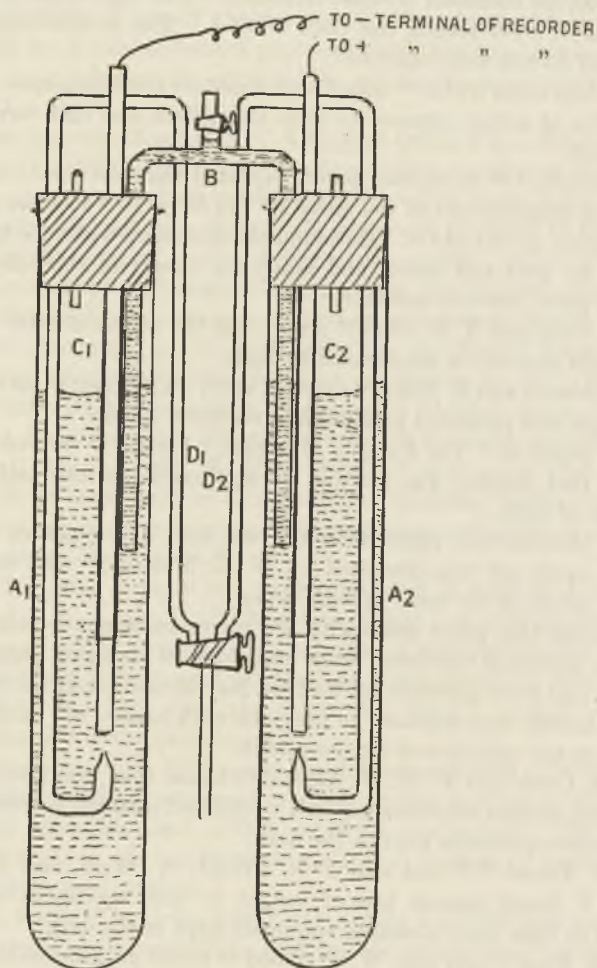


FIG. 1.

on the influence of oxygen on metals in acid solutions. For these experiments the apparatus consisted of two plates of amalgamated zinc immersed in dilute sulphuric acid and connected through a 10,000 ohms resistance to an automatic recorder consisting of a double thread recorder, made by the Cambridge Scientific Instrument company, from

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which all the resistance had been removed and the zero adjusted to the centre. The black thread was arranged to register zero and the red one to register changes of e.m.f. taking place, the threads registering alternately every half-minute. The drum of the recorder made a complete revolution in 25 hrs. It was noted that while, in general, the form of the e.m.f.-time curves was capable of explanation, occasional irregularities were observed. These irregularities took the form of increases in the e.m.f. of the combination, resulting in curves quite contrary to the very regular ones normally obtained with these electrodes. The only apparent explanation for this phenomenon was to be found in the observation that the maxima of these curves corresponded to periods of maximum illumination.

In order to verify this supposition, a Pyrex glass beaker was divided into two equal parts by means of a glass plate and the amalgamated zinc electrodes were hooked over the edge of the beaker, one on each side of this plate; a quartz-mercury vapour lamp was then arranged to illuminate one or other of the electrodes, and it was found that the illuminated electrode always became markedly cathodic.

In view of the surprising nature of the results obtained, the investigation was carried further and the simple arrangement described above was elaborated to render the shading of the dark electrode more effective and also to enable one or other of the electrodes to be aerated without the risk of the other electrode receiving aerated solution.

The apparatus adopted is shown in Fig. 1, and consisted of two transparent quartz tubes, *A1* and *A2*, clamped 3 in. to 4 in. apart and connected through rubber bungs by a syphon tube, *B*, 4 mm. in bore. The specimens of metal consisted of rods, *C1* and *C2*, each $\frac{1}{4}$ in. in diameter, also passed through the bungs into the tubes, the portion of each specimen from the bung to well below the level of the electrolyte used being waxed in order to eliminate disturbances due to local oxygen concentration; this left an actual working length of 1 in. For the supply of oxygen to one or other of the metal electrodes, heavy-walled glass tubes, *D1* and *D2*, of 1 mm. bore, were also passed through the bungs, each tube being turned up at the end in order to deliver the oxygen under the end of the metal specimen.

Zinc.

To take as an example the metal zinc, the method of procedure was to pass the rods of zinc, after polishing down to 1M Hubert French paper and degreasing, through the respective bungs and then to wax the surfaces down to exactly 1 in. from the bottom. The quartz tubes were then charged with 3 per cent. potassium chloride solution in

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ordinary laboratory distilled water, and the specimens immersed by fitting the bungs to the tubes. The syphon connecting the two tubes was then filled by suction at a T-piece provided at the highest point.

The zinc rods were connected to the two terminals of the thread recorder, and a record was thus obtained of the varying differences of potential obtained during periods of 24 hrs. or more.

The quartz-mercury vapour lamp was used with 225 w. actually in the arc and at a distance of 3 ft. from the quartz tubes. One or other of the two tubes could be shielded from the light by the interposition of an ebonite screen.

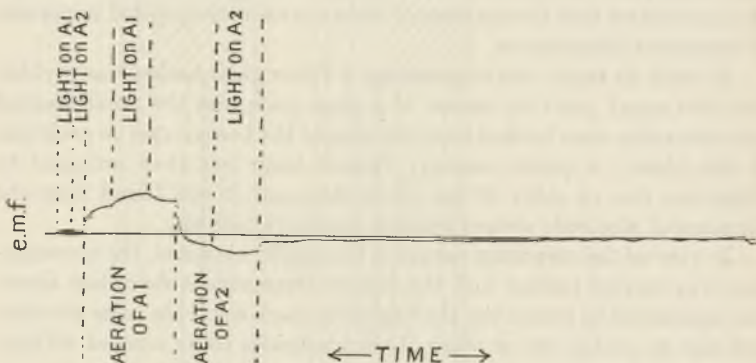


FIG. 2.—C1, Zinc.

The results given by zinc are shown in Fig. 2, which was obtained by first allowing the apparatus to run until the potential difference between the specimens was zero and tube A1 containing the electrode connected to the negative terminal of the recorder was illuminated, A2 being screened. As indicated in the curve, the result was a change in the electrode potential, the illuminated specimen becoming cathodic with the generation of an e.m.f. of 0.018 v. After this had persisted for some time, tube A1 was screened and A2, containing the electrode connected to the positive terminal of the recorder, was illuminated; the result was an immediate reversal of direction of e.m.f., as shown on the curve. After this had run sufficiently long to be confirmed, the source of light was cut off and a slow current of oxygen was bubbled around the electrode first illuminated, C1. This electrode immediately became cathodic, in accordance with the usual result of differential aeration. On the portion of the curve covering this differential aeration, the e.m.f. shows a rapid increase at first, which gradually slows off giving a horizontal portion, equal to 0.13 v.

When the curve had reached the horizontal position, the aerated

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electrode was illuminated; the result is well shown on the curve in an increase in e.m.f. to a maximum of 0.18 v. during 10–15 minutes and then a stationary period at this more cathodic value. On the removal of the light, the e.m.f. recorded decreased, as shown in the curve. From this it is seen that the influence of the light on the zinc is much greater in the presence of an increased supply of oxygen. When this point had been reached on the curve, the oxygen was cut off from *C1* and electrode *C2* was supplied with a stream of oxygen; the e.m.f. immediately decreased and actually crossed the zero line, indicating a change in condition of this electrode which now became the cathode. The curve fell below the zero line, but not to the extent that the first electrode rose above this zero line because of the oxygen present in the first tube not having been used up. After the curve had approached a horizontal direction, this *C2* electrode was illuminated, and again the curve responded with a further descent, finally tending to become horizontal and even to rise, probably owing to polarization. On cutting off the oxygen supply and removing the light there was a marked difference in the e.m.f., and then on allowing the record to continue without further change in aeration or illumination, the curve gradually returned to the zero position in 18–24 hrs.

The first two changes in e.m.f. noted on the curve show the influence of light in the presence of the oxygen contained in the distilled water solution of KCl and also indicate that the illuminated electrode becomes cathodic. On admission of oxygen to one of the tubes, even in the absence of light, an increased e.m.f. is set up as would be expected from the well-known theory of differential aeration as fostered by U. R. Evans. The e.m.f. is further increased by light and after a time reaches a maximum. On removal of the light the e.m.f. decreases and approaches that noted before light was used. The same changes take place in the reverse direction on the curve when the second electrode is aerated and illuminated, the reversal of direction being caused merely by the method of connecting the electrodes to the recorder.

With regard to the mechanism of the changes taking place in the completed cell with electrodes of an active metal like zinc, there are two opposing tendencies; on the one hand there is the oxygen in solution in the electrolyte tending to build up an oxide film on the metal, and on the other hand there are other ions present in the electrolyte, in this case chlorine, tending to form salts—corrosion products—and to break down the film, and the final value of the electrode potential of the metal will depend on the relative activities of these two actions.

Since it has been shown that the light tends to render the metal more cathodic, there are two possibilities of its mode of action: (1) it

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may catalyze the oxide film formation, or (2) it may retard the formation of the corrosion product. In effect these two possibilities are the same, for both result in the catalysis of the formation of the oxide film and an oxide film is rendered more stable at the expense of the formation of corrosion product.

Lead.

A series of experiments was carried out with metallic lead electrodes also in a 3 per cent. solution of potassium chloride. In this solution, even without bubbling oxygen, the effect of light was quite marked, the illuminated electrode becoming cathodic, undoubtedly due to the oxygen already present in the electrolyte. This is seen in Fig. 3 and is contrary to what might have been expected from the general inertness

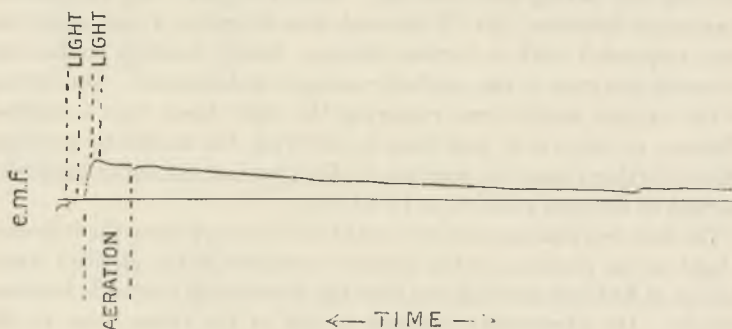


FIG. 3.—C14, Lead.

of the metal. In the next place the curve shows the influence of bubbling oxygen in rendering the specimen cathodic and the influence of light is seen to increase this tendency to about the same extent as it did in the absence of bubbling oxygen. On removal of the light, the curve returns to about its former value, whence it continues to fall while the oxygen is still bubbling. At the break in the curve, the oxygen was cut off and the curve drifts down to a value near zero in the course of something over 24 hrs. Fig. 4 gives the results of the effects of a variation of aeration and light on the specimens in the same electrolyte. From this curve it will be seen that the specimens of lead behave somewhat irregularly at first, the curve showing a rapid fall and rise in the dotted portion, then a tendency upwards; after this movement had become sufficiently steady the oxygen supply was turned on and the curve rose rapidly and then flattened out. At this point the aerated electrode was illuminated when a further slight rise was obtained, and after a short time the light was switched off when the e.m.f. decreased to a smaller value and then remained steady. When this condition had

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remained for some time, the oxygen supply was turned off and the light switched on, with the result that the curve fell back towards the axis. This shows the influence of illumination in the absence of fresh supplies of oxygen, the e.m.f. decreasing in less than half an hour to a value only reached in the absence of light in something over 24 hrs., as shown in Fig. 2. This effect is peculiar to lead and shows the rapidity of the destruction of the influence of aeration brought about by light, and is distinct and additional to the general effect being discussed. When this had reached its minimum value, the light was switched off and the cell was allowed to plot its new zero position again. When this was constant the light was again put on for a short time, which resulted in a small increase in e.m.f. about equal to that obtained in Fig. 3 before

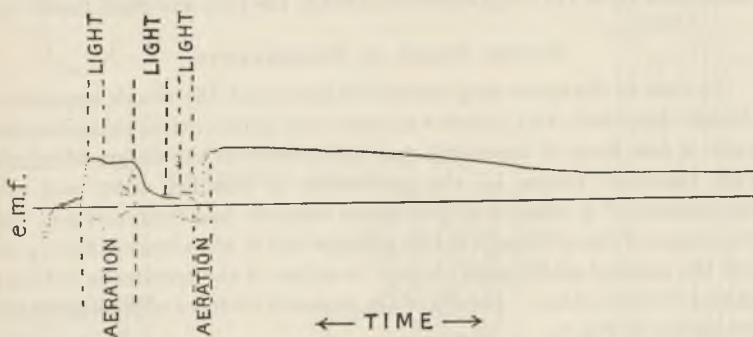


FIG. 4.—C15, Lead.

the electrode had been aerated with oxygen. Finally, the specimen was again aerated to increase its e.m.f. value to a maximum, the oxygen was then cut off, and the subsequent change without illumination shows a slow decrease in value during 16 hrs. in a similar manner to that shown in Fig. 2 and very different from the rapid decrease in value in the absence of bubbling oxygen but under the influence of the light.

Copper and Other Metals.

Several other non-ferrous metals were examined by the method as already described, but similar marked differences in e.m.f. were not obtained as with zinc and lead.

On examining copper in a 3 per cent. potassium chloride electrolyte, only slight changes in e.m.f. were obtained by light in the absence of bubbling oxygen. On admitting a very slow supply of oxygen to one of the tubes the copper became cathodic, and on illuminating the aerated electrode a small response only was obtained in the same direction as that obtained with zinc, but on continuing the illumination the effect

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died away thus giving results similar to those reported by Case.⁶ With a more rapid stream of oxygen the aerated specimen became anodic, as was to be expected from the work of Bengough and Hudson,⁷ Bengough and R. May,⁸ and Evans.¹³

Experiments with metallic antimony showed practically no response to aeration, and no light influence could be found in any circumstances. Platinum showed no response either to aeration or to illumination. Tin and cobalt also showed only slight effects on aeration and no response to illumination. These results are to be expected, since all four metals are known to form very stable oxide films and as a result the catalytic influence of light on the formation of these films cannot possibly be very marked. Some interesting results have also been obtained with ferrous metals and these are being communicated to the Iron and Steel Institute.

SECOND SERIES OF EXPERIMENTS.

In view of the interesting results obtained with the simple apparatus already described, and in order to carry out more critical experimental work, a new form of apparatus was constructed in the design of which were embodied means for the production of distilled water and the preparation of a solution of potassium chloride free from oxygen, the immersion of the specimens in this solution still in the absence of oxygen, and the gradual addition of oxygen to either of the specimens without adding it to the other. Details of the essential features of the apparatus are shown in Fig. 5.

The distilled water free from dissolved oxygen was obtained by distillation in a current of oxygen-free nitrogen which was obtained from a cylinder, *N*, and on its way was washed twice in a strong solution of caustic potash to remove any carbon dioxide present and was dried and passed over copper-foil heated to 750°–800° C. and then over granulated metallic chromium heated to 800°–880° C. This treatment was carried out in a long tube furnace, *F*, controlled by a thermocouple pyrometer, the gas passing first over the copper, this being placed at the cooler end of the tube, and then over the chromium packed in the centre. An escape tube, *E*, was fitted to the outlet from the furnace tube to enable the apparatus to be worked without danger of the blowing out of bungs, &c.

For the preparation of the distilled water, a barium hydroxide solution was placed in the flask, *L*, and a manganous sulphate solution was placed in a separating funnel, *S*. The furnace was now run up to temperature and the nitrogen allowed to flow through the apparatus for about 1 hr. The manganous sulphate was then run on to the barium hydroxide and the water was slowly distilled, about 30 c.c. per hr.,

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on to the potassium chloride contained in a mixer, *M*, which consisted of a large boiling tube with a 60 c.c. level marked and fitted with a

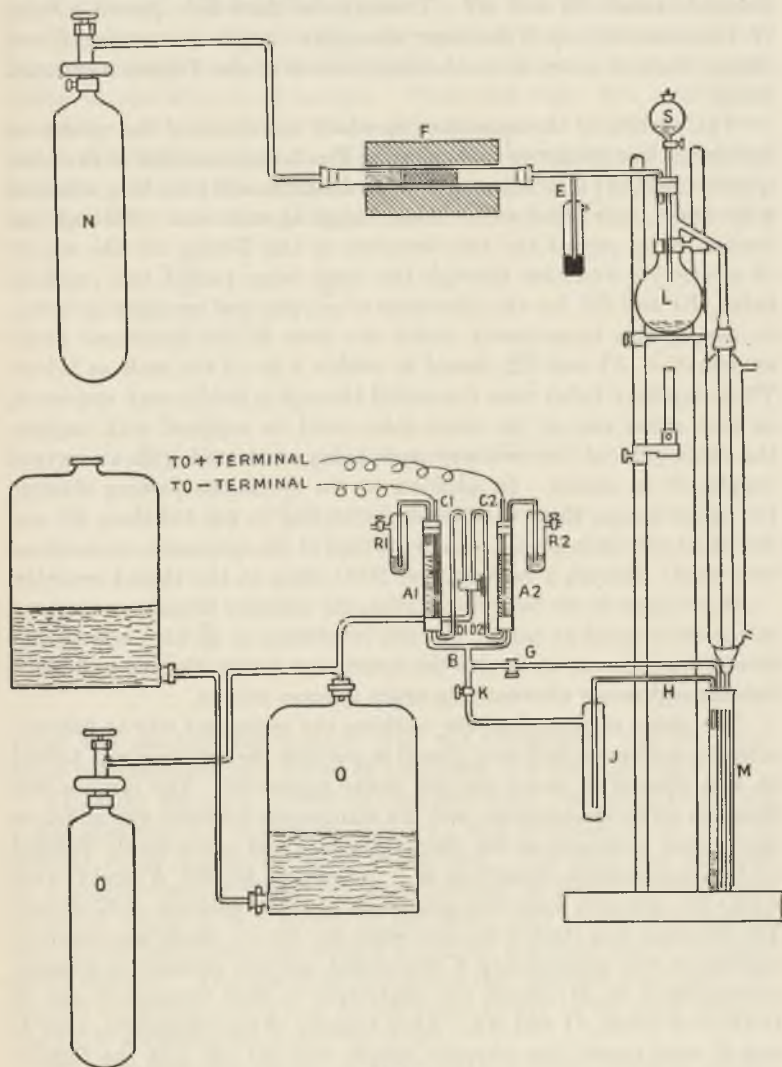


FIG. 5.

three-hole stopper. Through one of these holes the delivery tube of the distilled water condenser passed to the bottom of the mixer; through another hole and also from the bottom of the mixer passed another tube,

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G, fitted with a tap and connected by means of a side-branch to the T-piece, *B*, through which the solution was passed into the clear quartz electrode tubes, *A1* and *A2*. Through the third hole passed a tube, *H*, from near the top of the mixer through an empty gas washer, *J*, and thence through a tap, *K*, to the main branch of the T-piece mentioned above.

The portion of the apparatus in which treatment of the specimens took place was similar to that shown in Fig. 1, and consisted of two clear quartz tubes, *A1* and *A2*, each 1 in. in diameter and 5 in. long, clamped 4 in. apart, and fitted with rubber bungs at each end. Through the bottom bung passed the two branches of the T-tube for the supply of electrolyte and also through the same bung passed two capillary tubes, *D1* and *D2*, for the admission of oxygen and arranged as before to supply this immediately under the ends of the specimens under examination, *C1* and *C2*, waxed to within 1 in. of the ends as before. These capillary tubes were connected through a double-way stop-cock, so that either one or the other tube could be supplied with oxygen, the other tube of the two-way cock being connected with an oxygen supply, *O*, as shown. In addition to the specimens passing through the upper bungs, there were tubes connecting to gas bubblers, *R1* and *R2*, fitted with stop-cocks. From the tops of the specimens, connections were made through a resistance of 5000 ohms to the thread recorder.

In the case of the following curves, the recorder drum was operated at the same speed as before, *viz.* one revolution in 25 hrs., but the indicator bar was run at double the speed used before, the red and black threads registering alternatively every quarter-minute.

The order of procedure for working the apparatus was as follows: after the specimens had been placed in position the nitrogen was turned on and allowed to sweep out the entire apparatus. The furnace was then run up to temperature, and the manganous sulphate was added to the barium hydroxide in the distillation flask and water slowly distilled on to the potassium chloride in *M*. When taps *R1*, *R2*, *K*, and *G* were open, the nitrogen kept the potassium chloride solution well stirred. The recorder was started up and when the 60 c.c. mark was reached, distillation was stopped, tap *K* was closed, and the pressure of nitrogen accumulating in *M* caused the electrolyte to flow through *G* and *B* to the two tubes *A1* and *A2*. After transfer of the electrolyte, taps *K* and *G* were closed, the nitrogen supply was cut off, and the further method of procedure varied to suit requirements.

Zinc.

With the new apparatus the metal zinc was again examined, the same type of rod, waxed to leave 1 in. of bare metal, being used as

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described in connection with the earlier experiments in an electrolyte consisting of 3 per cent. solution of potassium chloride in oxygen-free distilled water. The results are shown in Fig. 6 in which is first shown a straight portion during which one specimen was illuminated for 10 minutes, then the other for 15 minutes, but neither gave any response owing to the absence of oxygen. When this state was established, an addition of about 1 c.c. of oxygen was made to the tube A1, from which the electrode was connected to the negative terminal of the thread recorder, and a rapid increase in e.m.f. resulted which was only momentary and from which it rapidly decreased to a steady value. When this

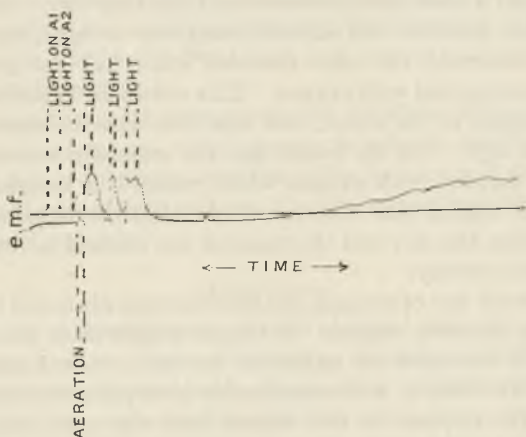


FIG. 6.—D3 Zinc.

value was reached, the aerated tube was illuminated and the e.m.f. again increased during a period of 5 minutes to a value of 0.09 v.

The light was then turned off, and the curve continued to rise for a few minutes to a maximum of 0.1 v., and then fell off to near its original value in the course of 33 minutes. The light was switched on a second time, a maximum again reached at which the light was removed, resulting in a return of the curve, and the same operation was carried out a third time during which the specimen was illuminated for 15 minutes. After the final removal of the light, the curve fell to its original value and slowly rose during about 16 hrs. to the peak value of the e.m.f. without illumination as shown.

By this series of experiments it is confirmed that the effects of light on zinc are only noted in the presence of oxygen.

A second series of tests was carried out with new specimens of zinc, using 3 per cent. solution of potassium chloride in oxygen-free distilled water as electrolyte. The curve showed, as before, no response to

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illumination in the absence of oxygen. The electrolyte in one tube was then supplied with a small quantity of oxygen when a less rapid response was obtained, similar to that already described with the first apparatus and shown in Fig. 2. On illuminating this electrode a further increase in e.m.f. was obtained as before and when the maximum was reached, the lamp was switched off; this was followed by only a slight decrease which continued until next day. On the second day this electrode was again illuminated, and showed a response but somewhat less than on the first day; at this point a little more oxygen was supplied and further response to light was obtained, and on removal of the light the curve showed a continued decrease until the next day. On the third morning the electrode still showed sensitivity to light, and after this had been confirmed, the other electrode which had not hitherto been aerated, was supplied with oxygen. This caused an immediate reversal of the direction of the e.m.f., and now this second electrode became sensitive to light. On the fourth day the originally aerated electrode was again supplied with oxygen which resulted in bringing back the curve to the original side of zero, and this electrode remained sensitive to light during this day and the recorder was allowed to run on during the fifth day, Sunday.

On the sixth day of running, the electrode was examined for response to different spectrum regions. A Chance's light filter No. 9 was first used, which transmits all radiations having a wave-length between 3250 and 8500-9000 A. with considerable absorption between 3700 and 5000 A. The response to this filtered light was quite marked, a rise in the curve being noted. The second filter used was Chance's No. 7, a blue glass transmitting wave-lengths between 3700 and 5000 A. and having considerable absorption between these values. The response to this light was equally marked to that through No. 9 filter, which appears to place the maximum effect between these two values. A third filter was used, Chance's No. 8, which is of very dense purple glass transmitting a very narrow band between 3400 and 4200 A., the response being again of the same magnitude as with the previous filters.

Thus, it will be seen that the maximum effect is obtained with light of wave-lengths between 3400 and 4200 A., *i.e.* confined to the violet and near ultra-violet region. This is of considerable interest since the solar spectrum only extends to 2950 A. and is particularly intense in the near ultra-violet region.

In this is to be found the reason for the superiority of a white flame arc over a quartz mercury arc of superior power, which had been found to be the case in certain experiments, because while the quartz mercury arc divides the energy radiated more or less regularly between the near

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and middle ultra violet regions, a white-flame arc resembles sunlight and has most of its energy concentrated in the near ultra-violet regions.

In order to influence the e.m.f. in the manner shown on the curves by illumination, it is obvious that absorption of energy must take place more or less between the limits indicated above, and it would appear that the effect takes place at the surface of the metal because, on removal of the specimens, it was found that the side exposed to the light was quite bright while the reverse side was coated with corrosion product. This leads to the view that absorption of energy must have taken place at the surface of the metal illuminated, for there is no evidence of metallic zinc having an absorption band peculiar to this region. The electrolyte itself is ruled out as it only begins to absorb at wavelengths of less than 3000 Å.

From the present work it transpires that the effect noted is dependent on the presence of oxygen, which appears to indicate that the resulting change in e.m.f. is due to the catalysis of the formation of an oxide film under the influence of light and that the active radiations are in or near the ultra-violet region.

Aluminium.

In the case of aluminium the results obtained with the earlier form of apparatus had not been satisfactory, excessive periodicity being obtained when potassium chloride or potassium sulphate solutions were used as electrolytes and other irregularities when potassium carbonate solution was used. The first experiments in the new apparatus were conducted with potassium carbonate solution as the electrolyte, but here again the results were worthless as gas evolution between the metal and the solution was so vigorous that it rendered the curve too unsteady to be of value. As a result of this irregularity, potassium chloride solution was substituted for the potassium carbonate solution and more regular results were obtained.

During a steady part of one of these experiments the opportunity was taken to examine the effect of heat, as it had been suggested by H. E. Armstrong,⁵ in the discussion of a paper dealing with the effect of light on the corrosion of iron, that under the conditions obtaining in those experiments the effects may have been due to temperature differences instead of to light. On heating the electrolyte in the tube which had shown sensitivity to light to 50° C., an e.m.f. was immediately developed but in the direction opposite to that in which it had been developed by light, the specimen in the heated electrolyte becoming decidedly anodic. It must be concluded, therefore, that any slight heating effect accompanying the light would not enhance the effects

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obtained but would rather tend to reduce them owing to the lower solubility of oxygen in warm than in cold electrolyte.

All the chief features met with in the case of aluminium during aeration and illumination of one of the electrodes are shown in the next series of curves, Figs. 7, 8, and 9.

The apparatus was fitted up in the usual way and, as already described, a 3 per cent. potassium chloride solution was used as the electrolyte. The curve recorded, Fig. 7, was somewhat irregular at first and gave merely a slight response to illumination of either electrode as was to be expected in the absence of oxygen. On admitting a small quantity of oxygen to one of the tubes A1 an immediate increase in

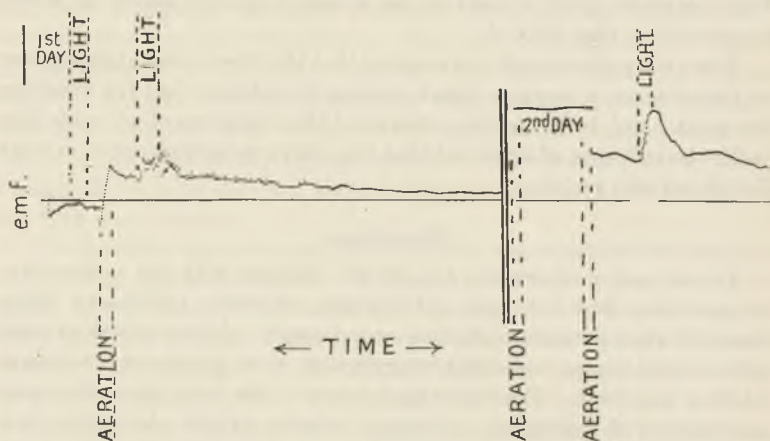


FIG. 7.—Aluminium.

e.m.f. took place in the same direction as with metallic zinc, the illuminated electrode becoming cathodic. At this point the curve shows signs of a rapid periodicity, and on trying the effect of light during this time only a small and irregular result was obtained. On leaving the recorder to run over night, a gradual lowering and steadying of the curve took place as indicated. On again admitting oxygen on the second day, a rapid increase in e.m.f. took place (Fig. 7), sufficient in fact, to cause the indicator to move to the extreme position on the drum; this was allowed to run for some time giving the straight line indicated well above the zero line. To bring this back to within the working range of the recorder, a little oxygen was fed to the electrolyte in tube A2 containing the second electrode.

This immediately brought back the indicator to a suitable position, and the recorder was again allowed to run for some time. The electrode

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first aerated, A1, was now illuminated with the result that the e.m.f. again responded up to the maximum of the indicator; at this point the light was switched off, which action was followed by a reduction in e.m.f. recorded as shown on the curve.

During the third day, the electrode C1 was again illuminated three times with periods in between during which the light was removed; the e.m.f. curve, Fig. 8, shows maxima 0.15 v. during the periods of illumination falling back on removal of the light. During the night the curve fell back more or less steadily to a point near the zero line.

During the fourth day the curve, Fig. 8, started by giving a steady value, then the light was put on and a maximum was reached not

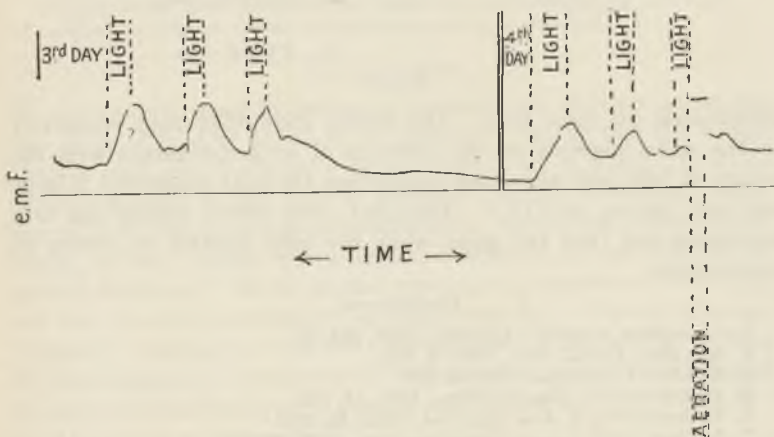


FIG. 8.

quite equal to the maxima reached the previous day, more time also being taken to reach this maximum. On removing the light, the record again fell as before, and when it marked a steady value, the light was put on and taken off with similar results, but a little irregularity occurred before a steady value was obtained. On putting on the light for the third time, a comparatively small maximum was recorded with a falling back on removal of the light. This was taken to indicate a lack of oxygen, so a further quantity was added to the tube A1, causing a high maximum as before which was brought back to a suitable position by again adding oxygen to the second electrolyte in A2, and the whole was allowed to steady by running over night.

On the fifth day, as shown in Fig. 9, a steady value being indicated, the light was switched on until maxima were obtained and switched off until minima were recorded three times with the result as shown,

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then the recorder was allowed to run on and the curve obtained records a gradually diminishing e.m.f. until the zero line is practically reached.

During similar experiments with aluminium it was confirmed that the tube to which no oxygen had been added remained absolutely insensitive to light, and even after aeration remained insensitive unless

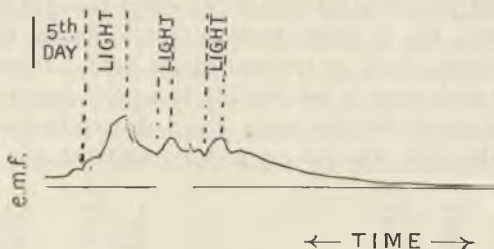


FIG. 9.

illuminated for some time. The results show that light sensitivity in the metal depends on the presence of oxygen together with the action of light and when once established the light sensitivity is large and may run up to 0.15 v. The e.m.f.-time curves usually rise to a maximum and then fall again while the light remains on, owing to polarization.

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INFLUENCE OF SURFACE CUPROUS OXIDE INCLUSIONS ON THE POROSITY OF HOT-TINNED COATINGS ON COPPER.*

By W. D. JONES,† M.Eng., Ph.D. (Liverpool), MEMBER.

SYNOPSIS.

A study of the causes of porosity of tin coatings on copper shows inclusions of cuprous oxide to be one of the most important. Amalgamation is suggested as a rapid means of estimating probable porosity. Various methods for reducing porosity are discussed; these include cathodic treatment in caustic soda solution, and treatment with hypophosphorous acid. Oxygen-free copper is recommended as the best material to employ if non-porous coatings are to be obtained.

INTRODUCTION.

WHEN copper is tinned by immersion in molten tin, there are, in general, two types of coating that can be obtained. In the first the copper emerges from the tin coated with a smooth layer of molten tin which remains in place as such until it solidifies, forming a coating, which, depending on the conditions of solidification, may either be smooth and bright, or may exhibit typical crystal boundaries or striations as described elsewhere.¹ In the second type less tin remains on the copper and may be either accumulated as ridges (see Fig. 1, Plate I) (Daniels' "rippled" coating²), or isolated globules (see top half of Fig. 5, Plate II), the remainder of the surface in each case being very thinly covered. In this work the first type of coating will be referred to as "smooth" and the second as "irregular."

Since the irregular coating is liable to occur in commercial tinning practice, it is a matter of considerable importance to understand the conditions which give rise to it.

In the investigation described in this paper consideration has been given only to the degree in which the quality of the basis metal influences the formation of either type of coating.

RELATION OF TYPE OF COATING TO POROSITY.

From the point of view of corrosion-resistance, it is important that a tin coating on copper should be as free from pores as possible.

* Manuscript received December 21, 1935

† Sir John Cass Technical Institute, London.

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

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The influence of the type of coating is made clear by the following porosity tests. A number of slips of tinned copper of equal areas, some with smooth coatings and some with irregular coatings, were soaked for 12 hrs. in 0.91 ammonia containing 1.5 per cent. of 20 vols. hydrogen peroxide. This porosity reagent was employed in preference to the more usual ammonia solution containing ammonium persulphate, since experiment has shown that this reagent has a slight attack on a tin-copper alloy. Direct determination of the copper taken into solution showed the porosity of the latter specimens to vary from five to twenty times that of the former.

RELATION OF INCLUSIONS TO POROSITY.

Preliminary investigations on a series of copper specimens containing various amounts of cuprous oxide inclusions indicated the importance of these inclusions as a possible major source of irregular coatings and their associated high porosity.

RAPID TEST FOR POROSITY.

It is important to be able to form an opinion rapidly on the presence or absence of cuprous oxide inclusions on the surface of the copper to be tinned. Microscopic examination, whilst revealing accurately the oxide content, nevertheless necessitates microscopic polishing.

Investigations showed that when a copper surface is amalgamated no adherence between mercury and cuprous oxide occurs. The amalgamation test takes only a few moments and, whilst it is essential to have a clean copper surface, it is unnecessary to produce a microscopic polish. Amalgamation is best performed by rubbing into the copper surface, with Selvyt cloth or similar material, a solution of mercuric chloride acidified with hydrochloric acid. After washing and drying, the specimen is examined microscopically. It is not advisable to use metallic mercury, since oxide inclusions are then liable to be obscured.

Fig. 3 (Plate I) shows amalgamated ordinary arsenical-copper, and Fig. 4 (Plate I) shows ordinary arsenical-copper with an irregular coating. The surface of the copper in each case was in the "as received" condition. The black spots are entirely due to cuprous oxide inclusions.

It is interesting to note that the foregoing amalgamation of the surface simulates the tinning operation with the merit of producing a smooth, shiny surface on which the amalgamated inclusions are readily distinguished, which is, of course, not the case when the surface is actually tinned.

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METHODS FOR OBTAINING COATINGS OF LOW POROSITY.

(a) Copper Containing Oxygen.

Tests were carried out to determine the possibility of securing reduction of surface cuprous oxide to copper. Annealing in a reducing atmosphere is scarcely possible in practice and in any case is likely to have a very detrimental effect on the mechanical properties of the copper. Heating the copper to redness after wetting with alcohol affords a reducing atmosphere, but although the tinning operation is facilitated, the reduction of cuprous oxide is not sufficiently extensive to be effective.

(1) *Treatment with Hypophosphorous Acid.*—There are a number of reducing agents which in solution will reduce cuprous oxide. One of the most successful of these is hypophosphorous acid.* As a convenient means of testing the action of this reagent and of others, solid crystalline cuprous oxide was employed; this was prepared by heating small discs of oxygen-free copper in air at approximately 1000° C., for 1 week. Careful grinding of the edges of those specimens with uncracked scales gave small discs the interior consisting of pure cuprous oxide.

Immersion of crystalline cuprous oxide in hypophosphorous acid produced immediate superficial reduction to copper. It is advisable that the acid should be used cold and in concentrations between 2 and 50 per cent., the time varying from 20 to 5 minutes, respectively. The solution has the advantage that it does not deteriorate appreciably by exposure to air, and it reacts only with cuprous oxide and not with copper, being, therefore, very economical in use. It has no action on cupric oxide. By washing and drying discs treated in this way it is possible to produce on them satisfactory tin coatings provided that the temperature is low enough, and the time of dipping short enough, to prevent the removal of all the deposited copper. The chief disadvantage of the treatment is that the deposited copper is in a very spongy condition, and in this respect it might be possible to bring about an improvement by adjusting the solution conditions. For the most part the copper coatings produced in these experiments were too spongy to permit even light rubbing. The same remarks apply to oxygen-containing copper treated similarly.

(2) *Cathodic Treatment.*—Cathodic treatment under conditions which cause evolution of hydrogen is much more successful.† Specimens of crystalline cuprous oxide were treated cathodically in a solution of 5 per cent. caustic soda, with nickel gauze anodes and current densities varying from 10 to 50 amp./ft.². Superficial reduction to copper takes

* Suggested to the author by Dr. A. M. Ward.

† Suggested to the author by Mr. D. J. Macnaughtan.

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place immediately, and usually a time of treatment of from 5 to 10 minutes is sufficient for tinning. Cupric oxide also becomes coated slowly with copper. Doubtless other solutions may be equally satisfactory, but the advantages of caustic soda solution are that it does not deteriorate appreciably, has a high conductivity, is cheap, and does not corrode the nickel anodes. The caustic soda should be washed off before tinning. The copper deposit is quite hard, bright, and tenacious. The rate of reduction has not been studied in detail, but appears to vary approximately directly with time.

Fig. 2 (Plate I) shows (top) a disc of cuprous oxide (natural size), compared with a similar treated disc (bottom), which has been tinned using stannic bromide as a flux.

The oxide inclusions in copper are normally very small, even viewed under high magnifications. To facilitate the study of cathodic treatment on copper, highly oxidized copper was prepared by exposing molten oxygen-free copper to the air for 1 hr. and casting into plates which were machined to sheets 0.075 in. in thickness, and polished. The oxygen content of the material averaged 0.86 per cent.

Cathodic treatment as described produced equally good reduction of cuprous oxide to copper, and the depth of penetration was uniform and regular. Treatment for 10 minutes secured conversion to such an extent that rubbing with a coarse emery cloth or a fine grinding wheel, followed by subsequent polishing, was necessary to expose the underlying oxide. The reduced surface appeared bright, and light polishing with magnesia, by the production of a flowed film, served to mask entirely any indications of inclusions.

Fig. 9 (Plate III) is a colour photograph of dendrites of cuprous oxide set in a background of eutectic. In Fig. 10 (Plate III), showing the same area after cathodic treatment; it will be seen that the reduction to copper is complete.

In spite of complete reduction to considerable depths, it was found quite impossible to secure smooth coatings with this copper, and it was not possible to obtain satisfactory amalgamation. This fact would appear to be due mainly to the eutectic, since colonies of finely-divided cuprous oxide will not be reduced to any appreciable depth in the copper, and unreduced portions will be exposed during the attack of the copper surface by the molten tin. The difficulty was obviated by annealing the copper at 1000° C. in nitrogen for 36 hrs. After re-polishing, the eutectic was found to be completely coagulated and the surface after treatment would then amalgamate and tin well.

Fig. 5 (Plate II) shows a slip of tinned oxidized copper in which only the lower half has been treated cathodically. The lower half has a



FIG. 1.—“Rippled” Tin Coating on Copper. $\times 1$.

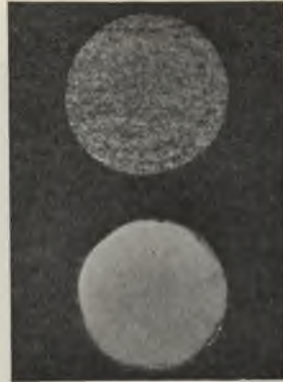


FIG. 2.—Top : Cuprous Oxide Disc. Bottom : Cuprous Oxide Disc, Tinned after Cathodic Treatment. $\times 1$.

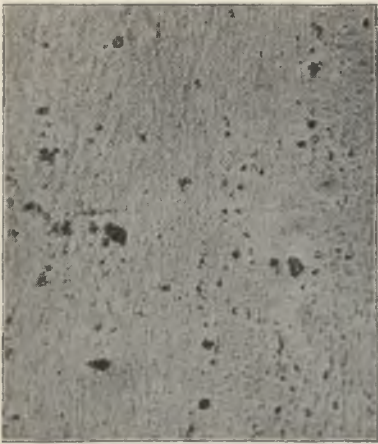


FIG. 3.—Amalgamated Copper Showing Cuprous Oxide. $\times 500$.

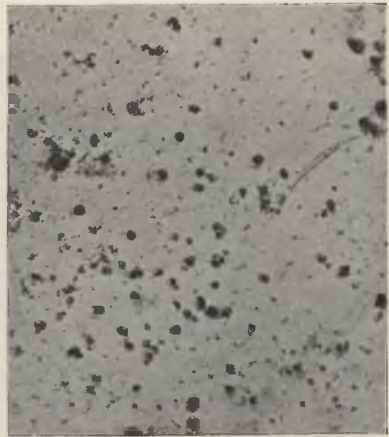


FIG. 4.—Copper Containing Cuprous Oxide which gave an Irregular Coating. $\times 500$.





FIG. 5.—Tinned Oxidized Copper; the Lower Half has been Treated Cathodically. $\times 1$.

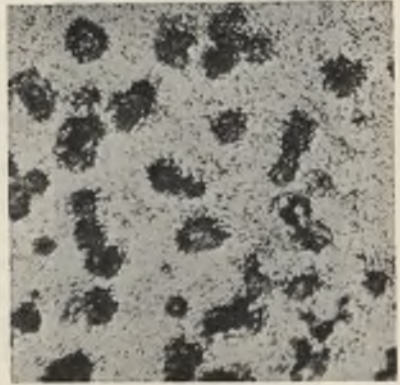


FIG. 6.—Pores in Tin Coating Produced by Cuprous Oxide. Top Half of Specimen Shown in Fig. 5. $\times 500$.

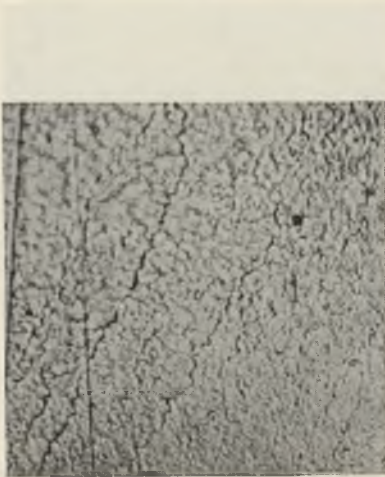


FIG. 7.—Non - Porous Tin Coating. Lower Half of Specimen (Cathodically Treated) Shown in Fig. 5. $\times 500$.

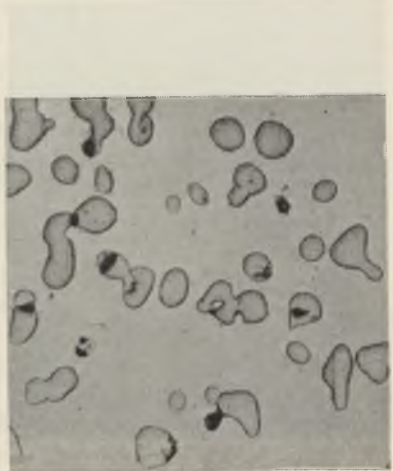


FIG. 8.—Cuprous Oxide Inclusions in the Untinned and Unetched Surface of Specimen Shown in Fig. 5. $\times 500$.

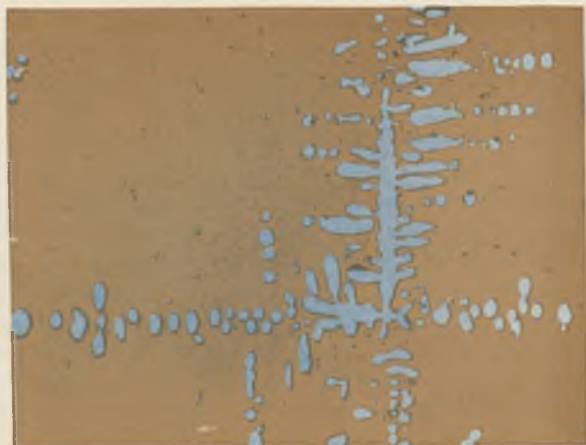


FIG. 9.—Dendrites of Cuprous Oxide Set in a Background of Eutectic. $\times 1000$.



FIG. 10.—Same Area as in Fig. 9, after Cathodic Treatment, in which Reduction to Copper is Complete. $\times 1000$.



Porosity of Hot-Tinned Coatings on Copper

smooth tin coating, whilst the upper half is only very lightly tinned and very irregular. Fig. 6 (Plate II) shows the pores produced by cuprous oxide in the tin coating in the untreated half of the same specimen, whilst Fig. 7 shows the perfect tin surface (crystal boundaries are visible) of the treated half. These samples were tinned using stannic bromide as a flux. Fig. 8, which should be compared with Fig. 6, shows the cuprous oxide inclusions in the untreated and unetched copper surface.

These experiments are completely confirmed using ordinary varieties of copper. It must be emphasized that the time of tinning must be short and the temperature as low as possible in order not entirely to remove the deposited copper. The beneficial effect of the treatment is mainly seen with irregular coatings, but there must necessarily be a reduction in number of the occasional pores obtained with smooth coatings which are due to oxide. In any case the coating over the oxide inclusions in these circumstances is no longer a matter of mechanical bridging but a case of true alloying.

Quite apart from cathodic treatment for the production of hydrogen, it is also possible simultaneously to deposit copper electrolytically by employing copper-bearing electrolytes. Substantial improvements in porosity can be secured in this manner.

(b) Oxygen-Free Copper.

This material may be used to give smooth tin coatings of low porosity without any special pre-treatment such as is described above. This confirms the action of surface cuprous oxide inclusions in producing irregular tinned coatings of high porosity.

SUMMARY AND CONCLUSIONS.

Preliminary tests indicated that the production of porous, irregular tin coatings on copper during hot-tinning is associated with the presence of inclusions of cuprous oxide in the copper base, and that relatively non-porous, smooth coatings are produced in the absence of such inclusions.

The presence of cuprous oxide inclusions can be readily detected by amalgamation of the copper surface at room temperature by the use of acid mercuric chloride.

Copper containing oxide inclusions can be made to give non-porous smooth coatings by certain special pre-treatments which reduce the cuprous oxide to metal. Thus, the copper may be simply immersed for some minutes in cold hypophosphorous acid (2-50 per cent.) or treated cathodically in dilute caustic soda solution, the latter process being the more satisfactory.

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Smooth tin coatings are readily obtained on oxygen-free copper in the absence of any special pre-treatment, and this material is recommended as the most suitable for hot-tinning. This is consistent with the view that cuprous oxide inclusions in other types of copper are a major cause of the production of irregular, highly porous coatings.

ACKNOWLEDGMENTS.

The investigation described forms part of a programme of research being carried out for the International Tin Research and Development Council, to whom the author is indebted for permission to publish these results. The author wishes to thank the Director of Research, Mr. D. J. Macnaughtan, for valuable advice. Grateful acknowledgment is also due to the Governors of the Sir John Cass Technical Institute for the facilities provided and to the Principal of the Institute for the interest that he has taken in the work. The author is greatly indebted to Mr. E. J. Groom and to Dr. B. Chalmers for collaboration in many ways.

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THE HOT-TINNING OF COPPER: THE ATTACK ON THE BASIS METAL AND ITS EFFECTS.*

By EDWARD J. DANIELS,† M.Sc., MEMBER.

SYNOPSIS.

A study was made of the nature and extent of the attack of copper by tin and solder during hot-dipping. It is shown that the compound layer is invariably duplex, consisting of Cu_3Sn and Cu_6Sn_5 . This layer breaks up under solvent attack and is removed from the basis metal almost as fast as it is formed. Contamination of the bath and coating owing to this action increases rapidly with increase in temperature and causes important effects on the smoothness of tin coatings to an extent that is influenced by the degree of the contamination and the quality of the basis metal.

INTRODUCTION.

ALTHOUGH the tinning of copper by hot-dipping has been carried out industrially on a large scale for many years, there appears to be a lack of data which fully explain the mechanism of the process, particularly with respect to the composition of the coating. It is well-known that copper derived from the basis metal is invariably present in this coating, and there is abundant evidence that this copper affects the technique of the hot-tinning process. The investigation described in the present paper was carried out to discover the method by which the copper enters the tin, the degree of contamination obtained, and its effect on the nature of the coating obtained.

PREVIOUS WORK.

The evidence regarding the nature of the compound formed on the surface of copper when immersed in molten tin is somewhat conflicting. From the work of Crow,¹ which was carried out with solder, it appeared that a layer of the material known as "H" (subsequently found to be Cu_6Sn_5) is formed at relatively low temperatures, and that a layer of η (Cu_3Sn) makes its appearance between the Cu_6Sn_5 layer and the copper at somewhat higher temperatures.

In other investigations^{2, 3} on the action of tin on copper, both of these layers appeared in the microstructures. Since, however, the experiments were conducted at high temperatures or for very long times,

* Manuscript received December 21, 1936.

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

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they do not provide conclusive evidence of their simultaneous formation at the low temperatures and short times ordinarily used in tinning operations. The experiments described below were carried out, therefore, over a wide range of temperature with short times of immersion in order to be comparable with commercial tinning practice.

EXPERIMENTAL WORK.

Small strips of annealed high-conductivity copper were tinned after fluxing and preheating, and then quenched in water. Two sets were prepared, the first in Chempur tin and the other in the tin-lead eutectic. The temperature varied from 250° to 450° C. in steps of 25° C., specimens being tinned for 5 and 30 seconds at each temperature. Before examination of the structure, the specimens were copper-plated and mounted so that an oblique section was obtained in order to exaggerate the width of the alloy layer.

The alloy layer was duplex in all specimens irrespective of the time or temperature of dipping or of the presence or absence of lead. Immediately adjacent to the copper was a band of grey alloy (Cu_3Sn), separated from the tin by a band of white alloy (Cu_6Sn_5). Figs. 1 and 2 (Plate I) show these layers on copper treated with tin for 30 seconds at 250° and 450° C., and Fig. 3 (Plate II) on copper treated with solder for 5 seconds at 400° C.

In Fig. 4 (Plate II) the compound layer is shown breaking up and becoming detached from the copper base. This phenomenon has been referred to frequently in previous investigations of tinned copper coatings and soldered copper.⁴

In comparison with the coatings produced on steel, which is the only other important metal that is coated with tin for industrial application, the contrast is marked, in that while the iron-tin compound grows with time in contact with molten tin it does not fragment and thereby influence the composition of the coating itself or of the molten tin bath.*

In the case of copper, the detached portions of compound proceed to dissolve to some extent in the tin, so that, on cooling, the number of particles of compound is increased by the crystallization of the tin-copper eutectic, the presence of which has been shown by Chalmers and Jones.⁷

INFLUENCE OF TEMPERATURE ON THE DEGREE OF CONTAMINATION.

To assess the influence of time and temperature on the degree of contamination, determinations were made of the amount of copper

* The chief source of contamination being the flux reaction.⁶

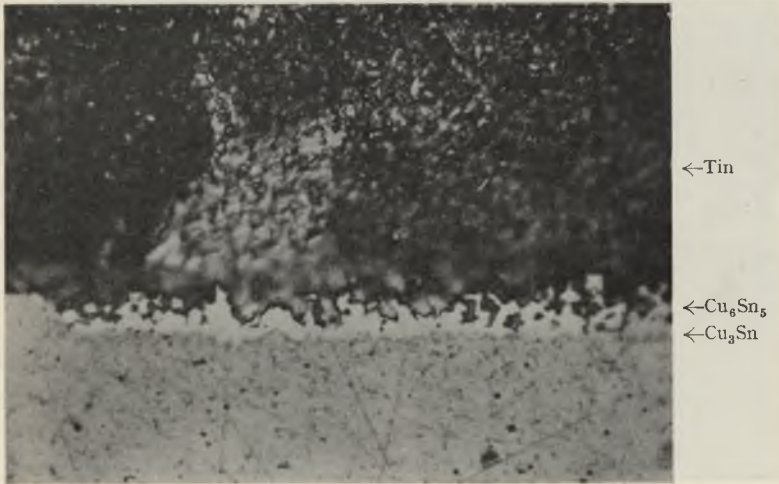


FIG. 1.—Tin on Copper, 30 Seconds, 250° C., Showing Duplex Compound Layer. Etched Dilute Ferric Chloride. $\times 1500$.

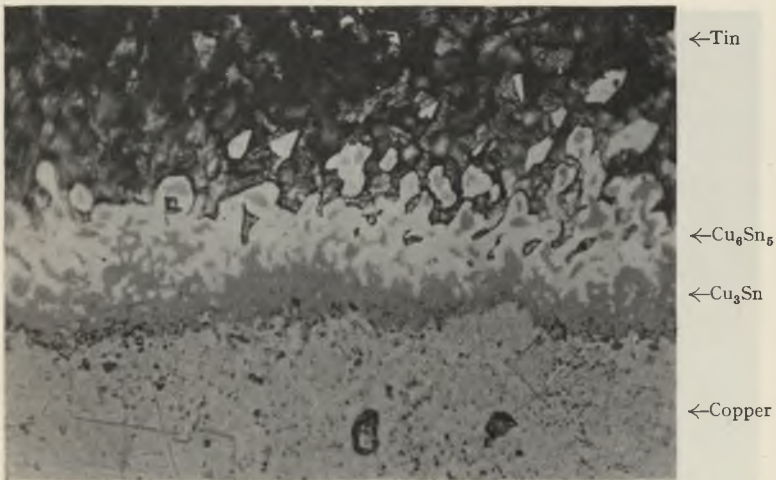


FIG. 2.—Tin on Copper, 30 Seconds, 450° C., Showing Duplex Compound Layer. Etched Dilute Ferric Chloride. $\times 1000$.



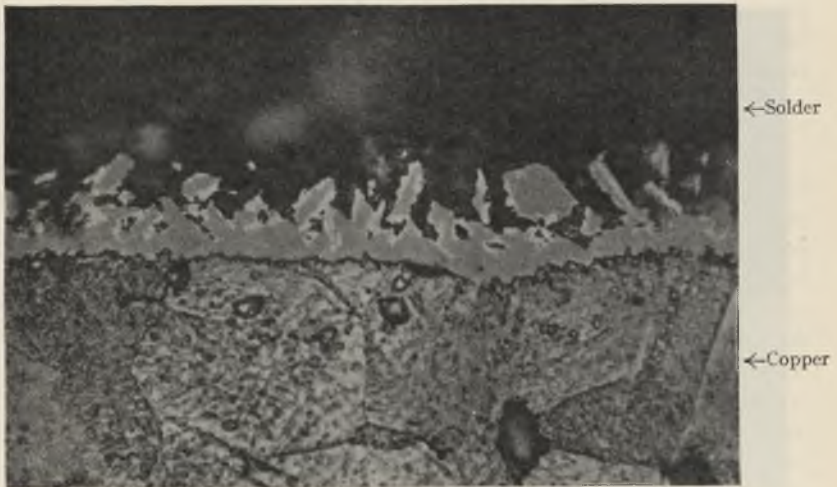


FIG. 3.—Solder on Copper, 5 Seconds, 400° C., Showing Duplex Compound Layer. Etched Dilute Ferric Chloride. $\times 1500$.

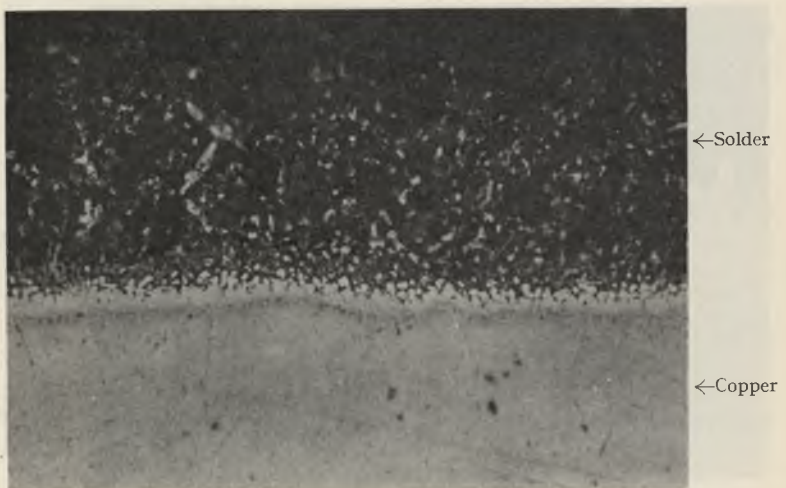


FIG. 4.—Solder on Copper, 30 Seconds, 325° C., Showing Breaking-Up of Compound Layer. Etched Dilute Ferric Chloride. $\times 500$.

The Attack on the Basis Metal and Its Effects

entering baths of tin and solder over periods of up to 36 minutes and at various temperatures. In each case a $\frac{1}{2}$ in. \times 2 in. rod of oxygen-free high-conductivity copper was fluxed, preheated, and immersed in 1200 gm. of Chempur tin or eutectic solder contained in a small electric crucible furnace and maintained at the desired temperature by a Cambridge regulator. At the end of periods of 4, 9, 16, 25, and 36 minutes, a small sample (approx. 50 gm.) of the molten metal was taken, after thorough stirring of the melt, and cast in a thin-walled steel dish which was water-cooled to ensure rapid chilling. The thin button so obtained was weighed and sawn through a number of times to give a sample which was then analyzed.

The relative rates of attack shown in Table I, calculated from the experimental data thus obtained, illustrate the marked effect of temperature of both tin and solder. The results also show that the lead in the solder acted as a diluent, although it did not affect fundamentally the nature of the reaction at the copper surface.

TABLE I.—*Relative Attack of Tin and Eutectic Solder (63 Tin, 37 Lead) on Copper at Various Temperatures.*

(Tin at 250° C. = 1.)

	Temperature, ° C.					
	250.	275.	300.	350.	375.	400.
Tin	1	1.50	2.19	4.43	5.65	7.57
Eutectic solder	0.28	0.42	0.61	1.18	1.58	2.07

EFFECTS OF DISSOLVED COPPER ON TIN COATINGS.

The effects of the copper removed in this way from the surface of material being coated with molten tin are liable to complications in that some of the copper escapes into the tin bath during the immersion period, whilst the remainder, together with an additional quantity subsequently produced when the article has been removed from the bath and before the coating has set, is retained in the coating. No discussion of the technique of tinning or of the characteristics of tin coatings on copper can be adequate, which overlooks the effects caused by differing concentrations of copper produced in the coating as a consequence of these actions. The influence of quantities of copper in the tin bath above the eutectic has been considered elsewhere by the author,⁵ but it is important to consider the effects of the copper contamination over the whole range liable to be present under industrial conditions.

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(a) Coatings Containing the Minimum Amount of Copper.

Such coatings will be produced in a new bath practically free from copper, and the copper content of the coating will be almost entirely that produced during the time which elapses between immersion of the article and solidification of the tin coating. In general, such a coating of normal thickness will consist of nearly pure tin at the surface with increasing concentration of the copper-tin eutectic as the surface of the compound layer is approached.

Hot-dipping tests over a wide range of temperatures showed that such coatings were particularly liable to be of irregular thickness. In the usual case, this irregularity revealed itself as a rippling of the tin surface, but in extreme cases it was so pronounced that only a few isolated patches of tin remained on the specimen. Since the term "rippled" does not cover both these cases, the term *irregular*⁸ is to be preferred. When, however, coatings containing the minimum amount of copper were formed on copper free from cuprous oxide inclusions, smooth coatings without any irregularity were obtained. Under identical conditions of tinning, effective quenching is essential to secure this result when working with ordinary copper containing cuprous oxide inclusions.

(b) Coatings Containing more Copper than the Above.

These consist of three classes, in which :

(1) The amount of contamination in the bath produces a coating in which a larger proportion of the copper-tin eutectic is present. Such coatings were found to be subject to the same tendency to irregularity, though to a somewhat lesser degree than those referred to in (a) above.

(2) The copper content is sufficiently high, as a result of greater contamination of the tin bath, to produce, as well as the eutectic, the separation during cooling of a certain amount of additional tin-copper compound throughout the whole body of the coating. Such coatings were not found to exhibit the characteristic of irregularity found in the class just discussed. The possible explanation, previously given,⁵ is that these extra crystals of compound serve as a kind of "grit" to stiffen up the liquid coating and prevent the development of irregularity by the action of surface tension and other forces. Because of the beneficial effect of this amount of "contamination," deliberate additions of copper are not infrequently made to a tin bath in its initial stages of use.

(3) The copper content of the coating is well beyond the eutectic composition. This occurs when there is excessive copper contamination

The Attack on the Basis Metal and Its Effects

of the tin bath. As a result, undissolved crystals of compound, which may have grown to large size, are trapped in the coating which in consequence is found to have a very rough surface.

COPPER CONTAMINATION UNDER INDUSTRIAL CONDITIONS.

It is obvious from the above that a certain optimum content of copper in the tin coating is in a variety of cases necessary, particularly when quenching is not practicable, and it is here that the influence of temperature of tinning is of significance. When operating at a high temperature, the rate of contamination of the bath to the stage at which rough coatings are produced is unduly shortened.

In general, if the conditions of working are suitably adjusted, it is found that the rate of contamination of the bath may not become too great. The aforementioned experiments, in which the increase in the copper content of the bath was obtained by continuous contact with copper, are not an actual index as to what will happen under normal operating conditions, in which a proportion of the copper contamination produced by attack is removed in the tin coatings. The effect of temperature in the latter case is indicated approximately by the following tests: 60 flat specimens, 2 cm. \times 7 cm., were tinned with a time of dipping of 5 seconds, in a bath of 1500 grm. of Chempur tin at 245° C., and a similar series was similarly treated in a fresh bath at 345° C.

245° C. Resulting copper in bath 0.5 per cent.

345° C. " " " 0.75 "

In view of what has been stated in section (2) above about the beneficial effect of "grit" produced by precipitation of tin-copper compound in the deposit itself, it would clearly be desirable, particularly when quenching is not practicable, to adjust conditions so that there is sufficient copper in the tin to ensure its presence. This implies that the percentage of copper in the bath should be just slightly above that in the eutectic composition. There is some doubt as to the actual composition of the eutectic, published figures varying from 0.75 to 1 per cent. copper. Practical experience indicates that with 1 per cent. copper in the bath smooth coatings can be regularly obtained.

FORMATION OF IRREGULAR COATINGS.

The classification given above with regard to the influence of dissolved copper in the avoidance of irregularity in the coating, becomes markedly altered when the basis metal used is oxygen-free copper. If this material is used the tendency to irregularity in the coatings containing only small amounts of copper does not occur, so that the whole question

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of control of the copper content of the bath merely relates to the avoidance of that excess which gives rise to roughness. This effect of replacing copper basis metal containing cuprous oxide by copper free from oxide, indicates the significant rôle which surface oxide inclusions play in the production of irregular coatings, which is more fully referred to by Jones⁸ in this volume of the *Journal*. The manner in which oxide inclusions exert this adverse effect requires full investigation. Examination of the junction between copper containing cuprous oxide and the layer of tin reveals the absence of any compound at the exposed cuprous oxide surface. The evidence so far obtained suggests that the diminished anchorage of the coating to the basis metal produced by the presence of such unalloyed areas, is an important cause of the retraction of the tin layer under surface tension and other forces which results in rippled coatings and in extreme cases of the accumulation of the tin in isolated patches.

SUMMARY AND CONCLUSIONS.

(1) Examination of cross-sections of tin and solder coatings produced on copper by dipping for short times comparable with practice, over a wide range of temperature (*viz.* 5 and 30 seconds; 250°–450° C.) has shown that the duplex compound layer of Cu_6Sn_5 superimposed on Cu_3Sn is invariably present.

(2) The duplex layer breaks up almost as fast as it forms, leading to contamination with copper of both the tin bath and the tin coating. Quantitative experiments in the range 250°–400° C. have shown that the resulting dissolution of copper proceeds at an accelerated rate with increase in temperature. In the case of eutectic solder, the lead present acts merely as a diluent, and the rate of attack is reduced between 3 and 4 times over the whole range of temperature.

(3) The effects in respect to irregularity, normal smoothness and roughness of the unquenched tin coating produced by varying degrees of copper contamination have been discussed in relation to :

(a) *Ordinary Copper Containing Cuprous Oxide Inclusions.*—When the copper content of the tinning bath is very low, irregular coatings are generally obtained. With higher percentages of copper, up to that of the eutectic, the tendency to irregularity in the coatings is diminished. Smooth coatings are generally obtained when the amount of copper in the tin is just above that of the eutectic composition. When the copper present considerably exceeds the eutectic composition, the coatings are rough.

(b) *Oxygen-Free Copper.*—Regular coatings are obtained with this material over a wide range of copper content in the tinning bath from

The Attack on the Basis Metal and Its Effects

practically pure tin to above the eutectic composition. When the amount of copper present is much higher it gives rise to rough coatings as in (a).

(4) It is suggested that lack of compound formation at the sites of surface inclusions of cuprous oxide is an important factor in causing irregular coatings. In the tinning of copper containing cuprous oxide and in the absence of effective quenching, the presence of a small amount of copper in the tinning bath is recommended to secure the production of regular coatings.

ACKNOWLEDGMENTS.

The author wishes to thank the International Tin Research and Development Council for permission to publish this paper, and their Director, Mr. D. J. Macnaughtan, for his advice and encouragement. Thanks are also due to Mr. R. M. Angles for assistance with some of the experimental work, to Mr. H. J. Taffs for taking the photomicrographs, and to Dr. W. E. Alkins for supplying the oxygen-free high-conductivity copper strip.

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MEETINGS OF OTHER SOCIETIES

MONDAY, FEBRUARY 17.

BRADFORD ENGINEERING SOCIETY.—C. G. Bainbridge: "Hand and Machine Cutting by Oxy-Fuel Flame." (Technical College, Bradford, at 7.30 p.m.)

FRIDAY, FEBRUARY 21.

INSTITUTE OF BRITISH FOUNDRYMEN, SHEFFIELD AND DISTRICT BRANCH.—J. H. D. Bradshaw: "Sand and Shot Blasting." (Grand Hotel, Sheffield, at 7.30 p.m.)

SATURDAY, FEBRUARY 22.

INSTITUTE OF BRITISH FOUNDRYMEN, EAST MIDLANDS BRANCH.—A. Logan: "Non-Ferrous Castings." (Loughborough College, at 6 p.m.)

INSTITUTE OF BRITISH FOUNDRYMEN, NEWCASTLE-UPON-TYNE AND DISTRICT BRANCH.—E. B. Ellis: "Foundry Products through the Microscope." (Neville Hall, Westgate Rd., Newcastle-upon-Tyne, at 6.15 p.m.)

SATURDAY, FEBRUARY 29.

INSTITUTE OF BRITISH FOUNDRYMEN, SCOTTISH BRANCH, FALKIRK SECTION.—Prof. J. H. Riley: "Foundry Coke." (Temperance Café, Lint Riggs, Falkirk, at 6 p.m.)

TUESDAY, MARCH 3.

ELECTRODEPOSITORS' TECHNICAL SOCIETY, BIRMINGHAM CONFERENCE.—R. E. Close: "Historical Development and Practice of Silver Plating." (James Watt Memorial Institute, Gt. Charles St., Birmingham, 3, at 7.30 p.m.)

WEDNESDAY, MARCH 4.

INSTITUTE OF BRITISH FOUNDRYMEN, LONDON BRANCH.—A. G. Robiette: "The Possibilities of the Electric Furnace in the Cast Iron and Brass Foundry." (Charing Cross Hotel, London, W.C.2, at 8 p.m.)

SATURDAY, MARCH 14.

INSTITUTE OF BRITISH FOUNDRYMEN, SCOTTISH SECTION.—W. Machin and M. C. Oldham: "Contraction." (Royal Technical College, George St., Glasgow, at 4 p.m.)

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METALLURGICAL ABSTRACTS
Members are Reminded of the

Part 2
Volume 3
DISCUSSION

ON

METALLIC WEAR

IN THE

PRESENCE OF LUBRICANTS

which will take place in

The Hall of the Institution of Mechanical
Engineers, Storey's Gate, London, S.W.1

at 7.30 p.m.

On Tuesday, March 10

Members of Allied Societies have been invited to
participate.

On the same day as the Discussion mentioned above,
and at the same place, there will be held at

5.30 p.m. an Extraordinary General

Meeting to consider proposals

for altering the Rules of

the Institute regarding

Membership of

the Council.

METALLURGICAL ABSTRACTS

(GENERAL AND NON-FERROUS)

Volume 3

FEBRUARY 1936

Part 2

I.—PROPERTIES OF METALS

(Continued from pp. 1-3.)

***The Electrical Resistance of Aluminium at Low Temperatures.** H. A. Boorse and H. Niewodniczański (*Proc. Roy. Soc.*, 1936, [A], 153, 463-475).—The electrical resistance of six polycrystalline aluminium wires was measured at 0° C. and at the temperatures of liquid nitrogen and liquid hydrogen; measurements at the temperature of liquid helium were made on four of the wires which were drawn from very pure aluminium (99.995% purity). The resistances of these four wires were found to be constant between 4.2° and 2.2° K. Reduced resistivities of these wires were calculated by the Matthiessen-Nernst formula and compared with values deduced from Grüneisen's expression. Satisfactory agreement was found for the values corresponding to the temperature of liquid nitrogen but not for those at liquid hydrogen temperatures.—J. S. G. T.

***On the Different Behaviour of Single Crystals of Aluminium of Different Purities Prepared from the Molten Metal and by Recrystallization.** F. Gisen (*Z. Metallkunde*, 1935, 27, 256-261).—Single crystals of aluminium of 99.5, 99.8, 99.87, and 99.998% purity were prepared by maintaining the metal in a molten state at 800°-820° C. until all nuclei had disappeared and then cooling very slowly. The tensile properties of these crystals were compared with those of single crystals prepared from the same grades of aluminium by recrystallization after critical extension. Large single crystals of the purest grade were obtained by drawing 8 mm. rod to 4.5 mm., annealing at 250° C. for 15 hrs. to obtain a homogeneous fine-grained structure, stretching 0.5-1%, and then slowly heating from 430° to 480° C. over a period of 45 hrs. Load-reduction in cross-section curves for the various grades showed that single crystals of aluminium prepared by recrystallization have a well-defined critical shear strength which steadily decreases with decreasing purity to about 70 gm./mm.² for the pure metal; for single crystals of aluminium prepared from the melt this value is certainly less than 20 gm./mm.² for all grades from 99.5 to 100%. This difference is attributed to the more pronounced mosaic structure of crystals prepared by recrystallization, a theory which is confirmed by intensity measurements of the reflections obtained in rotating crystal X-ray photograms.—A. R. P.

***The Change of Resistance of Bismuth Single Crystals in a Magnetic Field at Low Temperatures.** W. J. de Haas, J. W. Blom, and L. Schubnikow (*Physica*, 1935, 2, 907-914).—[In German.] Measurements of the change of resistance of bismuth single crystals in magnetic fields within the temperature range attainable with liquid helium show that the effect of the magnetic field at 4.22° K. is greater than that at 14.15° K. and almost the same as that at 1.35° K. The dependence of the resistance of a single crystal on the orientation of the binary crystallographic axes in relation to the lines of magnetic force is much more complicated in character at 1.35° and 4.22° K. than at 14.15° K. —J. S. G. T.

***Crystalline Properties and Magnetic Anisotropy of Distilled Bismuth.** A. Goetz, O. Stierstadt, and A. B. Focke (*Z. Physik*, 1935, 98, 118-127).—Apparatus for distilling and condensing bismuth in a high vacuum is described.

* Denotes a paper describing the results of original research.

† Denotes a first-class critical review.

The condensate is found to consist of a microcrystalline film of thickness 0.5 to 0.1 mm., upon which a macrocrystalline deposit of similarly oriented crystallites, with their [111]-axes arranged approximately parallel to the direction of growth, is deposited. These crystals are characterized by an approximately equidistant stratification of thickness 0.5μ . The magnetic anisotropy, R , *i.e.* the ratio of the magnetic susceptibilities measured normal to, and parallel to [111], is measured for single crystals prepared from the condensate. The effect of lead impurities, present in the bismuth at an atomic concentration N , on the value of R is found to be given by $R = R_0 + A \cdot N^\beta$, where β varies considerably with temperature and is > 0.5 and < 1 . Distillation does not appear to be a suitable process for purifying bismuth.

—J. S. G. T.

***X-Ray Investigation of the Thermal Expansion of Cadmium.** G. F. Kosolapow and A. K. Trapesnikow (*Z. Krist.*, 1935, **91**, 410–423).—[In German.] The lattice constants (a and c) of cadmium have been determined for the temperature range 26° – 189° C. The values at 26° C. agree well with those of Stenzel and Weerts and with those of Kozina and Rowinsky. The value of c/a increases with increase of temperature. Values of the coefficient of linear expansion respectively perpendicular (a_{\perp}) and parallel (a_{\parallel}) to the hexagonal axis were found as follows within this temperature range: a_{\perp} , 1.7 – 2.2×10^{-5} ; a_{\parallel} , 4.8×10^{-5} . Values of the volumetric coefficient of expansion, β , calculated from these values are $\beta_{83^\circ} = 8.33 \times 10^{-5}$; $\beta_{85^\circ} = 8.75 \times 10^{-5}$, and $\beta_{107^\circ} = 9.25 \times 10^{-5}$. These values are in agreement with those found by Uffelmann by an optical method.—J. S. G. T.

†Oxygen in Copper. H. J. Miller (*Metal Treatment*, 1935, **1**, 191–194, 201).—The relation between the oxygen and hydrogen contents of molten copper and the “set” and soundness of the ingots produced; the production of deoxidized and oxygen-free high-conductivity copper; the solubility and distribution of cuprous oxide in copper and its effect on softening temperature; tensile properties before and after drawing; impact and fatigue properties; and liability of the copper to “gassing” are dealt with in this review. A bibliography of 22 references is appended.—J. C. C.

***The Adsorption of Hydrogen and Deuterium on Copper at Low Pressures.** Ralph A. Beebe, George W. Low, Jr., Edwin Lincoln Wildner, and Seymore Goldwasser (*J. Amer. Chem. Soc.*, 1935, **57**, 2527–2532).—At -78° C. the rate of adsorption of deuterium on copper is less than that of hydrogen, but at equilibrium equal amounts of the two isotopes are adsorbed. Between 0° and 125° C. the ratio H_2/D_2 adsorbed undergoes an inversion, hydrogen being more strongly adsorbed at the lower temperatures and less strongly adsorbed at the higher.—A. R. P.

***Permeability to Hydrogen of Copper, Iron, Nickel, Aluminium, and Some Alloys.** W. Baukloh and H. Kayser (*Z. Metallkunde*, 1935, **27**, 281–285).—No hydrogen diffuses through drawn copper tubes or drawn aluminium tubes at temperatures almost up to the melting point, but diffusion occurs through iron, nickel, nickel-iron, and copper-nickel alloy tubes at temperatures above about 550° C., pure nickel being the most permeable metal. In the case of the alloy tubes the permeability increases with the nickel content and temperature and decreases with an increase in wall thickness. Nickel is impermeable to helium, argon, neon, and krypton.—A. R. P.

***Magnetism of Copper.** S. Ramachandra Rao (*Nature*, 1935, **136**, 436).—The magnetic susceptibility of copper increases with the degree of comminution of the metal. A critical stage is reached at 0.8μ , below which diameter the susceptibility undergoes a rapid increase.—E. S. H.

Copper Data. — (*Copper Development Association Publ. No. 12*, 1935, 64 pp.).—Deals with the properties of copper (mechanical; physical; electrical; corrosion-resistance), treatment and working (refining; oxygen in

copper and deoxidized copper; additions of other elements; working and annealing; tinning; joining; machining), commercial grades and applications (grades and forms; semi-manufactured—sizes, tolerances of plate, strip, tube, &c.; engineering and industrial applications). An appendix gives a graph showing average metal prices for copper and certain other metals for the period 1924–1934, a list of British Standard Specifications relating to copper, and weight tables.—S. G.

Thermo-E.m.f., Peltier Heat, and Photo-E.m.f. in the Cell Copper-Cuprous Oxide-Copper. G. Mönch (*Physikal. Z.*, 1935, **36**, 755–757).—Theoretical considerations relating to the calculation of values of the thermo-e.m.f., the Peltier effect, and the photo-e.m.f. in a circuit comprising two metal conductors, e.g. of copper, united by a semi-conductor, such as cuprous oxide, are discussed briefly.—J. S. G. T.

***Observations on the Rare Earths. XLVI.—The Atomic Weight of Gadolinium.** C. R. Naeser with B. S. Hopkins (*J. Amer. Chem. Soc.*, 1935, **57**, 2183–2184).—The value found was 156.85 ± 0.011 .—L. A. O.

***Revision of the Atomic Weight of Germanium. I.—Analysis of Germanium Tetrabromide.** O. Hönigschmid and R. Schlee (*Z. anorg. Chem.*, 1935, **225**, 81–89).—The value found was 72.59.—A. R. P.

***Mercury in Powder Form.** A. Galatzky (*Bull. Soc. chim. France*, 1935, [v], **2**, 1801–1807).—Mercury can be obtained in the form of an active, light grey powder, which coalesces to droplets only on heating to 150° C. or on grinding in a mortar, by reduction of an aqueous suspension of mercurous oxide with hydrazine, hydroxylamine, or formaldehyde. The powder consists of minute spheres of the metal coated with a very thin film of mercurous oxide; owing to its large surface area evaporation is relatively rapid and a strong metallic smell may be observed even some distance away. Mercury powder amalgamates instantaneously with gold or tin.—A. R. P.

***The Formation of [Diatomic] Mercury Molecules.** F. L. Arnot and J. C. Milligan (*Proc. Roy. Soc.*, 1936, [A], **153**, 359–378).—The existence of diatomic molecular ions of mercury has been established, for the first time, by magnetic analysis of ions produced in mercury vapour by electron impact. The mechanism of their production is discussed.—J. S. G. T.

***The Volume Magnetostriction Effect in Nickel and Magnetite.** M. Kornetzki (*Z. Physik*, 1935, **97**, 662–666).—The volume magnetostriction effects of three samples of nickel are measured and compared with results to be anticipated from a knowledge of the thermal expansion of nickel. The results are contradictory for the higher field strengths employed.—J. S. G. T.

***Investigation of the Change of the Alternating-Current Resistance of Nickel in Longitudinal Magnetic Fields.** M. M. Sen Gupta, H. B. Mohanti, and S. Sharan (*Z. Physik*, 1935, **98**, 262–266).—The hysteresis effect found in the case of the a.c. resistance of nickel in a longitudinal magnetic field is less than that characterizing the d.c. resistance. Moreover, no remanent resistance is found, and the mode of dependence of the resistance on the field strength is different in the two cases. The a.c. resistance–field strength curve is free from many of the irregularities found when d.c. is used.—J. S. G. T.

Magneto-Resistance Change of Nickel Studied with Alternating Current. M. M. S. Gupta, H. Mohanty, and S. Sharan (*Current Sci.*, 1935, **3**, 351; *Brit. Chem. Abs.*, 1935, [A], 567).—Cf. preceding abstract. Effects with a.c. and d.c. are compared. Hysteresis is not found with a.c.—S. G.

***Influence of Phosphorus and Sulphur on the Mechanical Properties of Platinum and Palladium.** A. Jedele (*Z. Metallkunde*, 1935, **27**, 271–275).—Small quantities of phosphorus in platinum or palladium and small quantities of sulphur in palladium increase the hardness, yield-point, and tensile strength, but decrease the ductility and working properties. Both metals become unworkable at 850° C. (hot-short) with about 0.005–0.006% phosphorus, and

palladium becomes hot-short with about 0.02% sulphur; these effects are due to the formation of readily fusible brittle compounds which are quite insoluble in the solid metal. The presence of sulphur in platinum has not nearly the same ill effects at high temperatures; even with 0.15% sulphur the metal is readily workable at 850° C., since the sulphide formed has a limited solubility in the metal. The tensile properties of alloys with up to about 1% of the non-metal are tabulated and characteristic photomicrographs of their structure are shown.—A. R. P.

***Alkali Films of Atomic Thickness on Platinum.** Herbert Mayer (*Physikal. Z.*, 1935, **36**, 845-848).—A method is described for preparing alkali films of atomic thickness, employing atomic rays, and the method is employed to investigate the photoelectric properties of platinum coated with such deposits of potassium.—J. S. G. T.

***The Emission of Positive Ions by Platinum when Heated in Oxygen.** T. B. Rymer (*Proc. Roy. Soc.*, 1936, [A], **153**, 422-442).—The variation with temperature of the positive ion emission from platinum heated in oxygen is examined experimentally and the results are satisfactorily interpreted in terms of Saha's theory.—J. S. G. T.

***On the Kinetics of the Precipitation of Silver by Metallic Lead from Silver Nitrate Solution.** S. Krzyżanski (*Z. anorg. Chem.*, 1935, **225**, 151-161).—The silver precipitated in unit time per unit area of a lead sheet immersed in silver nitrate solution is constant despite the progressive reduction in the concentration of silver in solution.—A. R. P.

***Revision of the Atomic Weight of Tantalum. Analysis of Tantalum Pentachloride.** O. Hönigschmid and R. Schlee (*Z. anorg. Chem.*, 1935, **225**, 64-68).—Cf. *Met. Abs.*, 1935, **2**, 500. The value found was 180.88 ± 0.01 .—A. R. P.

†**Intercrystalline Failure of Metals.** J. C. Chaston (*Metal Treatment*, 1935, **1**, 186-190).—Intercrystalline fractures in metals and alloys are surveyed. These are classified as caused by (1) failure of weak intercrystalline impurities; (2) weakness of the boundary cement at temperatures immediately below the melting point; (3) creep failure at the boundaries of stiffened alloys at temperatures in the recrystallization range; (4) selective boundary corrosion; (5) intercrystalline corrosion resulting from the simultaneous actions of stress and a specific corrosion agent; (6) imperfectly understood phenomena, some of which possibly involve the production of intense boundary stress concentrations. There is a *bibliography* of 24 references.—J. C. C.

†**The Relation of Fatigue to Modern Engine Design.** R. A. MacGregor, W. S. Burn, and F. Bacon (*Trans. N.E. Coast Inst. Eng. Ship.*, 1934-1935, **51**, 161-228; discussion, D99-D136; and (review) *Metallurgist* (Suppt. to *Engineer*), 1935, **10**, 18-19).—A paper in three distinct parts. In Part I a number of cases of failure in marine engine parts—principally crankshafts and tailshafts—are dealt with, and it is shown that these failures are initiated by impact at a stress raiser, corrosion-fatigue, heavy impact, or stress concentration resulting from various causes. The research work on the effect of discontinuities is also reviewed. Part II deals with a marine engine designer's problems especially the avoidance of stress raisers and of corrosion-fatigue. In Part III the evolution of certain modern views on elasticity and fatigue are discussed, and it is pointed out that the desirable properties, "notch-toughness" in fatigue and "high internal damping" tend to be related. Reference is also made to investigations on crack speed. An extended *bibliography* of 221 references is included.—J. W. D.

***Crystal Plasticity. IV.—Further Fundamental Considerations Relating to the Dynamical Law of Plasticity.** E. Orowan (*Z. Physik*, 1935, **97**, 573-595).—In continuation of previous work (*Met. Abs.*, 1934, **1**, 481) it is shown that the extension limit is practically unaffected by relaxation occurring during the course of the experiment, so that its dependence on temperature and the velocity of deformation cannot, on a static basis, be regarded as attributable to

relaxation; these effects, more especially the latter, suggest the idea of a dynamical law of plasticity. Flow curves obtained with zinc crystals are given which, in accordance with Becker's formula, indicate a very marked dependence of the flow on temperature, and immediately suggest the dynamical character of the law of deformation. The characteristics of elastic "after-effect" are discussed.—J. S. G. T.

***Crystal Plasticity. V.—Completion of the Formula for the Velocity of Slip.** E. Orowan (*Z. Physik*, 1935, **98**, 382–387).—The formula for the velocity of slip of a stressed crystal previously derived (*Z. Physik*, 1934, **89**, 642–645) is completed by taking into account fluctuations of stress during the deformation. The actual velocity of slip now appears as the joint algebraic sum of a forward and a backward slip. The correction in the case of metallic crystals is practically nil, but can be of significance more especially in the case of organic crystals.—J. S. G. T.

The Variation of Plasticity with Temperature. H. Ekstein (*Z. Krist.*, 1935, **92**, 253–274).—[In German.] The variation of the plasticity of tungsten and rock-salt with temperature agrees with that found for crystals previously examined, e.g. zinc and cadmium; in all cases the plasticity characteristics vary very little with temperature. It is concluded that the phenomenon of plasticity in crystals is essentially of an athermal character. Amorphous Bakelite shows a very large change of the initial plastic stress within the temperature range 16°–60° C.—J. S. G. T.

***The Significant Elasticity- and Deformation-Coefficients of Crystals, with Application to Isotropy.** P. Bechterew (*Z. Krist.*, 1935, **92**, 1–29).—[In German.] A mathematical theory of crystal elasticity, applied principally to anisotropic bodies and contemplating four systems of dimensionless significant coefficients is developed.—J. S. G. T.

***Modulus of Elasticity of Materials for Small Stresses.** R. H. Evans and R. H. Wood (*Phil. Mag.*, 1936, [vii], **21**, 65–80).—The value of Young's modulus, E , of steel, cast iron, glass, and other materials in compression is found to increase very considerably as the range of applied stress is increased from zero. Thereafter, in most cases, E decreases slightly, then increases slightly before falling to its final value. Values of E for a cast-iron column in extension, under small loads, decrease continuously to the final value as the load is increased. The results are explained in terms of a theory which contemplates the test column as composed of units some of which are in compression, some in tension.—J. S. G. T.

***The Frictional Oxidation at Solid Joints of Two Metals and Its Importance in Fatigue Fracture.** A. Thum and F. Wunderlich (*Z. Metallkunde*, 1935, **27**, 277–280).—Frictional oxidation at metal-to-metal joints is caused by the fatigue of the metal and the consequent entry of oxygen into the surface layers. Evidence in support of this is afforded by experiments on steels subjected to fatigue tests in dry and oiled steel clamps.—A. R. P.

†Gases in Metals. C. J. Smithells (*Metal Treatment*, 1935, **1**, 165–171).—Chairman's Address to the London Local Section of the Institute of Metals. A review is given of the factors which influence the adsorption and diffusion of gases in metals, present theories are outlined, and the relationship between these phenomena and the solubility of gases in solid metals is indicated.—J. C.

Metallic Surfaces and Thin Films. — (*Light Metals Research*, 1935, **4**, 189–194; and *Light Metals Rev.*, 1936, **2**, 197–202).—Summary of British Aluminium Co. Intelligence Memorandum I.D. 1/36. This is a review of the production, structure, and properties of thin metal films, with special reference to aluminium.—J. C. C.

Periodic Classification of the Rare Earths. Herman Yagoda (*J. Amer. Chem. Soc.*, 1935, **57**, 2329–2330).—Some reasons are advanced in support of Brauner's arrangement of the rare earth elements in the periodic system.

—A. R. P.

Electron Microscope Investigation of Electron Emission from Cold Metals. A. Wehnelt and W. Schilling (*Z. Physik*, 1935, 98, 286-287).—The electron microscope is applied to examine electron emission from a "cold" cathode. Electrons are emitted from centres which appear suddenly from time to time at different points of the cathode surface.—J. S. G. T.

***Electron-Optical Photography of [Electron]-Emitting Wires.** H. Mahl (*Z. Physik*, 1935, 98, 321-323).—The electron-optical photography of electron-emitting wires is briefly described and photographs of emitting wires of tungsten, thoriated tungsten, and molybdenum are given.—J. S. G. T.

***Relation Between the [Electron] Emission Constants of Single- and Polycrystalline Material.** A. Recknagel (*Z. Physik*, 1935, 98, 355-362).—Values of the constants in the Richardson formula for electron emission from heated metals for polycrystalline, cubic, hexagonal holohedral crystals are derived, and compared with the corresponding values for single crystals.—J. S. G. T.

The Sparking Voltage of Electrolytic Valve Action. Werner Bär (*Z. Physik*, 1935, 98, 267-279).—Characteristics of the valve action of electrodes of tantalum, aluminium, antimony, bismuth, and tungsten in solutions of sulphuric acid, borax, and boric acid are investigated.—J. S. G. T.

On the Thermoelectric Effect According to the New Electronic Theory. Mizuho Satō (*Sci. Rep. Tōhoku Imp. Univ.*, 1935, [1], 24, 523-536).—[In German.] Mathematical considerations based on Bloch's theory give values for the thermoelectric power, and the Thomson and Peltier effects which agree with those deduced from the Sommerfeld theory only at low temperatures but are three times as great at high temperatures. In the latter case the thermoelectric properties are dependent on the Debye limiting frequency but at low temperatures such is not the case.—A. R. P.

***The Electrical Conductivity of Compressed Metallic Vapours.** Werner Braunbek (*Z. Physik*, 1935, 97, 482-495; and *Physikal. Z.*, 1935, 36, 891-892).—The dependence of the electrical conductivity of a metallic vapour on pressure can be calculated by Bloch's theory; it appears not altogether unreasonable that metallic vapours under sufficiently high pressures may conduct electricity like metals. Measurements with mercury vapour at pressures up to 35 atm., and with potassium vapour at pressures up to 10 atm. did not support this suggestion. Metallic conductivity of mercury vapour was less than 10^{-12} ohm.⁻¹ cm.⁻¹; while that of potassium vapour was less than 10^{-7} ohm.⁻¹ cm.⁻¹.—J. S. G. T.

Incandescence Electron Emission and Electron Conduction in the Case of Solids. A. Gehrts (*Physikal. Z.*, 1935, 36, 764-767).—Electron emission from a metal coated with a monatomic adsorption layer, e.g. from thoriated tungsten, is considered as a purely surface phenomenon, and is discussed from this point of view.—J. S. G. T.

***The Effect of Heat Abstraction on the Electrical Characteristics of Resistances the Value of Which Depends on Temperature.** H. Lueder and E. Spenke (*Physikal. Z.*, 1935, 36, 767-773).—Electrical characteristics of electrical resistances supplied with heat by leads and cooled in various manners are described and illustrated.—J. S. G. T.

The Change of Electrical Resistance and of Reflecting Power of Metallic Mirrors Condensed at Low Temperatures. R. Suhrmann and G. Barth (*Physikal. Z.*, 1935, 36, 843).—The electrical resistances of mirrors of copper, silver, gold, cadmium, thallium, and lead deposited at 20°-80° K. decrease on heating to room temperature, while the reflection coeffs. simultaneously increase. The electrical resistance of bismuth mirrors deposited at 80° K. increases as the temperature is raised to room temperature.—J. S. G. T.

The [Electrical] Resistance of Very Thin Films of Foreign Matter in Contacts Between Metals. R. Holm and B. Kirschstein (*Physikal. Z.*, 1935, 36, 882-888).—The values of contact resistances between metals are discussed. In

accordance with observations by Holm and Meissner, such resistances are shown to be independent of temperature, and to obey Ohm's law for values of voltage applied across the contact up to 0.5 v.—J. S. G. T.

An Elementary Theory of the Change of Resistance in a Longitudinal Magnetic Field. A. Sommerfeld and B. W. Bartlett (*Physikal. Z.*, 1935, 36, 894–899).—A wave-mechanical theory of the phenomenon of the change of electrical resistance of a metal in a longitudinal magnetic field is developed.

—J. S. G. T.

Electron Configuration in the Superconducting Metals. U. Dehlinger (*Physikal. Z.*, 1935, 36, 892–894).—It is suggested that all those elements, and only those, with crystal lattices of high co-ordination number with not too small values of their atomic radius, and which have more than 1 electron per atom in the outermost shell are superconducting elements. This holds for all elements, including the transition elements but excluding some weakly-superconducting elements in which case the presence of impurities possibly is of importance. The law possibly also applies to the superconducting alloys.

—J. S. G. T.

A Refinement of the Heisenberg Theory of Ferromagnetism, Applicable to Simple Cubic Crystals. Charles H. Fay (*Proc. Nat. Acad. Sci.*, 1935, 21, 537–542).—The method used in comparing the simple Heisenberg theory with the Gaussian distribution approximation is especially applicable to cubic crystals, and hence can be experimentally verified only in the case of certain alloys: the micro-crystal is regarded as consisting of units larger than the atom, but sufficiently simple to permit their unperturbed energy levels to be calculated. The results deduced on this assumption are in good agreement with the simple Heisenberg theory, and it is suggested that the latter is preferable to the Gaussian approximation.—P. M. C. R.

***Analysis of the Process of Technical Magnetization. I.—Experiments Relating to Weiss's Theory of the Technical Magnetization Curve.** K. H. R. Weber (*Z. Physik*, 1935, 98, 155–180).—Weiss's theory of magnetization, proposed in 1907, is briefly reviewed, and is confirmed by results obtained with a nickel wire. The theory, however, requires amendment in three directions, which are briefly discussed.—J. S. G. T.

The Dependence of Volume Magnetostriction and the Weiss Factor on Temperature and the Lattice Constants. M. Kornetzki (*Z. Physik*, 1935, 98, 289–313).—A ferromagnetic material exhibiting volume magnetostriction in the region of technical saturation is found to be characterized by a change of spontaneous magnetization accompanying a change of pressure. To explain this, it is assumed that the Weiss factor and the Curie point of the material depend on its volume. A theory, correlating displacement of Curie point with change of volume, is developed. The change of volume is correlated with the lattice constants, and the theory indicates that the volume magnetostriction effect in the paramagnetic range increases with the square of the field strength. This effect is measured for iron, iron-nickel alloys, and a nickel-copper alloy in the temperature range 20°–90° C., and the theory confirmed in some respects. Satisfactory agreement is obtained between the number of magnetons per atom calculated from susceptibility data and that derived from saturation data. The Weiss factor, N , is found to be about 7000 in the region of the Curie point. The magneto-caloric effect is discussed in connection with Potter's results (*Proc. Roy. Soc.*, 1934, [A], 146, 362).

—J. S. G. T.

II.—PROPERTIES OF ALLOYS

(Continued from pp. 3-7.)

***Magnetic Investigation of Precipitation-Hardening [of Aluminium-Copper Alloys].** Hermann Auer (*Physikal. Z.*, 1935, **36**, 880-882).—The changes of paramagnetic susceptibility of aluminium-copper alloys during the improvement (*Vergütung*) process are investigated. A marked decrease in the value of the susceptibility (measured at 20° C.) occurs when the alloys are quenched from a suitable temperature. The velocity of transformation (u) at temperature T follows the law, $u = B + A/T$. The stoichiometric composition of the precipitated intermetallic compound (CuAl_2) can be determined from the susceptibility measurements. The dependence of susceptibility of pure aluminium and of the alloys after attaining precipitation-equilibrium is in accordance with an extended form of Curie law.—J. S. G. T.

***Researches to Determine the Best Hardening Temperature for Duralumin Alloys.** U. von Scheidt (*Z. Metallkunde*, 1935, **27**, 275-277).—The best quenching temperature for Duralumin containing copper 4-4.2, magnesium 0.5-0.8, silicon 0.2-0.4, and manganese 0.35-0.65% is 510°-515° C.; these alloys blister when heated at about 530° C. and after heating at 535° C. or higher a serious reduction in strength and ductility occurs. Duralumin with copper 3.6, magnesium 1.1, silicon 0.6, and manganese 1.1% fails at 520° C. and should therefore not be heated above 505° C. during heat-treatment.

—A. R. P.

***X-Ray Investigation of the Equilibrium Diagram of Aluminium-Lithium Alloys, and the Structure of the AlLi Compound.** G. Komovsky and A. Maximow (*Z. Krist.*, 1935, **92**, 275-283).—[In German.] The equilibrium diagram of aluminium-lithium alloys containing from 0 to 20.5% of lithium has been investigated by X-ray analysis; the existence of two phases (α and β) is confirmed. The β -phase is constituted of an intermetallic compound, AlLi , having a cubic crystal lattice with $a = 6.37 \text{ \AA}$., and a unit cell containing 16 atoms. The character of the α -phase was not accurately ascertained; the lattice parameters of the α -phase are the same as those of pure aluminium.—J. S. G. T.

The Properties of Silumin Containing Magnesium. G. Sachs and E. Scheuer (*Metallwirtschaft*, 1935, **14**, 937-941, 972-975; and (summary) *Light Metals Rev.*, 1935, **2**, 187-190).—The properties and uses of cast γ -Silumin (silicon 12, manganese 0.4, magnesium 0.5%) are discussed. Combined with excellent mechanical properties the alloy has good castability which renders it suitable for large and complicated castings of high strength. Quenching after casting in no way adversely affects the tensile properties. Hints for casting and heat-treatment are given and the influence of faults in the treatment is discussed.—v. G.

Cadmium-Nickel Bearing Alloys. A. J. Phillips (*Machinist (Eur. Edn.)*, 1935, **79**, 709-710E).—Cadmium-nickel bearing alloys consist essentially of pure cadmium with 1.3% of nickel and stiffening additions of copper, magnesium, silver, and even zinc. Microscopically they resemble an ordinary tin-base bearing alloy. They have a coeff. of friction slightly lower than that of S.A.E. 12 Babbitt, a fatigue strength of about 3800 lb./in.² (20×10^6 reversals), and a high melting point, the initial softening temperature being 604° F. (318° C.).—J. H. W.

***The Modulus of Elasticity of Copper-Beryllium Alloys.** Léon Guillet (*Compt. rend.*, 1935, **201**, 960-962).—Copper-beryllium alloys containing 2-18.5% of beryllium were cast and annealed for 8 hrs. at 800° C. Micro-examination confirmed the equilibrium diagram of Masing and Dahl. Determinations were made of the Rockwell hardness B and the modulus of elasticity

in bending. The hardness increased linearly with the beryllium content in the 2-constituent region, but the modulus increased throughout the whole range investigated. Beryllium appreciably increased the modulus of elasticity of copper, an alloy containing 15% beryllium having a modulus equal to that of steel. The high modulus of elasticity and the low density of beryllium explains the variation of the ring (number of transverse vibrations/second) of these alloys with the beryllium contents.—J. H. W.

Copper-Lead Bearings. D. E. Anderson (*Machinist (Eur. Edn.)*, 1935, 79, 723-724E).—Describes the properties and structure of copper-lead bearing alloys containing about 30% lead, and the requirements of these alloys for satisfactory performance.—J. H. W.

***Temper-Hardening of Commercial Nickel-Coppers Containing Phosphorus.** E. C. Rollason and T. G. Bamford (*Metals and Alloys*, 1935, 6, 345-346, 349).—The presence of small amounts of phosphorus in alloys of copper with 1-3% nickel produces precipitation-hardening after suitable heat-treatment. Thus, when copper containing nickel 1.73 and phosphorus 0.11% is quenched from 750° to 800° C. and reheated at 500° C. for 30 minutes, the tensile strength increases from 14.7 to 23 tons/in.², the elastic limit from 0.8 to 7 tons/in.², and the Brinell hardness from 42 to 82. Curves are given showing the effects of time and temperature of precipitation treatment on the hardness obtained.—A. R. P.

***Bronzes Formed with a Copper-Nickel-Tin Base, Capable of Being Hardened.**
VI.—The Addition of Cold-Working] Hardening and Precipitation-Hardening. Erich Fetz (*Z. Physik*, 1935, 97, 690-698).—Results with copper-tin alloys containing small proportions of nickel (2.5-3%) support the hypothesis that cold-working influences the atoms themselves as it is found that an addition of cold-working hardness and precipitation-hardness is possible even if the latter is smaller than the former. With increasing strain the additional precipitation effects become less; this is attributed to a directed diffusion and a vectorial increase of crystal nuclei. The maximum attainable strength of the tin-bronzes containing small proportions of nickel, capable of being hardened, is independent of the order in which hardening by cold-working and precipitation is effected. A very considerable acceleration of separation into components of the α -solution is observed in the cold-worked alloys, and is associated with an increase of total lattice energy.—J. S. G. T.

***Contribution to the Copper-Zinc [Equilibrium] Diagram.** J. Schramm (*Metallwirtschaft*, 1935, 14, 995-1001, 1047-1050).—Slight modifications of the phase boundaries in Bauer and Hansen's diagram are made as the result of very exact temperature measurements.—v. G.

The Mallechorts (Nickel Silvers). — (*Machines*, 1935, 12-13).—The commercially useful ranges of the ternary copper-nickel-zinc alloys are indicated on a constitutional diagram, and briefly described. The method of production is discussed, and suitable precautions regarding material, protection of the melt, deoxidation, and pouring are enumerated. Methods of cleaning the cast material are described.—P. M. C. R.

***On the Diffusion of Carbon, Silicon, and Manganese in Solid and Liquid Iron.** Max Paschke and Alexander Hauttmann (*Arch. Eisenhüttenwesen*, 1935-1936, 9, 305-309).—At 1400° C. the coeff. of diffusion of manganese into solid iron is 0.83×10^{-2} cm.²/day, and at 1600° C. the coeff. of diffusion of manganese into liquid iron is 9.6 cm.²/day.—A. R. P.

***The Melting-Time of [Electric Circuit] Fuses.** J. A. M. van Liempt and J. A. de Vriend (*Z. Physik*, 1935, 98, 133-140).—In continuation of previous work (*Met. Abs.*, 1935, 2, 644). Meyer's formula for the relation between time of fusion (t) and current strength (I) is established for thin wires of Monel metal and for values of I up to 20 times the limiting value. The formula $I^2t = \text{constant}$ is also found to hold for various forms of fuses used in domestic wiring systems.—J. S. G. T.

***The System Nickel-Manganese.**—II. S. Valentiner (*Z. Physik*, 1935, 97, 745-757).—Cf. *Met. Abs.*, 1935, 2, 421. The change of resistance of nickel-manganese due to a magnetic field is investigated at various temperatures between 14° and 300° C. Values of $(\Delta R/R_0) \times 10^4$ between -25 and +140 were found. Alloys containing up to 20% manganese showed a normal behaviour up to about the region of the Curie point. Alloys containing 25 and 30% manganese, owing to the effect of spontaneous magnetization, behaved abnormally, negative values of $\Delta R/R_0$ being found in moderate fields even well below the Curie point.—J. S. G. T.

†**The Mechanical Properties of Tin-Base Alloys.** D. J. Macnaughtan and B. P. Haigh (*Tech. Publ. Internat. Tin Res. Develop. Council*, 1935, [A], (26), 12 pp.; and *Met. Ind. (Lond.)*, 1935, 47, 441-444, 448).—Read before the International Congress on Mining, Metallurgy, and Applied Geology, Paris, 1935. The effects of the time-factor on tensile, compression, hardness, and fatigue tests of tin-base alloys are discussed, especially with regard to the phenomena of creep and self-annealing. Published work on the effect of different alloying elements on the properties of tin is reviewed.—E. S. H.

***Phase Changes During Ageing of Zinc-Alloy Die-Castings.** II.—Changes in the Solid Solution of Aluminium in Zinc and Their Relation to Dimensional Changes. M. L. Fuller and R. L. Wilcox (*Metals Technology*, 1935, 2, (Dec.); *A.I.M.M.E. Tech. Publ.* No. 657, 13 pp.).—Ageing at room temperature of die-castings of an alloy of zinc with 4% aluminium and 0.04% magnesium results in a slow separation of the γ -phase from the α -solid solution due to the change in solubility of aluminium in zinc from 0.78% at 375° C. to about 0.04% at 20° C. This separation results in shrinkage, and a subsequent anneal at 150°-175° C. of castings dimensionally stabilized at room temperature produces a redissolution of γ and a corresponding expansion. Stabilization of die-castings at 95° C. for 3 hrs. produces a more rapid separation of γ and therefore a more rapid shrinkage, but on storage at room temperature castings that have received this stabilization treatment undergo a further small shrinkage. This work indicates that all the dimensional changes that occur in normal ageing are due to changes in the α -phase and that the β -transformation contributes practically nothing to the observed shrinkage.—A. R. P.

***The Constitution of Liquid Zinc Amalgams.** Herman A. Liebhafsky (*J. Amer. Chem. Soc.*, 1935, 57, 2657-2662).—Re-examination of e.m.f. data for zinc amalgams affords strong indirect evidence that the zinc is present as Zn, Zn₂, and Zn₃ molecules in rapid equilibrium with one another.—A. R. P.

***The Exact Measurement of the Specific Heats of Solid Substances at Higher Temperatures.** XX.—On the Molecular Heats of the Alloys of Palladium and Antimony in Comparison with the Sum of the Atomic Heats of the Free Elements. XXI.—On the Molecular Heat of the Compound PbSb₂ in Comparison with the Sum of the Atomic Heats of the Free Composing Elements. XXII.—The Molecular Heats of the Supposed Binary Compounds of Copper and Palladium. T. J. Poppema and F. M. Jaeger (*Proc. K. Akad. Wet. Amsterdam*, 1935, 38, 822-833, 833-836, 836-841).—[In English.] (XX.—) The atomic heat, C_p , of palladium at t° C. is given by $C_p = 6.2288 + 0.12862 \times 10^{-2}t + 0.27528 \times 10^{-7}t^2$. In the binary system of palladium-antimony alloys three stable compounds, viz. PdSb (melting point 802° C.), PbSb₂ (melting point 676° C.), and Pd₃Sb (melting point 1218° C.) occur. Structural details of crystals of these alloys are given. The true specific heats, c_p , of granulated antimony at t° C. between 192° and 577° C. are given by $c_p = 0.048671 + 0.4832 \times 10^{-5}t + 0.31179 \times 10^{-7}t^2$. The atomic heat at t° C. is given by $C_p = 5.8501 + 0.5808 \times 10^{-3}t + 0.37477 \times 10^{-5}t^2$. Values of c_p and C_p for massive antimony are given by: $c_p = 0.050055 - 0.10004 \times 10^{-5}t + 0.40512 \times 10^{-7}t^2$; $C_p = 6.0952 - 0.12182 \times 10^{-3}t + 0.49331 \times 10^{-5}t^2$. There is no evidence of a transformation point above 413° C. The specific heats of

antimony depend on the size of grain. Values of c_p and the molecular heat C_p' for the compound PdSb are given by: $c_p = 0.0518615 + 0.171176 \times 10^{-4}t$; $C_p' = 11.8484 + 0.39104 \times 10^{-2}t$. These values are for temperatures between 190° and 600° C. Values of c_p and C_p' for PdSb₂, between 200° and 600° C. are given by $c_p = 0.048460 + 0.25202 \times 10^{-4}t$; $C_p' = 16.9716 + 0.88264 \times 10^{-2}t$. Values of c_p and C_p' for Pd₃Sb between 200° and 940° C. are given by $c_p = 0.05169 + 0.3416 \times 10^{-4}t - 0.61203 \times 10^{-7}t^2 + 0.5372 \times 10^{-10}t^3$; $C_p' = 22.7591 + 0.015041t - 0.26947 \times 10^{-4}t^2 + 0.23653 \times 10^{-7}t^3$. The heat effect accompanying the $\beta \rightarrow \alpha$ transformation at about 940° C. has the value - 4882 cal./gram. Deviations from the additive law of Neumann-Kopp-Regnault are only small. They increase with the percentage of palladium in the compounds and the corresponding increasing melting point; they are greatest (3-6%) for Pd₃Sb and negative; they are smallest (1.5-2%) for PdSb₂ with a maximum at 400° C. and an oscillating algebraic sign. For PdSb they are negative and vary from 1 to 4%. (XXI.—) Values of c_p and C_p' of the compound PtSb₂ at temperatures, t , between 0° and 629° C. are given by $c_p = 0.03820 + 0.132496 \times 10^{-4}t - 0.78762 \times 10^{-8}t^2$; $C_p' = 16.6400 + 0.577143 \times 10^{-2}t - 0.35108 \times 10^{-5}t^2$. Deviations from the Neumann-Kopp-Regnault "law" are very large, negative, and a function of the temperature. The largest deviation is - 19%. (XXII.—) Crystal data relating to the respective structures of the compounds CuPd and Cu₃Pd are given. Values of c and C_p' for CuPd are given by $c_p = 0.065396 + 0.41082 \times 10^{-4}t - 0.266055 \times 10^{-7}t^2$; $C_p' = 11.1346 + 0.699483 \times 10^{-2}t - 0.453 \times 10^{-5}t^2$. The values hold for temperatures, t° C., between 196° and 900° C. For the compound Cu₃Pd values of c_p and C_p' at temperatures t° C. between 200° and 900° C. are given by $c_p = 0.07345 + 0.50164 \times 10^{-4}t - 0.208332 \times 10^{-7}t^2$; $C_p' = 21.8445 + 0.14919 \times 10^{-4}t - 0.6196 \times 10^{-8}t^2$. Variations from results calculated by the Neumann-Kopp-Regnault law do not, in the case of each compound, exceed - 5.3% in the case of CuPd, and + 5.7% for Cu₃Pd.—J. S. G. T.

Permeability to Hydrogen of Copper, Iron, Nickel, Aluminium, and Some Alloys. (Baukloh and Kayser.) See p. 30.

On a Particular Phenomenon in Transformations Which Extend over a Temperature Range. A. Schulze (*Z. Metallkunde*, 1935, 27, 251-255)—In systems in which transformations occur over a temperature range, e.g. magnetic transformations or the change from regular to random orientation, the curves of electrical resistance, temperature coeff. of electrical resistance, and thermal expansion all show deviations from a linear course at temperatures just below the beginning of the transformation range. This anomaly is illustrated by curves for gold-copper, iron-nickel, and β -brass alloys and for the magnetic transformations in nickel and iron.—A. R. P.

On the Theory of Transformations in Metallic Solid Solutions.—III. G. Borelius (*Ann. Physik*, 1935, [v], 24, 489-506).—The subject is discussed on thermo-dynamical principles.—v. G.

III.—STRUCTURE

(Metallography; Macrography; Crystal Structure.)

(Continued from pp. 7-8.)

Tentative Recommended Practice for Metallographic Testing of Ferrous and Non-Ferrous Metals (E 3-35 T). — (*Book of A.S.T.M. Tentative Standards*, 1935, 1445-1477; and *Proc. Amer. Soc. Test. Mat.*, 1935, 35, (I)).—This is in effect a tentative revision of, and is intended to replace when adopted, the present Standard Methods (E 3-24 and E 5-27). It deals with iron and steel, aluminium and its alloys, copper and its alloys, lead and its

alloys, magnesium and its alloys, nickel and its alloys, precious metals, tin and its alloys, and zinc and its alloys, and gives tables of etching reagents, with remarks on their use. A bibliography of 94 references is appended.—S. G.

Preparing Metals for Microscopy. F. F. Lucas (*Bell Lab. Record*, 1935, 14, 116–120).—Recommended procedure involves grinding on Aloxit papers and polishing first with Alundum powder and water on a horizontal broadcloth-covered wheel and finally with magnesium oxide and water on another wheel covered with "Kitten's ear." An air separator for preparing suitably fine magnesium oxide, having an average particle diameter of 0.176μ , is described.

—J. C. C.

Phase Contrasts Applied to Microscopic Observation. F. Zernike (*Physikal. Z.*, 1935, 36, 848–851).—Abbe's theory of microscopic vision is briefly explained. A method for improving microscopic vision, employing a "phase-plate" device whereby only the direct light wave is changed in phase, is described.

—J. S. G. T.

***Researches on the Diffraction of Electrons by Metals and Organic Polymers.** J. J. Trillat and H. Motz (*Ann. Physique*, 1935, [xi], 4, 273–304).—Certain abnormalities in the electron diffraction patterns obtained with organic polymers and metals have been investigated. Thin films of gold (30–40 $\mu\mu$ thick), prepared by electrolysis using every biological precaution to exclude impurities of any kind, did not show the supplementary rings usually found. These appeared, however, on applying thin films of paraffin, stearic acid, and similar fatty bodies to the surface of the gold. It is concluded that these "abnormal" diagrams are produced by the crystallization, more or less rapid, of very thin films of fatty materials having molecules with long carbon chains, and derived from the impure air of the laboratory. The films can be removed by very careful washing with benzene or ether, or, preferably, can be destroyed by allowing a sufficiently intense beam of electrons to impinge for 15–30 minutes on the point to be studied. A bibliography of 24 references is appended.—J. C. C.

***The Distortion of β -Brass and Iron Crystals.** C. F. Elam (Mrs. G. H. Tipper) (*Proc. Roy. Soc.*, 1936, [A], 153, 273–301).—No essential difference is found between the distortion in tension of body-centred cubic crystals of iron and β -brass. Although slip-bands agreeing with possible crystal planes—chiefly {110} planes and less frequently {112} planes—are usual, calculations of the distortion do not agree with the occurrence of slip on these planes throughout the extension. The direction of slip is not always a [111] direction, although this is the most common found. It is suggested that deformation does not take place by slip on any definite crystal plane, but that distortion is effected by complicated movements originally related to the structure but finally having no obvious connection with it; the facts that the distortion cone usually consists of two planes limits the possibilities. Stress-strain curves of the crystals are given, and the fracture of β -brass crystals in tension and in rolling is described.—J. S. G. T.

***X-Ray Determination of the MgNi₂ Structure.** E. F. Bachmetew (*Metallwirtschaft*, 1935, 14, 1001–1002).—The compound has $a = 4.802$, $c = 15.82$ Å. Possible atomic arrangements are discussed.—v. G.

Remarks on the Foregoing Paper of E. F. Bachmetew: "X-Ray Determination of the MgNi₂ Structure." F. Laves and H. Witte (*Metallwirtschaft*, 1935, 14, 1002).—Cf. preceding abstract. Additional data on the subject are given.—v. G.

Note on MgZn and MgZn₅. L. W. McKeehan (*Z. Krist.*, 1935, 91, 501–503).—[In English.] McK. suggests that the crystal structures of MgZn and MgZn₅, given by Tarschisch (*Met. Abs.*, 1934, 1, 299), require more experimental verification before they can be regarded as established.—J. S. G. T.

***The Law of Melting Points and Lattice Structure.** Robert Forrer (*Ann. Physique*, 1935, [xi], 4, 202–269).—By suitable choice of values for the number

of "contacts" N between certain exterior orbits of the atom, it has been found possible to use the same factor F (about 300°C.) in the expression for the Curie point $T = F\sqrt{N}$, and obtain the absolute melting point. Melting occurs when the "contacts" between the electrons in these outer orbits are ruptured. The number of electrons involved is 1 for Li, Na, K, Rb, Cs, Ga, In, Tl, Zn, Cd, Bi, Sn; 2 for Pb and Mg; 3 for Ce, La, Cu, Ag, and Au.

—J. C. C.

***Precision Determination of the Lattice Constants of Silicon.** M. C. Neuberger (*Z. Krist.*, 1935, 92, 313-314).—[In German.] The length of edge (a) of the cubic crystal lattice of silicon at 20°C. is found to be $5.4173 \pm 0.0005 \text{ \AA.}$ Values of other lattice constants are derived by calculation.—J. S. G. T.

***Investigations Relating to the Dendritic Growth of Crystals.** A. Papapetrou (*Z. Krist.*, 1935, 92, 89-130).—[In German.] The growth of dendritic crystals of various chemicals from solutions and melts is investigated by means of the microscope. The results indicate that dendritic growth is the joint result of anisotropy of velocity of growth and of diffusion. Effects due to surface tension at curved surfaces are observed and discussed.—J. S. G. T.

Relationships in the Hexagonal Atomic Lattice and the Reciprocal Lattice in the Case of Four-Co-Ordinate Systems of Symbols. Ingeburg Schaake (*Z. Krist.*, 1935, 91, 466-472).—[In German.] The four-co-ordinate system of crystallographic description as applied to hexagonal crystals is described. The treatment is entirely mathematical.—J. S. G. T.

***The Electron-Optical Structure Image and Its Evidence Concerning the Emission-Characteristics of Barium-Nickel (Incandescent) Cathodes.** E. Brüche (*Z. Physik*, 1935, 98, 77-107).—The electron microscope is applied to study the characteristics of emission of electrons from incandescent cathodes. In the case of a barium-nickel cathode the barium is found to wander about over the surface of the nickel support. The energy of electron emission, electron-emission measurement effects considered as averages, the Schrot and similar effects are briefly discussed.—J. S. G. T.

†The X-Ray Powder Photography of Alloys. A. J. Bradley (*Met. Ind.* (Lond.), 1935, 47, 611-613; discussion, 613-619).—Abstract of a lecture to the Midland Metallurgical Societies (Birmingham Local Section of the Institute of Metals, Birmingham Metallurgical Society, and Staffordshire Iron and Steel Institute) and the Midland Section of the Institute of Physics. See *Met. Abs.*, this vol., p. 7.—J. H. W.

Calculation of the Intensities of Interference Lines on Debye-Röntgen Diagrams. N. Zelljakoff, A. Stefanowsky, and J. Hurgin (*Z. Physik*, 1935, 98, 66-71).—It is shown that, in calculating the intensities of interference lines in X-ray diagrams obtained by the Debye powder method, the width of the beam reflected must be taken into account before satisfactory agreement between experimental and calculated values can be obtained.—J. S. G. T.

A Back-Reflection Laue Method for Determining Crystal Orientation. Alden B. Greninger (*Z. Krist.*, 1935, 91, 424-432).—[In English.] The basis of the back-reflection Laue method is as follows: a beam of "white" X-rays, limited by a suitable pinhole system, passes normally through a hole in a photographic film, strikes the crystal, and is diffracted back to the film. One photograph, which can be taken in less than an hour and interpreted in a few minutes, completely establishes the crystal orientation. The method is particularly applicable to the study of most metallic crystals. For metals such as copper and iron, efficient filtering of secondary X-radiation is obtained by arranging a sheet of aluminium 0.01 in. thick in contact with the film.

—J. S. G. T.

Simplified Technique for Lattice Parameter Measurements. John J. Norton (*Metals and Alloys*, 1935, 6, 342-344).—Describes a simple X-ray apparatus and some results obtained by its use. The original must be consulted for details.—A. R. P.

IV.—CORROSION

(Continued from pp. 8-10.)

The Corrosion of Tinplate. T. P. Hoar (*Proc. Swansea Tech. Coll. Met. Soc.*, 1936, (Jan.), 13 pp.).—Discusses the corrosion of tin and steel alone, and in galvanic couple. The relation of their actions to the corrosion of tinplate is also indicated.—R. Gr.

***A Laboratory Study of the Atmospheric Corrosion of Metals. II.—Iron: the Primary Oxide Film. III.—The Secondary Product or Rust (Influence of Sulphur Dioxide, Carbon Dioxide, and Suspended Particles on the Rusting of Iron).** W. H. J. Vernon (*Trans. Faraday Soc.*, 1935, 31, 1668-1700).—(II.—) Marked differences in the properties of the oxide film on iron are observed according to whether the film is formed above or below a critical temperature of 200° C. The weight increment-time curves also show a point of inflection at this temperature, the equation $W^2 = kt$ being applicable above 200° C. and $W^{2.5} = kt$ below 200° C. As is the case with zinc, the oxide first formed is pseudomorphic with iron; but when unit cell dimensions have been completed further thickening proceeds by diffusion through the lattice. (III.—) Differences in the behaviour of iron and zinc in moist air containing traces of sulphur dioxide are ascribed to secondary critical humidity phenomena; at the primary critical humidity the magnitude of the change is almost the same for both metals, but at the secondary point there is a rapid increase in the rate of attack for iron and only a trifling increase for zinc. Copper behaves similarly to zinc except that after the secondary point the attack on zinc is linear whereas that on copper falls off rapidly. The presence of ammonium sulphate particles in the air has little effect on the corrosion of zinc, but a profound effect, under certain conditions, on the corrosion of iron; this difference is also ascribed to the relative inertness of zinc to secondary critical humidity.—A. R. P.

***Corrosion Tests on Galvanized Sheet by Preece's Immersion Method and by Schreiber's Boiling Method.** Franz Schreiber (*Illust. Zeit. Blechindustrie*, 1935, 64, 1446-1447).—Corrosion tests by these methods were carried out on 3 types of "Alplataer" (galvanized) zinc sheet, pure zinc sheet, and sheet galvanized with zinc containing additions of aluminium. One type of "Alplataer" resisted the action of boiling water almost as well as pure zinc; the alloy-coated sheet showed rapid deterioration under both methods of testing. S. emphasizes the danger of including aluminium in the galvanizing bath.—P. M. C. R.

***Oxide Film of Alloys Containing Small Percentages of Aluminium.** Ichirō Iitaka and Shizuo Miyake (*Nature*, 1935, 136, 437).—When copper alloys containing more than 2% aluminium were heated for many hours at 800°-900° C., no oxide scales were formed. Alloys containing about 10 atomic-% aluminium, when heated in an insufficient supply of oxygen, became covered with a colourless film of pure aluminium oxide.—E. S. H.

Methods of Investigating Corrosion. Nathalie Goldowski (*La Nature*, 1935, (2957), 69-72; and *Ann. Postes, Télég. Téléph.*, 1935, 24, 1002-1010).—Corrosive attack is considered mainly in its relation to aviation and marine construction. Sea-water is here the most important medium of attack: its variations and the methods of reproducing them artificially are considered. An account is given of marine exposure tests, and of laboratory methods (alternate immersion and drying, salt-spray, accelerated attack by oxygen and by oxygenated water). Methods of estimating the degree of corrosion are briefly described.

—P. M. C. R.

V.—PROTECTION

(Other than Electrodeposition.)

(Continued from pp. 10-12.)

Protection and Decoration of Aluminium and Its Alloys by Anodic Oxidation. — (*Industrie élect.*, 1935, **44**, 541-549).—A general account of the principles and applications of the chief processes used for the anodic oxidation of aluminium.—J. C. C.

The Films Responsible for the Colours on Molten Lead, Tin, Bismuth, and Zinc. H. A. Miley and U. R. Evans (*Chem. and Ind.*, 1936, **55**, 31-33).—The technique for removing oxide films mechanically from the surfaces of the metals is described. Addition of a trace of zinc causes a rapid increase in the rate of surface oxidation of tin and, to a less extent, of lead.—E. S. H.

Corrosion After Pickling Major Source of Galvanizer's Dress. Wallace G. Imhoff (*Iron Age*, 1935, **136**, (23), 30-33, 116, 118).—Experimental results show that one of the most prolific sources of galvanizer's dress is corrosion after pickling and during drying. The reducing action of molten zinc and the ferric oxide formed by corrosion have been studied in this connection.—J. H. W.

Tentative Specifications for Zinc-Coated (Galvanized) Wrought-Iron Sheets (A 163-35 T). — (*Book of A.S.T.M. Tentative Standards*, 1935, 234-238; and *Proc. Amer. Soc. Test. Mat.*, 1935, **35**, (I)).—Cover wrought-iron sheets for use in culverts, roofing, siding, for corrugating and moderate forming, with four classes of zinc coatings applied by the hot-dip process: *A* and *B*, extra-heavy and heavy coated sheets that are not intended to be formed other than by corrugating and curving to large radii; *C*, moderately heavily coated sheets for moderate bending, and *D*, ordinary sheets for general utility. —S. G.

VI.—ELECTRODEPOSITION

(Continued from pp. 12-13.)

The Spotting-Out of Cadmium Deposits. — (*Met. Ind. (Lond.)*, 1935, **47**, 521-523).—Report of a discussion held at the Midlands Centre of the Electrodepositors' Technical Society.—J. H. W.

Tentative Specifications for Electrodeposited Coatings of Cadmium on Steel (A 165-35 T). — (*Book of A.S.T.M. Tentative Standards*, 1935, 214-215; and *Proc. Amer. Soc. Test. Mat.*, 1935, **35**, (I)).—Cover electroplated cadmium coatings on steel that are required to withstand corrosion. Two types of coating are covered: Type NS, for general service, and Type TS, for mild service.—S. G.

Influence of Various Acid Radicals on Chromium Hardness. R. J. Piersol (*Metal Cleaning and Finishing*, 1935, **7**, 325-328, 385-387).—Addition of acid radicals other than sulphate or borate tends to reduce the hardness of chromium deposits and spoil their appearance; a combination of fluoride, chloride, and phosphate which has been recommended in some quarters gives an improved plate for a short time after making up a new bath, but the operation of the bath rapidly deteriorates.—A. R. P.

Influence of the Borate Radical on Chromium Hardness. R. J. Piersol (*Metal Cleaning and Finishing*, 1935, **7**, 487-490).—Addition of 2-10 grm./litre of boric acid to the ordinary chromium plating bath makes the plate whiter (the bluish tinge common to plated chromium is almost completely removed), reduces the resistance of the bath and admits of faster plating, and permits iron anodes to be used without fear of producing an excessive concentration of trivalent chromium ions.—A. R. P.

***Influence of Bath Temperature on Chromium Hardness.** R. J. Piersol (*Metal Cleaning and Finishing*, 1935, 7, 535-537).—Tests were carried out on the hardness of chromium plates produced at various temperatures and at various rates of deposition from a bath containing chromic acid 250, sulphuric acid 2-6, and boric acid 10 grm./litre after electrolysis with lead anodes to obtain a concentration of 2 grm./litre of trivalent chromium. At 135° F. (57° C.) the hardness increases with the rate of deposition of chromium to a maximum at 0.002 in./hr. then decreases, but at 155° F. (74° C.) there is no decrease in hardness with more rapid deposition once the maximum hardness is obtained. For constant rates of deposition the hardness of the deposit increases markedly with increase in plating temperature.—A. R. P.

Laminated Chromium Deposits. R. J. Piersol (*Metal Cleaning and Finishing*, 1935, 7, 587-590).—Contrary to statements which have appeared in the literature, a short interruption of plating during deposition of chromium does not result in peeling. In fact a thick deposit of chromium which does not crack cannot be built up by continuous plating, but only by plating for 5 minutes, raising the articles from the bath for 30-60 seconds to allow hydrogen to escape and replating for 5 minutes, and so on; in this way hard, adherent, laminated deposits have been obtained up to 0.005 in. thick.—A. R. P.

Gold-Plating Methods. W. A. Koehler (*Metal Cleaning and Finishing*, 1935, 7, 591-593).—A brief description is given of modern methods of gold-plating.—A. R. P.

Tentative Specifications for Electrodeposited Coatings of Nickel and Chromium on Steel (A 166-35 T). — (*Book of A.S.T.M. Tentative Standards*, 1935, 216-219; and *Proc. Amer. Soc. Test. Mat.*, 1935, 35, (I)).—Cover electroplated coatings on steel articles, including a final coating of nickel or chromium where both appearance and protection against corrosion of the base metal are important. Two types of coating are covered: Type KS, for general service, and Type QS, for mild service.—S. G.

Examination of Nickel-[Plating] Baths and Nickel Plating Salts. II.—The Quantitative Determination of Boric Acid and Citric Acid. (Raub and Nann.) See p. 47.

Tentative Specifications for Electrodeposited Coatings of Zinc on Steel (A 164-35 T). — (*Book of A.S.T.M. Tentative Standards*, 1935, 212-213; and *Proc. Amer. Soc. Test. Mat.*, 1935, 35, (I)).—Cover requirements for electroplated zinc coatings on steel articles that are required to withstand corrosion. Two types of coating are covered: Type LS, for general service, and Type RS, for mild service.—S. G.

Bright Zinc. C. M. Hoff (*Metal Cleaning and Finishing*, 1935, 7, 483-486, 490).—Owing to the recent rapid increase in the price of cadmium, zinc plating is replacing cadmium plating in many American plants. Bright plates and good throwing power are obtained only from cyanide baths. The operation of certain proprietary baths is described and the relative costs of zinc and cadmium plating are discussed.—A. R. P.

***Study of the Throwing Power of Electrolytic Baths.** Albert Portevin and Michel Cymboliste (*Compt. rend.*, 1935, 201, 819-821).—In order to overcome difficulties experienced in a previous investigation (*Met. Abs.*, 1935, 2, 473-474) and to increase the applicability of the tests, test-pieces are used consisting of 2 coaxial helices through which the electrolyte can freely circulate. These helices are 5 and 20 mm. in diameter, each having a surface area of 10 cm.², and are made of fine wire 0.5 mm. in diameter. Two non-conducting screens protect the extreme spirals, thus allowing the formation of an adherent and practically uniform deposit throughout the length. The increases in weight, p and P , of the inner and outer helices are measured, whence the throwing power, $\Pi = \frac{p}{P} \times 100$. The effect on the current efficiency, conductivity, and

throwing power of a number of variables has been studied, with the following results: (1) as the current density increases, Π decreases, except in certain cadmium or chromium baths; (2) as the temperature increases, Π decreases for copper, cadmium, and zinc, but increases for nickel in dilute baths, although it varies but little for chromium in concentrated baths, and in general with high current densities; (3) as the concentration of salts of the metal to be deposited increases, Π increases with nickel baths up to a certain limit; for chromium and copper the variation is small; (4) for equal conductivity, Π depends on the current density and the nature of the salts present; (5) increase in current density, which diminishes Π for all the metals studied, except cadmium, has little effect on the current efficiency for copper and nickel, and diminishes it for all the others, except chromium, for which the efficiency is increased.

—J. H. W.

The Production of Non-Adhesive Deposits. E. A. Ollard (*Met. Ind. (Lond.)*, 1935, 47, 519–521).—The processes which exist for electrodepositing metals in a form which can be readily stripped are tabulated and examined.—J. H. W.

VII.—ELECTROMETALLURGY AND ELECTROCHEMISTRY

(Other than Electrodeposition.)

(Continued from pp. 13–14.)

***The Antimony Electrode.—II.** A. Holmquist (*Svensk Kem. Tids.*, 1935, 47, 102–112; *Brit. Chem. Abs.*, 1935, [A], 826).—*Cf. Met. Abs.*, 1934, 1, 432. Measurements in air-free solution show that the potential varies with $[\text{Sb}^{+++}]$ according to the Nernst formula. In hydrochloric acid solutions more concentrated than about 0.05*N* the solid phase Sb_2O_3 changes to $\text{Sb}_4\text{O}_5\text{Cl}_2$, as shown by both solubility and e.m.f. determinations. The behaviour in citrate buffers is complicated by the formation of an antimony citrate complex. The effect of oxygen in making the potential more positive appears to be connected with the formation of hydrogen peroxide. Hydrogen peroxide is decomposed by antimony powder, the velocity varying with p_{H} .—S. G.

IX.—ANALYSIS

(Continued from pp. 14–16.)

Tentative Method of Test for Quantitative Spectrochemical Analysis of High-Grade Pig Lead for Copper, Bismuth, Silver, and Nickel (E 25–35 T). — (*Book of A.S.T.M. Tentative Standards*, 1935, 1478–1482; and *Proc. Amer. Soc. Test. Mat.*, 1935, 35, (I)).—The method described may be applied to any high grade of Pb, provided that the impurities, namely Cu, Ag, Bi, and Ni, are not present in quantities over 0.1%. Fe is seldom found, and then it is a question whether it was originally in the sample. An arc spectrum is used, employing graphite electrodes, one of which is treated with a solution of the sample to be analyzed. Quantitative estimations are made by the comparison of the spectrum of the sample with that of standard samples of known composition.—S. G.

Tentative Method of Test for Quantitative Spectrochemical Analysis of Zinc for Lead, Iron, and Cadmium (E 26–35 T). — (*Book of A.S.T.M. Tentative Standards*, 1935, 1483–1487; and *Proc. Amer. Soc. Test. Mat.*, 1935, 35, (I)).—This method may be applied to any grade of Zn provided that the Pb, Fe, and Cd contents are less than 0.1%. An arc spectrum is used, employing graphite electrodes, one of which is treated with a solution of the sample to be analyzed. Quantitative estimations are made by the comparison



of the spectrum of the sample being analyzed with spectra of samples of known composition.—S. G.

Tentative Method of Test for Quantitative Spectrochemical Analysis of Zinc Alloy Die-Castings for Minor Constituents and Impurities (E 27-35 T). — (*Book of A.S.T.M. Tentative Standards, 1935, 1488-1494*; and *Proc. Amer. Soc. Test. Mat., 1935, 35, (I)*).—This method refers particularly to the analysis of Zn-base die-casting alloys Nos. XXI and XXIII covered by the Tentative Specification for Zinc-Base Alloy Die-Castings (B 86-34 T). The method includes the determination of Cu in alloy No. XXIII and of Mg, Fe, Pb, Sn, and Cd in alloys Nos. XXI and XXIII. The determination of Ni in an alloy differing from alloy No. XXIII by the presence of Ni as a minor constituent is also included. An arc spectrum is used, employing graphite electrodes, one of which is treated with a solution of the sample to be analyzed. Quantitative estimations are made by the comparison of the spectrum of the sample with the spectra of standard samples of known composition.—S. G.

Tentative Method for Sampling Molybdenum Salts and Compounds for Metallurgical Use (A 156-34 T). — (*Book of A.S.T.M. Tentative Standards, 1935, 263-264*; and *Proc. Amer. Soc. Test. Mat., 1935, 35, (I)*).—S. G.

***On Studies on Eliminating the Effects of PO_4 -Radical in Qualitative Analysis.** —V. Saburō Ishimaru (*Kinzoku no Kenkyū (J. Study Metals), 1935, 12, 559-563*).—[In Japanese.] Cf. *J. Inst. Metals, 1933, 53, 710*; *Met. Abs., 1934, 1, 193*. Results are given of the examination of the methods of Scheinkmann, Kreskov, and Palmieri in connection with the elimination of the $PO_4^{''}$ without separating it from the analytical system. Scheinkmann's method is considered to be somewhat inferior to that of Smith, though it has advantages over that of Remy. Kreskov's method is not highly recommended, while Palmieri's method may be applied with the same merit as that of Smith.—S. G.

***A New Organic Reagent for Cadmium.** Alfred W. Scott and Eleanor G. Adams (*J. Amer. Chem. Soc., 1935, 57, 2541-2542*).—Cd may be detected in the presence of much Cu by adding KI to the solution (free from NH_4^+ and $SO_4^{''}$), followed by a saturated solution in 50% C_2H_5OH of 1-(2-quinolyl)-4-allyl thiosemicarbazide, and then by NH_4OH ; a yellow precipitate indicates Cd. The reagent is prepared by mixing allyl isothiocyanate and 2-quinolylhydrazine in ether.—A. R. P.

Critical Studies on Organic Compounds as Analytical Reagents. IV.—Paramitrobenzeneazoresorcinol as a Reagent for Magnesium. Laird Newell, Nathan R. Pike, and Joseph B. Ficklen (*Z. anorg. Chem., 1935, 225, 281-284*).—The reagent will detect 2 p.p.m. of Mg if groups I-III of the analytical system are first removed. NH_4^+ must be kept to a minimum. In making the test the reagent is added to the slightly acid solution, followed by NH_4OH until just alkaline; a sky-blue colour or precipitate indicates Mg.—A. R. P.

***The Separation of Europium from the Other Rare Earths.** Herbert N. McCoy (*J. Amer. Chem. Soc., 1935, 57, 1756*).—Eu can be detected in mixtures of the rare earth metals by treating the concentrated chloride solution with a pinch of Zn dust and immersing a piece of litmus paper in the solution; bleaching indicates Eu. The element can be separated from the other earths by running the concentrated chloride solution through a column of amalgamated Zn into $MgSO_4$ solution, whereby all the Eu is precipitated as europous sulphate; two repetitions of the process yield a pure preparation. For quantitative determinations the reduced solution is caught in standard iodine solution and the excess I_2 titrated with thiosulphate.—A. R. P.

Quantitative Separation of Lead from Other Cations by the Chromate Method. Z. Karaoglanov and M. Michov (*Z. anal. Chem., 1935, 103, 113-119*).—Addition of $(NH_4)_2CrO_4$ to a feebly acid nitrate solution precipitates $PbCrO_4$ free from Cu, Ag, Ni, Ca, Ba, Sr, Mn, Zn, Cd, Al, and Fe^{+++} . The operation is carried out at $100^\circ C.$, the precipitant being added slowly over a period of 10 minutes; the precipitate is dried at $140^\circ C.$ for weighing.—A. R. P.

***Organic Flocculating Agents in the Quantitative Precipitation of Zinc Sulphide.** John R. Caldwell and Harvey V. Moyer (*J. Amer. Chem. Soc.*, 1935, 57, 2372–2374).—Zn may be precipitated completely as flocculent, readily filtrable ZnS by passing H₂S through a solution containing not more than 0.25 gm. of Zn and 6–8 gm. of (NH₄)₂SO₄ in 250 c.c. just acid to methyl orange; coagulation is effected by addition of 5–10 c.c. of a 0.02% solution of gelatin, or a 0.06% solution of agar-agar.—A. R. P.

***A Separation of Zinc from Cobalt Based on a New Method for Reducing Post-Precipitation.** John R. Caldwell and Harvey V. Moyer (*J. Amer. Chem. Soc.*, 1935, 57, 2375–2377).—The method described in the preceding paper (abstract above) effects a complete separation of Zn from Co in one precipitation provided the solution contains 0.2 c.c. of acrolein in 250 c.c. and is free from chlorides.—A. R. P.

Examination of Nickel[-Plating] Baths and Nickel Plating Salts. II.—The Quantitative Determination of Boric Acid and Citric Acid. E. Raub and H. Nann (*Mitt. Forschungsinst. Edelmetalle*, 1935, 9, 77–85).—Cf. Vincke, *Met. Abs.*, 1935, 2, 611. NaOH is recommended instead of Na₂CO₃ for removing the NH₃ before titration of the H₃BO₃. Citric acid if present to the extent of more than 30% of the H₃BO₃ should first be destroyed by boiling with dilute H₂SO₄ and KMnO₄ and the Mn removed by boiling with NaOH. Citric acid is determined in a separate portion by Vincke's method.—A. R. P.

***Studies on the Elimination of the Effects of the PO₄^{'''} Radical in Qualitative Analysis.—I.—V.** Saburō Ishimaru (*Sci. Rep. Tōhoku Imp. Univ.*, 1935, [i], 24, 426–438, 439–447, 448–460, 461–472, 473–480).—[In English.] The accuracy of various methods which have been proposed for eliminating H₃PO₄ from solutions in qualitative analysis for metals was studied.—A. R. P.

Separation and Determination of Metal and Phosphate Ions in the Presence of One Another.—I.—II. Saburō Ishimaru (*Sci. Rep. Tōhoku Imp. Univ.*, 1935, [i], 24, 481–492, 493–516).—[In English.] (I.—) Mo can be determined accurately in the presence of P by treating the alkaline molybdate-phosphate solution with an acetone solution of 8-hydroxyquinoline, acidifying with CH₃·CO₂H, boiling to expel acetone and collecting, washing, drying at 140° C., and weighing the MoO₂(C₉H₆ON)₂ precipitate. The method is useful also for determining P in metals and alloys, the P being first precipitated as phosphomolybdate in HNO₃ and the washed precipitate dissolved in NH₄OH for the determination of its Mo content as above; the factor P : 12MoO₂(C₉H₆ON)₂ is 0.006212. (II.—) Analytical procedures are given for the separation of Mg, Al, Zn, Fe, Mn, Ni, Co, Cu, Cd, Bi, Th, Ti, U, V, and W from P₂O₅ by precipitation with 8-hydroxyquinoline in tartrate solutions containing CH₃·CO₂H, (NH₄)₂C₂O₄, CH₃·CONH₂, or excess of NH₄OH.—A. R. P.

***A Note on the Determination of Antimony in White Metals.** A. E. W. Smith (*J. Soc. Chem. Ind.*, 1935, 54, 372r).—The standard iodine method for titrating trivalent antimony gives good end-points when certain precautions (gentle boiling, correct acidity, and pure reagents) are observed. Iron does not interfere if less than 10% is present, but the method is useless in presence of Cu. When Cu is present, the standard permanganate titration is satisfactory; certain difficulties are discussed.—E. S. H.

Determination of Bismuth with Naphthoquinolme (Naphthine). Friedrich Hecht and Richard Reissner (*Z. anal. Chem.*, 1935, 103, 88–98).—The sulphate solution of the metal containing 3% of H₂SO₄ is treated with an excess of 2.5% naphthine sulphate solution and KI, heated to boiling, cooled, and filtered. The precipitate is dried in a current of cool, dry air and weighed as (C₁₃H₉N)HBrI₄ (25.98% Bi₂O₃).—A. R. P.

On the Possibility of Determining Bismuth as Basic Carbonate. Friedrich Hecht and Richard Reissner (*Z. anal. Chem.*, 1935, 102, 261–269).—Addition of a cold saturated solution of (NH₄)₂CO₃ to Bi(NO₃)₂ solution until no more precipitate, which flocculates on stirring, is formed produces complete precipita-

tion of the Bi as $(\text{BiO})_2\text{CO}_3$. The solution is heated to boiling and the precipitate collected, washed with hot water, and dried to constant weight in a stream of clean dry air.—A. R. P.

On the Determination of Bismuth with 8-Hydroxyquinoline (Oxine). Friedrich Hecht and Richard Reissner (*Z. anal. Chem.*, 1935, **102**, 261-269).—Bi oxine is quantitatively precipitated by addition of a 4% solution of the reagent in 8% acetic acid to the hot nitrate solution containing NH_4 tartrate. No compound of constant composition can be obtained by adding the oxine to an acid solution containing the HBIl_4 complex.—A. R. P.

***Note on the Volumetric Determination of Manganese.** J. Leroide and A. Bruillet (*Bull. Soc. chim. France*, 1935, [v], **2**, 740-742).—Mn can be determined by titrating hot neutral MnSO_4 solutions containing 20% of Na_2SO_4 with KMnO_4 (Volhard method) without addition of ZnO or acetates. The presence of much Fe^{+++} or of Cl⁻ interferes.—A. R. P.

Colorimetric Determination of Manganese in the Presence of Titanium. George J. Haigh (*Indust. and Eng. Chem. (Analyt. Edn.)*, 1935, **7**, 408-409).—In the colorimetric determination of Mn as HMnO_4 , Na bismuthate or KIO_4 should be used to oxidize the Mn instead of $(\text{NH}_4)_2\text{S}_2\text{O}_8$ when Ti is present.

—A. R. P.

Bismuthate Method for Manganese.—II. Bartholow Park (*Indust. and Eng. Chem. (Analyt. Edn.)*, 1935, **7**, 427).—If the oxidation to HMnO_4 is made in HNO_3 solution, the best catalyst for the arsenite titration is 0.01M- OsO_4 solution (3 drops); in H_2SO_4 solutions the same catalyst may be used but slightly more accurate results are obtained with 1 drop of 0.0025M- KIO_4 and 1 gm. of NaCl.—A. R. P.

***The Accuracy of the Titration of Thiocyanate with Mercuric Mercury.** I. M. Kolthoff and J. J. Lingane (*J. Amer. Chem. Soc.*, 1935, **57**, 2377-2379).—Titration of $\text{Hg}(\text{NO}_3)_2$ solutions with KCNS is accurate to $\pm 0.05\%$.—A. R. P.

Colorimetric Determination of Molybdenum. Loren C. Hurd and Harry O. Allen (*Indust. and Eng. Chem. (Analyt. Edn.)*, 1935, **7**, 396-398).—The solution should contain 5% of HCl, 0.6% of KCNS, and not less than 0.1% of SnCl_2 ; the coloured complex is best extracted with ether or cyclohexanol.—A. R. P.

***A New Method for the Indirect Volumetric Determination of Nickel.—II.** Saburō Ishimaru (*Kinzoku no Kenkyū (J. Study Metals)*, 1935, **12**, 564-566).—[In Japanese.] Cf. *Met. Abs.*, 1934, **1**, 194. The results obtained in the direct electrometric titration of Ni by means of dimethylglyoxime are given. Fairly reliable values were obtained when the concentration of standard $\text{K}_2\text{Cr}_2\text{O}_7$ solution is about N10 and the amount of the sample taken as Ni below 0.1 gm.; however, much higher concentration in the same solution, e.g. N5, cannot be recommended for the umpire method.—S. G.

***Potentiometric Determination of Quadrivalent Osmium with Chromous Sulphate.** William R. Crowell and Harlan L. Baumbach (*J. Amer. Chem. Soc.*, 1935, **57**, 2607-2609).—Os in solution as K_2OsCl_6 obtained by distillation of OsO_4 into HCl containing SO_2 and subsequent evaporation to dryness, may be determined potentiometrically with CrSO_4 in 0.5N-HCl.—A. R. P.

***A Procedure for the Separation of the Six Platinum Metals from One Another and for Their Gravimetric Determination.** Raleigh Gilchrist and Edward Wichers (*J. Amer. Chem. Soc.*, 1935, **57**, 2565-2573).—A complete scheme for the separation and determination of Os, Ru, Pt, Pd, Ir, and Rh, based on methods previously published, is put forward. The procedure consists, broadly, of the following series of operations: (1) distillation of the Os as OsO_4 by HNO_3 from an alkaline osmate solution, absorption of the OsO_4 in HCl containing SO_2 , hydrolytic precipitation of OsO_2 at p_{H} 6, ignition of the precipitate in H_2 to obtain Os; (2) distillation of RuO_4 from the residual solution by boiling with NaBrO_3 , followed by hydrolysis, &c., as for Os, finally weighing as Ru; (3) separation of the Ir, Rh, and Pd from Pt by

hydrolysis with NaBrO_3 first at p_H 6 then at p_H 8 in chloride solutions containing a little NaCl , double precipitation being generally necessary; (4) precipitation of the Pt in the filtrate by H_2S followed by ignition of the PtS_2 to Pt in air, the bromate being first destroyed by evaporation of the solution to dryness with HCl ; (9) dissolution of the Ir, Rh, and Pd hydroxides in HCl and precipitation of the Pd with dimethylglyoxime followed by weighing of the precipitate or ignition to Pd; (6) separation of the Rh from the Ir by double precipitation with $\text{Ti}_2(\text{SO}_4)_3$ and subsequent precipitation of both metals with H_2S after removal of the Ti with cupferron. No details are given for obtaining the metals together in one solution starting from alloys or sponges, and the disturbing effects of base metals are not considered.—A. R. P.

***Volumetric Determinations in Strongly Alkaline Solutions. III.—The Titration of Thallium and Cerium with Hypobromite.** O. Tomíček and M. Jasek (*J. Amer. Chem. Soc.*, 1935, 57, 2409-2411).—Ti⁺ can be titrated in 1.5-2*M* NaOH with NaOBr by the potentiometric method without taking precautions to exclude air, provided that the solution is stirred vigorously to flocculate the $\text{Tl}(\text{OH})_3$ as it forms. Ce^{+++} can also be titrated similarly in 20-30% K_2CO_3 solution, but, in this case, air must be rigorously excluded and the greater part of the necessary NaOBr must be added in one portion.—A. R. P.

***Determination of the Zirconium-Hafnium Ratio.** Grant Wernimont and Thomas de Vries (*J. Amer. Chem. Soc.*, 1935, 57, 2386-2387).—The increase in the optical rotation of basic tartrate solutions to which a solution of the two metals in HF has been added affords a means of determining the ratio of the metals in the mixture.—A. R. P.

X.—LABORATORY APPARATUS, INSTRUMENTS, &c.

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

(Continued from pp. 16-17.)

Measuring Eyepiece. — (*Eng. and Min. J.*, 1935, 136, 636).—Note on a direct-reading grain-size measuring eyepiece.—R. Gr.

Assay Balance. — (*Eng. and Min. J.*, 1935, 136, 636).—Describes briefly a dial-reading balance with a range of 0-20 mg., with an accuracy of 0.005 mg.—R. Gr.

XI.—PHYSICAL AND MECHANICAL TESTING, INSPECTION AND RADIOLOGY

(Continued from pp. 17-18.)

Tentative Definitions of Terms Relating to Methods of Testing (E 6-35 T). — (*Book of A.S.T.M. Tentative Standards*, 1935, 1440-1443; and *Proc. Amer. Soc. Test. Mat.*, 1935, 35, (I)).—Gives definitions of the terms "elastic limit" and "yield-strength"; these are intended to be added, when adopted, to the present Standard Definitions (E 6-30).—S. G.

New Inspection Methods in the Manufacture of Die-Castings. Rene Leonhardt (*Metal Treatment*, 1935, 1, 195-197, 201).—A brief account is given of the application of spectrographic analysis for checking the purity of raw materials; of pyrometer, density, and X-ray control in manufacture; and physical, mechanical, and corrosive tests of the finished product in the manufacture of high-quality die-castings. The composition and mechanical properties of a number of commonly used die-casting alloys are tabulated.—J. C. C.

The Mercurous Nitrate Test. H. C. Jennison (*Metals and Alloys*, 1935, 6, 348-349).—The mercurous nitrate test for internal stress cannot be used to

obtain quantitative results; long immersion in the solution will produce cracking in all copper alloys. Under certain standard conditions the test will determine only whether the stresses in the surface of the metal are less than a safe value; these conditions are a 15-minute immersion in a 10% solution of mercurous nitrate containing 13 c.c. of strong nitric acid per litre.—A. R. P.

Tentative Definitions of Terms, with Units and Symbols, Relating to Magnetic Testing (A 127-35 T). — (*Book of A.S.T.M. Tentative Standards, 1935, 265-270*; and *Proc. Amer. Soc. Test. Mat., 1935, 35, (I)*).—These are in effect a tentative revision of, and are intended to replace when adopted, the present Standard Definitions (A 127-34).—S. G.

Tentative Methods of Verification of Testing Machines (E 4-35 T). — (*Book of A.S.T.M. Tentative Standards, 1935, 1427-1438*; and *Proc. Amer. Soc. Test. Mat., 1935, 35, (I)*).—S. G.

Tentative Method of Test for Long-Time (Creep) High-Temperature Tension Tests of Metallic Materials (E 22-35 T). — (*Book of A.S.T.M. Tentative Standards, 1935, 1415-1426*; and *Proc. Amer. Soc. Test. Mat., 1935, 35, (I)*).—Covers long-time (creep) high-temperature tension tests of metals within the range room temperature to 2000° F. (1093° C.).—S. G.

Tentative Method of Test for Linear Expansion of Metals (B 95-35 T). — (*Book of A.S.T.M. Tentative Standards, 1935, 396-406*; and *Proc. Amer. Soc. Test. Mat., 1935, 35, (I)*).—This method is intended especially for determining the expansion of oxidation-resistant alloys at temperatures up to 1000° C. An appendix describes the dilatometer, tube and gauge carrier, general assembly of the expansion test apparatus, and assembly for use with the microscope.—S. G.

***On the Untenability of the Concept of Upper and Lower Yield-Point and Breaking Strength of Mild Steel and Other Metals.** G. Welter (*Metallwirtschaft, 1935, 14, 1043-1047*; and (translation) *Metallurgia, 1936, 13, 89-92*).—Attention is directed to the fact that in tensile tests the magnitudes of the decrease in load after passing the yield-point and between the maximum load and the breaking load depend on the construction of the machine. From these facts the false conclusion is reached that the observed decreases are fictitious and are caused solely by the construction of the machine.—v. G.

A Bend Tester for Vacuum Tube Wires. W. J. Farmer (*Bell Lab. Record, 1935, 14, 139-142*).—Describes and illustrates an impact bend tester, designed for measuring the stiffness of nickel wires from 0.003 to 0.125 in. in diameter. The angle through which the wire is bent when it is struck by a pendulum released from a given height is recorded.—J. C. C.

Modern Method of Hardness Testing in the Workshop. Karl Frank (*Werkstatt u. Betrieb, 1936, 69, (1/2), 11-14*).—The hardness testing machine described may be used for Rockwell, Brinell, or Vickers tests. The difficulty of correctly aligning the specimen under works' conditions is obviated by the provision of alternative platens for very large, very hard, or lamellar specimens. Brinell hardness figures for different diameters of ball and loads in kg. are correlated in a table.—P. M. C. R.

Tentative Specifications for Round-Hole Screens for Testing Purposes (E 17-35 T). — (*Book of A.S.T.M. Tentative Standards, 1935, 1364-1365*; and *Proc. Amer. Soc. Test. Mat., 1935, 35, (I)*).—These are in effect a tentative revision of, and are intended to replace when adopted, the present Standard Specifications (E 17-33).—S. G.

***Dynamic Elasticity of Metals.** A. Leblanc (*Métaux, 1935, 10, 209-213*).—The dynamic elasticity of a metal is defined as the elastic deformation produced in the metal by a series of dynamic stresses, or the capability of the metal to absorb work due to shock. An important ratio is that of the dynamic elasticity to the density. The higher the elastic limit of a metal and the lower the coeff. of elasticity, the more important is its dynamic elasticity and the higher will be its resistance to shock. This is discussed mathematically,

and the variation of this property with the temperature of annealing after quenching in the case of Duralumin- and Almasilium-type alloys is shown graphically.—J. H. W.

XII.—TEMPERATURE MEASUREMENT AND CONTROL

Recent Developments in Platinum Thermocouples. Bert Brenner (*Indust. and Eng. Chem. (Analyt. Edn.)*, 1935, 7, 438–440).—For use in making thermocouples the purest metals are essential; the best test of purity is the ratio of the electrical resistances (R) at 0° and 100° C., the values of $(R_{100} - R_0)/100R_0$ for pure platinum being 0.00392 and for pure rhodium 0.00434. Both the pure platinum and the rhodium-platinum alloy should be melted on pure lime with a strongly oxidizing oxy-hydrogen flame, cast into ingots, forged, rolled, swaged, and finally drawn through diamond dies. Variations in the diameter of the usual 0.5 mm. wires must be less than 0.005 mm., the difference in e.m.f. between every 4 metres less than 3 microvolts at 1200° C., and the variations in the readings of the couple at 1200° C. not more than $\pm 1^\circ$ C. The resistance to contamination in service is greatly affected by the temperature, time, and number of anneals, the sensitivity of platinum to contamination after annealing for 3 minutes at 1500° C. being ten times as great as that of the rhodium alloy due to the formation of large crystals, open grain boundaries, and severe pitting. For platinum the best annealing conditions are electric heating for 3 minutes at 600° C. (7 amp.) and for the rhodium alloy 2 minutes at 1200° C. (11 amp.). On subsequently annealing at 1500° C. for 6 hrs. the e.m.f. against the normalized wire should not exceed 5 microvolts at 1200° C. The tensile properties of both wires after various anneals are tabulated.

—A. R. P.

Thermocouples. W. Pratt (*Trans. N.E. Coast Inst. Eng. Ship.*, 1934–1935, 51, 103–118).—Thermo-electric currents in general are first considered, and it is indicated how the thermo-electric properties of all metals are shown on the thermo-electric diagram. The laws of thermo-electric effects are discussed and also the approximate equations to the e.m.f.–temperature difference curves. Typical arrangements of thermocouples for temperature measurement purposes are referred to, and the methods of measuring temperatures compared with special reference to cold-junction regulation and the constancy of thermocouples. Special data are given for a platinum/platinum-rhodium thermocouple and for two base-metal thermocouples.—J. W. D.

***Heat Capacities and Entropies of Organic Compounds. I.—A Thermodynamic Temperature Scale in Terms of the Copper-Constantan Thermocouple from 12° to 273° K.** J. G. Aston, Eugene Willihnganz, and George H. Messerly (*J. Amer. Chem. Soc.*, 1935, 57, 1642–1646).—The copper-Constantan couple has been standardized against the helium gas thermometer at temperatures below 0° C., and an e.m.f. table is given for temperatures between -261° and -183° C. and compared with the Leiden scale based on hydrogen and oxygen vapour-pressure thermometers. The results agree within $\pm 0.03^\circ$ C.

—A. R. P.

***Thermocouples from 2° to 90° Absolute.** J. Elston Ahlberg and Walter O. Lundberg (*J. Amer. Chem. Soc.*, 1935, 57, 2722–2723).—Experiments with copper-Constantan couples show that at 13° – 90° abs. the e.m.f. in microvolts (E) is related to the temperature (T) by the expression: $E = A + BT^2 + CT^3 + DT^4$, where A , B , C , and D are constants equal, respectively, to 6039.9, -1.5475×10^{-4} , 6.2064×10^{-4} , and -1.5652×10^{-6} .—A. R. P.

XIII.—FOUNDRY PRACTICE AND APPLIANCES

(Continued from pp. 18-19.)

Sulphur Absorption in Metal Melting. E. J. Bullen (*Met. Ind. (Lond.)*, 1935, 47, 540).—A letter. Experiments have shown that in melting nickel-bronzes, containing tin 10-13 and nickel 0.5-1.5%, in Salamander pots, there is no perceptible difference in the sulphur absorption or the physical properties of the alloy whether a coke furnace or an oil furnace is used. In the tests, oil containing 2.85% sulphur (much in excess of the normal 1-1.5%) was used in the oil furnace.—J. H. W.

The Castability of Aluminium Alloys. A. von Zeerleder (*Met. Ind. (Lond.)*, 1935, 47, 531-534, 540).—The methods for investigating the castability of alloys from 1898 to the present time are reviewed, and modern apparatus and methods of investigation (cf. Portevin and Courty) are described. The use of the spiral mould is exemplified in the case of a number of aluminium alloys, particularly Anticorodal. In the case of the aluminium-magnesium alloys, the castability decreases when the solidification range decreases, while for numerous other alloys it decreases when the solidification range increases. 11 references are given.—J. H. W.

Recommended Practice for Sand-Cast Aluminium Alloys. Non-Ferrous Division Committee on Recommended Practices (*Trans. Amer. Found. Assoc.*, 1935, 43, 1-26; and *Found. Trade J.*, 1935, 53, 454-455, 471-473).—A good moulding sand for aluminium alloys has a compressive strength of 5-9 lb./in.², a permeability of 4-8, a clay content of 20-35, and a fineness number of 175-250. Gates, risers, and feeders must be so placed that the metal flows evenly into thick and thin sections and no pressure is exerted on portions of the casting by shrinkage during solidification. Care should be taken to avoid entry of dross into the mould and to keep agitation to a minimum during pouring so as to avoid inclusions of oxide skins. Cores should be soft to offer the minimum resistance to contraction of the solidifying metal. Cast-iron melting pots are satisfactory provided they are coated with whiting each day before use and scraped every evening; graphite or carborundum pots are best for alloys containing silicon and magnesium, since introduction of iron into these alloys has a detrimental effect on the mechanical properties and corrosion-resistance. Melting, holding, and casting temperatures should be kept as low as possible to prevent gas absorption, oxidation, and coarse grain growth during solidification. Recommended casting practice for numerous aluminium alloys is given together with tabulated specifications for composition and mechanical properties.—A. R. P.

The Deoxidation of Copper Melts with Beryllium. R. Marker (*Metall-Woche*, 1935, 237-238).—The use of 0.005-0.02% of beryllium, added as a 10% beryllium-copper alloy, for the deoxidation of copper is recommended. By suitable adjustment of the quantity of deoxidizer used very high conductivity values can be obtained combined with freedom from porosity in castings.—A. R. P.

Large Centrifugal Castings. — (*Met. Ind. (Lond.)*, 1935, 47, 585).—Bronze tubes up to 44 in. diameter, 30 ft. long, and 50,000 lb. in weight are cast in horizontal water-cooled casting machines. The melting equipment consists of oscillating oil-fired furnaces of 13,000 lb. capacity, fitted with high- and low-pressure blowers, top pour ladles being used for small castings and bottom pour for large ones.—J. H. W.

Die-Casting. A. H. Munday (*Found. Trade J.*, 1935, 53, 383-386; discussion, 386; and *Machinery (Lond.)*, 1935, 47, 277-281, 352-353).—Summary of a paper read before the Lancashire Branch of the Institute of British Foundrymen. The methods of type, slush, Corthias, gravity, and pressure die-casting

are briefly described, and the alloys used commercially for these methods are discussed. The Doehler, goose-neck, and Polak machines are described, and the importance of die design is pointed out. In the discussion, reference was made to the Soag machine, to die production, and to the difficulties of casting gun-metal and yellow-brass.—J. H. W.

Principles of Present Die Design. Technique for Various Die-Casting Alloys. E. Stevan (*Met. Ind. (Lond.)*, 1935, 47, 579–582).—A discussion of the factors to be considered in die design, standard types of die, material for die construction, methods of parting moulds, differences of treatment, and the removal of cores.—J. H. W.

The Expansion and Contraction of Moulding Sand at Elevated Temperatures. H. W. Dietert and F. Valtier (*Trans. Amer. Found. Assoc.*, 1935, 43, 107–122; discussion, 122–124).—Expansion of moulding sand is reduced by increasing the grain-size, reducing the proportion of fines, adding combustible materials (e.g. sea-coal), reducing the hardness of the mould, increasing the permeability, and reducing the moisture content. Opposing stresses between expansion and contraction are reduced by reducing the clay content and by all of the factors which reduce expansion, except addition of combustible materials. After heating the sand above 1300° C. the expansion is reduced by 50%. The use of sands with unsuitable expansion and contraction properties often gives rise to such defects as “scabs” and “rat-tails.” Apparatus for testing the expansion and contraction of moulding sands is described, and methods of controlling these properties are discussed.—A. R. P.

Continuous Production in the Foundry. — (*Aluminium and Non-Ferrous Rev.*, 1935, 1, 42–44).—The use of conveyor systems in aluminium foundries is discussed generally.—J. C. C.

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

†**The Economy of Old Metals, Especially Copper, Lead, Zinc, and Tin.** W. R. Ingalls (*Min. and Met. Soc. Amer., Bull.* No. 235, 1935, 75–95; and *Amer. Metal Market*, 1935, 42, (218), 2; (219), 3, 4; (220), 2; (221), 3, 6).—Great reserves of secondary metals do not exist, the normal supply of this material, other than that of precious metals, being that which accrues from scrapping obsolete plant or stripping useful plant. The cycle of production, distribution, consumption, and “reflux” of lead, tin, zinc, and especially copper is traced out, and that of aluminium, gold and silver, iron and steel is indicated, and some general observations on the subject are put forward.—J. H. W.

The Attractiveness and Importance of Secondary Metals. F. H. Brownell (*Min. and Met. Soc. Amer., Bull.* No. 235, 1935, 95–100).—Discusses the reasons why large primary metal companies in the U.S.A. deal with secondary metals, and the effect this has on the production of virgin metal.—J. H. W.

The Influence Wielded by Scrap Copper. Benno Elkan (*Min. and Met. Soc. Amer., Bull.* No. 235, 1935, 100–101; discussion, 101–102).—The history of the commercial refining of copper in the U.S.A. is briefly outlined, and a plea is made for common sense in the policy of production and marketing.—J. H. W.

Reclaiming Metals from Slag. — (*Eng. and Min. J.*, 1935, 136, 600).—A note stating that it was found that 35–72% of the different precious metals contained in a refining slag, settled in the crust which solidifies on the surface of the pot in about 6 minutes after the pot is filled. Slag is now bled after the crust has formed and the two portions separately treated.—R. Gr.

XV.—FURNACES AND FUELS

(Continued from p. 19.)

Electric Furnace Successful in Precious Metal Melting. S. Bennis (*Edison Elect. Inst. Bull.*, 1935, 3, (4), 125).—A small electric furnace with Globar heating elements and $10 \times 7 \times 7$ in. heating chamber is described. The working temperature is 700° – 1500° C., and the capacity sufficient for 100 oz. of gold alloy: the approximate melting time is 15 minutes, whilst the furnace can be heated from room temperature to about 1350° C. in 30 minutes. A special regulator limits the power input to a safe value.—P. M. C. R.

Electric Heat Furnaces. George H. Hall (*Elect. World*, 1935, 105, 2104–2106).—A brief review of the construction of the principal types of electric heat-treatment furnaces.—J. C. C.

Controlled Atmospheres in Electric Furnaces. George H. Hall (*Elect. World*, 1935, 105, 2205–2207).—Includes an illustrated description of the construction of bell-type bright-annealing furnaces. Reference is made to electric brazing, and a comparison is given of the relative costs of various gases used in controlled-atmosphere furnaces.—J. C. C.

Small Electric Resistance Furnaces. E. Schmidt (*A.E.G. Mitt.*, 1935, (11), 351–352).—Illustrated descriptions are given of a small hardening furnace working at 1350° C., with brine quenching bath; an annealing furnace operating at 950° C.; electrically-heated melting crucibles for lead and tin; a drying furnace; and an electrically-warmed brine bath.—P. M. C. R.

Rod-Shaped Heating Elements for Heavy Duty. H. Bachmann (*A.E.G. Mitt.*, 1935, (8), 274–276).—The element described consists of a heating coil embedded in a packing material which conducts heat well; this is enclosed in a tube, which is coated with steel, brass, nickel silver, or is Alumetized or nickel-plated. A graphical record of the life of different types of envelope plotted against working temperature shows the superiority of the Alumetized type. The nature and purity of the packing material and the taper of the rod on which the heating coil is carried are of great importance.—P. M. C. R.

Pulverized-Fuel Firing Without a Pulverizer. Advantages Derived from Bulk Supply. H. D. Tollemache (*Iron Coal Trades Rev.*, 1936, 132, 103–104, 105).—The main objection to the use of pulverized coal in metallurgical works has been overcome, since it can now be obtained in ready pulverized form without the necessity to instal a pulverizing plant. The cost of converting furnaces and of maintenance are discussed, comparative figures being given for electricity, gas, oil, and pulverized coal. Methods of production and transport are described and the qualities desirable in a good-class pulverized fuel are discussed.—L. A. O.

***The Resistance to Flow of Gases Through Masses of Heaped Granular Material.** E. Diepschlag (*Feuerungstechnik*, 1935, 23, 133–136).—An experimental investigation relating to the resistance offered to the passage of air through columns of packed spheres of respective diameters 3, 2, and 1.32 mm. and through angular grains of quartz is reported. A formula summarizing the results is given.—J. S. G. T.

Unburnt Carbon, Considered from the Point of View of the Determination of Excess Air Factor. M. S. Maslenikoff (*Feuerungstechnik*, 1936, 24, 7–9).—The significance of the excess air factor in the discussion of the completeness or otherwise of the combustion of solid fuels is discussed.—J. S. G. T.

†The Tasks and Purpose of Combustion Technique. Wilhelm Gumz (*Feuerungstechnik*, 1936, 24, 1–3).—The purpose and tasks of combustion control are briefly reviewed.—J. S. G. T.

Tentative Specifications for Classification of Coals by Rank (D 388–35 T). — (*Book of A.S.T.M. Tentative Standards*, 1935, 617–623; and *Proc. Amer.*

Soc. Test. Mat., 1935, 35, (I).—The basic scheme of classification is according to fixed carbon content and calorific value (expressed in B.t.u.) calculated to the mineral-matter-free basis. The higher rank coals are classified according to fixed carbon on the dry basis, and the lower rank coals according to B.t.u. on the moist basis. Agglutinating and slacking indices are used to differentiate between certain adjacent groups.—S. G.

Tentative Definitions of the Terms Gross Calorific Value and Net Calorific Value of Fuels (D 407-35 T). — (*Book of A.S.T.M. Tentative Standards*, 1935, 640; and *Proc. Amer. Soc. Test. Mat.*, 1935, 35, (I)).—S. G.

XVI.—REFRACTORIES AND FURNACE MATERIALS

(Continued from pp. 19-20.)

Some Uses of Insulating Fire-Brick in Modern Foundry Practice. C. L. Norton, Jr. (*Trans. Amer. Found. Assoc.*, 1935, 43, 54-58; discussion, 59-74).—Modern light-weight insulating bricks when properly faced with heavy non-porous bricks or refractory cement effect considerable heat economies in the melting of non-ferrous metals. Thus in a properly constructed gas-fired furnace for melting brass gas consumption was only 3 ft.³ per lb. of metal, and the reduction in zinc losses over those experienced in a furnace lined with heavy refractories was sufficient to pay the whole fuel bill. Owing to the more rapid melting of the charge the zinc content could be more effectively controlled so that the metal was more ductile and there were fewer rejects; in addition tool and die costs were materially reduced due to the better grade of alloy produced.—A. R. P.

The Chilling of Refractories: Method for the Simultaneous Determination of Stability under Temperature Changes and Resistance to Corrosion. Adolf Möser (*Feuerungstechnik*, 1936, 24, 9-10).—An experimental method based on passage of water through the mass is described.—J. S. G. T.

Tentative Definitions of Terms Relating to Refractories (C 71-35 T). — (*Book of A.S.T.M. Tentative Standards*, 1935, 555; and *Proc. Amer. Soc. Test. Mat.*, 1935, 35, (I)).—Gives definitions of 6 terms; these are intended to be added when adopted to the present Standard Definitions (C 71-35).
—S. G.

Tentative Revision of Standard Definitions for Fireclay Refractories (C 27-35). — (*Book of A.S.T.M. Tentative Standards*, 1935, 1522; and *Proc. Amer. Soc. Test. Mat.*, 1935, 35, (I)).—A definition of "Super Duty Fireclay Brick" is added.—S. G.

XVII.—HEAT-TREATMENT

(Continued from p. 20.)

***The Effect of Annealing on the Release of Internal Stress in Cold-Drawn Rods.** Kisukey Saito (*Kinzoku no Kenkyu (J. Study Metals)*, 1935, 12, 551-558). —[In Japanese.] The effects of annealing on the release of internal stress and the change in hardness in cold-drawn rods was studied for seven materials: copper, brasses (70 : 30 and 60 : 40), Armco iron and steels containing 0.3, 0.8, and 1.3% carbon. The release of internal stress was inferred from the change of length of the rod, measured in the direction of drawing at room temperature, to which the specimen was cooled slowly in the furnace after annealing at different temperatures for $\frac{1}{2}$ hr. The annealing was repeated at successively higher temperatures. In general, the length of the rod decreases in the cases of copper and the brasses in the whole range of annealing temperatures, but in the cases of iron and steels it increases in a certain range of temperature, and

afterwards decreases. The temperatures at which internal stress is released are about 300° C. for copper, 370° C. for brasses, and 650° C. for iron and steels, and the increased hardness due to cold-working is reduced to its original value in the vicinity of these temperatures.—S. G.

The Bright-Annealing of Silver in Gas Furnaces. P. Hopkinson (*Met. Ind. (Lond.)*, 1935, 47, 614).—A brief description is given of a continuous type of gas-fired furnace, having no muffle or special form of atmosphere, and producing thoroughly annealed and perfectly bright silver, free from "fire."

—J. H. W.

XVIII.—WORKING

(Continued from p. 20.)

Metallurgical Control in the Production of Non-Ferrous Sheet and Strip. A. F. Dunbar (*Met. Ind. (Lond.)*, 1935, 47, 603-607, 630-632).—Read before the Melbourne University Metallurgical Society. A description is given of the foundry and rolling-mill practice of the Ammunition Factory of the Munitions Supply Board, Australia, with particular reference to the laboratory control of the quality of the finished product.—J. H. W.

Three-Phase Regulating Drives in Rolling Mills. — (*A.E.G. Progress*, 1935, (2), 26-28).—The advantages and disadvantages of the Krämer, Scherbius, and 3-phase commutator cascade regulating systems are compared: the circuit diagram is reproduced in each case.—P. M. C. R.

Brass and Copper Forgings, Their Manufacture, Properties, and Uses. Edwin F. Cone (*Metals and Alloys*, 1935, 6, 337-341).—Brass for forging should have the composition: copper 58.5-61.5, lead 1.5-2.5, total impurities less than 0.5%, zinc remainder. Forging tools and manual and mechanical methods of forging are briefly described and some characteristic microstructures of forgings are reproduced. Surface stresses induced by forging may be relieved by annealing for 30 minutes at 315°-425° C. prior to pickling and plating.

—A. R. P.

Some Metallurgical Aspects of the Radio Tube Industry. Stanton Umbreit (*Metals and Alloys*, 1935, 6, 273-277, 279).—Modern methods of manufacturing the various parts of radio valves are described, with especial reference to the preparation and drawing of filaments of tungsten, platinum, or nickel coated with thorium, caesium, or barium compounds, the production of carbon-coated anodes, and the construction of molybdenum wire grids. The use of magnesium and barium as "getters" is also discussed.—A. R. P.

The Machining of Automobile Pistons with Diamond Tools. C. A. Birkebak (*Machine moderne*, 1935, 29, 615-616).—Light-alloy pistons of 12-43 mm. diameter are machined by this method. Full details regarding preliminary and final machining include cutting speeds, feed, and average production. The machine employed is described and illustrated.—P. M. C. R.

The Machining of Light Alloys. — (*Machine moderne*, 1935, 29, 549-554).—A rough classification of the principal types of light alloy includes their approximate compositions. The special properties of each class with regard to drilling, cutting, grinding, and turning are discussed and compared graphically, and characteristic types of turning are illustrated. The design of appropriate drills is discussed.—P. M. C. R.

XX.—JOINING

(Continued from p. 21.)

Soft Solders. A. H. Falk (*Bell Lab. Record*, 1935, 14, 89-93).—Rosin should be used as a flux for electrical work, where corrosion must be guarded against. If a more active flux is essential, ammonium and zinc chlorides may

be used, but only if followed by a citrate or cyanide wash; alternatively, naphthalene tetrachloride, followed by an alcohol wash, is advised. Recommendations are tabulated for solder compositions, fluxes, and neutralizing agents for typical soldering jobs. Lead-tin solders with 45 or 33% tin are recommended for general use. The higher working temperatures and wider solidification ranges of the lower-tin solders may retard the rate of working, but more efficient soldering irons to counteract this are being developed.

—J. C. C.

Resistance Welding of Light or Special Metals and Alloys. R. Salleles (*Rev. Soudure autogène*, 1935, 27, (260), 2-7; and (summary) *Met. Ind. (Lond.)*, 1935, 47, 489-493).—The Sciaky system is described, in which a pressure cycle is synchronized with the current timing, the contact pressure being high just before the making of the weld in order to make good contact; being reduced during the passage of the current, in order to increase the resistance of the interface; and, finally, being increased again to give a forging action. The "accumulation of energy" system is also described, in which electromagnetic induction is used, the primary circuit being fed by d.c. The secondary circuit is shorted to make the weld, the primary being cut simultaneously, so that the built-up energy is used to make the weld. The advantages of the system are said to be the reduced and more uniform load on the supply main, the possibility of using extremely short welding times, and the very high accuracy of control of both time and current. Many examples of spot-welded members in stainless steel and Duralumin are illustrated and described.—H. W. G. H.

Copper Welding. — (*Indoxco*, 1936, 1, (3), 21-22).—A general description of copper welding.—W. E. B.

The Autogenous Welding of Copper and Its Alloys. — (*Illust. Zeit. Blechindustrie*, 1935, 64, 1412-1415, 1442-1443, 1473-1475).—Directions are given for the welding of copper wire and sheet, and Bengough's table connecting welding temperature and tensile properties is quoted. Suitable fluxes and welding wire are recommended, and the structures and mechanical properties of welds thus produced are illustrated. Similar directions are given for brass, bronze, Neusilber, and Monel metal.—P. M. C. R.

***Thermal Study of Welds.** A. Portevin and D. Sférian (*Chaleur et Industrie*, 1935, 16, 409-424).—A theoretical study has been made of the temperature distribution which occurs in a long bar and an infinite plate after a given zone is raised rapidly to the temperature of fusion. Experimental verification of the results has been obtained by observing temperature changes after welding by means of platinum/platinum-rhodium thermocouples 0.2 mm. in diameter fixed both on the surface and in the interior of the samples. Tests were carried out on samples of mild steel, austenitic nickel-chromium steel, copper, and aluminium welded by oxy-acetylene in several different conditions, and on electric arc-welded steel samples. From the results, "thermal surfaces," showing the thermal distribution after welding, have been constructed. Arc-welding results in steeper temperature gradients and more rapid cooling rates than oxy-acetylene welding. The calorific properties of the metal, the temperature of preheating, and the size and shape of the pieces welded are among the principal factors influencing the temperature distribution.—J. C.

***Some Residual Stress Effects in Static Tension Specimens.** R. E. Jamieson (*J. Amer. Weld. Soc.*, 1935, 14, (9), 16-21).—M.S. plates $4\frac{3}{4}$ in. \times $\frac{5}{8}$ in. \times 5 ft. long were grooved on their longer edges, the grooves being filled with weld metal by arc-welding, and the plates then tested in tension. Two pairs of extensometers were fixed on lines at 1 in. from each edge of the plate, and the load-deformation curves are given, being compared with a curve obtained from an unwelded plate. The average ultimate stress of the welded plates was about 9% less than that of the unwelded plate, and the elongations were

of the order of 12 and 33%, respectively. The curves of the welded plates showed a deviation, practically from the beginning of loading, from the standard curve, there being a larger average deformation for a given applied average stress. The welding appeared to raise the yield-point and decrease the ductility of the plates.—H. W. G. H.

A New General-Purpose Meter for Resistance Welding. C. Stansbury (*J. Amer. Weld. Soc.*, 1935, 14, (9), 32-35).—A meter is described by which the primary and secondary welding currents, the welding voltage, and the duration of the weld may be measured. The instrument uses neon glow tubes and is based on the facts that these have a definite critical voltage which must be exceeded before a glow discharge will start, and that a discharge for a period as short as one cycle can readily be seen. The primary welding current is measured directly, the secondary by means of an air-core current transformer, and the time by charging a condenser through a calibrated rheostat which is adjusted so that the voltage across the condenser just reaches the critical value which will cause a glow in the neon tube at the instant that the weld is terminated.—H. W. G. H.

Control of Spot- and Seam-Welding Machines Operating on the Grid System. C. Fröhmer (*A. E. G. Mitt.*, 1935, (10), 321-325).—A suitable system for securing rapid and accurate control of the welding current is described: circuit diagrams are given for the welding of light alloys and for stainless steel.—P. M. C. R.

New Transformer for Arc-Welding with Alternating Current. R. Hofmann (*A. E. G. Mitt.*, 1935, (12), 399-401).—The transformer described is available for ordinary and for especially heavy welding. Full working details are tabulated for three ordinary supply voltages and for various welding currents, and efficiency and power-factor diagrams are given for both light and heavy types for two types of electrode.—P. M. C. R.

British Standard Specification for Carbide of Calcium (Graded Sizes). — (*Brit. Stand. Inst.* No. 642, 1935, 20 pp.).—S. G.

XXI.—INDUSTRIAL USES AND APPLICATIONS

(Continued from pp. 21-23.)

The Use of Aluminium in the Manufacture of Acids. — (*Illust. Zeit. Blechindustrie*, 1935, 64, 1380-1381, 1410-1411).—The results of investigations by various groups of workers on the resistance of aluminium to various acids, under various conditions of temperature and concentration, are summarized. The materials considered are formic, acetic, oleic, palmitic, stearic, lactic, oxalic, benzoic, carbolic, boric, hydrofluoric, hydrochloric, nitric, sulphuric, sulphurous and citric acids, and acetone: where effective protection is practicable a method is indicated.—P. M. C. R.

Reflecting Surfaces of Aluminium. J. D. Edwards (*J. Soc. Motion Picture Eng.*, 1935, 24, 126-132; *Phot. Abs.*, 1935, 15, 98).—It is shown that aluminium is inherently a good reflector of ultra-violet, visible and infra-red radiations, and means are described for developing and maintaining high reflection efficiency. The Alzak process of electrolytic brightening is described; with this process specular and diffuse aluminium surfaces can be made having reflection factors of about 85%. The Alzak reflectors have a hard surface of transparent aluminium oxide, and are consequently weather-resisting and easily cleaned.—S. G.

Light Metal Bobbins. — (*Spinner und Weber*, 1935, 53, (37), 8-9; *J. Textile Inst.*, 1935, 26, 557A).—The disadvantages of ordinary paper, wood, Bakelite, and metal bobbins and tubes are discussed and the advantages of hard light metal bobbins are pointed out. Hard light metal is harder than paper board and the walls can be made very thin so that the bobbins are lighter in weight

than paper bobbins. The process of construction can be controlled accurately, so that there are no variations in dimensions, and light metal bobbins have a life duration about 35 times that of the paper board variety. Bobbins made from hard light metal are not affected by wet treatments as in steaming and dyeing, and are resistant to attack by acids. The grip of these bobbins on spindles can be improved by the use of an intermediate layer of rubber.

—S. G.

New "Compound Casting" Process for the Manufacture of Pistons, Especially of the "Fire-Proof" Type. G. Gressenich (*Automobiltech. Z.*, 1935, 38, 623-625).—The unequal distribution of heat in an automobile piston is illustrated by a graph, and the advisability of combining alloys of different wearing properties and thermal conductivity is emphasized. A description is given of a piston in which the body consists of "EC 24" (a hard aluminium-silicon alloy) and the centre of the head of "Y" alloy. A photomicrograph of the transition zone is reproduced.—P. M. C. R.

Cast Materials: A Guide to the Machine Constructor and Works' Engineer (Light Alloys). Albert Achenbach (*Werkstatt u. Betrieb*, 1936, 69, 9-10).—This review of the engineering and constructional applications of the principal light alloys includes brief accounts of the composition and properties of the copper-aluminium group, "Y"-alloy, Hydronalium, K.S.-Seewasser, Silumin, Kupfer-Silumin and its derivatives, and Elektron.—P. M. C. R.

Increased Activity in Old and New Consuming Fields Gives Bright Outlook for Aluminium. George J. Stanley (*Amer. Metal Market*, 1936, 43, (2), 1, 6).—A brief review of the uses of aluminium.—L. A. O.

British Aluminium Company Limited Intelligence Memorandum [Aluminium Specifications]. — (*Light Metals Research*, 1935, 4, (12), 5 pp.).—A bibliography of the British Standard Specifications, British Standard Specifications for Aircraft Materials, and Air Ministry Material Specifications which are of direct interest to the aluminium industry.—J. C. C.

Aluminium Alloy Sand- or Die-Castings. — (*Brit. Air Min. Specification No. D.T.D. 269*, 1935, 3 pp.).—Covers the material generally known as NA 222 alloy.—S. G.

Aluminium-Silicon Alloy Sand- or Die-Castings (Not Suitable for Pistons). — (*Brit. Air Min. Specification No. D.T.D. 272*, 1935, 3 pp.).—Covers the material generally known as NA 125/W. 60 alloy.—S. G.

Aluminium-Silicon Alloy Sand- or Die-Castings (Not Suitable for Pistons). — (*Brit. Air Min. Specification No. D.T.D. 276*, 1935, 3 pp.).—Covers the material generally known as NA 125/T. 67 alloy.—S. G.

Aluminium Alloy Sheets and Strips. — (*Brit. Air Min. Specification No. D.T.D. 270*, 1935, 5 pp.).—Covers the material generally known as NA 24 S alloy (sp. gr. ≈ 2.85).—S. G.

Aluminium Alloy Bars (Extruded or Rolled) and Extruded Sections. — (*Brit. Air Min. Specification No. D.T.D. 280*, 1935, 4 pp.).—Covers the materials generally known as NA 24 S alloy, Duralumin G, and Hiduminium 72 (sp. gr. ≈ 2.80) for bars up to 4 in. diam. or width across flats and extruded sections up to 3 in. in thickness.—S. G.

Aluminium Powder as a Metal Finish. — (*Aluminium and Non-Ferrous Rev.*, 1935, 1, 19-20).—J. C. C.

Aluminium Packing in the Canning Industry. — (*Aluminium and Non-Ferrous Rev.*, 1935, 1, 17-18).—Aluminium packing is particularly suitable for herrings in oil. In 1934-1935, 8 million boxes were packed in Norway.

—J. C. C.

Modern Practice in Heat Insulation. C. Ellis (*Eng. Rev.*, 1935, 49, 170-176, 354).—Aluminium foil, and other non-metallic materials are described, and their special applications are indicated. A table shows their approximate working temperature ranges.—P. M. C. R.

Tentative Specifications for Aluminium-Manganese Alloy Sheet and Plate (B 79-34 T). — (*Book of A.S.T.M. Tentative Standards, 1935, 293-297*; and *Proc. Amer. Soc. Test. Mat., 1935, 35, (I)*).—A revision of the tentative specification re-issued in 1933. Commercial flat sheet is to be supplied on orders for sheet, except where coiled or strip sheet is specifically ordered. Requirements for chemical composition are: aluminium (minimum) 97.0, manganese 1.0-1.5, and copper (maximum) 0.2%.—S. G.

Tentative Revision of Standard Specifications for Copper Trolley Wire (B 47-32). — (*Book of A.S.T.M. Tentative Standards, 1935, 1517*; and *Proc. Amer. Soc. Test. Mat., 1935, 35, (I)*).—Fig. 1 now appearing in the specifications, which shows permissible variations in the dimensional requirements of the standard sections of grooved trolley wire, is to be replaced by Fig. 1 as given in *Book of A.S.T.M. Tentative Standards, 1935, 341*.—S. G.

Tentative Specifications for Bare, Stranded Copper Cable: Hard, Medium-Hard, or Soft (B 8-35 T). — (*Book of A.S.T.M. Tentative Standards, 1935, 330-333*; and *Proc. Amer. Soc. Test. Mat., 1935, 35, (I)*).—These are in effect a tentative revision of, and are intended to replace when adopted, the present Standard Specifications (B 8-27). They cover bare, stranded cables made from round copper wires, for general use as electrical conductors.—S. G.

Tentative Specifications for Insulated Wire and Cable: Class AO, 30 Per Cent. Hevea Rubber Compound (D 27-35 T). — (*Book of A.S.T.M. Tentative Standards, 1935, 1135-1160*; and *Proc. Amer. Soc. Test. Mat., 1935, 35, (I)*).—Cover the conductors, insulation, cable tape, cotton braid, and lead sheaths of Class AO rubber-insulated wire and cable.—S. G.

Tentative Specifications for Insulated Wire and Cable: Class A, 30 Per Cent. Hevea Rubber Compound (D 393-34 T). — (*Book of A.S.T.M. Tentative Standards, 1935, 1173-1174*; and *Proc. Amer. Soc. Test. Mat., 1935, 35, (I)*).—S. G.

Tentative Specifications for Insulated Wire and Cable: Performance Rubber Compound (D 353-35 T). — (*Book of A.S.T.M. Tentative Standards, 1935, 1161-1172*; and *Proc. Amer. Soc. Test. Mat., 1935, 35, (I)*).—Cover wire and cable insulated with a vulcanized rubber compound.—S. G.

Copper Roofs. — (*Bull. Copper Brass Res. Assoc., 1936, (85), 10-11*).—The uses of copper and its alloys in the construction of roofs are illustrated. Copper sheets are used to make houses termite-proof. A copper shingle, easy to apply, has recently been introduced for roofing purposes.—J. S. G. T.

Drama of the Skies under a Copper Dome. — (*Bull. Copper Brass Res. Assoc., 1936, (85), 13*).—The construction of the copper dome of the Hayden Planetarium, New York, is illustrated. When finished, the dome was washed with lye and sprayed with acid to hasten formation of a patina finish.

—J. S. G. T.

Copper and Its Alloys. — (*Bull. Copper Brass Res. Assoc., 1936, (85), 8-9*).—The use of copper and its alloys in the building of the town of Hershey, Pennsylvania, is briefly illustrated.—J. S. G. T.

Wider Colour Range of Copper Metals is Available with Nickel Silver Alloys. — (*Bull. Copper Brass Res. Assoc., 1936, (85), 14*).—Copper-nickel-zinc alloys of colours ranging from the white of nickel silver through those of copper, brass, to those of bronze are now available for architectural, decorative, and other structures, which are illustrated.—J. S. G. T.

Automobile Industry, a Large Copper Consumer. — (*Bull. Copper Brass Res. Assoc., 1936, (85), 2-7*).—The development of travel in America and the growth of the automobile industry are briefly illustrated. This industry, next to the electrical industry, is the largest consumer of copper and its alloys in the country.—J. S. G. T.

Iron and Copper Bonded in Composite Cylinder Heads. Irving E. Aske (*Automotive Ind., 1935, 73, 724-727, 733-734*).—A combination of cast iron

and copper in automobile cylinder heads results in lower heat losses to the jacket through the iron, and prevents excessive rise in temperature at the end of the combustion process. The method of casting is described; a special type of cast iron must be used, and the design of the copper insert must be varied according to the form of the combustion chamber. Comparative curves show the improved performance of composite cylinder heads as against similar members of "high conductivity alloy" and cast iron. Copper inserts are stated to be more effective than those of aluminium.—P. M. C. R.

Copper Plating for Power. — (*Motor*, 1936, 68, 1063).—The improved performance effected by spraying the combustion heads of motor engines with aluminium led to the experimental use of copper plating on both cylinder heads and valves. Subject to necessary adjustments in the composition of the mixture, the pulling power of the engine tested was increased by 20%, with a considerable decrease in fuel consumption; cooler running was also noted. A reference is made to a compound cylinder head, of cast iron with pinned copper inserts, where the thermal conductivity of the copper is used in cooling. (Cf. preceding abstract.)—P. M. C. R.

Tentative Specifications for Copper-Silicon Alloy Wire for General Purposes (B 99-35 T). — (*Book of A.S.T.M. Tentative Standards, 1935*, 359-361; and *Proc. Amer. Soc. Test. Mat.*, 1935, 35, (I)).—Cover round copper-silicon alloy wire for general structural purposes except for electrical transmission cable. Requirements as to chemical composition are: silicon 1.00-5.00; manganese (maximum) 1.50; zinc (maximum) 5.00; iron (maximum) 2.50; tin (maximum) 2.00; aluminium (maximum) 2.00; copper remainder; sum of above elements (minimum) 99.50%.—S. G.

Tentative Specifications for Bronze Trolley Wire (B 9-35 T). — (*Book of A.S.T.M. Tentative Standards, 1935*, 338-343; and *Proc. Amer. Soc. Test. Mat.*, 1935, 35, (I)).—These are in effect a revision of, and are intended to replace when adopted, the present Standard Specifications (B 9-32). They cover round and grooved bronze trolley wire.—S. G.

Bearing Bronzes. — (*Copper Development Assoc. Publ. No. 15, 1935*, 31 pp.).—Deals with requirements of a bearing metal, general range of British bearing bronzes, properties of copper-tin bearing bronzes, bronze bearing shells, bearing brasses, copper-lead bearing alloys ("lead-bronzes"), bushes for light-duty applications, bearings moulded from copper powder mixtures, installation of bronze bearings, and where to specify bronze or bronze-backed plain bearings. A table of some typical bearing bronzes (compositions, average mechanical properties, and applications) is given.—S. G.

Tentative Specifications for Wrought Phosphor-Bronze Bearings and Expansion Plates for Bridges and Structures (B 100-35). — (*Book of A.S.T.M. Tentative Standards, 1935*, 326-329; and *Proc. Amer. Soc. Test. Mat.*, 1935, 35, (I)).—Cover two classes of wrought bronze bearing metals for movable bridges and structures: *Class A.*—for contact with hardened steel disks under pressures over 1500 lb./in.², e.g. bearing metals, expansion plates, &c., used in centre-bearing swing bridges, and *Class B.*—for contact with soft steel at low speeds under pressures not over 1500 lb./in.², e.g. expansion plates, &c., trunnions and journals of bascule and lift bridges. The requirements as to chemical composition are: *Class A.*—tin (minimum) 7.0, phosphorus 0.05-0.50%, copper remainder, copper + tin + phosphorus (minimum) 99.50%; *Class B.*—tin (minimum) 3.5, phosphorus 0.05-0.50%, copper remainder, copper + tin + phosphorus (minimum) 99.50%.—S. G.

Brass and Other Copper Alloy Wire and Wire Products. — (*Copper Development Assoc. Publ. No. 16, 1935*, 49 pp.).—Deals with composition and mechanical properties, sizes and shapes available, applications (rivets, pins, and cold-headed products; screws, bolts, and screwed products; chains and bent products; springs; gauze cloth, &c.); and production and treatment

(wire manufacture, annealing and heat-treatment, pickling and bright dipping, colouring). Weight tables complete the booklet.—S. G.

Crank-Case Oil Improved [Tests on Bearing Metals]. — (*Nat. Petrol. News*, 1935, 27, (46), 38–42).—A series of film-strength and wear tests in the Timken and Alman machines is described in connection with the effect of lubricating oil containing various additions on the performance of bearing metals. The materials tested were a cadmium-silver alloy, "S.A.E. 11," a bearing bronze (F1), and a copper-lead alloy, and the wear of steel on steel, bronze, and brass was studied. A Sibley corrosion-testing machine, which incorporated a connecting-rod bearing, was used in further tests on copper-lead and cadmium-silver bearings lubricated with a variety of treated oils. The cadmium-silver alloy was highly resistant to ordinary corrosion and to wear in the Timken machine, but its wearing quality as tested by the Sibley machine was inferior to that of copper-lead.—P. M. C. R.

Tentative Specifications for Lead-Coated Copper Sheets (B 101–35 T). — (*Book of A.S.T.M. Tentative Standards*, 1935, 344–347; and *Proc. Amer. Soc. Test. Mat.*, 1935, 35, (I)).—Cover lead-coated sheet copper for architectural uses. It is supplied in two types (Type I, by application of molten lead; Type II, by electrodeposition) according to the method of manufacture, and in three classes according to weight of coating.—S. G.

Lead-Bronze Ingots and Bars (Suitable for Bearings). — (*Brit. Air Min. Specification No. D.T.D. 274*, 1935, 1 p.).—S. G.

Tentative Specifications for Lead and Tin-Base Alloy Die-Castings (B 102–35 T). — (*Book of A.S.T.M. Tentative Standards*, 1935, 364–365; and *Proc. Amer. Soc. Test. Mat.*, 1935, 35, (I)).—Cover die-castings made by pressure casting from the following alloys: tin-base, lead-base, and intermediate. Five typical alloys are specified, designated Grades 1–5, in order of decreasing tin content.—S. G.

Magnesium in Aeronautical Construction. R. de Fleury (*Publ. Sci. Tech. Ministère de l'Air*, No. 75, 1935, 112 pp.).—Recent French work on the constitution of magnesium alloys, on the recovery and refining of magnesium, and on the casting, working, and uses of the metal and its alloys is summarized and discussed.—A. R. P.

Molybdenum: Its Sources and Industrial Uses. Maurice Dérivière (*Métaux et Machines*, 1935, 19, 407–411).—An account is given of the occurrence and principal natural compounds of molybdenum; molybdenite and wulfenite are described in some detail. The extraction and physical and chemical properties of the metal are considered, and the uses of the more important salts of molybdenum, of the metal itself, and of its alloys (mainly ferrous) are enumerated.—P. M. C. R.

Marking Articles Made of Silver in Combination with Gold. — (*[U.S.] Bur. Stand. Commercial Standard*, CS 51–35, 1935, 9 pp.).—Covers marking for sale in the U.S.A.—S. G.

Tin and Its Uses. D. J. Macnaughtan (*Misc. Publ. Internat. Tin Res. Develop. Council*, 1935, (4), 16 pp.).—The uses of tin in bronzes, bearing metals, solders, die-casting alloys, pewter, and tinplate are briefly reviewed.

—A. R. P.

Advances in the Field of Hard Metals. Karl Becker (*Metallwirtschaft*, 1935, 14, 1004).—A review of recent patent literature.—v. G.

Tentative Revision of Standard Specifications for Slab Zinc (Spelter) (B 6–33). — (*Book of A.S.T.M. Tentative Standards*, 1935, 1517; and *Proc. Amer. Soc. Test. Mat.*, 1935, 35, (I)).—Amendments are made to Sections 1, 2, 4, and 8.—S. G.

The Use of Cast Materials [—I.—II.]. Albert Achenbach (*Werkstatt u. Betrieb*, 1935, 68, 285–288, 316–318).—(I.—) Deals with cast ferrous materials only. (II.—) The advantages and special applications of castings of lead, ordinary

and special bronzes, brass (including red brass, Delta, and Durana metal), nickel, and the nickel-iron and nickel-copper alloys, are indicated, and certain necessary precautions in the selection of materials are indicated in each case.

—P. M. C. R.

XXII.—MISCELLANEOUS

(Continued from pp. 23-24.)

The Institute for Metallurgical Engineering and Electrometallurgy at the Technical High School, Aachen. Paul Röntgen (*Metall u. Erz*, 1935, **32**, 265-269; and *Abhandl. Inst. Metallhütt. u. Elektromet. Tech. Hochschule Aachen*, 1935, [N.F.], **3**, 5 pp.).—S. G.

The Nickel Industry in 1935. R. C. Stanley (*Amer. Metal Market*, 1936, **42**, (247), 2).—A review.—L. A. O.

The Zinc Industry in 1935. E. V. Gent (*Amer. Metal Market*, 1936, **43**, (9), 3, 6).—Economic.—L. A. O.

Some Problems of Metal Physics. Walther Gerlach (*Metallwirtschaft*, 1935, **14**, 1010-1012).—A popular lecture on the importance of physical points of view in the study of metals.—v. G.

Metallurgical Progress. Its Bearing on the Electrical Industry. L. Sanderson (*Elect. Rev.*, 1935, **117**, 444).—J. C. C.

Salvaging and Reclaiming Items in Every-Day Uses. T. H. Owens (*Amer. Metal Market*, 1935, **42**, (118), 6, 7; (120), 6, 7).—Methods used by the Westinghouse company are briefly outlined.—A. R. P.

Research Laboratory of the London, Midland and Scottish Railway. — (*Met. Ind. (Lond.)*, 1935, **47**, 591-593).—See also *Met. Abs.*, this vol., p. 24. The equipment of a large modern research laboratory is described.—J. H. W.

Research and Management. Peter A. Thiessen (*Metallwirtschaft*, 1935, **14**, 1007-1009).—The need for high schools and universities in connection with the advancement of the science of metals is shown.—v. G.

XXIII.—BIBLIOGRAPHY

(Continued from pp. 24-28.)

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XXIV.—BOOK REVIEWS

Modern Uses of Non-Ferrous Metals. Edited by C. H. Mathewson. (A.I.M.M.E. Series.) Post 8vo. Pp. x + 427, illustrated. 1935. New York: American Institute of Mining and Metallurgical Engineers. (\$3.00 net.)

This is one of the series of books sponsored by the Seeley W. Mudd Memorial Fund Committee of the American Institute of Mining and Metallurgical Engineers, and has been specially written for the junior members of the metallurgical and engineering professions. It contains twenty-one chapters written by well-known metallurgists who survey the common non-ferrous metals and many minor metals so far as possible in non-technical language and narrative style.

The first chapter, by Zay Jeffries, deals with the new industrial development and exploitation of metals and alloys but includes an account of the occurrence of metals in the earth, the nature of metallic products, the constitution of alloys, and the future of the non-ferrous metal industry. In connection with this latter subject, the author concludes that it is practically certain that the suitability of non-ferrous metals for engineering purposes will be in much greater proportion to iron than the recent ratio of the consumption of these metals and also

that in selecting metals in the future, engineering suitability will gradually be given a greater weight as compared with cost.

In most of the chapters the occurrence and methods of extraction and properties of the metals are dealt with very briefly, the greater portion of the matter being devoted, as indicated by the title, to the uses to which they are put.

Twenty-one of the twenty-two authors responsible for the matter of the book are engaged in American metallurgical work; the exception is D. J. Macnaughtan of the International Tin Research and Development Council, London, who has written on tin, and his choice could not have been bettered for the subject-matter of this chapter. The book is well written and forms easy reading, and at the same time gives useful information on many matters not easily accessible in laboratories. It is curious that the chapter on chromium should be, for the most part, devoted to iron and steel alloys.

The book will undoubtedly prove useful both as an introduction to the study of non-ferrous metals and alloys to engineers and students studying metallurgical subjects, and as a revision book for metallurgists who have been inclined to specialize too strongly on one metal or on a limited branch of the subject only.—C. O. BANNISTER.

General Foundry Practice. By Andrew McWilliam and Percy Longmuir. Fourth Edition, Revised Throughout and Enlarged by Percy Longmuir. Med. 8vo. Pp. viii + 457, with 2 Plates and 303 illustrations in the text. 1935. London: Charles Griffin and Co., Ltd. (21s. net.)

The present edition of this book, which has come to be regarded as one of the standard works on foundry practice, has been enlarged by a further 73 pages and 57 illustrations and improved by a general re-arrangement of the later chapters. The scope of the book has been extended to include modern plant and equipment, and developments in alloys, such as improved drying stoves, electric, oil and pulverized-fuel melting furnaces, alloy steels and cast irons, &c.

In certain directions the revision could have been more complete. More recent types of base-metal couples and recorders might have been mentioned. Whilst the chapter on non-ferrous alloys has been enlarged in certain directions, the importance of the subject, especially aluminium-base light alloys, calls for fuller treatment than has been given. No reference is made to the troubles associated with the casting of these alloys or to the various treatments evolved in recent years for overcoming them. The specification quoted for Admiralty gun-metal has been obsolete for some years. The photomicrographs in Chapter XXXVIII could have been improved and made more representative.

These few shortcomings do not seriously detract from the value of this work, which is so well known to all associated with foundries. The binding and printing are excellent, and the Index has been carefully compiled.—J. E. NEWSON.

Electric Melting Practice. By A. G. Robiette. Med. 8vo. Pp. viii + 324, with 87 illustrations, including 3 folding plates. 1935. London: Charles Griffin and Co., Ltd. (15s.)

The author provides an up-to-date review of electric furnace applications to the melting of ferrous and non-ferrous metals and alloys. The book gains much advantage from his practical acquaintance with the installation of such plant in this country, and the survey of published information on British and foreign practice is well done. No attempt has been made to deal with the early history and the many forms of plant which led up to those which are in successful operation to-day, and the book has thus been kept within reasonable compass.

The economics of electric melting compared with fuel melting are adequately dealt with, so far as the ordinary reader is concerned, and the relative advantages of different types of electric furnace appear to have been fairly put forward. A most useful summary is given of the work which has been carried out on the mechanism and reactions concerned in the refining of steels in arc and coreless induction furnaces.

A chapter on resistor melting furnaces is particularly welcome, as it refers to the melting of aluminium and the heating of galvanizing baths, applications in which this country seems to have rather lagged behind others and where considerable developments are to be expected within the next few years.

Who's Who, 1936. Eighty-Eighth Year of Issue. Post 8vo. Pp. lx + 3764. London: A. & C. Black, Ltd. (60s.)

The new edition of "Who's Who" serves to remind us of the loss to Britain and to the world of him who, when the book was issued last month, was still the revered head of the British Commonwealth of Nations. The first entries are those of His late Majesty King George V, of whose photographs three excellent reproductions are given, and of his son, now King Edward VIII, whose well-known features figure in two excellent plates.

The rest of the biographies, numbering tens of thousands, follow the lines of those which have appeared in "Who's Who" for many decades, and go to make up an ever-swelling volume as humanly interesting as it is indispensable.



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