94, 695, & 696
to be printed in the half-yearly volume:
Journal of the Institute of Metals,
1935, Vol. LVI.

Vol. 2. Part 2.

The Monthly Journal of the

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and

METALLURGICAL ABSTRACTS

FEBRUARY, 1935

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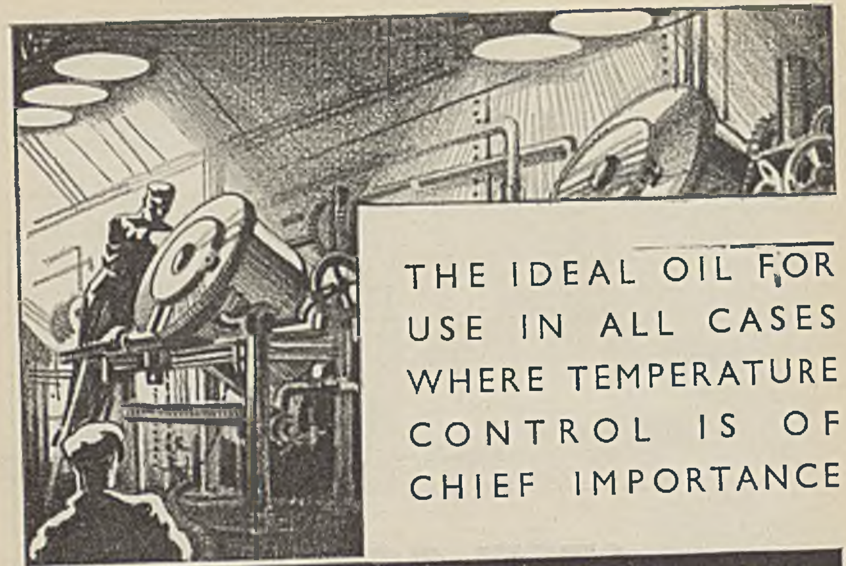

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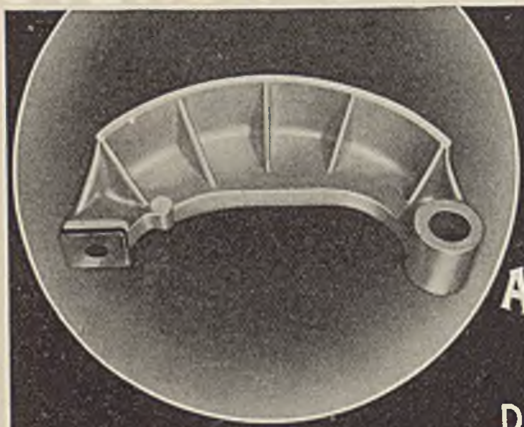

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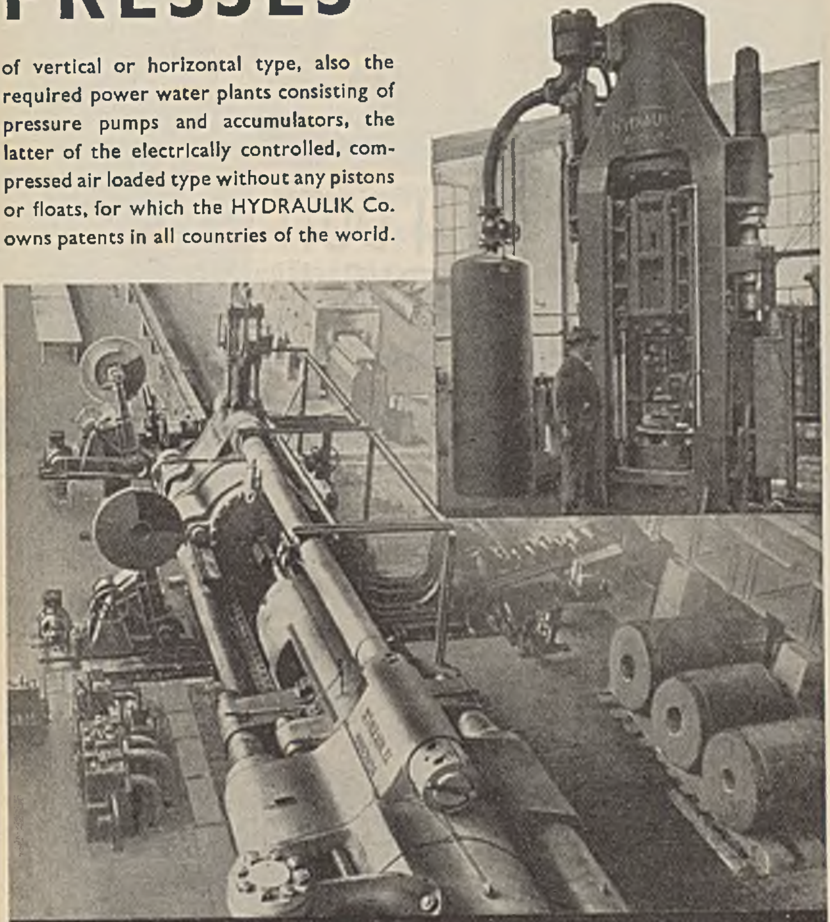

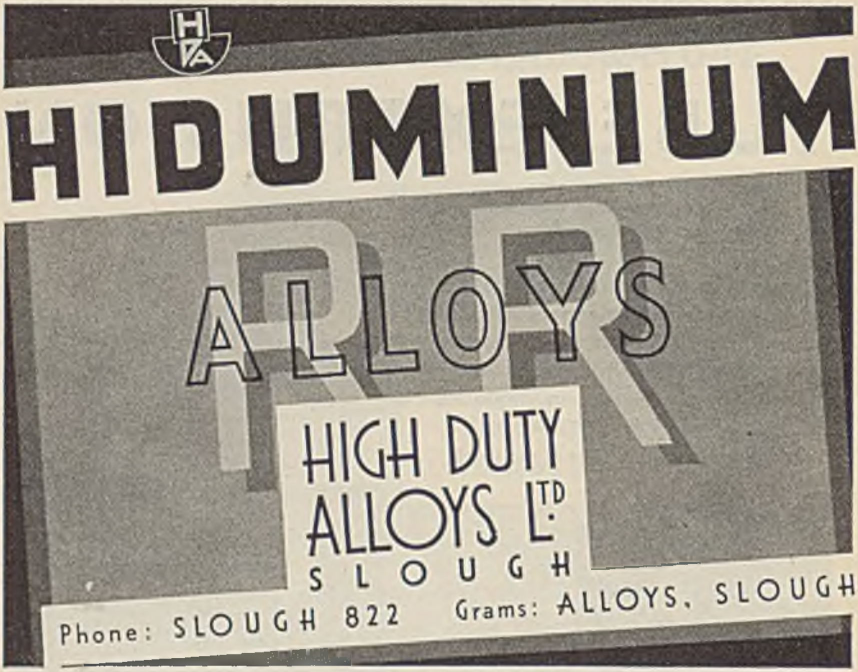

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THE INSTITUTE OF METALS

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WITH
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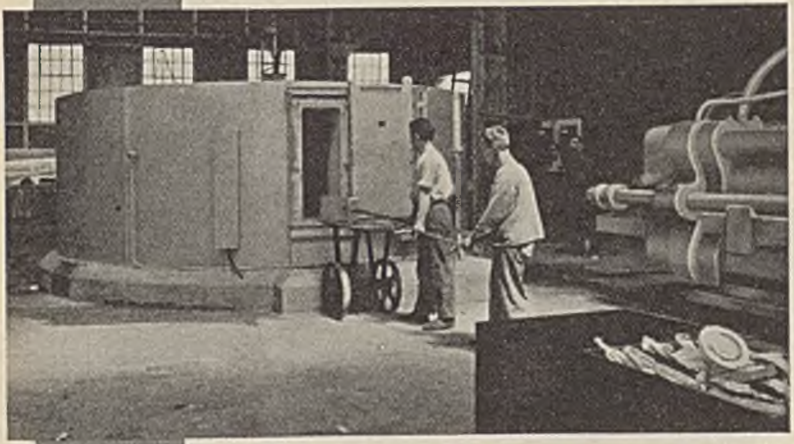
This Contents List, issued in a stiff cover, with an Author Index, will facilitate reference to the papers published in the *Journal* since the Institute's foundation. It should be found most valuable pending the issue of the 10-year Index. Copies are obtainable from the Secretary. **Price 2s. 7d. each, post free.**



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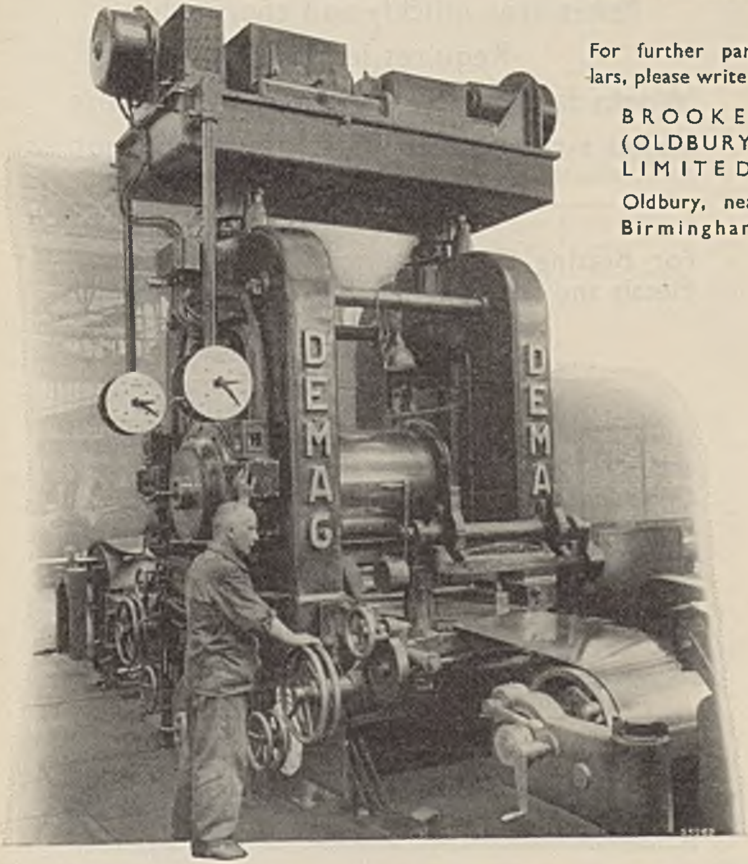

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THE
Monthly Journal of the
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ADVERTISING
DEPARTMENT:
T. G. SCOTT & SON,
Ltd.
63 Ludgate Hill,
London, E.C.4.
TELEPHONE:
CITY 4211 (2 lines).
Assistant Editor:
S. C. GUILLAN

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INSTITUTE NEWS AND ANNOUNCEMENTS

ANNUAL GENERAL MEETING, LONDON

MARCH 6–7, 1935.

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, London, S.W.1 (by kind permission of the Council of that Institution), on Wednesday, March 6, and Thursday, March 7, beginning at 10 a.m. each day. A detailed programme of the meeting was posted to each member on January 18, together with a form intended to be used to apply for tickets for the Annual Dinner and Dance on March 6, the visit to the Battersea Power Station on March 7, and for luncheons on March 6 and 7.

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

Papers at Annual General Meeting.

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

Serial
No.

685. DURRANT, P. J., M.A., Ph.D.: "The ϵ, γ, and β Phases of the System Cadmium–Silver."
686. HANSON, Professor D., D.Sc., and W. T. PELL-WALPOLE, B.Sc.: "The Constitution and Properties of Cadmium–Tin Alloys."
687. GOUGH, H. J., M.B.E., D.Sc., F.R.S., and D. G. SOPWITH, B.Sc.Tech.: "Some Further Experiments on Atmospheric Action in Fatigue."
688. GERARD, I. J., M.Sc., and H. SUTTON, M.Sc.: "Corrosion-Fatigue Properties of Duralumin With and Without Protective Coatings."
689. ALKINS, W. E., D.Sc., and A. P. C. HALLOWES: "The Reduction by Hydrogen of Stannic Oxide Contained in H.-C. Copper."
690. HUDSON, J. C., D.Sc., D.I.C., A.R.C.S.: "The Effect of Five Years' Atmospheric Exposure on the Breaking Load and the Electrical Resistance of Non-Ferrous Wires."
691. WEAVER, FRANCES D., B.Sc.: "Type Metal Alloys."
692. HANSON, Professor D., D.Sc., and E. J. SANDFORD, B.Sc.: "Some Properties of Tin Containing Small Amounts of Aluminium, Manganese, or Bismuth."
693. PRYTHERCH, W., M.Sc.: "Alloys of Magnesium. Part II.—The Mechanical Properties of Some Wrought Magnesium Alloys."
694. HANSON, Professor D., D.Sc., and I. G. SLATER, Ph.D., M.Sc.: "Unsoundness in Aluminium Sand-Castings. Part III.—Solidification in Sand Moulds under Pressure."
695. VAN EWIJK, L. J. G., Dr.-ir.: "The Penetration of Steel by Soft Solder and Other Molten Metals at Temperatures up to 400° C."
696. SMITH, D. M., B.Sc., D.I.C., A.R.C.S.: "The Spectrographic Analysis of Aluminium."

All the above-mentioned papers have been published in recent issues of the *Monthly Journal*, beginning with that dated October, 1934. Members should bring to the meeting copies of the *Monthly Journal* containing papers in which they are interested as no separate copies will be available.

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

Annual Dinner and Dance.

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

The Battersea Power Station.

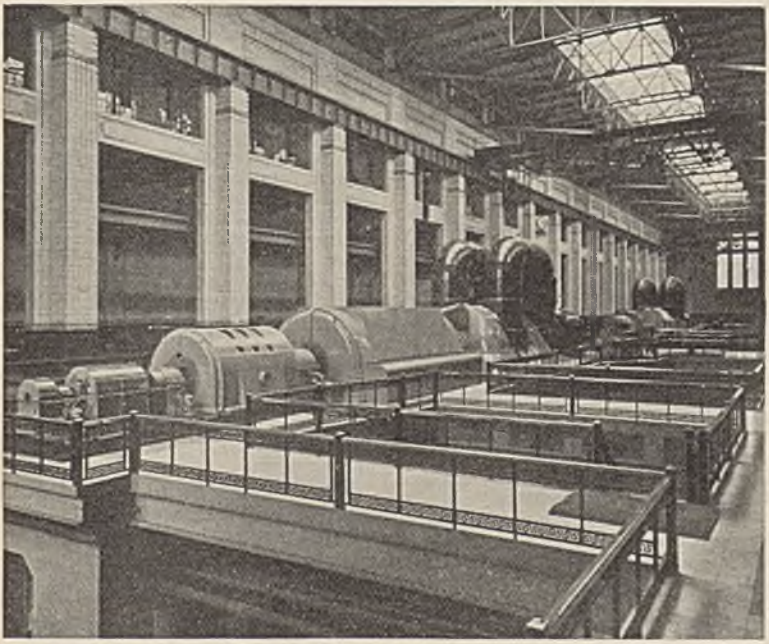
The Battersea Power Station.

The site of the Battersea Station, to be visited by members on March 6, is on the south bank of the Thames, and comprises about fifteen acres. The river frontage is 677 ft. in length, and has a jetty of reinforced concrete, 426 ft. by 36 ft., which accommodates the 2000-ton colliers owned by the Power Company. Between the river wall and the north front of the buildings is a sunken concrete coal-store, 580 ft. long by 188 ft. wide, capable of holding 75,000 tons.

The main buildings comprising the first half of the station are 480 ft. in length by 270 ft. in width, and consist of Switch House, Turbine House, and Boiler House. Approximately 19,500 tons of steelwork and 8,000,000 bricks were used in the construction of this half of the station.

At each end of the Boiler House a reinforced concrete chimney stands on a massive steel tower cased in brickwork. The tops of the chimneys are 337 ft. 6 in. above ground level, and have an internal diameter tapering from 28 ft. to 22 ft. These are the tallest chimneys in London. Very elaborate precautions have been taken to prevent the emission of sulphur oxides from the chimneys, and a unique system of gas washing has been installed.

The coal used in the station is mainly water-borne by means of five 2000-ton colliers. The cranes on the jetty take the coal from the boats and discharge it through hoppers on to two belt-conveyors running the length of the jetty. The coal is then transferred to another pair of belt-conveyors running to a control tower containing weighing machines, and from here the coal is conveyed direct to the Boiler House bunkers or to the coal store.



Turbine House, Battersea Power Station.

When complete, the existing Boiler House (which is 480 ft. long by 105 ft. wide) will contain nine boilers. Six have already been installed, and each boiler has a maximum output of 330,000 lb. of steam per hr. at a pressure of 625 lb./in.^{2} and a total temperature of 875°–900° F.

The Turbine House is 475 ft. long by 80 ft. wide, and at present contains two 64,000-kw. turbo-alternators, to each of which is coupled a 5000-kw. house-service alternator. The third turbo-alternator, which is to be housed in the same building, is now on order, and will be a 100,000-kw. set.

The output of each main alternator is generated at a pressure of 11,000 v., 3-phase, which is then stepped up to the busbar pressure of 66,000 v. by means of 3-phase transformers, each having a capacity of 80,000 kVA. These transformers, together with the smaller transformers for furnishing the 22,000 v. distribution, are housed in chambers below the floors carrying the switchgear and cables.

Each pair of turbine condensers has a total cooling surface of 60,000 ft.^{2}, made up of over 11,000 tubes of 1 in. external diameter. The amount of river water which has to be circulated through the condenser tubes is 2,850,000 gall./hr. under normal load and river temperature conditions, but pump capacity is installed to supply up to 4,000,000 gallons per hour. This water is taken from and returned to the river through 12-ft. diameter tunnels. The total length of these water tunnels is 950 ft.

The 66,000-v. main switchgear is of an entirely new design, and is located in a Switch House, 370 ft. long by 47 ft. wide. All the circuit breakers are electrically operated from the Control Room, which is on the same level as the Switch Room, and from which a view of the Turbine Room can be obtained. This Control Room contains all the control panels, on which are fixed the necessary control switches, indicating lamps, and instruments for the main equipments. An illuminated diagram has been erected, which shows by different colours the electrical condition of the circuits and plant.

Cables carrying current at a pressure of 66,000 v. run from the Battersea Station to the Deptford West, Willesden, and Grove Road Generating Stations of the Power Company. There are also 22,000-v. cables furnishing supplies to certain distributing stations. These cables run out through a tunnel extending under the Thames from the station to the Grosvenor Embankment. This cable tunnel is 500 yd. long and of 10 ft. internal diameter, and is built on the same principle as the Underground Railway tubes.

The Battersea Station was designed by, and the work carried out under the supervision of, Dr. S. L. Pearce, C.B.E., M.Inst.C.E., M.I.E.E., M.I.Mech.E., the Engineer-in-Chief of the London Power Company.

International Foundry Congress of 1935.

The annual International Foundry Congress of 1935 will be held in Belgium during the second fortnight of September next coincidentally with the Brussels International Exhibition, and will be organized by the Association Technique de Fonderie de Belgique. The Council of the Association has issued an invitation to members of the Institute of Metals to contribute papers to and to participate in the Congress, which will include visits to the Brussels International Exhibition as well as visits to works and a tour of Flemish towns and the Belgian Ardennes. Papers are specially invited dealing with bronzes and aluminium alloys and the casting of these under pressure. Members who desire to contribute papers and/or to participate in the congress should advise the Secretary of the Institute of Metals.

Discussion on Cold-Presswork.

In the evening before the Annual General Meeting there will be held in the Hall of the Royal Geographical Society, Kensington Gore, London, S.W.7 (Exhibition Road entrance), a Joint Meeting to discuss the subject of cold-presswork. Sir Harold Carpenter, F.R.S. (Past-President of the Institute of Metals) will preside. The meeting is being organized by the Institution of Automobile Engineers in co-operation with the Institute of Metals and the following other societies: The Chemical Engineering Group, The Institute of Fuel, The Institute of Marine Engineers, The Institution of Mechanical Engineers, The Institution of Petroleum Technologists, The Iron and Steel Institute, The Junior Institution of Engineers, The North-East Coast Institution of Engineers, The Royal Aeronautical Society, and The Society of Engineers.

The following papers will be introduced and discussed :—

"Cold-Pressing and Drawing."

(a) **From the Mechanical Point of View**—by Dr. H. J. Gough, M.B.E., F.R.S.

(b) **From the Metallurgical Point of View**—by Dr. C. H. Desch, F.R.S.

"New Researches on the Drawing of Cylindrical Shells," by Professor Dr. G. Sachs.

Time-Table.

7.0–8.15 p.m.	Introduction of papers and commencement of discussion.
8.15–8.45 p.m.	Interval for light refreshments.
8.45–10.15 p.m.	Continuation of discussion and authors' replies.

It is hoped that there will be a large attendance of members of the Institute of Metals. Members who desire to be present should apply for tickets on the reply form that accompanied the Annual General Meeting circular letter which was sent to all members last month. As the meeting is being held on the evening previous to the Annual General Meeting it may be possible for many members from the provinces conveniently to arrange to attend both gatherings. *Members who expect to attend the meeting on March* 5 can be supplied with copies of the papers then to be read on application to Mr. Shaw Scott, who should also be advised by members who intend to take part in the discussion.

Educational Tour to Germany.

The detailed programme of the Educational Tour to the Rhineland of Germany, to take place from April 6 to 15, is nearing completion, and will be forwarded shortly to all who have indicated a desire to join in, or have expressed an interest in, the tour.

On arrival in Germany, the party will visit, first, the Technical High School at Aachen, afterwards proceeding to Stolberg to see the works of the firm of Asten & Lynen, the oldest brassworks in the Rhineland, dating back about 400 years. On the way thence to Cologne a visit will be paid to the Dürener Metallwerke, A.-G., at Düren; and in Cologne the works of Felten & Guilleaume Carlswerk will be inspected. Proceeding to Düsseldorf—after, possibly, a visit to Bonn—the party will be able to see over the Kaiser-Wilhelm-Institut für Eisenforschung, afterwards proceeding to Duisburg (Vereinigte Deutsche Metallwerke A.-G., Zweigniederlassung C. Heckmann) and Essen (Fried. Krupp A.-G.) before returning to England. Activities of a social character are also being arranged.

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 the present is a particularly appropriate moment to apply for membership. **The first subscription covers the extended period ending June 30, 1936,** instead of the usual twelve months; whilst it brings a corresponding extra number of *Journals*. A convenient means of introducing the work of the Institute to non-members is to be found in the new edition of the illustrated folder —" The Institute of Metals : Its Aims and Objects "—copies of which can be obtained from the Secretary. A membership form will be found in each folder, as well as in each recently issued volume of the *Journal*. Nominations should be addressed to the Secretary. **The next election is due to take place on April 4, 1935.**

PERSONAL NOTES

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

Mr. R. S. Archer, M.S., Chief Metallurgist, Chicago District, Republic Steel Corporation, was elected Vice-President of the American Society for Metals, at its New York meeting.

Dr. C. R. Austin, M.Sc.Tech., has been appointed Associate Professor of Metallurgy, The Pennsylvania State College, U.S.A.

Dr.-Ing. Max Haas, Manager of the Aluminium-Zentrale, will be glad to see members of the Institute of Metals at the International Motor-Car Exhibition in Berlin on February 16–26, on the stand of Aluminium-Zentrale, which is arranging a joint exhibit by the German aluminium industry of the possibilities of the use of aluminium and its alloys in the construction of motor vehicles.

Dr. Vsevolod N. Krivobok, Professor of Metallurgy at the Carnegie Institute of Technology, recently associated himself with the Research

Department of the Allegheny Steel Company at Brackenridge, Pa. Dr. Krivobok will divide his time equally between these two institutions.

Mr. P. C. Lockyer, B.Sc., left England on January 25 to take up an appointment with the Rhokana Corporation, Northern Rhodesia.

Mr. H. J. Miller, M.Sc., has been appointed metallurgist to the Copper Development Association, London. He took up his new duties at Thames House, Millbank, S.W.1, on January 1.

Professor Albert Sauveur, S.B., Sc.D., has received the first award of the Albert Sauveur Achievement Medal, awarded by the American Society for Metals, for outstanding achievement in the field of metallurgy.

Mr. John Scott, J.P. (father of the Institute's Secretary), who is now in his eighty-fourth year, appears to be the oldest living member of the Institute, as no other member has stated his date of birth to be earlier than Mr. Scott's birthday of August 28, 1851—a date that was given in a paragraph in the *Monthly Journal* for November, 1934, which was inserted with a view to determining who was the Institute's oldest member. Mr. Scott is still active and took part, with Mrs. Scott, in the recent Autumn Meeting in Manchester.

Mr. B. F. Shepherd, Chief Metallurgist, Ingersoll Rand Company, has been elected President of the American Society for Metals.

Professor G. B. Waterhouse, B.Met., Ph.D., Professor of Metallurgy, Massachusetts Institute of Technology, was elected a Director of the American Society for Metals, at the recent New York meeting of the Society.

LOCAL SECTIONS NEWS

SYNOPSES OF PAPERS TO BE READ IN MARCH.

Birmingham Section.

The Rarer Metals—Gold, Silver, and Platinum. By Edmund Downs. (*February* 28.)

A general survey will be given of the metals gold, silver, and platinum from the practical point of view.

London Section.

Failures in Service. By H. J. Gough, M.B.E., D.Sc., Ph.D., F.R.S. (*March* 14.)

A number of service failures which have been examined will be reviewed and discussed in general terms. It will be emphasized to the general methods employed and the results obtained. The point will be made that the solution of this type of investigation affords an exceptionally good opportunity for the engineer and metallurgist to collaborate in the closest possible way : in certain cases, the physicist also furnishes very valuable assistance.

North-East Coast Section.

The Improvement of White Metal Bearing Metals for Severe Service : Some General Considerations. (Institute Paper No. 673, by D. J. Macnaughtan.) (*March* 12.)

The paper, which is to be discussed at this meeting of the Section, appears both in the *Monthly Journal* for July, 1934, and in *J. Inst. Metals*, 1934, **55**, 33. The latter volume includes a record of the discussion that took place when the paper was originally discussed at the Autumn Meeting in Manchester last September. A synopsis of the paper is given in each of these publications.

Scottish Section.

Fusion Welding. By J. H. Paterson, D.Sc. (*March* 11.)

Only those processes of welding are considered in this paper in which the metal to be welded is brought to a liquid state and the weld completed by the addition of liquid metal of the same or similar composition from some external source.

Three principal methods of fusion welding are: the electric arc, the carbon arc, and oxy-acetylene welding. The high temperature of the electric-arc and carbon-arc processes results in the production of a considerable amount of vaporized metal, and the mechanical properties of the weld are influenced to a very large extent by the reactions taking place between the metal vapour phase and the atmosphere. Highly volatile and readily oxidized metal like zinc completely disappear from the welding during this process. In oxy-acetylene welding the liquid metals rarely reach the boiling temperature, and the combination between the metals and atmospheric gases is greatly reduced. Loss by volatilization also becomes considerably less.

In the arc-welding processes it is shown that the speed of melting of the metal in the arc varies with its thermal conductivity, and the limitations of these processes are shown to be intimately connected with this property.

The phenomena associated with the thermal disturbance of the parent metal, due to the heat from the welding process, is discussed and methods outlined by which it may be minimized or counteracted.

Sheffield Section.

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

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

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

Swansea Section.

Some Recent Developments in the Hardening of Non-Ferrous Metals by Heat-Treatment. By W. T. Griffiths, M.Sc., F.I.C. (*March* 12.)

While the use of heat-treatment to produce hardening or strengthening is extensively used in the case of steels, and knowledge has been available for some time of the possibility of employing heat-treatment to improve the properties of non-ferrous alloys in a similar manner, except in the case of certain light alloys the application of this knowledge has been limited. Some reasons for this will be examined and the possibilities of a more general utilization of this type of heat-treatment discussed, with particular reference to data obtained during recent years.

Subject to revision. Not to be published, wholly or in part, until presented at a Meeting to be held on March 6, 1935, 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, 1934.

The work of the Institute has been fully maintained during 1934 in spite of a further slight decrease in membership and some consequent loss of revenue. The utmost economy has been exercised, throwing additional burdens on the hard-working staff, in order that there should be no falling off in the two main directions of activity of the Institute, the publication of original papers and an unsurpassed series of metallurgical abstracts, and the holding of the regular meetings, both of the Institute and of the Local Sections, for scientific and technical discussion. The services of the Institute to its members have, indeed, been extended by the new method of publishing all papers in the *Monthly Journal* as well as in the half-yearly volumes. This change has been an unqualified success, the earlier publication and the longer time given for consideration of papers, before they are presented at meetings, having a marked effect on the quality of the discussions. The *Monthly Journal*, containing on the average in each issue three original papers as well as about 60 pages of classified up-to-date abstracts, is a publication of which the Institute may well be proud.

During the year there was a net loss of membership of 42, as indicated in the following table, bringing the total to 2089, the lowest figure since 1928 when the number was 2003. It should be noted that the loss of membership since the maximum of 2232 was reached in 1931 has been predominantly in the number of overseas members. Undoubtedly the causes are to be found in the world depression and in the financial, economic, and other obstacles to friendly and unfettered international association which have most unfortunately arisen in late years. Until these obstacles become less formidable the Institute must look to a substantial development of home membership if it is to continue its work free from the threat of a dangerous discrepancy between income and expenditure.

Losses by death have been particularly heavy, numbering 21 as compared with 13 in the previous year. A great loss to the Institute and to the whole metallurgical world was caused by the death, on March 17, 1934, of Dr. Walter Rosenhain, a Past-President and Fellow. The Institute, more than any other metallurgical society, is conscious of the gap that his passing has left, for he had associated himself closely with its work since its foundation, in which he took an active part. His influence was particularly profound and valuable during the many years that he acted as chairman of the Publication Committee.

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, 1930.	Dec. 31, 1931.	Dec. 31, 1932.	Dec. 31, 1933.	Dec. 31, 1934.
Honorary Members	5	5	5	5	5
Fellows . .	7	7	8	8	7
Ordinary Members	2083	2146	2073	2038	1992
Student Members .	65	74	79	80	85
	2160	2232	2165	2131	2089

OBITUARY.

In addition to the loss of Dr. Rosenhain the deaths of the following members were notified to the Secretary: William Bamford; W. H. Bassett; A. Bowker; F. G. Britton; E. L. Crosby; J. H. S. Dickenson; W. Donnan; W. N. Duff; J. H. Ellison; M. B. Fowler; J. K. G. James; Professor W. E. Gibbs; Professor A. Johansson; Professor C. Matignon; Dr.-Ing. K. L. Meissner; Grand Uff. Ing. Luigi Orlando; Geh. Reg. Professor R. Otzen; E. R. Perry; L. H. Quin; and L. Vogelstein.

MEETINGS OF THE INSTITUTE.

The Annual General Meeting took place in London on March 7 and 8, 1934, when thirteen papers were presented. Of these, eleven had been previously printed in the *Monthly Journal*, the remaining two, which were not discussed, being printed in the *Monthly Journal* for March, 1934.

The Meeting on March 7 was followed by a Dinner and Dance at the Trocadero Restaurant. In the afternoon of March 8 members were privileged to pay a visit to the Post Office Engineering Research Station at Dollis Hill.

On May 9, the second General Meeting was held, this being the occasion of the Annual May Lecture, which was delivered by Professor E. K. Rideal, F.R.S., on " Gases and Metal Surfaces."

The Twenty-Sixth Annual Autumn Meeting was held in Manchester from September 3 to 6. This was the third occasion on which similar Autumn Meetings had been held in Manchester, the previous gatherings taking place in 1909 and 1923. Eighteen papers were presented at the meeting, and the Autumn Lecture was given by Dr. J. L. Haughton on " The Work of Walter Rosenhain." Following the reading and discussion of papers, members visited works and other places of interest in Manchester and district.

LOCAL SECTIONS.

Meetings were held during the winter months by each of the six Local Sections of the Institute. At most of these meetings papers were read, a list of which is included in an Appendix to this Report.

A new function, arranged jointly by the London Local Section and the Institute of Metals, was the holding of a Supper-Dance on November 30. This was well attended by members and much appreciated.

EDUCATIONAL TOUR.

The first Educational Tour to be arranged by the Institute took place between April 8 and 14. A party numbering 45, and consisting for the most part of student members, proceeded to Belgium where several days were profitably spent in visiting metallurgical works, the University of Brussels, and other institutions. In view of the success of this tour, a similar visit has been planned to the Rhineland of Germany for the period April 6–15, 1935.

LIBRARY.

During the past year 119 new text-books were acquired and 2920 books and periodicals have been sent on loan to members. Many enquiries concerning technical questions have also been received by telephone and correspondence. More members have visited the Library than in any previous year.

The number of periodicals filed in the Library has increased to such proportions that it has been necessary to construct extensive new shelving; this has involved a considerable amount of reorganization and rearrangement of the periodicals. Files of certain periodicals which were outside the scope of the Institute's work have been transferred to the Science Library at South

Kensington; as, however, the arrangement for borrowing literature from this source continues, these files are still available to members on the rare occasions on which they are required. The Council desires to thank the Director, Brigadier E. E. B. Mackintosh, D.S.O., R.E., and his staff for their invaluable assistance and co-operation throughout the year.

The Council is grateful to several members for presenting much needed books to the Library. Further gifts of books required—a list of which is printed from time to time in the *Monthly Journal*—will be welcomed.

Members, particularly those residing overseas, are reminded of the photostat service, by means of which they may obtain copies of papers not otherwise easily procurable, at a moderate cost. The conditions on which these photostat copies can be supplied are set out in the *Journal*, vol. XLII, p. 387.

BEILBY MEMORIAL AWARD.

The Council is glad to report that a member, Dr. W. Hume-Rothery, M.A., received a Beilby Memorial Award of One Hundred Guineas.

COMMITTEES.

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

	Chairman
COUNCIL NOMINATION	The President
FINANCE AND GENERAL PURPOSES .	Sir Robert Dixon
LOCAL SECTIONS	Mr. W. R. Barclay
MEETINGS	Dr. H. W. Brownsdon
MEMBERSHIP	Mr. W. R. Barclay
PUBLICATION	Dr. Richard Seligman

Some reorganization of the Committees of the Council has been effected with a view to better co-ordination. A larger responsibility for the regular work of the Council is now undertaken by the main committees, and the Council is more free to devote the time available at its monthly meetings to major questions of policy. A long period of arduous and valuable service as Chairman of the Finance Committee has been brought to an end by Professor Turner's resignation of this important office, and Sir Robert Dixon has undertaken the work, with the assistance of Mr. E. L. Morcom as Vice-Chairman. Dr. H. W. Brownsdon has agreed to serve as Chairman of the new Meetings Committee, while Dr. Richard Seligman took charge of the Publication Committee on the election of Dr. H. Moore, its previous Chairman, as President.

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 Commitee 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.

Constantine Technical College, Middlesbrough (Foundry Advisory Committee): Professor J. H. Andrew and Mr. G. Mortimer.

Sir Charles Parsons Memorial Committee: Dr. H. Moore (President).

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

Parliamentary Science Committee (British Science Guild): Dr. H. Moore and Mr. G. Shaw Scott.

Corresponding Members to the Council.

The Council would again extend its thanks to the following members who have acted as Corresponding Members during the past year: Mr. H. Norman Bassett (*Egypt*); Professor Dr. 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, D.Sc. (*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 17, 1935.

APPENDIX.

LOCAL SECTIONS' PROGRAMMES, 1934–1935.

BIRMINGHAM LOCAL SECTION.

Chairman: M. Cook, Ph.D., M.Sc.

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

1934.

Programme.

Oct. 25.	Open Discussion: "The Production of Brass Ingots."
Nov. 20.	H. J. Gough, M.B.E., D.Sc., Ph.D., F.R.S. "Fatigue in Metals."
Nov. 29.	R. G. Johnston. "Directionality in Some Annealed Non-Ferrous Alloys."
Dec. 18.	N. P. Allen, D.Sc., M.Met. "Interpretation of the Equilibrium Diagram."

1935.
Jan. 3. A. W. HOTHERSALL, M.Sc. "The Microstructure of Electro-Deposited Coatings." (Joint Meeting with the Electrodepositors' Technical Society.)
Jan. 15. "The National Smelting Works, Avonmouth." By a member of the staff.
Feb. 12. Symposium on Pickling Problems.
Feb. 28. EDMUND DOWNS. "The Rarer Metals—Gold, Silver, and Platinum."
Mar. 19. R. T. ROLFE. "Bearing Materials."

All Meetings are 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:* J. MCNEIL, A.R.T.C.;
Messrs. The Mond Nickel Co., Ltd.,
Thames House, Millbank, S.W.1.

1934. PROGRAMME.

Oct. 11. C. J. SMITHELLS, M.C., D.Sc. Chairman's Address: "The Emission of Light and Electrons by Metals and their Industrial Application."
Nov. 8. H. MOORE, C.B.E., D.Sc., Ph.D. "Recent Trends and Future Developments in Metallurgical Research." (Meeting at the Royal School of Mines, South Kensington, S.W.7.)
Nov. 30. SUPPER-DANCE. (Thames House, Millbank.)
Dec. 5. WESLEY LAMBERT, C.B.E. "Manganese–Bronze." (Joint Meeting with the Institute of British Foundrymen.)

1935.
Jan. 10. J. C. CHASTON, B.Sc., A.R.S.M. "The Manufacture and Uses of Powdered Metals."
Feb. 14. W. H. J. VERNON, D.Sc., Ph.D. "The Protection of Metals by Coatings." (Joint Meeting with the Electrodepositors' Technical Society.)
Mar. 14. H. J. GOUGH, M.B.E., D.Sc., Ph.D., F.R.S. "Failures in Service."
Apl. 11. Annual General Meeting and Open Discussion.

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

NORTH-EAST COAST LOCAL SECTION.

Chairman: W. RICHARDSON, B.Sc. *Hon. Secretary:* C. E. PEARSON, M.Met.,
Armstrong College, Newcastle-on-Tyne.

1934. PROGRAMME.

Oct. 9. W. RICHARDSON, B.Sc. Chairman's Address.
Nov. 10. Combined Lecture and Visit to Armstrong-Saurer Motor Works. Lecture by Mr. NICHOLSON.
Dec. 15. F. W. ROWE, B.Sc. "Problems in Non-Ferrous Foundry Practice." (Joint Meeting with Newcastle Branch of the Institute of British Foundrymen.)

1935.
Jan. 15. Visit to Messrs. Vickers-Armstrong's Extrusion and Rolling Departments.
Feb. 12. G. L. CASSIDY. "Melting Furnaces for Non-Ferrous Metals."
Mar. 12. Discussion of Institute of Metals Paper No. 673: "The Improvement of White Bearing Metals for Severe Service: Some General Considerations." By D. J. MACNAUGHTAN.
Mar. 22. R. D. BURN. "Copper Production."

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

SCOTTISH LOCAL SECTION.

Chairman : J. W. DONALDSON, D.Sc.

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

1934. PROGRAMME.

Oct. 8. J. W. DONALDSON, D.Sc. Chairman's Address.

Nov. 12. W. C. DEVEREUX. "The Influence of Manufacture of Wrought and Cast Aluminium Alloys on Design."

Dec. 10. A. SPITTLE. "Improvements in Surface Condenser Tubes."

1935.

Jan. 14. Professor C. O. BANNISTER, M.Eng., A.R.S.M. "Some Aspects of the Corrosion of Non-Ferrous Metals."

Feb. 11. A. G. ROBIETTE, B.Sc. "Recent Developments in Electric Furnaces for Non-Ferrous Metals."

Feb. 18. A. MCCANCE, D.Sc., A.R.S.M. "Recent Advances in Metallurgy." (Joint Meeting with the Scottish Branch of the Institution of Automobile Engineers.)

Mar. 11. J. H. PATERSON, D.Sc. "Welding." Annual General Meeting.

The Meetings 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.

1934. PROGRAMME.

Oct. 19. KENNETH GRAY. Chairman's Address : "Some Manufacturing Faults and Other Defects in Extruded Lead Products."

Nov. 9. C. E. PEARSON, M.Met. "The Flow of Metals in the Extrusion Process."

Dec. 14. A. W. SCOTT. "Rhodium Plating and its Applications."

1935.

Feb. 8. Captain F. ORME, M.Met. "The Manufacture of Pewter."

Mar. 8. A. G. LOBLEY, M.Sc. "Electric Annealing and Heat-Treatment Furnaces."

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 : Professor L. TAVERNER, A.R.S.M.

Hon. Secretary : ROOSEVELT GRIFFITHS, M.Sc., Metallurgical Department, University College, Singleton Park, Swansea.

1934. PROGRAMME.

Oct. 9. Professor L. TAVERNER, A.R.S.M. Chairman's Address.

Nov. 13. W. H. J. VERNON, D.Sc., Ph.D. "Copper in Architecture: Some Chemical and Other Aspects."

Dec. 11. Professor W. R. D. JONES, D.Sc. "Refractory Materials of South Wales."

1935.

Feb. 12. C. E. DAVIES. "Design of Rolling-Mills for Cold-Rolling of Metals both Ferrous and Non-Ferrous."

Mar. 12. W. T. GRIFFITHS, M.Sc. "Some Recent Developments in the Hardening of Non-Ferrous Metals by Heat-Treatment." Annual General Meeting.

The Meetings are held at the Y.M.C.A., Swansea, at 6.15 P.M.

REPORT OF THE HONORARY TREASURER

(Mr. JOHN FRY)

For the Financial Year ended June 30, 1934.

The Institute has had another difficult financial year, resulting in an excess of expenditure over income of £359; yet it is gratifying to note some encouraging features. Last year the adverse balance was £402.

Had the subscription income of £5838 been maintained at the 1933 level of £6038, and had income from War Stock been the same as before, the excess of expenditure over income would have been only £69. The decrease in rate of interest is beyond control, but accounts for only a minor part of the loss of revenue since, unfortunately, the Institute's investments are small.

It is clear from these figures that every effort must be made to increase income through additional membership or other means. Beyond subscription income the only appreciable sources of revenue are those arising from sales of the Institute's publications and advertisements in the *Monthly Journal*. It is to be hoped that members who can do so will use their influence to bring about an increase in one or both of these directions.

The Council is satisfied that everything possible has been done on the expenditure side to reduce the cost of running the Institute. The net cost of the *Journal* has been reduced by about £300, a notable achievement and one on which the Publication Committee is to be congratulated. The Committee has had to work very hard indeed to effect this saving without detriment to the *Journal*. Still further to reduce expenditure would be to lower the efficiency of the organization and its power of rendering to members that good service of which they have every reason to be proud.

It will be appreciated that the gross cost of the *Journal* considerably exceeds £4000 per annum and that the members receive the equivalent of this sum in kind, apart from all the other services of the Institute. The Council is most anxious to maintain the high level of efficiency of this record of original researches, both academic and industrial, as well as of the valued *Metallurgical Abstracts*.

The Institute is still feeling the effects of the depression; until this passes the active co-operation of every individual member is invited to ensure the removal of the consequential financial anxieties of the Institute. A steady influx of new members is required for general as well as financial reasons; if members make known the advantages of the Institute to their friends and colleagues in the profession and to engineers, manufacturers, and merchants, the anxieties of the Council will be removed and the prosperity of the Institute assured.

THE INSTITUTE OF METALS

INCOME AND EXPENDITURE ACCOUNT FOR THE YEAR ENDED JUNE 30, 1934.

30.6.1933. £		£	s.	d.	30.6.1933. £		£	s.	d.
2,095	To Salaries	2,103	6	8	*6,038*	By Annual Subscriptions	5,838	16	5
960	„ Wages and National Insurance	936	3	9	*217*	„ Interest on War Loan	178	17	8
1,911	„ *Journal* Account	1,606	18	1	*51*	„ War Loan Bonus			
833	„ Rent, Telephone, Lighting, and Insurance	827	17	9	*18*	„ Sundry Donations and Miscellaneous Receipts	37	17	3
199	„ Printing and Stationery	170	4	2	*52*	„ House Fund Rent	35	0	0
414	„ Postages, Travelling, and Sundry Expenses	409	19	8	*402*	„ Excess of Expenditure over Income for Year	359	15	6
42	„ Library Expenses	73	17	4					
179	„ Subscriptions and Grants to Local Sections	147	12	0					
97	„ Expenses of Meetings	91	17	3					
9	„ Repairs and Renewals	40	12	3					
14	„ Bank Charges	12	12	11					
26	„ Audit Fee	26	5	0					
£6,778		£6,450	6	10	*£6,778*		£6,450	6	10

JOURNAL ACCOUNT FOR THE YEAR ENDED JUNE 30, 1934.

		£	s.	d.			£	s.	d.
182	To Sundry Debtors for *Journals* sold and Advertisements at June 30, 1933	151	11	2	*284*	By Reserves for Production and Abstractors' Fees, June 30, 1933	1,144	1	9
1	„ Stock of *Journals* at June 30, 1933	1	0	0	*1,741*	„ Receipts from Sales of *Journals* and Index	997	5	11
2,762	„ Payments for Production and Abstractors' Fees	3,547	0	5		„ Receipts for Advertisements	580	3	4
1,144	„ Reserves for Production and Abstractors' Fees at June 30, 1934	866	17	4	*152*	„ Sundry Debtors at June 30, 1934. Sales	75	9	2
						„ Sundry Debtors at June 30, 1934. Advertisements	161	10	8
					1	„ Stock of *Journals* at June 30, 1934	1	0	0
					1911	„ Net Cost of *Journal* for Year to June 30, 1934	1,606	18	1
£4,089		£4,566	8	11	*£4,089*		£4,566	8	11

"HOUSE FUND" ACCOUNT FOR THE YEAR ENDED JUNE 30, 1934.

		£	s.	d.			£	s.	d.
52	To Rent paid to Institute of Metals	35	0	0	*1,050*	By Balance at June 30, 1933	1,049	19	7
1,050	„ Balance at June 30, 1934	1,049	19	7	*42*	„ Interest on War Loan	35	0	0
					10	„ (Bonus)			
£1,102		£1,084	19	7	*£1,102*		£1,084	19	7

WOODHOUSE BENEVOLENT FUND.

		£	s.	d.
13	By Balance at June 30, 1934	£13	8	6

SILVER JUBILEE FUND.

		£	s.	d.
...	By Balance at June 30, 1934	£672	5	0

THE INSTITUTE OF METALS

BALANCE SHEET AS AT JUNE 30, 1934.

30.6.1933. £	£	LIABILITIES.	£ s. d.	£ s. d.
		Creditors :		
	126	Sundry Creditors for Accrued Expenses, *less* proportions in advance	121 2 8	
	1,144	*Journal* Account	866 17 4	
	738	Subscriptions paid in advance	772 6 3	1,760 6 3
2,008				
		Cash :		
	948	Balance due to Bank—Current Account	558 2 11	
		Less Balance at Bank—Deposit Account	4 12 6	
			553 10 5	
	80	*Less* Petty Cash in hand	10 17 11	542 12 6
868				
		Entrance Fees Account :		
	1,112	Balance as at June 30, 1933	1,313 19 4	
	202	Amount receivable for year to June 30, 1934	224 9 3	1,538 8 7
1,314				
		Woodhouse Fund Account :		
13		Balance at June 30, 1934		13 8 6
		House Fund Account :		
1,050		Balance at June 30, 1934		1,049 19 7
		Silver Jubilee Fund :		
		Balance at June 30, 1934		672 5 0
		Excess of Assets over Liabilities :		
	2,794	Balance at June 30, 1933	1,807 9 0	
	402	*Less* Excess of Expenditure over Income for the year to June 30, 1934	359 15 6	1,447 13 6
	2,392	*Journal* Account		
	585	Adjustment		
1,807				
£7,060				£7,024 13 11

30.6.1933. £	£	ASSETS.	£ s. d.	£ s. d.
		Office Furniture :		
200		Balance at June 30, 1933		200 0 0
		Library Books, &c. :		
100		Balance at June 30, 1933		100 0 0
		Sundry Debtors :		
	13	For Entrance Fees	6 6 0	
	665	" Subscriptions	622 4 8	
	151	" *Journal* Accounts	236 19 10	
	829		865 10 6	
	216	*Less* Reserve for Doubtful Subscriptions	288 4 6	577 6 0
613				
		Stock of Journals :		
1		At Nominal Valuation		1 0 0
		Investments :		
5,083		£4,438 16*s.* 8*d.* 3½% War Loan at Cost		4,410 14 10
		Woodhouse Fund :		
13		Balance at Lloyds Bank		13 8 6
		House Fund :		
		£1,000 3½% War Loan at Cost	1,044 19 1	
1,050		Cash at Lloyds Bank	5 0 6	1,049 19 7
		Silver Jubilee Fund :		
		£672 5*s.* 3½% War Loan at Cost		672 5 0
£7,060				£7,024 13 11

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 affairs of the Institute of Metals as on June 30, 1934, according to the best of our information and from the explanations given to us and as shown by the books of the Institute.

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

November 8, 1934.

PAPER No. 694. This paper is copyright. It may be reprinted, wholly or in part, in the Press (with due acknowledgment) after being presented at a meeting of the Institute to be held on March 6–7, 1935, in the Hall of the Institution of Mechanical Engineers, Storey's Gate, Westminster, London, S.W.1. The Institute as a body is not responsible for the statements or opinions expressed in this paper, on which written discussion may be sent to the Secretary not later than April 1, 1935.

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

UNSOUNDNESS IN ALUMINIUM SAND CASTINGS. PART III.—SOLIDIFICATION IN SAND MOULDS UNDER PRESSURE.*

By Professor D. HANSON,† D.Sc., Vice-President, and I. G. SLATER,‡ M.Sc., Ph.D., Member.

Synopsis.

By allowing gassy aluminium-alloy melts to solidify in sand moulds under an extraneous pressure of air or nitrogen, pinholes are reduced in size and ingots of high density may be obtained. With most aluminium alloys a pressure of 50 lb./in.^{2} is sufficient to remove all visual traces of pinholes from a 2 in. × 2 in. diameter sand-cast block. At higher pressures ingots having densities approaching the optimum are obtained. The applied pressure appears to affect the gas cavities by compressing them to finer dimensions. The mechanical properties of the alloys are much improved by solidification under pressure, whilst shrinkage is confined to a single cavity.

Introduction.

This paper describes further stages § of an investigation carried out for the British Non-Ferrous Metals Research Association on unsoundness in castings and ingots of aluminium and its alloys. The work now described concerns experiments in which aluminium alloy melts cast into sand moulds were allowed to solidify under an extraneous pressure of air or nitrogen. It was discovered that complete elimination of pinholes could be attained by suitable adjustment of the experimental conditions, a result considered to be of great interest from both theoretical and practical aspects.

Apart from a brief mention by Budgen[1] that gassy aluminium alloys, when allowed to solidify under considerable pressure, are remarkably free from pinholes, no previous work on similar lines had been carried out in so far as the authors were able to ascertain at the time of the commencement of these experiments (September, 1931). The principle

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* Manuscript received November 27, 1934.

† Professor of Metallurgy, Birmingham University.

‡ Research Investigator, British Non-Ferrous Metals Research Association, London.

§ For Parts I and II, see *J. Inst. Metals*, 1931, 46, 187–237.

Note to Abstractors and Other Readers.—This paper will be published, in permanent form, in the *Journal of the Institute of Metals*, Vol. LVI, 1935. Reference should accordingly be as follows—*J. Inst. Metals*, 1935, 56 (Advance copy).

of casting metals under pressure has been known for many years and forms a very important branch of metallurgical engineering. In this process, the melt is forced under pressure into a metal die where rapid solidification ensues. Pinholes, which are due to the presence of dissolved gases in the melt, are not usually evident in such castings because of the rapid rate of solidification. The possibility of influencing the mechanism of the formation of pinholes in sand-castings by the application of an external gaseous pressure appeared to be worthy of investigation, and the results obtained in some experiments carried out on these lines are described in the paper.

EXPERIMENTAL METHODS EMPLOYED.

The aluminium alloy melt to be treated was poured into a skin-dried green-sand mould contained in an autoclave, which was immediately closed up, and a gaseous pressure of air or nitrogen applied so that the metal cooled and finally solidified under pressure. The autoclave * used (see Fig. 1) was fitted with an arrangement for rapidly securing the pouring inlet and applying the pressure. The experimental procedure was as follows :

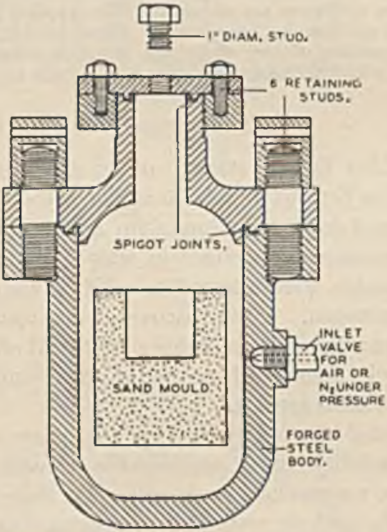

FIG. 1.—Arrangement of Autoclave for the Solidification of Aluminium Alloys under Pressure in Sand Moulds.

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* Kindly loaned by the National Physical Laboratory.

The skin-dried green-sand mould was placed in position in the autoclave and the cover bolted down. A quantity of stock alloy was melted in an electric furnace and the temperature increased to 750° C. When ready, the melt was poured *via* a funnel through the inlet into the mould. The pouring inlet was then quickly secured, and the predetermined pressure of gas turned on from a storage cylinder fitted with a reduction valve. This operation, from the finish of pouring to the application of the pressure, took not more than 20 seconds. The smallest ingot cast (2 in. × 2 in. diam.) took 1½–2 minutes to solidify, so that the pressure was applied in ample time before solidification commenced. Subsequently, the ingot produced was sectioned, polished, and etched for visual examination of pinholes. This was supplemented by density determinations. The black-and-white illustrations given on Plate I are reproduced from ink contact prints taken from the ingots.

EXPERIMENTAL RESULTS.

For the preliminary experiments, two batches of gassy stock "3L11" alloy (8 per cent. copper–aluminium) were taken. Each batch was of uniform composition and gas content, the second batch having been made very gassy by melting and stewing some of the first batch at 800° C. Table I gives details of the results obtained with these materials when cast into a 2 in. × 2 in. diam. sand mould and allowed to solidify under a pressure of nitrogen. Sections of Ingots Nos. 346, 350, and 362 are illustrated in Plate I.

TABLE I.

Pressure, Lb./in.^{2}.	Stock "3L11" Alloy.			Gassy "3L11" Alloy.		
	Ingot No.	Density.	Appearance, Pinholes.	Ingot No.	Density.	Appearance, Pinholes.
Atm.	341	2·780	moderately bad	346	2·749	bad
15	352	2·812	few	351	2·772	moderately bad
25	345	2·816	very few	350	2·802	few
50	344	2·835	sound	349	2·821	sound
100	343	2·844	sound	348	2·844	sound
200	342	2·851	sound	247	2·856	sound
700	361	2·862	sound	362	2·858	sound

By allowing the alloy to solidify under pressure, an ingot having an increased density and visually showing greater soundness may be obtained. A pressure of 50 lb./in.^{2} was found to be sufficient to remove all visible traces of pinholes from the 2 in. ingot As might be anticipated, a somewhat greater pressure is required for the very gassy alloy, but at the higher pressures the densities are much the same for the two batches. The two tests at 700 lb./in.^{2} were made to determine whether the curve correlating pressure and density became asymptotic. Little increase in density is apparent above a pressure of 200 lb./in.^{2}.

For comparison, ingots were prepared from the stock "3L11" alloy, after various degassing treatments had been applied to the melts, by casting in chill and sand moulds of various sizes. Particulars of these ingots are given in Table II.

TABLE II.

Stock "3L11" Alloy. Treatment and Casting Conditions.	Density.
None—cast in iron chill 2½ in. diameter	2·809
,, ,, ,, 1 in. ,, ...	2·844
,, ,, ,, ½ in. ,, ...	2·871
,, ,, sand mould 3 in. ,, ...	2·765
,, ,, ,, 2 in. ,, ...	2·780
,, ,, ,, 1 in. ,, ...	2·803
,, ,, ,, ½ in. ,, ...	2·830
Degassed by presolidification and cast in sand mould, 3 in. diameter	2·830
,, repeated melting and solidification *in vacuo* and cast in sand mould, 3 in. diameter	2·841
,, nitrogen treatment and cast in sand mould, 3 in. diameter	2·814
,, nitrogen + chlorine treatment and cast in sand mould, 3 in. diameter	2·830
,, nitrogen + bromine treatment and cast in sand mould, 3 in. diameter	2·834
,, titanium tetrachloride treatment and cast in sand mould, 3 in. diameter	2·821
None—solidified under 700 lb./in.^{2} pressure and cast in sand mould, 2 in. diameter	2·862

Thus, by solidification under pressure, a sand-cast ingot may be produced having a density appreciably greater than that obtainable from ingots cast under atmospheric pressure in sand moulds from melts treated by any of the above degassing processes. It is probable that the density of 2·862 nearly approaches the theoretical optimum for this alloy when sand-cast. The actual analysis of this alloy was copper 8·15, silicon 0·35, iron 0·47 per cent., aluminium remainder.

A number of other alloys of aluminium which contained a moderate amount of gas were cast by the method of solidification under pressure in a 3 in. × 3 in. diameter sand mould, and the results obtained are collected in Table III. Sections of Ingots Nos. 443, 447, and 455 are illustrated in Plate I.

By the application of a gaseous pressure during solidification, all the alloys examined improved in density and soundness. With those alloys which show a more marked tendency to form internal shrinkage cavities, such as the eutectic silicon–aluminium alloy and the eutectic nickel–aluminium alloy, the increase in size of this cavity with increase

PLATE I.

FIG. 3.—Ingot 346 ("3L11"). Solidified under Atmospheric Pressure.

FIG. 4.—Ingot 350 ("3L11"). Solidified under 25 lb./in.^{2} Pressure.

FIG. 5.—Ingot 362 ("3L11"). Solidified under 700 lb./in.^{2} Pressure.

FIG. 6.—Ingot 443 (12% Si). Solidified under Atmospheric Pressure

FIG. 7.—Ingot 447 (12% Si). Solidified under 50 lb./in.^{2} Pressure.

FIG. 8.—Ingot 455 (12% Si). Solidified under 200 lb./in.^{2} Pressure.

PLATE II.

Fig. 9.—Blisters on "3L11" Alloy Solidified in a Sand Mould under 700 lb./in.^{2} Pressure and Reheated at 595° C. for 10 minutes. No. 361C under Atmospheric Pressure. No. 361E under 3 mm. Pressure. × 4.

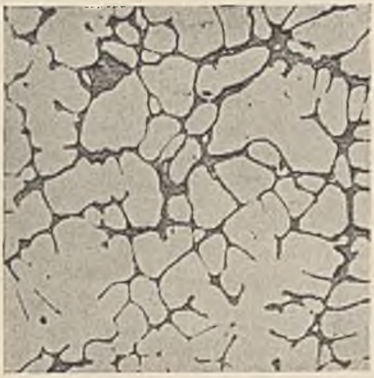

FIG. 10.—Ingot No. 361. "3L11" Alloy Solidified in a Sand Mould under 700 lb./in.^{2} Pressure. × 50.

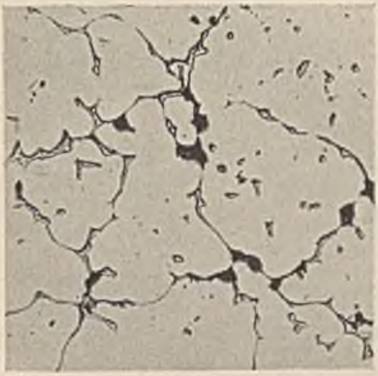

FIG. 11.—Ingot No. 361C. After Heating at 595° C. under Atmospheric Pressure. × 50.

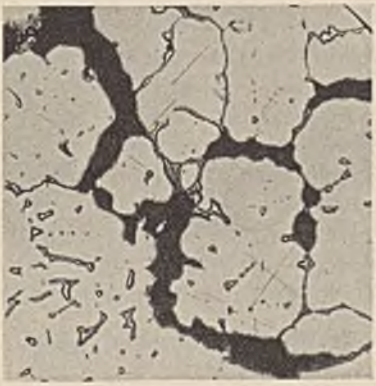

FIG. 12.—Ingot No. 361E. After Heating at 595° C. under 3 mm. Pressure. × 50.

in pressure is to be noted. This is clearly shown in the illustrations of Ingots Nos. 443, 447, and 455 (Plate I). The density of the 6 per cent. nickel-aluminium series was determined with the internal shrinkage cavity closed and with the cavity open, so that the volume of the shrinkage cavity apart from the volume occupied by the pinholes could be ascertained. With the shrinkage cavity closed, the density remained practically constant for all pressures on solidification. This indicates that the total volume occupied by both the shrinkage cavity and the pinholes is constant, so that an interchange in the respective volumes occupied by the shrinkage cavity and the pinholes has taken place as the pressure is varied. The densities given in Table III were obtained after the specimens had been boiled in water prior to the weighing in water determination. In this manner, all cavities connected with the exposed surfaces are filled with water. In some cases, particularly with the " Y " alloy, small cavities due to shrinkage were found isolated from the main cavity, so that the observed density is in consequence rather lower than the true density of the sounder portions of the ingot.

TABLE III.

Alloy.	Ingot No.	Pressure During Solidification.	Density.
" 2L5 "	441	Atmospheric	2·819
	457	25 lb./in.^{2}	2·830
	445	50 ,,	2·840
	449	100 ,,	2·860
	453	200 ,,	2·866
" Y "	442	Atmospheric	2·701
	458	25 lb./in.^{2}	2·710
	446	50 ,,	2·720
	450	100 ,,	2·729
	454	200 ,,	2·735
12% Si–Al	443	Atmospheric	2·602
	459	25 lb./in.^{2}	2·624
	447	50 ,,	2·644
	451	100 ,,	2·646
	455	200 ,,	2·654
6% Ni–Al	469	Atmospheric	2·748
	479	25 lb./in.^{2}	2·750
	478	50 ,,	2·773
	476	100 ,,	2·777
	477	200 ,,	2·786

Mechanical Tests on Sand-Cast Bars Solidified under Pressure.

Hardness tests were carried out on the ingots described in Table I. It was found necessary to use a Brinell ball of 10 mm. diameter with a load of 500 kg. applied for 30 seconds. Smaller indenters, such as the Vickers Diamond Pyramid, gave erratic results, especially with the less sound ingots due to the pinholes present. The Brinell hardness value increased from 52 to 62 according to the soundness of the ingot, which depends on the pressure applied during solidification. Actual values obtained are shown in Fig. 2. This increase in hardness appears to be due to the greater soundness of the pressure-cast ingots, since no material difference could be detected in the metallographical features of the various ingots.

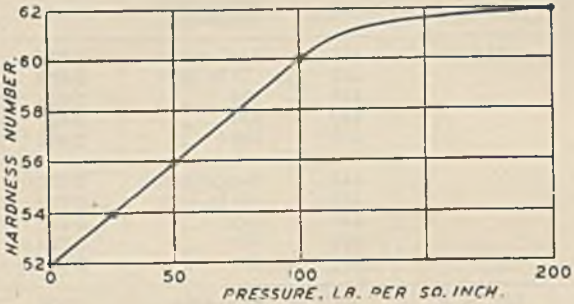

Fig. 2.—Effect of Pressure Applied During Solidification on the Hardness of "3L11" Alloy Cast into a Sand Mould 2 in. × 2 in. in Diameter.

Some sand-cast tensile test-bars of various alloys were prepared by solidification under pressure. The standard 1 in. diameter bars proved impracticable to make, since experiment showed that on casting from 750° C., this size completely solidified in less than 30 seconds—an insufficient time in which to carry out all necessary operations on the autoclave after pouring and to ensure that the pressure operated whilst the whole of the ingot was liquid. Bars of 1½ in. diameter were used, therefore, with a casting temperature of 750° C. This size and pouring temperature should be borne in mind when considering the results given in Table IV. Considerable difficulty was encountered in casting perfectly sound bars, due to the entrapping of dross and oxide caused by the turbulent conditions of pouring. This could not be avoided, since, with the autoclave used, there was a perpendicular drop of 12 in. between the teeming funnel and the top of the mould. By using a central runner feeding, at the bottom, two test-bars, more satisfactory results were obtained, and in Table IV are given the results of tensile tests made on some of the sounder bars. The bars were turned to standard British Standards Institution dimensions of 0·564 in. diameter on a test length of 2 in.

TABLE IV.

Material.	Pressure During Solidification.	Ultimate Strength, Tons/in.^{2}.	Elongation on 2 in., Per Cent.
"3L11" (as cast)	Atmospheric	6·4	2
		5·84	2
	50 lb./in.^{2}	7·48	2
		7·72	2
	200 ,,	8·76	2
		10·92	2
"Y" (as cast)	Atmospheric	8·96	1
		9·2	1
	50 lb./in.^{2}	11·6	1·5
	100 ,,	11·84	2·5
	200 ,,	11·6	2·5
		12·6	2·5

A marked improvement was shown in the ultimate strength for both alloys when solidified under pressure. With the "Y" alloy, the percentage elongation was also substantially increased.

Effect of Heating "3L11" *Ingots Solidified under Pressure at Temperatures Above and Below the Solidus.*

In order to throw some light on the mechanism whereby the formation of pinholes is suppressed by the application of pressure during solidification, the following experiments were carried out. Rectangular blocks of about 10 grm. weight were cut from ingot No. 361, which was the moderately gassy "3L11" alloy solidified under a pressure of 700 lb./in.^{2}. The specimens were polished, and, after the treatments as detailed in Table V, the density was determined and observations made on the previously polished surfaces.

TABLE V.

Specimen No.	Treatment.	Density.	Appearance of Polished Surface.
361	As solidified under 700 lb./in.^{2} pressure	2·862	bright and uniform
361A	Heated to 500° C. for 2 hrs. at atmospheric pressure	2·861	no change
361B	Heated to 550° C. for 1 hr. at atmospheric pressure	2·842	eutectic had sweated out as blisters and eruptions
361C	Heated to 595° C. for 10 minutes at atmospheric pressure	2·829	large blisters formed
361D	Heated to 500° C. for ¾ hr. at 3 mm. pressure	2·851	little change
361E	Heated to 595° C. for 10 minutes at 3 mm. pressure	2·800	large deflated blisters formed

The solidus of this alloy is at 548° C., and the liquidus at 630° C.

The surface appearance of specimens 361C and 361E is shown in Fig. 9 (Plate II). Blisters on specimen 361C stand up from the surface as definite excrescences, dendritic crystal forms being visible on their surface. With the specimens treated *in vacuo* the blisters have been deflated and occur as crater pits. Photomicrographs of sections cut from specimens 361, 361C, and 361E are given in Figs. 10, 11, and 12 (Plate III), respectively, and show the formation of the inter-eutectic cavities resultant on treatment. These cavities are similar in character to normal pinholes of finer dimensions formed when the alloy is cast under atmospheric pressure. The changes in density are significant of the formation of these cavities.

Treatment at a temperature below the solidus produced a slight effect only with the specimen heated *in vacuo*. At temperatures above the solidus, portions of the specimen in the region of the eutectic constituent were liquid and free to move, and at the same time the mass had little rigidity. Thus the presence of gas in the metal manifested itself by accumulation and expansion at these areas in the form of gas-filled cavities.

That the total gas content of ingots solidified under pressure undergoes no change by this treatment is shown on remelting such ingots in an electric furnace and allowing to solidify in air. The ingots so obtained had a density similar to that of the original material.

DISCUSSION.

Sieverts,[2] Röntgen and Braun,[3] Röntgen and Moller[4] have shown that hydrogen is not soluble in solid aluminium and such of its alloys as have been examined. Thus the effect of pressure on the solubility in the solid state will be negligible, whereas in the liquid state increase in pressure results in a proportional increase in solubility. It is evident that the dissolved gas (consisting mainly of hydrogen) is rejected from solution on solidification, and, in ingots solidified under pressure, the evolved gas is retained as a separate phase under pressure. The nett effect of solidification under pressure appears, therefore, to be the squeezing up to smaller dimensions the pinholes, which normally would be formed. As solidification proceeds under these conditions, the period at which gas is evolved from still liquid metal is delayed, due to the increase in solubility resultant on the application of pressure. When finally the gas is evolved as the last portions of interdendritic material solidify, the applied pressure further operates in compressing their volume according to Boyle's Law. Moreover, the pressure applied ensures that interdendritic liquid is forced into regions where shrinkage cavities are liable to occur and thus completely feeds the ingot, apart from the main pipe cavity, providing that the pressure is high enough. This effect is shown particularly with the eutectic alloys cast at the higher pressures.

The immediate practical considerations which arise from these observations may be summarized as:

(*a*) A method for the production of aluminium alloy castings, which may be produced from melts of indifferent quality as regards gas content, whereby the castings are free from pinholes. This effect will operate independently of the rate of cooling as determined by the material of the mould and the size of the casting. In addition, the castings will have enhanced physical and mechanical properties.

(*b*) A method for the production of castings which are free from isolated shrinkage cavities. It will be necessary to allow for the additional volume of metal required due to the increased total shrinkage. This is a matter of simple foundry technique in the provision of adequate feeding gates and in the design and lay-out of the mould, whereby solidification proceeds progressively and is finally completed in such feeding devices. This application is not only confined to sand-castings but also to chill-castings, in particular those intended for subsequent rolling. The principle will apply in addition to all metals and alloys as well as the aluminium alloys now discussed.

Discussion of the technique for applying to industrial practice the principles now described is a matter for the engineer. It would be uneconomical to use a method developed on the lines of the present experiments in which a single autoclave is used, except for particularly important castings. Certain engineering operations are conducted in enclosed spaces under pressure, such as in tunnelling, where air pressures up to 50 lb./in.^{2} are often employed. The transference of the casting section of the foundry to a subterranean vault maintained at a suitable pressure is considered, therefore, not to be beyond the realms of possibility.

SUMMARY.

1. By allowing aluminium alloy melts to solidify under pressure in sand moulds, ingots showing less unsoundness and of higher density may be obtained. A pressure of from 50 to 100 lb./in.^{2} (dependent on the initial unsoundness of the metal) is sufficient to remove all visual traces of pinholes from a 3 in. × 3 in. diameter sand-cast ingot.

2. The densities of ingots cast at higher pressures are appreciably greater than those obtainable in ingots poured from melts treated by various degassing processes.

3. The tensile properties of sand-cast "3L11" and "Y" alloy test-bars are considerably enhanced by solidification under pressure.

4. On heating pressure-solidified 3L11 alloy to temperatures between the solidus and the liquidus, the presence of gases retained in the ingot is shown by the appearance of blisters and cavities.

5. The nett effect of solidification under pressure appears to be the squeezing up of the pinholes, which normally would be formed, to smaller dimensions. At the same time, the casting is more completely fed and shrinkage is confined to one local area.

6. The principles now discussed are probably applicable to all metals and alloys whether sand- or chill-cast.

ACKNOWLEDGMENTS.

The authors wish to thank the Council of the British Non-Ferrous Metals Research Association for permission to publish an account of this investigation. They also thank Professor R. S. Hutton, M.A., D.Sc., and the members of the Aluminium Founding Research Committee of the Association for help in many directions. Their thanks are also due to Mr. L. Booth for assistance in the experimental work, which was carried out in the Department of Metallurgy, Birmingham University.

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THE PENETRATION OF STEEL BY SOFT SOLDER AND OTHER MOLTEN METALS AT TEMPERATURES UP TO 400° C.*

By L. J. G. van EWIJK,† Dr.-ir.

Synopsis.

Investigation of the failure of a nickel–chromium steel axle-tube of an aeroplane showed that the material had been weakened by intercrystalline cracks due to a soft-soldering operation. Experiments were made with test-pieces of a number of steels, by stressing the specimen during exposure to molten metals and alloys at temperatures up to 400° C. Cracking occurred in several of the steels, and microscopic examination showed characteristic intercrystalline penetration by the molten metal. The steels varied in their behaviour, certain specimens being particularly sensitive. Tests were made to determine the effects of temperature of the molten metals and treatment of the steel. The nature of the type of attack studied and its practical significance are discussed.

Introduction.

The penetration of solder and other molten metals in brass and bronze at low temperatures was investigated by Dickenson,[1] and by Miller[4] and Hartley.[2] Penetration in steels stressed at temperatures above 800° C. whilst in contact with molten metals and brazing alloy, has been studied by Genders[3] and by Schottky, Schichtel, and Stolle.[7] In all these cases the attack of the molten metal was found to occur by intercrystalline penetration of similar microscopic character to the cracking of stressed brass by mercury (as described by Moore, Beckinsale, and Mallinson[5]).

The present investigation was undertaken as the result of the examination of a nickel–chromium steel axle-tube which failed after a service of about 300 hrs. This tube was supported by the undercarriage near to the landing wheels as shown in Fig. 1. In the middle of the tube a brass number-plate was attached by soft solder. A

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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. LVI, 1935. Reference should accordingly be as follows—*J. Inst. Metals*, 1935, 56 (Advance copy).

fracture had occurred transversly through the tinned area at the edge of the number-plate, following an irregular path round the tube. Whilst a portion of the fracture was distinctly of the fatigue type, a longitudinal crack of different character was present (about 2 in. in length), crossing the end of a fatigue fracture (see Fig. 2, Plate I). Microscopic examination showed the longitudinal crack to be irregular and of characteristically intercrystalline form, of the same type as those illustrated in Figs. 6 and 7 (Plate II). At several places in the tinned area similar smaller cracks were found.

Surmising that the flux (zinc chloride) used for the soldering might have played a part in the formation of the cracks, tests were carried out in which rings from the tube were heated and wetted with flux.

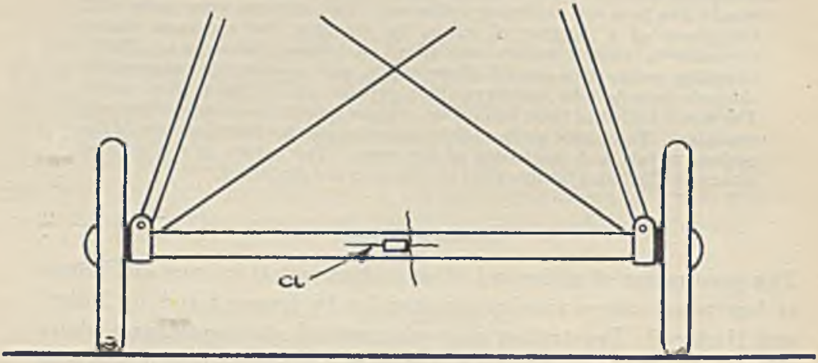

Fig. 1.—Type of Axle-Tube A.

No cracking occurred, and cracks could not be produced when the rings were put under stress by compression to an oval shape in a vice. On application of soft solder (lead–tin, 50 : 50) to the stressed rings, however, the specimens rapidly ruptured by the formation of cracks of the same type as those found in the failed portion of the tube, and some penetration of the solder was observed. Similar effects were produced by pure tin, lead, zinc, cadmium, or Lipowitz alloy (tin 4, lead 8, bismuth 15, cadmium 3 parts; melting point 60° C.).

Since in the assembling of aeroplane parts, tinning or soft soldering was frequently used for the mounting of fittings, it was important to know whether this practice might endanger the service reliability of these parts of the structure. A preliminary study was made, therefore, of the penetration and cracking of steels by contact with liquid metals at temperatures of 400° C. and lower, and of possible means by which the effect might be avoided.

EXPERIMENTAL WORK.

The samples used for the tests were:

A. The above-mentioned nickel–chromium steel axle-tube, broken in service. External diameter, 55 mm.; wall thickness, 2 mm.

B. A second nickel–chromium steel axle-tube, also broken in service. Type of under-carriage, see Fig. 4; ruptured at the end in the tinned area; tin used for mounting the end-piece. The fracture of this tube is shown in Fig. 3 (Plate I). External diameter, 44·5 mm.; wall thickness, 1·5 mm.

C. A third nickel–chromium steel axle-tube, broken in service, similar to B; also broken in tinned area. External diameter, 40 mm.; wall thickness, 1·5 mm.

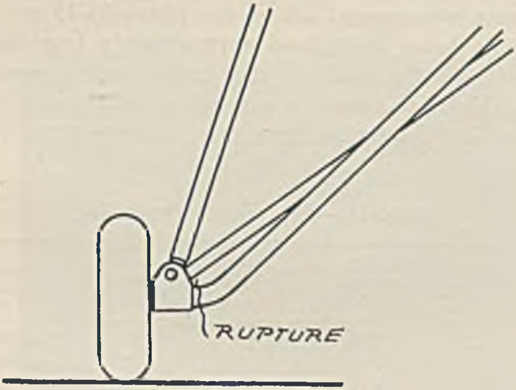

FIG. 4.—Type of Axle-Tube B.

D. A fourth nickel–chromium steel axle-tube, of the same type and same dimensions as C, broken in service; failure caused by corrosion.

E. A nickel–chromium steel axle-tube, not broken in service. Type of under-carriage as in Fig. 1; no number-plate or tinning. External diameter, 65 mm.; wall thickness, 2·5 mm.

F. A new nickel–chromium steel axle-tube. External diameter, 55 mm.; wall thickness, 2·5 mm.

G. A low-carbon steel tube, new, suitable for welding, complying with Dutch Military Aircraft Materials Specification No. A5.2. External diameter, 55 mm.; wall thickness, 2·5 mm. Used for comparative tests.

H. A medium-carbon steel strip, not suitable for welding, complying with Dutch Military Aircraft Materials Specification A4.3. Dimensions 25 × 12 mm. Used for comparative tests.

The results of chemical analyses of the materials are given in Table I.

TABLE I.—*Chemical Composition.*

Sample.	Carbon, %.	Chromium, %.	Nickel, %.	Silicon, %.	Manganese, %.	Phosphorus, %.	Sulphur, %.
A	0·31	0·80	1·22	0·30	0·52	0·020	0·010
B	0·15	1·44	3·92	0·32	0·58	0·008	0·019
C	0·23	1·30	4·25	0·45	0·63	0·020	0·004
D	0·22	1·29	4·10	0·41	0·62	0·019	0·006
E	0·25	0·96	1·20	...	0·60	0·01	0·01
F	0·28	1·40	4·10	...	0·58	...	0·01
G	0·13	...	...	0·08	0·50	0·050	0·030
H	0·42	...	...	0·31	0·58	0·022	0·013

Tensile tests were carried out on test-pieces 10–13 mm. in width, the yield-points being determined approximately from the diagram recorded by the testing machine. For impact tests a machine of the Izod type (8·5 KgM.) was used; in consequence of the small dimensions of the test-pieces, the figures have only a comparative value. The results of the mechanical tests are given in Table II.

TABLE II.—*Mechanical Properties.*

Specimen.	Yield-Point, Tons/in.^{2}.	Tensile Strength, Tons/in.^{2}.	Elongation, Per Cent. $L = 5{\cdot}65\sqrt{a}$.	Impact Value, KgM./cm.^{2}.	Appearance of Impact Fracture.
A	87·4	99 0	10	1·5	Somewhat coarse-grained
B	74·8	91·7	9·5	...	...
C	81·9	93·8	7·3	...	...
D	82·5	94·1	9·1	2·4	Less coarse than A
E	68·9	73·6	13·4	3·1	Fine-grained
F	...	98·4	...	2·8	Fine-grained
G	27·4	30·5	...	...	...
H	25·3	42·9	...	...	...

Preliminary penetration tests were made by clamping sections of the sample tubes in a vice, compressing diametrically, heating to soldering temperature, fluxing with zinc chloride, and wetting with different soldering metals. The two tubes, E and F, showed only small effects under these conditions, but all four of the failed tubes A–D were distinctly sensitive to penetration and cracking. Tube A was most readily affected, cracking within a few seconds in contact with tin, solder, cadmium, and lead, and more slowly with zinc and Lipowitz alloy. Representative test-rings from tube A showing rupture after varying degrees of compression, compared with one compressed to rupture without tinning, are illustrated in Fig. 5 (Plate I). Figs. 6

FIG. 2.—Axle-Tube A. Showing Transverse Fatigue Fracture and Longitudinal Intercrystalline Crack.

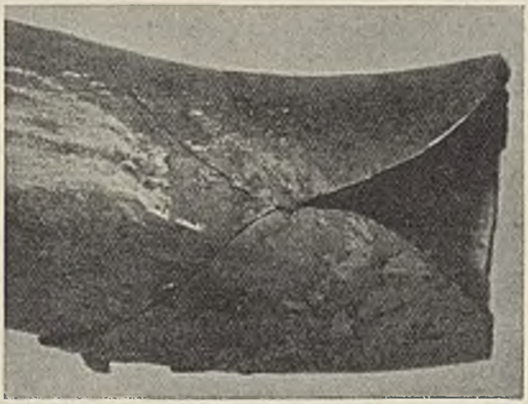

FIG. 3.—Fractured Axle-Tube B. Actual Size.

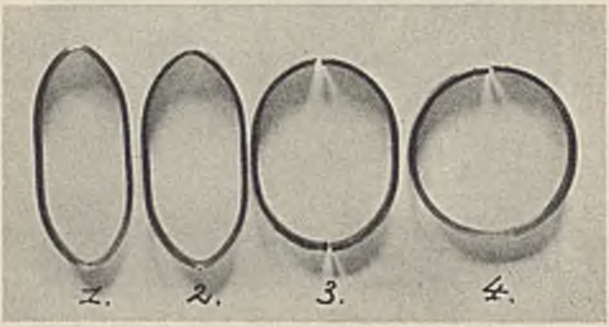

FIG. 5.—Test-Rings after Varying Amounts of Compression and Wetting with Molten Metal Compared with Ring Compressed to Rupture without Tinning.

PLATE II.

FIG. 6.—Intercrystalling Cracks in Tinned Area Section from Tube A. × 40

FIG. 7.—Intercrystalline Cracks with Penetration of Tin. × 85.

FIG. 8.—Coarse Structure of Tube A and Intercrystalline Cracks (at γ Boundaries). × 800.

and 7 (Plate II) are photomicrographs of typical cracks produced in the sections; some were apparently clean, as in Fig. 6, whilst in others (Fig. 7) appreciable quantities of solder metal had penetrated. Tests with unfluxed specimens gave no cracking. Ammonium chloride fluxes gave slower wetting and consequently slower fracture. With resin, glycerine, palm-oil, borax, sulphur, and stearine, adequate wetting could not be obtained.

The carbon steel tube G gave no definite effect, and tests on rolled medium-carbon steel strip H showed that sensitiveness to penetration was not induced by cold-working.

TABLE III.—*Effect of Variation of Temperature of Liquid Metal.*

Sample D.—External diameter, 40 mm.; wall thickness, 1·5 mm.

	Test No.	Dipping Temperature, ° C.	Test-Piece Compressed to Diameter of	Results.
Lead–tin alloy 50 : 50	1	400	37 mm.	No rupture after *ca.* 3 minutes
	2	400	36	,, ,, ,,
	3	400	35	Rupture after some seconds
	4	350	37	No rupture after *ca.* 2 minutes
	5	350	36	Rupture after some seconds
	6	300	37	No rupture after *ca.* 2 minutes
	7	300	36	Rupture after some seconds
	8	250	36	,, ,,
Lipowitz alloy	9	250	36 mm.	Rupture after some seconds
	10	200	36	,, ,,
	11	175	36	,, ,,
	12	162	36	,, ,,
	13	150	36	No rupture after *ca.* 2 minutes
	14	150	32	Rupture after second dipping
	15	110	34	Rupture after 3–4 minutes
	16	100	34	No rupture after 1 minute
	17	100	32	Rupture after *ca.* 40 seconds

Tests to determine the influence of temperature of the molten metal were made on specimens from tube D. The clamped, compressed sections were fluxed cold with zinc chloride and dipped in the molten metal. If no rupture occurred, the sections were compressed further, refluxed, and again dipped. Lead–tin alloy (50 : 50) was used at temperatures of 250°–400° C. and Lipowitz alloy at 100°–250° C. The results, given in Table III, showed that rupture occurred rapidly in lead–tin alloy at temperatures of 250° C. and above, but that in Lipowitz alloy, although rupture was obtained down to a temperature of 100° C., a slightly greater amount of compression was required as the temperature was lowered.

Tests to examine the effect of heat-treatment of the steel were carried out, also on the material of tube D, after heating the specimens to various temperatures and quenching in water, and after hardening and tempering. Each section was compressed to 38 mm. diameter, fluxed and dipped in lead–tin alloy (50 : 50) at 250° C. If no rupture occurred in 30 seconds the amount of compression was progressively increased for successive dippings. The results, given in Table IV, showed that only in the specimen reheated to 700° C. was the liability to rupture under the test markedly decreased. Reheating the steel at other lower temperatures had apparently little influence.

TABLE IV.—*Effect of Variation of Heat-Treatment of Steel.*

Test No.	Treatment.	Diameter at which Rupture Occurred on Compression.	
		Without Dipping. mm.	On Dipping in Molten Solder. mm.
1	As received	22	36
2	Re-heated at 300° C.	22	36
3	,, 500	16·5	33
4	,, 550	16	33
5	,, 700	13·5	18
6	,, 700	27	No rupture at 27
7	,, 750	32	38
8	,, 950	36	38·5
9	Hardened at 950 and reheated at 350° C.	21	37
10	ditto and reheated at 550° C.	18·5	37
11	ditto and at 650	8	25
12	,, ,, 750	35	36
13	,, ,, 850	32	37·5

CONCLUSIONS.

1. The tests which have been carried out show clearly that nickel–chromium steels may be liable to rupture when put under stress and brought into contact with molten solder, lead, tin, zinc, cadmium, or Lipowitz alloy. For carbon steel no such liability could be observed.

2. Variation in temperature of the molten metal does not appreciably affect the action. Rupture of the specimen occurred after a time of contact of less than 1 minute in Lipowitz alloy at 100° C.

3. As regards the influence of heat-treatment of the steel, the few tests made suggest that tempering within the range of temperature commonly used has little effect on the sensitiveness of the steel to penetration and rupture. By tempering the particular steel used at 700° C.,

however (*i.e.* in the neighbourhood of the critical range), the liability to rupture under the test was greatly reduced.

4. The attack of nickel–chromium steel by molten metals shows a close resemblance to the attack of manganese–bronze and brass as described by previous investigators. The cracks are characteristically intercrystalline, and in many cases show the penetration of the applied metal. Frequently, however, no trace of penetration is visible. It may be that in these cases the penetrated layer is too fine to be detected microscopically, and this is accounted for by the fact that a very superficial penetration appears to be sufficient to start the crack. Since Daniels [6] has shown that the coating of steel with cadmium and lead by hot-dipping is accompanied by the formation of chemical compounds, there is no anomaly in the fact that the action of these metals on stressed nickel–chromium steel is of the same nature as that of the others investigated by the author.

5. The fact that, in the short time of the tests described, no rupture occurs in a particular specimen, does not necessarily indicate that the steel is not liable to damage when soldered or tinned in the stressed condition. The danger may still be present, and it is to be expected that, for instance, the resistance to fatigue may be decreased in such a measure that sooner or later the failure will develop. It is of considerable importance that this matter should be further investigated. In the laboratories of the Dutch National Institute for Aeronautical Research an apparatus for fatigue tests on tinned specimens has been partly developed, but an opportunity for further tests has not yet presented itself.

6. The reason for the different behaviour of the six nickel–chromium steel samples used in the tests is not clear. The steel sample A shows a rather low chromium and nickel content, whereas the carbon is rather high. The mechanical properties, however, were suitable for the purposes required. The greatest divergence in properties was in impact value, but impact tests on such small specimens as are obtainable from tubes of small wall thickness are of questionable utility. A certain relation between the properties and sensitiveness to penetration can be observed in so far that of the six samples used, sample A with the lowest impact value and the coarsest grain was most liable to rupture by contact with molten metal (see Fig. 8, Plate II), whereas sample D gave a higher impact value and a finer grain than sample A, but a lower impact value and a coarser grain than samples E and F which showed greater resistance against the attack by molten metal.

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THE SPECTROGRAPHIC ANALYSIS OF ALUMINIUM.*

By D. M. SMITH,† A.R.C.S., B.Sc., D.I.C., Member.

Synopsis.

Ordinary photographic records of arc and spark spectra of graded series of standard alloys of aluminium with copper, iron, manganese, silicon, and titanium have been investigated from the point of view of the establishment of a satisfactory routine method of analysis. The spark gives a steadier and more reproducible source of light and, since adequate sensitivity of detection of the impurities usually occurring in aluminium is obtained, analytical tables have been compiled for use with the spark method. For routine testing of samples an auxiliary alloy of aluminium with 1 per cent. nickel is used for the auxiliary spectrum method, but further accuracy of determination would be obtained by direct comparison with suitably selected standard samples. The arc method is more sensitive for the detection of traces of such impurities as lead and gallium.

Introduction.

In continuation of the programme of standardization of spectrographic methods, the earlier results of which were published [1] in 1933, the present paper deals with their further application to the quantitative spectrographic determination of the usual impurities in pure and commercial brands of aluminium. Earlier work on this subject has been dealt with in some detail elsewhere.[1, 2] More recently, W. Gerlach and E. Riedl [3] have proposed the "intermittent arc" (*Abreissbogen*) by means of which 14 elements were detected and semi-quantitative indications of the amounts present are given for 10 samples of aluminium of 99·89–99·97 per cent. purity and 2 samples of Silumin. H. Triché described methods for the estimation of magnesium in aluminium and Duralumin [4] and of silicon in aluminium.[5] A recent paper by E. van Someren [2] dealt with alloys of aluminium, whereas the present contribution applies principally to the analysis of unalloyed aluminium.

While the data in these papers have been considered in conjunction with the present work, it was deemed advisable to proceed along the

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* Manuscript received October 20, 1934.

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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. LVI, 1935. Reference should accordingly be as follows—*J. Inst. Metals*, 1935, 56 (Advance copy).

lines previously adopted for the other metals and alloys studied. For quantitative estimations the "comparison sample" and "internal standard" methods have been examined and suitable groups of lines in both arc and spark spectra, due to the various constituents, which are easily recognizable and which are not liable to confusion with, or masking by, neighbouring lines of other elements, are enumerated in this paper. The use of an auxiliary alloy, the lines in whose spectrum serve as supplementary standards of intensity (an extension of the internal standard principle), is also described.

STANDARDS.

Graded series of standard samples of aluminium with small quantities of copper, iron, manganese, silicon and titanium were placed at the author's disposal by the British Aluminium Company, Ltd., and the spectrographic examination of these standards has formed the basis of the investigations to be described.

STANDARDIZATION OF TECHNIQUE.

A. *Form of Sample.*

Rod samples, $\frac{5}{16}$ in. in diameter and 4 in. long, which had been cast in a pencil mould, were available for practically all the standard alloys. This form of sample is very convenient for both arc and spark electrodes, and the use of such a mould is recommended for the preparation of electrodes of the samples for analysis. Spark electrodes 1 in. long and filed at one end to a cone of 60°–70° were cut from these rods. For arc electrodes, two 4-in. rods were used.

B. *Choice of Spectrograph.*

Two Hilger quartz spectrographs were available for this work, the small size of 20·3 cm. and the medium size of 61 cm. focal length.

Whilst the spectrum of pure aluminium is comparatively simple, the general presence of iron in samples of commercial aluminium introduces a large number of lines due to this element which may give rise to masking and confusion with silicon and other lines. For a considerable amount of work the small-size instrument would no doubt have given satisfactory results, but for greater facility in examining the spectra and certainty in their interpretation (especially when the auxiliary spectrum is used for comparison) the medium-size instrument is preferable, and was accordingly adopted for the investigations to be described. A slit width of 0·02 mm. was used in the case of spark spectra and 0·007 mm. for arc spectra.

Photographic Plates.—Most of the investigations described have been carried out with Wellington Antiscreen plates. Photographs of the standardized spark spectra have also been obtained with Ilford Auto-Filter plates, and the data in the analytical tables were confirmed. The region of the spectrum in which the selected lines for analysis are found is a region which is usually recorded on standard photographic plates, and this most probably accounts for the fact that either of these makes of plate may be used for this work.

The plates were developed with a two-solution developer [1] which gave adequate contrast.

C. *Arc Technique.*

For the arc, a d.c. supply of 220 v. was connected through a resistance to give a current of 2·5 amp., and the following variations of this method were tried:

(1) Arc between metallic electrodes.

(2) Arc between graphite or carbon electrodes, a small sample being placed in a cavity in the lower electrode.

In spite of the marked tendency of the discharge to wander, on account of the rapid formation of a non-conducting layer of oxide, it is nevertheless possible, with care, to obtain fairly reproducible spectra.

(3) The device of directing a small luminous gas-flame on to the surface of the metal * did not effect any apparent decrease in the oxidation.

(4) Arc in nitrogen. Preliminary experiments, carried out with improvised apparatus, showed that under favourable conditions a comparatively steady discharge could be obtained, giving a spectrum nearly free from oxide bands. On the other hand, in routine work, the necessity for rapid changing of electrodes and the consequent flushing of the apparatus with nitrogen between each change somewhat discounts the value of such a method.

D. *Spark Technique.*

The standard Hilger ¼-kw. spark equipment was used for the production of the spark, the capacity of the condenser being 0·006 μF.

The electrical conditions for the spark spectra were standardized by varying the amount of self-inductance in the circuit until equality of intensity was obtained between the spark line 2816·2 A. and the arc line 2575·1 A.† This occurred with a self-inductance of 0·19 millihenry.

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* As used by C. S. Hitchen [6] in his work on the analysis of tin.

† In order to facilitate the comparison of these lines, which are somewhat widely separated, it is an advantage to screen the intervening region with a suitably cut piece of card. The lines are strong, and consequently for the testing of equality the spectra should be under-exposed (and under-developed) to give lines weak enough for comparison. Even so, the change in relative intensity is not very marked, but an examination of the spectrum did not reveal a more suitable pair of lines for this purpose.

A standard distance of $\frac{1}{8}$ in. (3 mm.) between the electrodes was adopted, the spark being 20 cm. from the spectrograph and no condensing lens used.

DATA FOR QUANTITATIVE ANALYSIS BY SPARK SPECTRA.

1. *Comparison Sample Method.*

(a) *Copper.*—With 0·03 per cent. copper and less, only the most persistent copper lines, 3247·5 and 3274·0 A., are present.

(b) *Iron.*—Even with comparatively low percentages of this element a large number of lines appear in the spectra. For the quantitative determination of iron in aluminium the following characteristic groups will be found suitable :

2382·0
2388·6
2395·6
2399·2
2404·9
2406·7
2410·5
2410·9
2414·3

2483·3
2488·2
2490·7

2585·9
2598·4
2599·4
2607·1
2611·9
2613·8

2739·6
2746·0
2749·3
2755·7

2966·9
2973·2
2983·6
3020·7
3021·1

The most persistent lines are 2382·0 and 2395·6 A.

(c) *Manganese.*—The most persistent line, 2576·2 A., is difficult to detect (even with the medium-size spectrograph) on account of masking by the strong aluminium lines 2575·1 and 2575·4 A. These aluminium lines are not resolved and appear as a single diffuse line. The close triplet $\left\{\begin{array}{l}4030{\cdot}8\\4033{\cdot}1\\4034{\cdot}5\end{array}\right.$ is only resolved by the medium-size spectrograph when a narrow slit is used. The most suitable lines for the estimation of small quantities of manganese are given in Table I.

TABLE I.

λ Mn.	Neighbouring Lines.
2593·7	
2605·7	2607·1 Fe
2794·5	2795·5 Mg
2798·3	
2801·1	2802·7 Mg
2933·1	
2939·3	
2949·2	

(d) *Silicon.*—The most persistent lines are 2516·1 and 2881·6 A. In addition to the line 2435·2 A., the group of silicon lines listed in Table

II is distinctive and easily recognized except when much iron is also present. The neighbouring iron lines which are present with 0·2 per cent. iron are also listed.

TABLE II.

λ Si.	Neighbouring Iron Lines.	
2506·9		
2514·4	2510·8	2511·8
2516·1		
2519·2	2518·1	
2524·2	2522·9	2525·4
2528·6	2527·4	2529·8

(e) *Titanium.*—The most sensitive lines are 3349·4, 3361·2 and 3372·8 A., of which 3349·4 A. is the most persistent. Other sensitive lines are :

3234·5
3236·6
3239·0

3261·6
3685·2

3321·7
3340·3
3377·6
3383·8

2. *Internal Standard Method.*

The only aluminium lines which appear suitable as intensity standards are :

3995·9
3900·7
3612·4
3601·6
2669·2
2378·4

and possibly the group of stronger lines :

3074·7
3066·2
3064·3
3057·2
3054·7
3050·1
3041·3

These lines do not, however, give an adequate range of intensities for the application of this method, and tests were accordingly carried out on several auxiliary metals and alloys in order to obtain suitable intensity standards.

3. *Auxiliary Spectrum Method.*

It was not found possible to reproduce the conditions for an auxiliary copper spectrum, as standardized by A. Schleicher and J. Clermont,[7] by varying either the self-inductance in the spark circuit or by different methods of aligning or focussing the spark on the spectrograph slit or prism face. E. van Someren [2] has also experienced the same difficulty.

Various alternative metals and alloys were then tried; copper with

1 per cent. tin, tin, nickel, and aluminium with 1 per cent. nickel. Of these, the alloy of aluminium with 1 per cent. nickel gave the most promising results and was finally adopted. The nickel lines appearing as "impurity" lines were consequently very suitable as standards of intensity for the impurity lines in the spectra of aluminium samples; moreover, the spectra of the samples and of the auxiliary alloy are photographed under the same conditions. This type of auxiliary has been found satisfactory in previous work on the analysis of copper (alloy with 1 per cent. tin) and lead (alloy with 0·4 per cent. tin).[1]

Preparation and Standardization of the Auxiliary Alloy.

The alloy was prepared by the direct addition of Mond nickel shot to Hoope's aluminium, the metal being vigorously stirred for 45 minutes to ensure complete solution of the nickel and then cast in a pencil mould.

Two alloys were made, and spark electrodes were prepared from several pencils in each casting and their spectra compared. No differences in the relative intensities of the nickel and aluminium lines were detected.*

Equality of intensity of the lines 2375·4 Ni and 2370·2 Al provides a check on the composition of the auxiliary alloy. The aluminium line 2370·2 (reading slightly less than 2370 by the scale in the spectra reproduced in Plate I) is the weaker of the two lines appearing between the strong aluminium lines 2373·1 and 2367·1 A.

ANALYTICAL TABLES.

The notation in the following tables conforms with the usual conventions, "<," "=," and ">," indicating that the line due to the impurity or alloying constituent in question is respectively weaker than, equal in intensity to, or stronger than the aluminium or nickel line quoted as the internal standard.

TABLE III.—*Copper.*

Copper, Per Cent.	3274·5 Cu.		3274·0 Cu.	
0·001	= 3225·0 Ni	< 3233·0 Ni	< 3315·7 Ni	bv
0·006	>	≦	=	
0·01	< 3134·1 Ni	>	>	< 3233·0 Ni
0·02	=		< 3134·1 Ni	> (0·01–0·015)
0·03	>		=	

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* Chemical determinations of the nickel contents of samples taken from different parts of the castings, kindly carried out by Mr. B. Drinkwater, A.R.C.S., A.R.S.M., F.I.C., did not show variations of more than ± 7 per cent. from the nominal content.

TABLE IV.—*Iron.*

Iron, Per Cent.	2395·6 Fe.	2404·9 Fe.	2966·9 Fe.	2973·2 Fe.	2983·6 Fe.	3020·7 Fe.	3440·6 Fe.	3570·1 Fe.
0·05			< 2984·1	< 2984·1	< 2984·1			< 3571·9
0·12			> Ni	> Ni	= Ni	< 3037·9		= Ni
0·2			< 2981·7		>	= Ni		>
0·27	< 2394·5		= Ni			>		
0·4	= Ni	< 2416·1	>				< 3437·3	
0·5	>	= Ni					> (0·45)	
0·6		>					= 3433·6	
0·7							> Ni	<
0·78								= 3566·4
0·9								= Ni
1·0								>

TABLE V.—*Manganese.*

Manganese Per Cent.	2593·7 Mn.		2605·7 Mn.	2798·3 Mn.	2933·1 Mn.	2939·3 Mn.	2949·2 Mn.
0·001	bv						
0·003	< 2545·9						
	Ni		< 2545·9				
0·005	> (0·004)		= Ni				
0·01		< 2669·2	>				
		Al	< 2669·2			< 2943·9	< 2943·9
0·02	< 2510·9	> (0·015)	> Al			= Ni	> Ni
0·027	= Ni		(0·025)	< 2669·2	< 2943·9	>	(0·015)
0·04	>		< 2510·9	> Al	= Ni		
			Ni	(0·035)			

The most persistent line, 2576·2 A., is only distinguished with difficulty from the strong aluminium lines $\left\{\begin{matrix}2575{\cdot}4\\2575{\cdot}1\end{matrix}\right.$ A.

TABLE VI.—*Silicon.*

Silicon, Per Cent.	2435·2 Si.	2506·9 Si.	2514·3 Si.	2516·1 Si.	2519·2 Si.	2528·5 Si.	3905·5 Si.
0·05						= 2545·9	
0·06				< 2510·9		= Ni	
0·08	< 2433·6			= Ni		>	
0·12	= Ni	<		>			
0·2	>	= 2510·9					bv
0·3		= Ni	< 2510·9				
0·4		>	= Ni		< 2510·9		
0·5			>		= Ni		
0·6					>		
0·73							
0·8							
0·9							< 3900·7
1·0							= Al
1·2	< 2437·9						>
1·4	= Ni						

TABLE VII.—*Titanium.*

Titanium Per Cent.	3234·5 Ti.	3236·6 Ti.	3349·4 Ti.	3361·2 Ti.	3372·8 Ti.		3393·8 Ti.
0·003				by			
0·0073	< 3234·7 Ni		< 3366·2 Ni				
0·01	=		=				
0·014	=	< 3234·7 Ni	>				
0·018	>	=					
0·02		=					
0·027		>			< 3366·2 Ni		
0·033	< 3233·0 Ni				=		
0·043	=				>	< 3391·1 Ni	
0·047	>	< 3233·0 Ni				=	
0·05		=				>	
0·056		=		< 3369·6 Ni			< 3423·7 Ni
0·073		>		=	< 3369·6 Ni		=
0·08			< 3414·8 Ni	>	=		=
0·1			=		>		>

4. ANALYSIS BY MEANS OF ARC SPECTRA.

The sensitive lines selected for analysis by spark spectra are in most cases suitable for arc spectra, but the most persistent lines are different in the case of iron, being in arc spectra $\begin{cases} 2483{\cdot}3 \\ 2488{\cdot}2. \\ 2490{\cdot}7 \end{cases}$ For the quantities of iron usually present in aluminium the groups of lines listed on p. 122 are applicable.

The arc method is more sensitive than the spark method for the detection of traces of gallium and lead, the most sensitive lines of which are as follows :—

Gallium.

2874·2 near Pb 2873·3 A.
2943·6
4033·0 liable to be masked by the manganese triplet, when present.
4172·1

Lead.

3639·6
3683·5
4057·8

Other suitable lines for detecting the presence of this element are :

2614·2
2802·0 near Mg 2802·7 A.
2833·1
2873·3 near Ga 2874·2 A.

The ordinary spectrographic methods of analysis do not offer much promise of the quantitative analysis of this element as segregation appears even for small quantities. For example, lead was only detected in three of the seven manganese standards, although all the standards were prepared from the same aluminium base (containing 0·004 per cent. lead—average analysis). In the other series, the relative lead contents determined spectrographically varied from sample to sample, even in cases where two samples were taken from the same ingot.

EXAMPLE OF THE SPECTROGRAPHIC ANALYSIS OF ALUMINIUM.

Duplicate specimens from four samples of commercial aluminium were analyzed by means of their spark spectra, the results obtained with the use of the auxiliary alloy being confirmed or refined by direct comparison with standard alloys. The spectrographic analyses together with chemical analyses, subsequently received, are compared in Table VIII.

TABLE VIII.

	Sample A.	Sample B.	Sample C.	Sample. D.
Copper.				
Spectrographic	0·003–0·004% in all samples.			
Chemical	0·004%	0·003%	0·003%	0·003%
Iron.				
Spectrographic	0·27%	0·27–0·3%	0·25–0·27%	0·25–0·27%
Chemical	0·33%	0·33%	0·23%	0·25%
Manganese.				
Spectrographic	0·002–0·003% in all samples.			
Chemical	0·0014%	0·0014%	0·0014%	0·0016%
Silicon.				
Spectrographic	0·15%	0·15%	0·15%	0·2%
Chemical	0·18%	0·18%	0·16%	0·18%
Titanium.				
Spectrographic	0·015%	0·015%	0·013%	0·013%
Chemical	0·015%	0·016%	0·012%	0·012%

Note.—Slight variations were observed in the spectra of the duplicate samples, particularly with regard to the copper and iron lines. It is possible that such variations might have been due, in some measure, to contamination of the electrodes while filing, although precautions were taken to avoid errors due to this cause. The spectrographic analyses, therefore, represent either the best average value in each case or the value considered to be the most reliable.

With regard to results for manganese in Table VIII, subsequent re-examination of the spectra showed the spectrographic estimation to be somewhat high. By comparison with the standard samples there is definitely more than 0·001 per cent. and less than 0·003 per cent., but the spectra indicate a content nearer 0·002 than 0·0015 per cent.

Generally speaking, however, the agreement between the spectrographic and chemical data may be regarded as satisfactory.

COMPARISON OF ARC AND SPARK METHODS.

The investigations described have been carried out by means of arc and spark spectra, using relatively simple technique. Of the two methods, the spark gives a much steadier form of discharge and has consequently proved the more satisfactory for the routine quantitative analysis of aluminium. It is also adequate from the point of view of sensitivity of detection of the usual impurities, the lower limits being as follow :

Copper—probably somewhat less than 0·001 per cent.
Iron—0·004 per cent., approximately.
Manganese—0·001 per cent., approximately.
Silicon—somewhat less than 0·005 per cent.
Titanium—0·001 per cent., approximately.

Where the smallest traces of impurities are sought, in particular gallium, lead, and manganese, and possibly others, the arc method will be required. From the preliminary results so far obtained it seems that unless the "intermittent arc" of W. Gerlach[3] be adopted, the best results would be obtained by running the arc in an inert atmosphere such as nitrogen, in order to obviate the difficulties arising from the rapid formation of a non-conducting film of oxide. Experiments are at present being carried out with the intermittent arc, and some promising results have been obtained.

SUMMARY AND CONCLUSIONS.

1. The standardization of a rapid spectrographic method for the quantitative estimation of copper, iron, manganese, silicon, and titanium in aluminium, using ordinary photographic records of spark spectra, is described.

2. For the routine analysis of aluminium samples of unknown composition, one standard alloy of aluminium with 1 per cent. nickel suffices for the estimation of the above impurities by the auxiliary spectrum method. The results can be confirmed, and in some cases further accuracy can be obtained, by comparison with standard samples selected on the basis of the analysis by the auxiliary spectrum method.

3. While the spark has been found to give more reproducible spectra, the arc is useful for qualitative analysis and for the detection of traces of several elements.

4. Other metallic impurities in aluminium could be dealt with on lines similar to those described in this paper.

ACKNOWLEDGMENTS.

The author's thanks are due to the Director and Council of the British Non-Ferrous Metals Research Association for permission to publish this paper, and to the British Aluminium Company, Ltd., in particular to Mr. G. B. Brook (Kinlochleven), for the valuable collection of standards kindly placed at the author's disposal and for their interest in this work.

Acknowledgment is also made to the Chairman and members of the Sub-Committee of this research, under whose guidance these investigations have been carried out, and to Mr. L. Reeves, who has photographed the spectrograms and assisted in their examination.

REFERENCES.

[1] D. M. Smith, "Metallurgical Analysis by the Spectrograph," *B.N.F.M.R.A. Monograph* No. 2, 1933.

[2] E. van Someren, *J. Inst. Metals*, 1934, **55**, 265–274.

[3] W. Gerlach and E. Reidl, *Sitzungsber. bayer. Akad. Wiss.*, 1933, **2**, 227–236.

[4] H. Triché, *Bull. Soc. chim. France*, 1934, [v], **1**, 495–505.

[5] H. Triché, *Compt. rend.*, 1934, **199**, 419–421.

[6] C. S. Hitchen, *Trans. Amer. Inst. Min. Met. Eng.*, 1933, **104**, 353.

[7] A. Schleicher and J. Clermont, *Z. anal. Chem.*, 1931, **86**, 191–216, 271–288; 1932, **90**, 1–15, 321–330.

DESCRIPTION OF PLATE I.—SPARK SPECTRA OF ALUMINIUM.

The region of the spectrum studied, from 2340 to 4050 A., is reproduced in two portions. In each portion two spectra are shown in juxtaposition, the upper spectrum being that of the auxiliary alloy of aluminium with 1 per cent. nickel, the lower spectrum that of a sample of aluminium of the following composition (determined spectrographically):

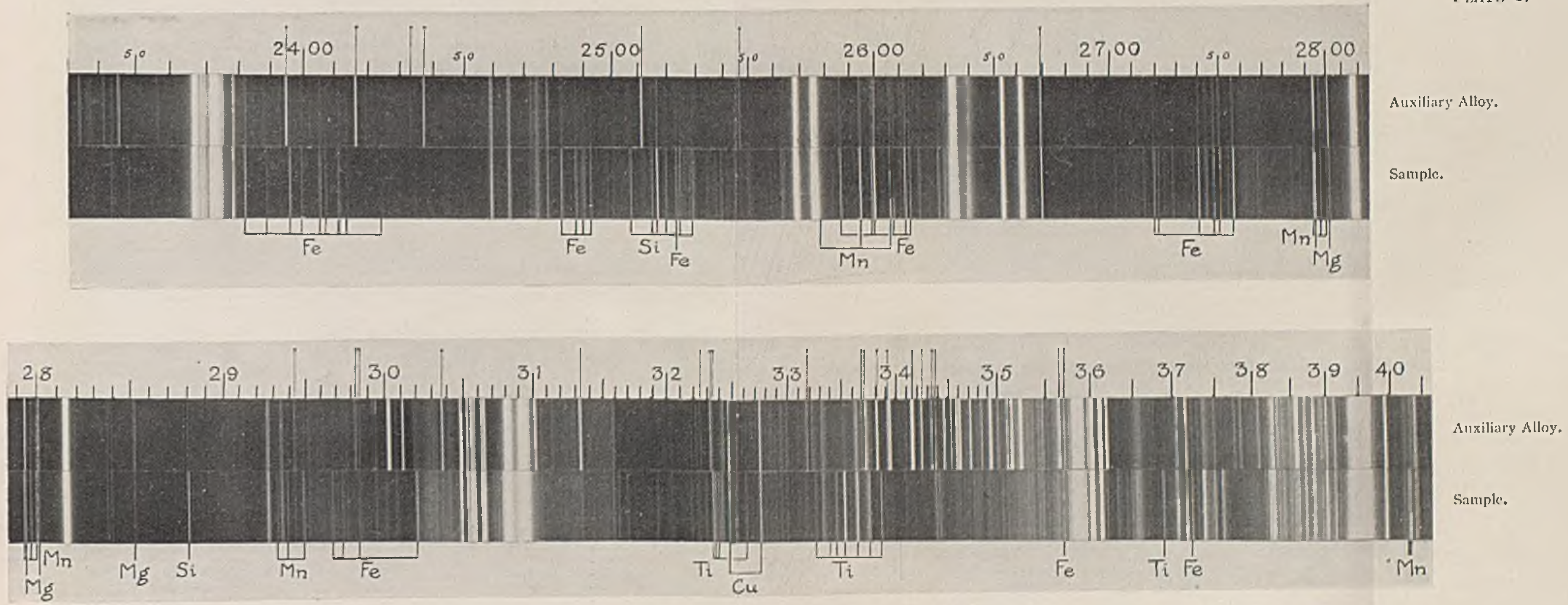
Copper	0·015%	Silicon	0·07%
Iron	0·1%	Titanium	0·035%
Manganese	0·015%		

Combined chemical and spectrographic analysis of the auxiliary alloy gave the following results:

Nickel	1%	Manganese	0·0038%
Copper	0·02%	Silicon	0·0053%
Iron	0·07%	Titanium	0·0011%

Characteristic lines and groups of lines due to the impurities in these samples are shown.

PLATE I.



Spark Spectra of Aluminium. Photographed on the Medium-Size Quartz Spectrograph. For description, see p. 130. × 4.

The Nickel Lines and the Aluminium Line 2669·2 A., in the Spectrum of the Auxiliary Alloy of Aluminium with 1% Nickel, which are used as Standards of Line-Intensity, are Marked thus | at the Top of Each Pair of Spectra. Impurity Lines are Marked Below Each Pair of Spectra.

[*To face p.* 130.

MEETINGS OF OTHER SOCIETIES

TUESDAY, FEBRUARY 19.

Institution of Welding Engineers, North-Eastern Branch.—S. Bryant Roberts: "Gas and Arc Welding as Applied to Repair Work." (Neville Hall, Westgate Rd., Newcastle-upon-Tyne, at 7.15 p.m.)

WEDNESDAY, FEBRUARY 20.

Institution of Electrical Engineers, Scottish Centre, Students' Section.—A. P. M. Fleming: "Development in the Materials of Construction of Electrical Plant and Apparatus—Magnetic, Insulating, Conducting, and Mechanical." (Heriot-Watt College, Chambers St., Edinburgh, at 7.15 p.m.)

Society of Consulting Marine Engineers and Ship Surveyors, Scottish District.—"Some Industrial Uses of the Oxy-Acetylene Blowpipe in Great Britain." Film and lecture by C. Helsby. Institution of Engineers and Shipbuilders in Scotland, 39 Elmbank Crescent, Glasgow, C.2, at 7 p.m.)

THURSDAY, FEBRUARY 21.

Institution of Electrical Engineers, Scottish Centre, Students' Section.—A. P. M. Fleming: "Development in the Materials of Construction of Electrical Plant and Apparatus—Magnetic, Insulating, Conducting, and Mechanical." (Royal Technical College, George St., Glasgow, C.1, at 7.30 p.m.)

SATURDAY, FEBRUARY 23.

Institute of British Foundrymen, East Midlands Branch.—"Bells—Their History and Manufacture." (Loughborough College, at 6 p.m.)

Institute of British Foundrymen, Newcastle-upon-Tyne and District Branch.—A. L. Key: "The Making of Castings for Internal Combustion Engines." (Neville Hall, Westgate Rd., Newcastle-upon-Tyne, at 6.15 p.m.)

Institute of British Foundrymen, Scottish Branch.—H. C. Biggs: "Refractories in the Foundry." (Heriot-Watt College, Chambers St., Edinburgh, at 4 p.m.)

WEDNESDAY, FEBRUARY 27.

Institute of British Foundrymen, Lancashire Branch.—J. Sadler: "How Welding has Displaced Castings in Manufacture by Fabrication." (College of Technology, Sackville St., Manchester, at 7 p.m.)

Institution of Structural Engineers, Scottish Branch.—E. T. Painton: "Structural Uses of Aluminium and its Alloys." (129 Bath St., Glasgow, at 7.15 p.m.)

SATURDAY, MARCH 2.

Institute of British Foundrymen, Lancashire Branch.—H. Stead: "Patternmaking—The Craftsman and His Craft." (Engineers' Club, Albert Sq., Manchester, at 4 p.m.)

Institute of British Foundrymen, Scottish Branch, Falkirk Section.—Prof. H. L. Riley: "Some Recent Investigations on the Production and Utilization of Metallurgical Coke." (Temperance Café, Lint Riggs, Falkirk, at 6 p.m.)

WEDNESDAY, MARCH 6.

Institute of British Foundrymen, Lancashire Branch, Preston Section.—W. H. Meadowcroft: "Making a Chemical Pan." (Technical College, Corporation St., Preston, at 7.30 p.m.)

Institute of British Foundrymen, London Section.—Capt. G. Mortimer: "Pinholes in Aluminium Alloy Castings." (Charing Cross Hotel, London, W.C.2, at 8 p.m.)

FRIDAY, MARCH 8.

Institute of British Foundrymen, Birmingham, Coventry, and West Midlands Branch.—J. E. Newson: "The Founding of Manganese-Bronze Propellers." (James Watt Memorial Institute, Gt. Charles St., Birmingham, at 7.30 p.m.)

SATURDAY, MARCH 9.

Institute of British Foundrymen, Scottish Branch.—A. Logan: "Some of the Factors which Influence the Soundness of Non-Ferrous Castings." (Royal Technical College, George St., Glasgow, at 4 p.m.)

Institute of British Foundrymen, West Riding of Yorkshire Branch.—S. Carter: "Complex Foundry Problems." (Technical College, Bradford, at 6.30 p.m.)

WEDNESDAY, MARCH 13.

Electrodepositors' Technical Society.—H. Marston: "Electrodeposition of Cadmium in Electrical Engineering." (Northampton Polytechnic Institute, St. John St., Clerkenwell, London, E.C.1, at 8.15 p.m.)

Institution of Welding Engineers. O. Bondy: "Recent Developments Regarding Arc-Welded Joints and the Effects of Fatigue." (The Institute of Marine Engineers, The Minories, London, E.C.3, at 7.45 p.m.)

Royal Society of Arts.—S. A. Main: "Properties, Characteristics, and Uses of Stainless Steel." (The Society, John St., Adelphi, London, W.C.2, at 8 p.m.)

THURSDAY, MARCH 14.

Institution of Structural Engineers.—C. Helsby: "Welding Construction." (The Institution, 10 Upper Belgrave St., S.W.1, at 6.30 p.m.)

FRIDAY, MARCH 15.

Institute of British Foundrymen, Lancashire Branch, Junior Section.—J. E. Cooke: "Is the Foundry a Cul-de-Sac?" (College of Technology, Sackville St., Manchester, at 6.30 p.m.)

Institute of British Foundrymen, Sheffield and District Branch.—Dr. J. G. A. Skerl and F. J. Cook: "Foundry Machinery with Particular Reference to Sand Handling Plant." (Grand Hotel, Sheffield, at 7.45 p.m.)

Institution of Welding Engineers, Midlands Branch.—Dr. J. Newton Friend: "Diseases of Metals." (James Watt Memorial Institute, Gt. Charles St., Birmingham, at 7.15 p.m.)

THE INSTITUTE'S LIBRARY

Donations of any of the under-mentioned would be welcomed to complete the Institute's files :

Encyclopædia Britannica (latest issue).

Sutton H. "A Systematic Handbook of Volumetric Analysis." (J. & A. Churchill.)

"Brass World." Volumes 2–6.

Electrochemical and Metallurgical Industry. Volumes 1–3.

Metallurgical and Chemical Engineering (Chemical and Metallurgical Engineering). Volumes 12–21.

Mineral Industry. Issues since 1932 (incl.)

Foundry Trade Journal. Volumes 1–25.

Journal of the Electroplaters' and Depositors' Technical Society. Volume 1.

Journal of the Iron and Steel Institute. Volumes 1–15.

Metal Industry (London). Volumes 1–4.

Metallwirtschaft. Volumes 1–5.

Mitteilungen aus dem Kaiser-Wilhelm-Institut für Eisenforschung zu Düsseldorf. Volumes 1–10.

Proceedings of the Institute of British Foundrymen. 1916–17. (Volume 10.)

Revue de Métallurgie. Volume 1.

Transactions of the American Electrochemical Society. Volumes 1–3 and Volume 11.

Transactions of the American Foundrymen's Association. Volumes 1–15, 18–27 incl.

Transactions of the American Institute of Metals (American Brass Founders' Association). Volumes 3–5.

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CORRIGENDA.

Monthly Journal, 1935, January.

Page 16, bottom line. *For* " 99·97 " *read* " 99·99."

Page 33, line 7. *For* " Sb, Sn, SbSn " *read* " Pb, Sb, SbSn."

line 6 from bottom. *For* " lead 86 per cent." *read* " lead 85 per cent."

Metallurgical Abstracts, 1935, January.

Page 12, line 26. *Delete* " or bronze."

METALLURGICAL ABSTRACTS

(GENERAL AND NON-FERROUS)

Volume 2 FEBRUARY 1935 Part 2

I.—PROPERTIES OF METALS

(Continued from pp. 1–7.)

***A Transition in Aluminium at 79° C.** William Band (*Phys. Rev.*, 1934, [ii], **46**, 934–935).—A note. Thermoelectric measurements in homogeneous aluminium circuits suggest that a transition of some kind occurs at 79° ± 0·5° C. —W. H.-R.

Insulating Value of Bright Metallic [Aluminium] Surfaces. F. B. Rowley (*Heating, Piping, Air-Conditioning*, 1934, **6**, 263–266; and (abstract) *Light Metals Research*, 1934, **1**, 127–131).—Aluminium foil which has a low emissivity coeff. does not always give the same results when tested for insulating value, since the condition of the surface, *e.g.* state of polish, freedom from moisture, &c., will greatly alter the coeff. From the results of numerous tests under varying conditions, values are obtained for air conductance, surface emissivity, and surface transmission coeff. for insulation built up of spaced aluminium foil.—W. P. R.

Optical Constants and the Conduction Electrons of Beryllium and Silicon. H. M. O'Bryan (*Phys. Rev.*, 1934, [ii], **46**, 336).—Abstract of a paper read before the American Physical Society. The optical constants of beryllium as measured by the phase shift of reflected light show an abrupt increase in the strength of absorption (n^2Kv) at 5000 A. (2·5 v.) which coincides with the minimum of reflection found by Coblentz and Stair. The increasing reflecting power and constant value of the strength of absorption towards the infra-red indicates the presence of empty levels very little above those filled with conduction electrons, to which transitions are possible through collisions with the lattice. Both the optical constants and the soft X-ray emission give much greater transition probabilities for electrons more than 2·5 v. below the surface of the Fermi–Dirac distribution of conduction electrons. Silicon and germanium show a more gradual increase in the strength of absorption from 1·5 μ where both are almost transparent.—S. G.

Beryllium and Its Use. D. M. Zaslavski (*Redkie Metalli* (*Rare Metals*), 1933, 2, (5), 34–39).—[In Russian.] A short review of the chemical and physical properties and uses of beryllium and certain of its alloys.—D. N. S.

***Thermal Expansion of Bismuth Single Crystals Near the Melting Point.** J. W. Buchta and A. Goetz (*Phys. Rev.*, 1934, [ii], **46**, 1092–1095).—Cf. *Met. Abs.*, 1934, **1**, 487. The macroscopic thermal expansion of single crystals of bismuth has been studied near the melting point with a new dilatometer (Goetz, Buchta, and Ho, *Met. Abs.*, this volume, p. 68). Crystals grown from highly purified metal show no decline in the coeff. of thermal expansion as the melting point is approached. Very small quantities of certain impurities (lead, silver, cadmium, or tin) cause the coeff. to decline in a range of 10° or 20° C. below the melting point, and may even produce a negative coeff. The precise absolute values of the coeff. were not determined. The discrepancies between previous results are discussed.—W. H.-R.

***Thermal Conductivities of Bismuth Single Crystals as Influenced by a Magnetic Field.** Milward T. Rodine (*Phys. Rev.*, 1934, [ii], **46**, 910–916).—The thermal and electrical conductivities of 2 single crystals of bismuth have

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* Denotes a paper describing the results of original research.

† Denotes a first-class critical review.

been determined as a function of the temperature and of the orientation of the magnetic field (7800 gauss) relative to their crystallographic axes, over the range − 50° to − 170° C. The first specimen was mounted with its trigonal axis parallel to the flow of heat or electric current, and at right angles to the magnetic field, which was rotated about the specimen. In this case the decrease in both thermal and electrical conductivity was greater with the field perpendicular to any one of the binary axes than when the field was parallel to any one of them. The second specimen had its trigonal axis at right angles to the flow of heat or current, and either at right angles or parallel to the magnetic field according to the rotation of the latter. In this case, the decrease in thermal conductivity was greater with the field perpendicular to the trigonal axis than when it was parallel, whilst the decrease in electrical conductivity was in the reverse order.—W. H.-R.

***Diamagnetism of Bismuth.** S. Ramachandra Rao (*Indian J. Physics*, 1932, **7**, 35–42; *C. Abs.*, 1932, **26**, 4738).—Carefully prepared colloidal bismuth was treated with tartaric acid to remove the oxide, dried and sealed in highly evacuated glass bulbs. By a Curie balance, χ was measured on these samples. The bulbs were then heated to 275°–280° C. for some time to melt the bismuth, and it was allowed to crystallize. The measurements with the Curie balance were repeated and it was found that the value of χ had increased, the increase being greatest for the particles of the smallest diameter. When χ is plotted against particle diameter, the curve bends rapidly at about diameter = 1·5 μ, after which the change of χ with diameter is much more rapid. Goetz showed that in bismuth crystals a macroscopic structure, with 1·4 μ as the length of the side of the elementary pyramid, is superimposed on the crystal lattice. R. suggests that the rapid decrease in χ below diameter = 1·5 μ may be associated with the breaking up of this macroscopic superstructure.—S. G.

***The Vapour Pressure of Calcium Between 500° and 625° C.** Erik Rudberg (*Phys. Rev.*, 1934, [ii], **46**, 763–767).—The vapour pressure of solid calcium was measured by a process of molecular effusion in which the metal was maintained at constant temperature in a high vacuum, and the amount diffusing through a very small hole in a surrounding screen was determined by allowing it to condense on glass plates. The results may be expressed by the equation $\log p$ (in mm.) $= 8{\cdot}15 - 9670/T$, where T is the absolute temperature. The vapour pressures are only about one-tenth of those given by Pilling (*J. Inst. Metals*, 1922, **28**, 530), but the present results give the correct value for the chemical constant. The heat of evaporation at $T = 0$ is calculated as $4{\cdot}53 \times 10^4$ cal./mol., and the chemical constant (i) as 15·4.—W. H.-R.

Effect of Oxygen and Reducing Gases on Copper. Anon. (*Engineering*, 1934, **138**, 60).—Deals in a general manner with the embrittlement of copper by oxygen and subsequent exposure to hydrogen and other reducing gases at elevated temperatures. Copper is now being made commercially to a specification which requires an embrittlement depth of not more than 0·003 in., capable of withstanding an oxidation–reduction test in which the copper is first heated for 15 minutes in air at 900° C. and then in hydrogen for 15 minutes at 800° C.—W. P. R.

***Planimetric Determination of Cuprous Oxide.** B. Grashchenko (*Zavodskaya Lab.*, 1934, **3**, 38–47; *C. Abs.*, 1935, **29**, 93).—[In Russian.] The method was applied to rolled and drawn copper, in which the cuprous oxide inclusions are granular. The photomicrographs were made on paper and then planimetrically determined directly from negatives. The surface etching of samples with pre-eutectic structure was made with a mixture of 4 parts of ammonia (d 0·92) and 1 part of 3% hydrogen peroxide, and that of samples with post-eutectic structure with 1% hydrochloric acid. Quicker results can be obtained by tracing, cutting, and weighing than by the planimetric determination.—S. G.

***Influence of Rate of Shear on Shearing Strength of Lead.** James Jamieson (*Trans. Amer. Soc. Mech. Eng.*, 1934, **56**, 579–582; discussion, 582–583).—The shear stress of lead varies from 1310 lb./in.^{2} for a velocity of shear of 0·0135 rad./in./second to 2875 lb./in.^{2} for a velocity of 94·4 rad./in./second. At low speeds of deformation a definite yield-point occurs. Over the range of deformation speeds investigated the following equation appears suitable: $\sigma = \sigma_1 + c \log \frac{v}{v_1}$, where σ is the stress and v is the deformation rate, and σ_1, c, and v_1 are constants.—W. P. R.

***The Thermal Elongation of Some Alkali Halides and Metals [Lead, Silver, Copper, Nickel] at High Temperatures.** A. Eucken and W. Dannöhl (*Z. Elektrochem.*, 1934, **40**, 814–821).—The coeff. of linear expansion of a number of alkali halides and of lead, silver, copper, and nickel have been determined from room temperature to various temperatures up to 860° C. The results agree satisfactorily with those of previous workers, especially at the lower temperatures. The results obtained for the metals differ from the calculated values less absolutely than those for the alkali halides, but more on a percentage basis. For silver, $\alpha_{\text{calc.}} = 0{\cdot}0_4 1872 + 0{\cdot}0_8 7393t + 0{\cdot}0_{11} 7381t^2$ (t in ° C.); for copper, $\alpha_{\text{calc.}} = 0{\cdot}0_4 1589 + 0{\cdot}0_8 4492t + 0{\cdot}0_{11} 3888t^2$; for lead, $\alpha_{\text{calc.}} = 0{\cdot}0_4 2877 - 0{\cdot}0_9 2095t + 0{\cdot}0_{10} 6030t^2$. The curve for nickel shows a peak in the vicinity of the Curie point, in complete analogy with the curve of specific heat.
—J. H. W.

***Absorption of Hard X-Rays by Lead.** A. Alihanjan and M. Kosman (*Zhurnal eksperimentalnoy i teoreticheskoy Fiziki* (*J. Exper. and Theoret. Physics*), 1934, **4**, 550–556).—[In Russian.] Absorption curves in water and lead have been obtained for X-rays in the region 24–60 XU. after a preliminary filtration through lead, and the absorption coeff. in lead has been determined. The results are not in agreement with those of German and Jaeger and Namias.
—N. A.

***Some Considerations of Sputtering Applied to Purification of Mercury by Electric-Arc Still.** R. K. Cowsik (*Indian J. Physics*, 1934, **9**, 21–33).—Processes, successively applied, for the purification of mercury, *viz.* mechanical purification, oxidation and reduction of impurities, treatment with mercurous nitrate solution, and distillation, are discussed. The last may be effected in a gas-heated still or in a mercury-arc still. Certain metals, *e.g.* silver and copper, are removed by the gas-heated still but not by the arc still. This difference is found to be attributable to sputtering at the cathode of the arc still.—J. S. G. T.

***Action of Magnesium on Solutions of Nickel Sulphate and of Cobalt Sulphate.** G. Gire (*Bull. Soc. chim. France*, 1934, [v], **1**, 1241–1247).—Sheet magnesium reacts readily with solutions of nickel and cobalt sulphates, hydrogen being evolved, magnesium sulphate passing into solution, and a basic nickel or cobalt sulphate being precipitated. Neither nickel nor cobalt metal is deposited.—A. R. P.

Manganese: Its Occurrence, Milling, and Metallurgy. II.—Thermodynamic Properties of Manganese and Its Metallurgically Important Compounds. C. G. Maier (*U.S. Bur. Mines Information Circ.* No. **6769**, 1934, 99–163).—A review.
—S. G.

***The Variation of the Coefficient of Rigidity of Nickel as a Function of Magnetization.** Raymond Jouaust (*Compt. rend.*, 1934, **199**, 1193–1196).—The effect of magnetization on the coeff. of rigidity of nickel has been investigated by suspending a torsion pendulum by a commercial nickel thread in the interior of a solenoid which gives rise to longitudinal magnetism in the thread. The period of oscillation is determined: (1) by free oscillation of the pendulum, or (2) by oscillations originated and synchronized by an electrically-operated pendulum. From the difference between the periods of the synchronized

and the synchronizing pendulums [*Note by abstractor:* An error is suspected in the equation given], the variation in the coeff. of rigidity can be deduced. By both methods of measurement, it is found that there is a decrease for magnetic fields of 15–70 oersted, in the case examined, by up to 2%. These results confirm those of Honda and Terada (*Physikal. Zeit.*, 1905, 6, 622).
—J. H. W.

***Thermal Expansion and the Ferromagnetic Change in Volume of Nickel.** Clarke Williams (*Phys. Rev.*, 1934, [ii], 46, 1011–1014).—The coeff. of thermal expansion has been measured, at intervals of 2·5° C., from 200° to 500° C. for (*a*) a single crystal of pure Mond nickel grown in hydrogen at a pressure of 1 mm.; (*b*) single- and polycrystalline nickel contaminated with carbon and molybdenum; and (*c*) hard-drawn and annealed commercial nickel. The abnormal change in volume accompanying the ferromagnetic transformation (*i.e.* the expansion in excess of that to be expected from a normal expansion over the temperature range in which the transformation occurs) is $3{\cdot}24 \pm 0{\cdot}15 \times 10^{-4}$ per unit volume of pure nickel.—W. H.-R.

***The Determination of the Thermoelectric Homogeneity of Platinum Wire.** A. W. Makarow and J. W. Plastinin (*Zhurnal Tehnicheskoy Fiziki* (*J. Tech. Phys.*), 1934, 4, 1195–1203).—[In Russian.] An electric furnace for determining the thermoelectric homogeneity of platinum wire is described. Its advantages are the small length of the hot zone which ensures that the e.m.f. value obtained is near to the real one, and the rapidity and simplicity of the measurement. Some examples are given of the use of the furnace.—N. A.

***Energy Distribution of Photoelectrons as a Function of the Thickness of a Potassium Film.** James J. Brady (*Phys. Rev.*, 1934, [ii], 46, 768–772).—Current-voltage curves were taken for the emission of electrons from thin potassium films of varying thickness deposited on silvered glass surfaces. The curves were in good agreement with the theory of Du Bridge (*J. Inst. Metals*, 1933, 53, 343). Films less than 3 molecular layers in thickness failed to show saturation up to accelerating potentials of 20 v., and gave an emission which decreased after the formation of the film. For thicker films the photocurrent was constant, and began to saturate at lower voltages.—W. H.-R.

***Some Information on the Secondary Electron Emission from Potassium Surfaces.** L. Groschew (*Zhurnal Tehnicheskoy Fiziki* (*J. Tech. Phys.*), 1934, 4, 363–367).—[In Russian.] The secondary electron emission from several potassium surfaces of different structures and from potassium hydride has been measured; it varies with the different potassium surfaces, and from potassium hydride is nearly the same as from pure potassium, though the photoelectric current increases 15 times.—N. A.

***The Oxidation of Silicon at Low Temperatures.** André Sanfourche (*Compt. rend.*, 1934, 199, 726–729).—Samples of 3 varieties of silicon, said to be variously soluble in hydrofluoric acid and containing 99·12, 96·14, and 90·46% of silicon, respectively, were treated with chlorine gas, the attack being marked by incandescence. The volatile silicon chloride was formed, leaving any silica present behind. The samples were found by this experiment to contain 0·46, 3·01, and 8·60% of silica, respectively, and it is this, present in the metal as a superficial film, that is in fact dissolved by the hydrofluoric acid. Small samples of two crystalline forms of silicon were subjected to successive attacks of hydrofluoric acid, and the loss in weight confirmed that silicon in a fine state of division is readily oxidizable at low temperatures.
—J. H. W.

***The Anodic Behaviour of Thallium in the Halogen Hydrogen Acids.** Otto Pip (*Z. Physik*, 1934, 91, 329–335).—Only in hydrochloric and hydrobromic acids and in aqueous solutions of the sodium salts of these acids does a thallium anode exhibit the phenomenon of electrolytic valve action associated with the production of a protecting layer covering the anode. The mechanism of the action is discussed.—J. S. G. T.

***The Difference Between the Specific Heat of Solid and Liquid Tin in the Vicinity of the Melting Point.** L. D'Or and C. Degard (*Bull. Soc. chim. Belg.*, 1934, 43, 510–512).—The atomic heat of solid tin just below the melting point is 7, and that of the liquid at just above the melting point is 7·435.—A. R. P.

***The Spontaneous Ionization of Sodium and Cæsium Vapour at Incandescent Tungsten and Rhenium Surfaces.** H. Alterthum, K. Krebs, and R. Rompe (*Z. Physik*, 1934, 92, 1–18).—The yield and the temperature coeff. of the yield of ionized sodium and cæsium atoms at incandescent surfaces of tungsten and rhenium are determined experimentally. Results relating to sodium vapour ionized at a tungsten surface are in agreement with Langmuir's older formula; the remaining results do not agree with the theory, the yield in these cases being considerably less than the theoretical values.—J. S. G. T.

***The Photoelectric Emission from Thoriated Tungsten.** R. E. Smith and L. A. DuBridge (*Phys. Rev.*, 1934, [ii], 46, 339).—Abstract of a paper read before the American Physical Society. A complete set of photocurrent *versus* frequency curves was obtained for a 12 mil. thoriated tungsten filament in various stages of activation. In this preliminary work, photoelectric measurements were restricted to single temperature (900° K.) and to a single accelerating field (100 v. on the collector). Gas-free conditions were maintained throughout. It was found: (1) At any stage of activation the photocurrents vary with frequency according to Fowler's equation, out to frequencies as much as 1·3 v. from the threshold. Fowler's theory thus applies to composite surfaces as well as clean ones. (2) Beyond 1·3 v. from the threshold the points fall below the Fowler curve, as expected. (3) At each stage of activation the photoelectric work-function at 900° K. (by Fowler's method) agrees with the thermionic work-function, for an average temperature of 1400° K., within the limits of error. The values range from 2·6 to 4·52 v. in agreement with previous thermionic work. (4) At higher activation there is a tendency for ϕ_p to be less than ϕ_t by an amount just about equal to the possible error (0·05 v.). This may be a real temperature effect. (5) The value of the constant B in Fowler's equation is the same for all surface conditions.—S. G.

***Thermionic Electron Emission from Tungsten.** W. B. Nottingham (*Phys. Rev.*, 1934, [ii], 46, 339).—Abstract of a paper read before the American Physical Society. The electron current from an equipotential surface at 1857° K. has been observed as a function of the potential v from $-$ 3·5 to 750 v. Over the range $-$ 3·5 to $-$ 1·5 the Maxwellian curve is an exact representation of the data, while between $-$ 1·5 and $-$ 0·6 v. the observed current falls below the theoretical curve. The current at $-$ 0·6 v. (zero field) is about 50% below that expected. The extrapolated Schottky mirror-image curve obtained from the high field data falls very close to the extrapolated Maxwellian curve. Energy distribution curves taken at 9 temperatures between 1218° and 1857° K., when plotted as a function of v/T, are all exactly alike. This indicates that the effective integrated transmission coeff. at zero field is independent of the temperature and is, therefore, probably controlled by mechanical imperfections of the wire such as die marks, crystal irregularities, &c. If the contact potential between the filament and the collector followed the equation $V = V_0 + \alpha\, 8{\cdot}62 \times 10^{-5}T$ (where αk = temperature coeff. in ergs./deg. and V_0 = contact potential at 0° K.), then by plotting the observed relative positions of zero applied potential as a function of $1/T$ for the superimposed set of observed curves, the values of V_0 and α could be obtained from the slope and the intercept, respectively. This assumes that the contact potential at a single temperature is known. Observed results seem to follow two lines instead of one. This interpretation gives $\alpha = -$ 1·1 for 1857°–1625° and $\alpha = -$ 1·6 for 1508°–1218° K. If the best single line through all points is chosen $\alpha = 0{\cdot}68$.—S. G.

***Application of the Forsythe–Watson Temperature Scale for Tungsten.** W. B. Nottingham (*Phys. Rev.*, 1934, [ii], 46, 341).—Abstract of a paper read before the American Physical Society. Forsythe and Watson (*J. Opt. Soc. Amer.*, 1934, **24**, 114) have published new values of resistivity R and total radiation W characteristic of pure tungsten wire as a function of the temperature. The "derived" functions of Langmuir–Jones, namely, $VA^{1/3}/l = X$ and $A/d^{3/2} = Y$, are more useful for the determination of the temperature in well-evacuated tubes than the specific functions R and W. (R = resistivity in micro-ohm cm.; W = total radiation watts/cm.^{2}; V = potential drop over uniform filament in v.; A = current in amp.; l = length in cm.; d = diameter in cm.) Tables and curves showing dependence of X_0 and Y_0 on temperature have been computed directly from R and W, which apply for surroundings at 0° K. from the relations $X_0 = (4\pi)^{1/3} W^{2/3} R^{1/3}$ and $Y^{\circ} = \pi W^{1/2}/2R^{1/2}$. In order to determine the temperature from observed values of V, A, l, and d the following formulæ are useful: $X_0 = X\left(1 + \frac{2}{3}\frac{W_1}{W_2} + \frac{2}{3}\frac{d}{c} - \frac{2}{3}\frac{\Delta d}{d}\right)$, $Y_0 = Y\left(1 + \frac{1}{2}\frac{W_1}{W_2} + \frac{1}{2}\frac{d}{c} + \frac{\Delta d}{d}\right)$. W_1/W_2 = ratio of the W's for room temperature and filament temperature, respectively. In case the filament is surrounded by a collector of diameter c, which has approximately the same total emissivity as tungsten over the range 300°–600° K., the third term should be used. (Omit if the collector forms part of the outside wall.) On account of die-grooves found on most filaments the true outside diameter as determined by an interferometer gauge is larger than that obtained from the weight or the resistance. The difference in these diameters is Ad. Although the Forsythe–Watson values of R and W differ appreciably from those of Langmuir and Jones, temperatures calculated from the 2 scales agree remarkably well over the range 900°–2200° K. and show about the same degree of self-consistency, which is not quite perfect.—S. G.

***Electrical Resistivities of Single and Optically Mosaic Zinc Crystals.** Willard J. Poppy (*Phys. Rev.*, 1934, [ii], **46**, 815–821).—The specific resistances of single crystals grown from two batches of very pure Evanwall zinc have been determined with extreme precautions to avoid strain. The Voigt–Thomson symmetry relation is accurately obeyed, the principal resistivities for the 2 series being (at 20° C.) $\rho_0 = 6{\cdot}218$ and $6{\cdot}161$; $\rho_{90^{\circ}} = 5{\cdot}882$ and $5{\cdot}842$, respectively. For pure zinc the ratio may be taken as between 1·054 and 1·057, the exact value possibly depending on the nature of the impurities. Strains produced by the application of micrometer calipers are sufficient to produce distinct deviations from the symmetry law, and may either increase or decrease the resistance. The effect of annealing strained specimens was studied. Long annealings at 190° C. restored the resistivities of slightly strained crystals to their initial values in a remarkable way when high-temperature annealing had failed. Optically mosaic specimens were also studied, and gave abnormal values which were very sensitive to strain. Previous results are discussed, and the discrepancies regarded as due to the presence of strains or of a mosaic structure.—W. H.-R.

†Review of Researches Relating to the Free Alkali Metals (1930–1933). H. Alterthum and R. Rompe (*Physikal. Z.*, 1934, **35**, 814–836).—Researches relating to the physico-chemical properties of the alkali metals, carried out during the period 1930–1933, are reviewed. Amongst the subjects discussed are: nuclear properties, electronic shells, properties of atoms and molecules in the gas and disperse (colloid) phases, crystal structure, thermal, magnetic, and electric properties. An extensive *bibliography* is included.—J. S. G. T.

***The Nature of the Metallic Bond.** Hans Bomke (*Z. Physik*, 1934, **91**, 400–409).—A critical review of the properties characterizing the metallic state leads to the conclusion that interatomic forces in a solid or liquid metal are purely electrostatic in character. Cohesion as exhibited by metal crystals is attributable to electrostatic interaction between the positive ionic lattice and the uniformly superimposed charged cloud of metal electrons. The lattice energy under these conditions attains its maximum value. A relation between the lattice energy and the latent heat of vaporization and also the ionization potential of the free atoms is deduced. The results accord well with observational values of these constants. The force of repulsion between metallic atoms varies as the inverse cube of the inter-atomic distance.—J. S. G. T.

†**Significance of the Properties of Technical Metals Based on the Behaviour of Single Crystals and on the Texture.** W. Boas and E. Schmid (*Berg.- u. Hütt. Jahrb. Montan. Hochschule, Leoben*, 1934, **82**, 138–144).—A critical review of recent work on the properties of single crystals of metals and the application of the results obtained to the study of the mechanism of deformation of polycrystalline aggregates, with especial reference to their anisotropic behaviour.—A. R. P.

***Calculation of the Elastic Moduli for Different Textures of the Regular Metals.** D. A. G. Bruggeman (*Z. Physik*, 1934, **92**, 561–588).—A theory for calculating the elastic moduli of crystals of regular metals of various textures, *e.g.* isotropic, cast, recrystallization, electrolytically-deposited, rolled, drawn and beaten textures, is developed. The parts played by texture and other characteristics of multi-crystals in determining the values of the elastic constants are examined. Generally, texture is found to play a predominant part except in the case of tungsten.—J. S. G. T.

†***Fundamentals of the Theory of Practical Tenacity.** A. W. Stepanow (*Z. Physik*, 1934, **92**, 42–60).—The strength of crystals is conditioned by surface and volume distortions produced by plastic deformation. Both the type and the number of distortions are significant in this matter. Three types of distortions are important: (1) permanent, (2) temporary, and (3) distortions associated with the incidence and completion of the stress. The nature of the distortions depends on temperature, velocity of strain, and magnitude of the stress. The incidence of conditions favouring fracture is determined by the equation $S \cdot \Delta =$ a constant, S denoting the thrust in the slip-planes, and Δ denoting approximately the inverse of the consolidation due to deformation. The Joffé effect is attributable to removal of the superficial distortions produced by plastic strain. Plastic deformation always reduces the strength of a crystal below its theoretical value. The brittle condition corresponds with conditions favouring the creation of large internal stresses and strains. Maximum strength corresponds with the exclusion of the possibility of plastic deformation.—J. S. G. T.

Plastic Behaviour in the Light of Creep and Elastic Recovery Phenomena. M. F. Sayre (*Trans. Amer. Soc. Mech. Eng.*, 1934, **56**, 559–561).—No sharp differentiation can be drawn between creep, the so-called elastic creep, and elastic recovery, and the amount of creep and hysteresis seems to be related to the temperature of the metal and to the state of its internal stress. The creep effects which occur below the elastic limit gradually merge into the larger plastic yielding which occurs at higher stresses.—W. P. R.

Some Remarks on the Development of the Quantum Theory of Plastic Deformation. U. M. Pokrovskiy and B. A. Krasuk (*Vestnick Ingenerov i Tehnikov* (*Messenger Eng. and Technol.*), **1934**, (6), 271–274).—[In Russian.] The electrostatic theory of lattice structure is considered insufficient to explain plastic deformation; the subject is discussed from the point of view of quantum mechanics and the kinetic theory.—N. A.

***On the Measurement of the Viscosity of [Liquid] Metals.** August Rademacher and F. Sauerwald (*Mitt. Forsch. Anst. G.H.H.-Konzern*, 1934, **3**, 124–140).—A critical examination has been made of the following methods of determining the viscosity of liquid metals: (*a*) the logarithmic decrement method in which the torsional swinging of a sphere immersed in the liquid metal is measured, (*b*) the viscosimeter method in which the rate of flow through a vertical capillary is measured, and (*c*) the method using a horizontal capillary and measuring the flow of metal along it under a constant head. Method (*a*) is unsatisfactory at high temperatures unless complete thermostatic control can be obtained, since otherwise the effects of convection currents vitiate the results. Method (*b*) is satisfactory only at relatively low temperatures and with metals of high viscosity, and then only when the effects of surface tension are eliminated by a suitable construction of the apparatus. Method (*c*) seems to give the best results, especially when the ends of the capillary are widened to eliminate surface tension effects. The results obtained in a series of tests of all the methods with mercury are shown in tables and graphs, and are critically discussed.—A. R. P.

***The Cause of the Odour and Taste of Metals.** E. Raub (*Angew. Chem.*, 1934, **45**, 673–675).—Experiments on silver, copper, nickel, and their alloys show that when perfectly clean they have no odour or taste. Silver and copper and their alloys, however, readily acquire the odour and taste of certain sulphur-containing organic compounds with which they come into contact, *e.g.* mercaptans. These tastes are very difficult to remove by ordinary washing or mechanical cleaning, but are readily eliminated by washing in dilute hydrochloric acid or in solutions of certain reducing agents. Tin, nickel, chromium, gold, platinum, or palladium do not acquire these tastes, and aluminium does so only to a very small extent.—A. R. P.

***Cathodic Sputtering of Metals.** R. K. Cowsik (*Indian J. Physics*, 1933, **8**, 209–229).—The thermal theory of cathodic sputtering is given and extended, and a form of discharge tube which enables the sputtering values of different metals to be accurately determined is described. Sputtering data relating to 12 metals are given.—J. S. G. T.

***The Effect of Light on Thin Metal Films.** Quirino Majorana (*Physikal. Z.*, 1933, **35**, 740–744).—In a previous paper M. has shown that the electrical resistance of thin metal films increases when the films are exposed to light (*ibid.*, 1932, **33**, 947). The phenomenon was attributed to a new type of photoelectric effect, termed metallic photo-resistance. The effect is observed very clearly with films of platinum, silver, gold, and tin; it is very small, or non-existent, in the case of aluminium and possibly of zinc and sodium. It is now established that the phenomenon is not entirely attributable to a thermal effect but is new in character and indicates a direct effect of light upon the electrical resistance of metals.—J. S. G. T.

***The Optical Constants of Thin Metal Films in the Long-Wave Ultra-Red Region.** Wilhelm Woltersdorff (*Z. Physik*, 1934, **91**, 230).—The reflectivities R of the films of tin, gold, silver, aluminium, antimony, bismuth, and tellurium for wave-lengths 25–100 μ are determined. The results can be expressed in the form $R = (1 + c/2\pi\sigma d)^{-2}$, in which d is the thickness of the film, σ its specific electrical conductivity, and c the velocity of light (expressed in volts). Combining this result with that previously obtained for the transparency D of the thin films, *viz.* $D = (1 + 2\pi\sigma d/c)^{-2}$, it follows that $\sqrt{D} + \sqrt{R} = 1$. The theory is best verified by metals which are outstandingly good conductors, *viz.* silver, aluminium, and gold. Discrepancies in other cases are possibly attributable to an effect associated with the metals being characterized by a dielectric constant.—J. S. G. T.

***Method of Determining the Thermal Resistance of Metal Single Crystals at Low Temperatures.** W. J. de Haas and W. H. Capel (*Physica*, 1934, **1**, 725–734; *C. Abs.*, 1935, **29**, 32).—The thermal resistance of single-crystal bismuth rods was determined by connecting them to the platinum ends of 2 long glass tubes filled with liquid hydrogen. One of these tubes contained a heating coil, the second was connected to a vacuum pump and kept at constant pressure (and temperature). From the difference in temperature of the tubes (by pressure measurement) at temperature equilibrium (heat introduced =

heat conducted) the thermal resistance was found. Details of construction and calculation are given. The entire apparatus is set up in a vacuum vessel. Among the values found for 99·995% pure bismuth as a 5 × 5 × 28 mm. rod are at 16·54° abs. specific thermal resistance (cal.$^{-1}$ cm. sec.) 6·6, at 18·33° 7·3, at 20·01° 8·3, and at 81·44° 25·2.—S. G.

***Symmetry of the Thermoelectric Effects in Single Crystals.** H. P. Stabler (*Phys. Rev.*, 1934, [ii], 46, 938).—Abstract of a paper read before the American Physical Society. In a single-crystal rod of a non-cubic metal a transverse temperature gradient produces a longitudinal e.m.f. As a result of this fact the longitudinal thermoelectric power of such a rod must depend not only on its crystallographic orientation but also on the orientation of the temperature gradient. Assuming Kelvin's "axiom of the superposition of the thermoelectric effects" it is shown that

$$\tau \frac{dE}{d\tau} l = P_{\perp} + \frac{\cos\theta\cos\phi}{\cos(\theta-\phi)}(P_{\parallel} - P_{\perp}).$$

where θ is the angle between the principal crystallographic axis and the geometric axis, ϕ the angle between the crystallographic axis and the temperature gradient. If the temperature gradient is determined largely by heat-flow along the crystal then $\tan\phi = k_{\parallel}/k_{\perp} \tan\theta$. The above relation has been found to be compatible with all the existing data on thermoelectric symmetry. In particular, it explains the apparent deviation from Kelvin's $\cos^2\theta$ law found by Bridgman and others for *tin* and *bismuth*. The non-linearity with $\cos^2\theta$ of the direct measurements of the Peltier heat for bismuth, as reported by Fagan and Collins, may be accounted for by a similar neglected transverse effect.—S. G.

***Temperature Coefficient of the Electrical Conductivity of Thin Metal Films.** R. Deaglio (*Z. Physik*, 1934, 91, 657–659).—Values of the temperature coeff. (α) of the electrical conductivity of thin gold films, between − 40° and 40° C., confirm Biltz's conclusion that α, in the case of such films, is a characteristic function of the specific conductivity of such films.—J. S. G. T.

†*The [Electrical] Conductance of Thin Metal Films and the Superficial Conductivity of Metals. E. Perucca (*Z. Physik*, 1934, 91, 660–669).—Experimental results and hypotheses due to various authors relating to the anomalous electrical conductivity associated with thin metal films are reviewed. Objections offered to P.'s postulation of the existence of a non-conducting superficial layer of normal metal are rejected, and additional evidence supporting this postulate is presented.—J. S. G. T.

The Transition of Electrons from Metal to Dielectric. N. Kalabuchow (*Z. Physik*, 1934, 92, 143–147).—The energies of transition of electrons from silver to mica and rock-salt are, respectively, about 0·5 and 1·8 v. less than the values for passage into a vacuum.—J. S. G. T.

***The Determination of Magnitude of the Motion of Conducting Electrons.** E. Patai (*Physikal. Z.*, 1934, 35, 837).—A method for determining the motion of conducting electrons in metals is sketched. Essentially the method is as follows: a current is established in a superconducting metal at the temperature of liquid helium, the metal being suspended by a fine torsion wire. The temperature of the wire is gradually raised up to the critical temperature; the current vanishes suddenly and a deflection of the torsion wire is observed, and therefrom the mechanical impulse due to cessation of motion of the conducting electrons can be calculated.—J. S. G. T.

***Deduction of the Magnetization–Function of Ferromagnetics which is Valid over the Complete Range of Temperatures.** H. Ludloff (*Z. Physik*, 1934, 91, 742–764).—On the basis that the energy values of a ferromagnetic are perfectly analogous to the energy values of a gas obeying van der Waals's equation and that the Bose statistical theory is applicable, a form of the magnetization function, which reduces to the Heisenberg and Bloch functions at high and low temperatures respectively, is deduced. The function also affords a satisfactory interpretation of the magnetization curve in the middle temperature range between the Curie points.—J. S. G. T.

***Ferromagnetism and Liquid Mixtures.** Clarence Zener (*Phys. Rev.*, 1934, [ii], 46, 824–825).—A theoretical note. The analogy between the development of magnetization as the temperature is lowered below the Curie point, and the separation of two immiscible liquids from a homogeneous liquid is developed (cf. Bitter, *Met. Abs.*, 1934, **1**, 380).—W. H.-R.

II.—PROPERTIES OF ALLOYS

(Continued from pp. 7–14.)

***On the Tensile Properties of Ordinary and Improved Aluminium Sand Casting Alloys as Compared with Cast Iron and Steel.** Alfred Evers (*Dissertation, Tech. Hochschule, München*, 1932, 63 pp.).—The mechanical properties of cast rods of alloys of aluminium with (*A*) zinc 14, copper 2%; (*B*) copper 8%; (*C*) zinc 13, copper 3·8, alkali and alkaline earth metals 0·2%; (*D*) copper 9·8, alkali metals 0·2%, have been compared with those of the commercial German and American casting alloys, Alufont and Lautal. The results are shown in a series of tables and graphs with the corresponding values for cast iron and steel. Taking into account their low sp. gr., the age-hardened alloys (*C*) and (*D*) have a much superior elastic limit to cast iron, while Alufont has a better tensile strength than electric-furnace cast iron and is practically the equivalent of a good cast steel. Only at temperatures above 250° C. are the ferrous metals superior to light metal castings. In dynamic tests, cast steel has a better " figure of merit " than any of the aluminium alloys, but these are in all cases superior to cast iron.—A. R. P.

***On the Eutectoid Transformation of the Aluminium–Zinc System.** Hiroshi Imai and Masami Hagiya (*Mem. Ryojun Coll. Eng.* (*Inouye Commemoration Vol.*), 1934, 83–105).—[In English.] The eutectoid transformation $\beta \longrightarrow \alpha + \gamma$ in the 21% aluminium–zinc alloy occurs at 270° C.; if this alloy is quenched from above this temperature a spontaneous heat evolution occurs immediately after quenching, and 3·5 minutes later the alloy reaches a maximum temperature of 50° C. above that of the quenching liquid. After the first minute, a rapid contraction occurs, the rate of contraction subsequently decreasing with time. The resistance after quenching increases abruptly for 2·5 minutes, then more slowly for another minute, and finally decreases slowly. Maximum hardness is reached 13 minutes after quenching, and 2 minutes later a second slow heat evolution occurs, accompanied by a slight contraction in volume, a second small increase in resistance, and a rapid fall in hardness. Normal resistance is attained after ageing for 1 month or by gradual heating to 150° C., and minimum hardness after tempering for 1 hr. at 100° C. Tempering at high temperatures accelerates the contraction in volume and again increases the hardness. It is concluded that the decomposition of β proceeds in three stages: $\beta \longrightarrow \beta'$ occurring rapidly and $\beta' \longrightarrow \beta''$ slowly at room temperature, and $\beta'' \longrightarrow \alpha + \gamma$ being complete only by tempering at just below the eutectoid point.—A. R. P.

***The Aluminium-Rich Alloys of the Ternary System Aluminium–Zinc–Manganese.** Alfred Schück (*Dissertation, Tech. Hochschule, Dresden*, 1934, 28 pp.).—The properties of aluminium alloys with 0–20% tin and 0–6% manganese have been examined. The structure shows $MnAl_7$ to be the only compound present; the melting point of the binary aluminium–$MnAl_7$ eutectic (649° C.) is depressed by addition of tin, decreasing to 620°–622° C. with 20% tin. Characteristic microstructures of all the alloys examined are shown. The tendency of alloys with a high tin content to segregate on solidification is prevented by addition of more than 3% manganese, since the $MnAl_7$ separates primarily as radial clusters which hinder the settling-out of the heavier tin. The alloys can readily be cast and worked but are comparatively soft, the 10 : 6 tin–manganese alloy having a Brinell hardness of only 50; this alloy cannot be appreciably hardened by heat-treatment. The resistance to corrosion is, on the whole, poor, considerable surface oxidation occurring in moist air.—A. R. P.

***Measurements of the [Magnetic] Susceptibilities of Aluminium Solid Solutions.** H. Auer (*Z. Physik,* 1934, 92, 283–290).—The magnetic susceptibilities of pure aluminium and of aluminium alloys containing various small proportions (up to 2·54%) of manganese, indium, germanium, gallium, copper, silver, zinc, lithium, and magnesium, respectively, have been determined by Gouy's balance method. The results show systematic deviations from an additive law, and these are attributable to effects associated with both alloying metals. The " free " ferromagnetic iron content of the test-pieces is deduced from the value of the susceptibility which is independent of the field-strength and compared with the iron content derived from spectral analysis. It is suggested that the greater part of the iron contained as an impurity in aluminium is present in the form of a paramagnetic combination with aluminium.
—J. S. G. T.

†Self-Hardening of Aluminium Alloys. M. von Schwarz (*Berg.- u. Hüttenw. Jahrb. Montan. Hochschule, Leoben,* 1934, 82, 133–137; discussion, 137).—The effect of heat-treatment on the properties of " Y," " R.R.", and some other aluminium casting alloys is described, and the value of these alloys for constructional work is discussed.—A. R. P.

Properties and Uses of Hydronalium. Paul Spitaler (*Berg.- u. Hüttenw. Jahrb. Montan. Hochschule, Leoben,* 1934, 82, 162–165).—The mechanical properties of several Hydronalium alloys are tabulated, and their use in constructional work designed to withstand sea-water corrosion is described.
—A. R. P.

†Modern Light Metal Pistons. M. von Schwarz (*Berg.- u. Hüttenw. Jahrb. Montan. Hochschule, Leoben,* 1934, 82, 148–157).—The composition, structure, and properties at high temperature of numerous modern piston alloys are described with reference to recent work.—A. R. P.

†Determination of Structure as an Aid in Alloy Research. E. Schmid (*Berg.- u. Hüttenw. Jahrb. Montan. Hochschule, Leoben,* 1934, 82, 126–132).—The value of a knowledge of the equilibria in alloy systems for determining suitable heat-treatment of alloys is illustrated with reference to various aluminium and magnesium alloys.—A. R. P.

†Special Cupro-Nickel Alloys. Léon Guillet (*Cuivre et Laiton,* 1934, 7).—A summary of the mechanical properties of (1) 70 : 30 copper–nickel alloys to which up to 6% of silicon has been added; (2) 80 : 20 copper–nickel alloys containing up to 0·7% silicon; and (3) various copper–nickel alloys containing aluminium. Platnam is an alloy containing copper 33–35, nickel 54–50, and tin 13–15%. Many of these special cupro-nickel alloys require complex heat-treatment in order to produce their most useful properties.—W. A. C. N.

***The Age-Hardening Characteristics of Some Copper–Nickel–Silicon Alloys.** Bruce W. Gonser and L. R. van West (*Metals and Alloys,* 1934, 5, 251–255, 281–283).—Comparative tests have been carried out on the age-hardening of copper alloys containing (*A*) nickel 4·4, aluminium 5·3, silicon 1%, and (*B*) nickel 1·8, silicon 0·4%. For complete solid solution of the constituents (*A*) must be heated at 900° C. for 2 hrs. and (*B*) at 775° C. for 1 hr. On quenching, (*A*) has a Brinell hardness of 68 and (*B*) 54; after ageing at 500° C. for 6 minutes (*A*) has a hardness of 215, and (*B*) after 4 hrs. at 500° C. a hardness of 180. The hardness of (*B*) is increased to 215–220 by working after quenching, and to 250 by working after hardening; X-ray photograms show that this alloy undergoes a structural change at 500°–700° C., the nature of which is as yet unknown.—A. R. P.

†**The Effect of Bismuth in Coinage Bronze.** S. W. Smith (*Rep. Roy. Mint (Lond.)*, 1933, 64, 58–60).—Certain brands of fire-refined copper have a copper content comparable with that of electrolytic copper, but retain small amounts of bismuth. While suitable for many purposes, bronze made from this metal frequently exhibits defects in rolling and "marking" (edge-smoothing) in coinage work. The severity of these defects does not appear to bear a quantitative relation to the amount of bismuth present, but does appear to be related to the degree of oxidation of the metal. Thus, under reducing conditions, bismuth, which in oxidized metal might be relatively innocuous, is rendered harmful. Owing to its very low solid solubility in copper, bismuth is thrown out of solution during solidification and forms brittle films between the grains. By allowing the metal to solidify very slowly, it has been possible to detect bismuth in this condition as finely branching threads running through portions of the cast structure, forming lines of weakness. If the metal survives the initial stages of rolling, it can generally be further rolled without any marked increase of brittleness, but the inherent weakness of the metal is shown by the tendency of subsequently made blanks to crumble at the edges when being "marked" or edge-smoothed.—J. H. W.

***Effect of Small Amounts of Nickel on the Properties of Bronze and Brass.** Ivan Čerkesov (*Chem. Obzor*, 1934, **9**, 156–160; *C. Abs.*, 1935, **29**, 101).—Investigations of the effect of nickel on some important properties of copper alloys are summarized. Their ductility, toughness, strength and hardness are increased; fine grain, compactness and homogeneous structure are also increased; greater strength is given to bronze at high temperatures, the corrosion-resistance and working are improved, and the solubility of lead in copper is increased.—S. G.

***Magnetic, Electrical, and Spectrographic Investigation of Gold–Silver Alloys.** H. Auer, E. Riedl, and H. J. Seemann (*Z. Physik*, 1934, 92, 291–302).—Measurements of the magnetic susceptibility and the electrical resistance of 2 series of gold–silver alloys extending over the complete range of compositions, subjected to various types of preliminary treatment, *viz.* heating *in vacuo*, and in nitrogen, recasting *in vacuo*, do not confirm the results of Shimizu, who found very marked changes of susceptibility associated with the different types of preliminary treatment. In general, the changes of susceptibility and electrical resistance are found to be less than 1%. Spectrographic investigations suggest that by far the greater proportion of the iron impurity present in the test-pieces of the alloys is present on the surface, and that the ferromagnetism exhibited by the test-pieces is principally attributable to this superficial iron and not to the relatively small proportion of iron dissolved in their interiors.—J. S. G. T.

***The Mobility of Gold in Solid Lead.** W. Seith and H. Etzold (*Z. Elektrochem.*, 1934, 40, 829–833).—The rate of diffusion of gold in lead between 113° and 300° C. has been measured, and the solubility of gold in lead at different temperatures has been determined. A series of experiments in which rods of lead–gold alloys were exposed to a flow of current of more than 100,000 amp.-hr. showed an excess of gold in the positive end from which a transference number of about 10^{-10} was deduced. No effect of the pressure on the rate of diffusion could be established.—J. H. W.

†**Bearing Metals of Lead Hardened with Alkali and Alkaline Earth Metals.** Leland E. Grant (*Metals and Alloys*, 1934, 5, 161–164, 191–195).—The properties of lead-base bearing metals of this type are critically discussed and compared with those of tin-base bearing metals. It is concluded that lead bearing metals will not carry as high loads nor function properly at as high speeds as the best tin-base metals, and, except in the case of Satco metal,

they lose appreciable amounts of the hardener on remelting. Nevertheless, the high compressive strength, the hardness, the high melting point, the low coeff. of friction, and the satisfactory resistance to wear give long life and good service under suitable conditions.—A. R. P.

***Bonding Strength of Babbitt to Steel and Bronze.** E. G. Soash (*Thesis: Ohio State Univ.*, **1934**, and (summary) *Metals and Alloys*, 1934, **5**, 268).—Large crank-pin and cross-head bearings, operating at 1200–1900 lb./in.^{2} maximum bearing pressure on the low-pressure side of compressors operating at 120 r.p.m., are subject to very severe service where there is a reversal of motion. In these circumstances, bearings lined with Babbitt metal (tin 83, copper 9·5, antimony 7·5%) ¼ in. thick give trouble by squeezing out and cracking; this trouble has been found to be due to the poor bond between the Babbitt and the shell. Cementation of the latter with copper or pickling with hydrochloric acid prior to tinning does not cure the trouble, but treatment with hot 30% caustic soda improves the bond. By tinning with a 50 : 50 lead–tin alloy at 300° C. using a zinc ammonium chloride flux, and applying the Babbitt immediately after tinning, a joint with a strength of 7000 lb./in.^{2} is obtained using a steel shell. Much better results have been obtained, however, with the same procedure using a 88 : 7 : 3 : 2 copper–tin–zinc–lead bronze shell; the joint has a strength of 13,000 lb./in.^{2}, and the bearings have run for 9000 hrs. without any sign of deterioration.—A. R. P.

***Electrical Conductivity and Equilibrium Diagram of Binary Alloys. XV.—The Lithium–Lead System.** G. Grube and H. Klaiber (*Z. Elektrochem.*, 1934, **40**, 745–754).—The lithium–lead alloys have been investigated by thermal analysis and by means of the temperature–resistance curves of the solid alloys. From the results, a complete equilibrium diagram has been constructed. The existence of the following intermetallic compounds was established: LiPb, Li_5Pb_2, Li_3Pb, Li_7Pb_2, and Li_4Pb. The compounds LiPb, melting at 482° C., and Li_7Pb_2, melting at 726° C., can be melted without decomposing; the remaining compounds are formed by peritectic reactions. The upper temperature limits for these latter compounds are: Li_5Pb_2, 642° C.; Li_3Pb, 658° C.; and Li_4Pb, 648° C. Lead takes up the compound, LiPb, within a narrow range of composition to form the α-solid solution. The saturation composition of this solid solution is dependent on the temperature. The compound LiPb exists in two forms with a transformation point at 214° C.; below this temperature the stable form has a negative, and above a positive, coefficient of electrical resistance. With excess lithium, the compound LiPb, within a limited range, forms the β-solid solution, which changes to the β′-solid solution below 214° C. The saturation composition of the β-solid solution is 53·3% of lithium. The compound Li_7Pb_2 with excess lithium forms the γ-solid solution whose range of homogeneity is only about 1%.—J. H. W.

***Electrical Conductivity and Equilibrium Diagram of Binary Alloys. XVI.—The Lithium–Tin System.** G. Grube and E. Meyer (*Z. Elektrochem.*, 1934, **40**, 771–777).—The lithium–tin alloys have been investigated by thermal analysis and by means of the temperature–resistance curves of the solid alloys. From these results a complete equilibrium diagram has been constructed. The existence of the following intermetallic compounds has been established: $LiSn_2$, LiSn, Li_2Sn, Li_5Sn_2, Li_7Sn_2, and Li_4Sn. The compounds LiSn, melting at 485° C., Li_7Sn_2, melting at 783° C., and Li_4Sn, melting at 765° C., can be melted without decomposing; the remaining compounds are formed by peritectic reactions. The upper temperature limits of these latter compounds are: $LiSn_2$, 326° C.; Li_2Sn, 502° C.; and Li_5Sn_2, 720° C. Pure tin takes up lithium in appreciable quantities with the formation of a solid solution. The compound LiSn with excess lithium forms solid solutions with the very narrow range of composition of 1%. The compound Li_7Sn_2 with excess tin forms the α-solid solution, whose saturation composition is 76·0% of lithium at 720° C.—J. H. W.

†**Development and Present Position of Elektron.** Paul Spitaler (*Berg.- u. Hüttenw. Jahrb. Montan. Hochschule, Leoben*, 1934, **82**, 113–121).—A very complete account is given of the structural characteristics, working and mechanical properties of Elektron alloys, the tensile properties of 19 alloys for extrusion and forging, and of 3 alloys for rolling being tabulated.—A. R. P.

Manganese : Its Occurrence, Milling, and Metallurgy. IV.—Ferrous Alloys of Manganese and Their Use in the Steel Industry. G. R. Fitterer and M. B. Royer (*U.S. Bur. Mines Information Circ.* No. 6771, 1934, 253–308).—A review, including the phase diagrams of the systems Fe–Mn, Mn–C, Mn–Si, Fe–Mn–Si, Fe–Mn–Si–C.—S. G.

†**The " 720 " Silver–Copper Alloy.** S. W. Smith (*Rep. Roy. Mint* (*Lond.*), 1933, **64**, 56–58).—Recent silver coinages for foreign countries have been made of an alloy with copper and containing 720 parts per 1000 of silver, *i.e.* approximately the eutectic alloy, which melts at 778° C. Unless the temperature of pouring is kept as low as possible and the consequent chilling and solidification are fairly rapid, there is a great tendency for the strip to split on rolling. There are wide differences in the structure of the quickly and the slowly solidified metal. The former consists of a very fine microstructure in which it is almost impossible to resolve the two constituents even under very high magnification, while the macrostructure is coarse and well-defined. The portions immediately adjacent to the surfaces of the mould consist of columnar crystals perpendicular to those surfaces, while the interior portions, the last to solidify, consist of spherulitic grains which have apparently solidified radially from a nucleus. This is an unusual form of crystallization and may have some bearing on the observations of Andrade and Martindale (*Nature*, 1934, **134**, 321) on the character of metal spherulites. In very slow solidification, the well-developed laminated microstructure results, the macrostructure consisting of fern-like dendrites of fine eutectic colonies surrounded by somewhat coarser eutectic. In this condition, the metal is unsuitable for working. The observations made show that this alloy, when rapidly solidified from a temperature little above its melting point, may be regarded for all practical purposes as *almost* a solid solution.—J. H. W.

***Solidification Diagrams of Alloys Formed by Two Alkali Metals : The Sodium–Cæsium Alloys.** E. Rinck (*Compt. rend.*, 1934, **199**, 1217–1219).—The equilibrium diagram of the sodium–cæsium alloys has been determined by thermal analysis. A eutectic point occurs at 75 atomic-% of cæsium and — 30° C., and a transition point at 71 atomic-% and — 8° C., a new compound, Na_2Cs, being deposited between these two points. The cryoscopy of sodium in rubidium and in cæsium confirms Jouniaux's observation that at temperatures above 63·5° C. sodium is sensibly monatomic, the molecular weights being 23·6 and 22·4. A number of conclusions are drawn as to the molecular weights of potassium, rubidium, and cæsium as a result of the consideration of the equilibrium diagrams of these metals with sodium. —J. H. W.

†**Tungsten and Chromium Alloys in the Production of Stainless Steel [Tungsten–Iron, and Chromium–Iron Alloys].** Bernhard Matuschka (*Stahl u. Eisen*, 1934, **54**, 845–853).—The compositions of, and the impurities in, commercial tungsten–iron and chromium–iron alloys, rich in tungsten and chromium, respectively, are discussed. Photomicrographs are reproduced. —W. H.-R.

†**Zinc Die-Casting Alloys.** R. G. Kennedy (*Metallurgist* (Suppt. to *Engineer*), 1934, **10**, 151–152).—A critical summary of a paper by K. in *Metals and Alloys*, 1934, **5**, 106, 112, 124–126. See *Met. Abs.*, 1934, **1**, 346, 381.—R. G.

***Initial Wear [in Bearings].** Harry Shaw (*Machinery* (*Lond.*), 1934, **45**, 427–431).—" Initial wear " in a new bearing depends partly on the roughness of the bearing surfaces. In these experiments it was considered to be in progress so long as $\frac{1}{20}$ grain of metal could be detected in 1 gall. of clear oil fed through the bearing in an hr. Determinations were made of the wear occurring in this period in bearing assemblies of cast-iron shafts in cast-iron bearings, steel in phosphor–bronze, and steel in white metal. Three different finishes—fine-boring, honing (reaming in the white-metal bearings), and grinding—were tested with each combination at a series of running speeds and pressures, lubrication being effected by both plain and graphited oil. The wear was measured in respect to datum faces by a " Contorograph," in which the movements of a fine needle traversing the surface were magnified optically and recorded on a photographic plate. The wear on honed or ground surfaces was less than on fine-bored surfaces. The wear in the reamed white-metal bearings was considerably less than in any other combination. The use of graphited oil reduced the initial wear in all tests by $\frac{5}{8}$–$\frac{1}{8}$.—J. C. C.

Directionality in Some Annealed Alloys. R. G. Johnston (*Met. Ind.* (*Lond.*), 1934, **45**, 560–562, 588–590, 613–614; discussion, 615–616).—Read before the Midland Metallurgical Societies (Birmingham Local Section of the Institute of Metals, Birmingham Metallurgical Society, and Staffordshire Iron and Steel Institute). The directions of the maximum diameter, that is, the longest line that can be drawn on a grain-section, are plotted in the manner of polar co-ordinates for all grains visible in a given photomicrograph. The grains are thus found to have a preferred orientation, and the eccentricity of the ellipse which will best fit the points obtained is called the " Index of Directionality." Prolonged high temperature appears to lower the directionality. The preferred orientation is across the direction of previous rolling, and reasons for this are suggested.—J. H. W.

***The Preparation of Certain Definite Alloys.** Pierre Pingault (*Compt. rend.*, 1934, **199**, 1223–1225).—When definite alloys cannot be easily formed by simple mixing of their constituents, they can sometimes be made by adding a compound of one to the other. Combinations of some metals with metalloids are examples, and, in particular, the iron–tin alloy corresponding with the compound $FeSn_2$ is such an alloy. This can be made by mixing pure tin and a solution of ferrous chloride in zinc chloride at 250° C. Part of the tin reacts with the ferrous chloride to form stannous chloride, which decomposes to the oxychloride, and the iron set free acts on the remaining tin. After treatment for 12 hrs. an alloy results containing 18·9% of iron ($FeSn_2$ contains 19·04% theoretically), and can be isolated either chemically (nitric acid attack) or mechanically (compression at about 290° C. under 20 tons/cm.^{2} pressure). The zinc chloride acts as an autoclave and can in certain circumstances be omitted.—J. H. W.

†The Diffusion of the Elements in the Solid State: a New Aspect. Binayendra Nath Sen (*Compt. rend.*, 1934, **199**, 1189–1190).—It is claimed that a relation exists between the minimum atomic distances and the direction of diffusion in the solid state. Diffusion takes place in such a direction that the element which penetrates into the other is that whose minimum atomic distance is the lesser. It has already been shown (*Chem. News*, 1932, **145**, (3774), 93; and *Z. anorg. Chem.*, 1933, **212**, 410) that solid diffusion is analogous to the formation of amalgams, the only difference is that the latter is much more rapid and causes a rupture of the metallic lattice which the former does not.—J. H. W.

III.—STRUCTURE

(Metallography; Macrography; Crystal Structure.)

(Continued from pp. 14–17.)

***The Recrystallization of Elektron.** A. P. Guljev (*Vestnick Ingenerov i Tehnikov* (*Messenger Eng. and Technol.*), 1934, (9), 420–421).—[In Russian.] The annealing of cold-worked (hammered) Elektron (aluminium 3·93, manganese 0·55, zinc 0·96%) at 300°, 325°, 350°, and 375° C. for periods up to 24 hrs. is described. At all these temperatures recrystallization is complete in 1 minute, in which time the tensile strength is reduced from 35 to 28 kg./mm.^{2} and the elongation increased from 2–3 to 15–20%. Curves are given showing the change in mechanical properties with time of annealing.—N. A.

***The Nature of Recrystallization Processes.** Horst Guido Müller (*Physikal. Z.*, 1934, 35, 646–649).—Read at the 18 Tagung des Gauvereins Thüringen-Sachsen-Schlesien der Deutschen Physikalischen Gesellschaft. The process of recrystallization in solid rock-salt crystals (natural and artificial) is investigated experimentally. Amongst matters examined are: the dependence of the velocity (v) of recrystallization upon temperature in the case of crystals subjected to various degrees of compression between 1000 and 4000 grm. mm.^{2}; the relation of v to the electrolytic conductivity of the crystals. The process of recrystallization is considered to depend upon processes of diffusion; the production of recrystallization grains is not dependent upon any special nuclei being present.—J. S. G. T.

***Plasticity and Mosaic Structure of Cast [Metals] and of Recrystallized Metals.** U. Dehlinger and F. Gisen (*Physikal. Z.*, 1934, 35, 862–864).—In continuation of previous work (*Met. Abs.*, 1934, 1, 77) D. and G. investigated the effect of purity on the plasticity and mosaic structure of cast and recrystallized aluminium. The results show that recrystallized grains of the metal which have not attained a state of thermodynamic equilibrium possess a more marked mosaic structure than the cast metal. The mosaic structure produces a marked effect on the shear limit of the recrystallized metal, which steadily decreases with increasing purity of the metal but does not attain zero value for the pure metal. Cast metal has a shear limit certainly less than 20 grm./mm.^{2}. Impurities up to 0·5% do not increase this value appreciably. The effects of crystal structure and equilibrium on shear limit are briefly discussed.—J. S. G. T.

***X-Ray Determination of Residual Distortion of the Space-Lattice of Pressed Duralumin.** F. F. Kosolapov and E. F. Bachmetev (*Vestnick Metallopromishlennosti* (*Messenger Metal Ind.*), 1934, 14, (3), 76–82).—[In Russian.] See *Met. Abs.*, 1934, 1, 446.—D. N. S.

***Fatigue and Crystal Recovery in Aluminium.** Howard A. Smith (*Physics*, 1934, 5, 412–414).—X-ray work on fatigue in copper, silver, and steel is briefly reviewed. Results of an investigation of service fatigue fractures in high-voltage transmission cables made of aluminium are discussed. Crystals forming the shallow surface layer of the fractures had recovered sufficiently from the microscopic distortion due to cold-drawing, to enable individual monochromatic diffraction spots to be identified. Possible causes contributing to this crystalline recovery are briefly discussed.—J. S. G. T.

***Röntgenographic Investigations on α-Tin Bronzes.** Takesaburo Isawa and Ichiji Obinata (*Mem. Ryojun Coll. Eng.* (*Inouye Commemoration Vol.*), 1934, 235–242).—[In German.] Copper–tin alloys with up to 18% tin have been rolled, homogenized at temperatures up to 750° C., and examined with X-rays. The results show that the solubility of tin in copper is at 750° C., 14·45%; 700° C., 15·20%; 645° C., 15·43%; 600° C., 15·70%; 550° C., 15·90%; 500° C., 15·50%; 400° C., 13·90%; 218° C., 13·90%. Maximum solubility is reached, therefore, at the eutectoid temperature. Tempering of the quenched solid solution with maximum tin content results in a slow separation of the excess tin accompanied by lattice distortion.—A. R. P.

***Comparative Metallographic Study of Hard Alloys of the Stellite Type [Sormite, Celsite, Acrite, Reinite, Studite].** N. Zarubin and Yu. Raikhlin (*Zavodskaya Lab.*, 1934, 3, 141–152; *C. Abs.*, 1935, 29, 98).—[In Russian.] The results of metallographic tests of alloys of the Stellite type, such as Sormite, Celsite, Acrite, Reinite, and Studite, by etching with various common reagents, are shown by 28 photographs. A number of references is given.—S. G.

X-Ray Analysis of the Structure Changes on Cold-Deformation of Metals. G. S. Zhdanov (*Zavodskaya Lab.*, 1934, 3, 48–56, 156–158; *C. Abs.*, 1935, 29, 91). —[In Russian.] The discussion of the structural and physical changes of various metals produced by cold-rolling and -drawing, and the technique of X-ray investigation, is based on the literature. A *bibliography* is given.—S. G.

***X-Ray Investigation of Lattice Recovery of Metals after Cold-Working.** J. E. Wilson and L. Thomassen (*Phys. Rev.*, 1934, [ii], 46, 337).—Abstract of a paper read before the American Physical Society. Copper, nickel, iron, and a number of alloys have been studied to find the time–temperature relationship of X-ray line sharpening on annealing. The line broadness of nickel was investigated as a function of annealing time at a constant temperature. After an initial drop, the broadness is constant for a certain time, then decreases to its original value. For constant annealing time, individual metals vary widely both in temperature of initial line sharpening and in temperature range of the complete recovery process. For completion of the second stage of line sharpening, an expression $T = K_1/(\log t + K_2)$ is found, where T is annealing temperature in ° abs., t is annealing time in seconds, and K_1 and K_2 are characteristic constants of the metal. Results have been correlated with hardness measurements and available data on electric and magnetic recovery from cold-work. These stages of recovery and recrystallization have been interpreted on the basis of reformation of undisturbed electron shells and differences in rates of diffusion of atoms.—S. G.

†The Dispersion of X-Rays in Liquid Metals and Alloys. V. I. Danilov (*Uspehi Fizicheskih Nauk* (*Progress Phys. Sci.*), 1934, 14, 449–469).—[In Russian.] A comprehensive review with 27 references.—N. A.

***Determination of Elastic Stresses in Micro-Crystalline Aggregates by the Debye–Scherrer Method with Regard to the Anisotropy.** G. J. Aksenow (*Zhurnal eksperimentalnoy i teoreticheskoy Fiziki* (*J. Exper. and Theoret. Physics*), 1934, 4, 627–642).—[In Russian.] The influence of elastic stresses on the position of the lines on the Debye–Scherrer diagram is investigated theoretically, taking into account the anisotropy of the microcrystals forming the body.—N. A.

***A New Characteristic of Structural Analysis.** N. Seljakow (*Z. Physik*, 1934, 92, 543–546).—The relationship between stereographic crystal projection and X-ray spectra obtained by the rotating crystal method is discussed. It is shown that the X-ray photograph obtained by this method is affected to a greater degree by reflections at large angles than by those at small angles.
—J. S. G. T.

†Adsorptive Growth (Einbau) and the Production of Solid Solutions. Adolf Smekal (*Physikal. Z.*, 1934, 35, 643–646).—Read at the 18 Tagung des Gauvereins Thüringen-Sachsen-Schlesien der Deutschen Physikalischen Gesellschaft. Literature relating to the significance of similarity of crystal structures, lattice energy, and the presence of small proportions of impurities in the production of solid solutions is critically reviewed.—J. S. G. T.

***Electronic Functions for a Metallic Crystal.** W. V. Houston and C. B. Crawley (*Phys. Rev.*, 1934, [ii], 46, 329).—Abstract of a paper read before the American Physical Society. Variation methods have been fruitful in obtaining good approximations for the characteristic functions of atoms with many electrons. A similar method can be applied to crystals. It can be shown that the functions first introduced by Bloch are good approximations to the exact solution, even when the electronic interaction is included, if the proper atomic functions are used in them. These atomic functions can be determined by the variation method. This method has been applied to lithium. The atomic functions were taken as simple 2 *s* functions of Slater's type with a single parameter. They were made orthogonal to the 1 *s* function by the inclusion of a suitable amount of the 1 *s*. The best value of the parameter was determined to get the lowest value of the energy. The results show fair agreement with the lattice constant, the lattice energy, and the compressibility.—S. G.

***On the Interaction of Electrons in Metals.** E. Wigner (*Phys. Rev.*, 1934, [ii], **46**, 1002–1011).—The energy of interaction between free electrons in an electron gas is considered, and the results are compared with the observed lattice constant and binding energy of metallic sodium.—W. H.-R.

IV.—CORROSION

(Continued from pp. 17–19.)

Physico-Chemical Characteristics of Light Metals. Robert Müller (*Berg.- u. Hüttenw. Jahrb. Montan. Hochschule, Leoben*, 1934, **82**, 121–124: discussion, 124–126).—A discussion of the electrochemical properties of aluminium, magnesium, and beryllium with especial reference to their bearing on the behaviour of the metals in corrosive media.—A. R. P.

***Investigation of the Structural Corrosion of Aluminium Alloys. II.—Microscopic Investigation of the Process of the Structural Corrosion of Aluminium Alloys.** G. W. Akimov and A. S. Oleshko (*Zhurnal Fizicheskoy Khimii* (*J. Phys. Chem.*), 1934, **5**, 434–445).—[In Russian.] The corrosion of alloys of aluminium with (*a*) 8·8 and 27·5% zinc and (*b*) 6·5% copper has been followed with the aid of the metallographic microscope, alizarin being added to the corroding medium to indicate the formation of aluminium hydroxide. The corrosion of the zinc alloys (*a*) is caused by the heterogeneity of the individual grains, the variations in the distribution of zinc in which are such that the edges and adjacent regions act in the first instance as cathodes. Again, variations in the surface condition can be produced by a peculiar structure of the solid solution and also by inequalities in the natural protective layer. In the copper alloys (*b*), segregations of $CuAl_2$ are cathodic and the solid solution is anodic, those parts of the latter which form the eutectic being particularly rapidly destroyed. In iron–aluminium alloys, the $FeAl_3$ inclusions act as very strong cathodes, corrosion being very intensive in their vicinity, but in aluminium–manganese and –nickel alloys the $MnAl_3$ and $NiAl_3$ inclusions are very feebly cathodic, and in alloys containing magnesium and silicon, the Mg_2Si is strongly anodic and therefore rapidly destroyed.—N. A.

Aluminium in Chemical Plants. Francis C. Frary (*Chem. Industries*, 1934, **35**, 499–503).—The rate of corrosion of aluminium by acetic acid at 50° C. decreases rapidly with increase in concentration about 80%, and is practically nil in 100% acid. In 0·1% acid, the rate of penetration is, however, only 0·0020 in. per year. Aluminium is also unattacked by nitric acid of greater concentration than 80% and by organic resins and lacquers. Attack by refrigerating brines may be prevented by addition of potassium dichromate equivalent to 1% of the chlorine content of the brine. Alloys for various chemical purposes are indicated, and some notes are given on their working and heat-treatment.—A. R. P.

***Effect of Fluid Velocity on Heterogeneous Reactions. II.—Effect of Fluid Velocity on Solution Velocity of Metallic Copper in Ammoniacal Cupric Solutions.** Sun-ichi Ichida and Ichirō Nakayama (*Kōgyō Kwagaku Zasshi* (*J. Soc. Chem. Ind. Japan*), 1933, **36**, (11).—[In Japanese, with full English summary in supplemental binding, pp. 635–642.] Ammoniacal cupric solution saturated with oxygen was passed through copper tubes of 3 different diameters at 25° C., and the reaction velocity constant k was found to be expressed by $kd = 0{\cdot}0000225 \left(\frac{d\bar{u}\rho}{\mu}\right)^{0{\cdot}79}$, where d is the inside diameter of the copper tubes, $\bar{u}$ the mean velocity of the fluid, ρ its density, and μ its velocity. From $d\bar{u}\rho/\mu$ = about 4000, the pure chemical reaction begins to play a part and the deviation from the above equation occurs in the direction of kd to become independent of $d\bar{u}\rho/\mu$. The manner in which $d\bar{u}\rho/\mu$ affects the reaction velocity constant is similar to heat-transfer processes. The viscous flow region was not distinct because of probable disturbances.—S. G.

***Corrosion of Iron, Copper, and Lead in Calcium Chlorate Liquors.** S. S. Shraĭbman and A. V. Balečv (*Khimistroĭ*, 1934, **6**, 460–461; *C. Abs.*, 1935, **29**, 102).—[In Russian.] The corrosion of iron is greater than that of copper and lead, and is greatly increased with increasing temperature (to 100 times from 20° to 100° C.). With increased duration of the action of liquor the absolute value of the corrosion of copper and lead per 24 hrs. is decreased by the formation of a protective film. Lead is more resistant to corrosion at lower temperatures (20°–45° C.), but loses resistance rapidly at higher temperatures. The corrosion of copper increases with increasing temperature but less than that of lead and still less than iron (about 5–6 times). The difference in the duration of liquor action has no effect on the corrosion magnitude of iron for 24 hrs. The corrosion magnitude of copper at 20°–45° C. is also little affected by the changes in the duration of liquor action. Copper at 75° and 100° C. and lead at all temperatures show a decrease in the magnitude of corrosion with the increased duration of the liquor action, which may be explained as due to the formation of protective film.—S. G.

Electrolytic Destruction of Direct Current Feed [Lead-Covered] Cables for Tramways. W. Wegener (*Korrosion u. Metallschutz*, 1934, **10**, 213–217).—A description is given of a case of corrosion of an underground lead-covered cable feeding a street tramway. Tests have shown that this trouble can be avoided by well insulating the cable in the earth and by providing between the cable and the water-pipes a sensitive relay which cuts out the section when the insulation fails; an automatic cut-out to guard against overloading of the cable should also be used.—A. R. P.

Factors Causing Danger of Corrosion of [Lead] Towers and Chambers in Sulphuric Acid Production and Their Action. V. N. Ignat'eva (*J. Chem. Ind.* (*U.S.S.R.*), **1934**, (8), 35–36; *C. Abs.*, 1935, **29**, 297).—[In Russian.] When a small excess of N_2O_3 in sulphuric acid solution is allowed to stand in the apparatus, a galvanic element is created, and corrosion of the lead follows. —S. G.

***Studies on the Oxidation of Metals.—I [Lead; Tin].** G. D. Preston and L. L. Bircumshaw (*Phil. Mag.*, 1935, [vii], **19**, 160–176).—Oxide films formed on lead and tin have been examined by the electron diffraction method. Films have been examined at room temperature by removing them from the molten metal on wire loops and by preparing them by heating foils supported on wire loops. Films formed on molten drops at temperatures a little above their melting point have also been examined. Oxide films of tin possess the usual SnO_2 crystal structure—a tetragonal cell of side 4·72 A. and height 3·17 A. Traces of SnO are possibly present, and the SnO_2 film is probably oriented with the "c" axis perpendicular to the surface of the drop. The oxide films of lead prepared by heating foil and by removing the oxide from the molten metal consist of orthorhombic (yellow) PbO with possibly traces of the tetragonal (red) modification. They show orientation with the "c" axis perpendicular to the plane of the film. The oxide film on drops of molten lead is tetragonal (red) PbO; orientation has not been found in this film. —J. S. G. T.

***Influence of Manganese on the Corrosion of Magnesium.** W. O. Kroenig and S. E. Pavlov (*Korrosion u. Metallschutz*, 1934, **10**, 254–263).—The potential of vacuum-sublimed magnesium in distilled water is − 1·78 v. against the *N*-calomel electrode, whereas that of 99·72% magnesium (manganese 0·08, silicon 0·04, iron 0·04, and aluminium 0·12%) is − 1·66 v. immediately after immersion and − 1·49 v. when equilibrium is reached; addition of further manganese between 1·3 and 4·1% still further reduces this negative potential. These effects are shown to be due to the formation of a protective film of manganese and magnesium hydroxides, the former slowly oxidizing to the hydrated dioxide and imparting first a golden, then a brown, and finally an almost black colour to the metal when exposed to sea-water. The manganese dissolves only to a limited extent in the magnesium, the remainder being present as a finely divided, evenly distributed compound of the two metals. The behaviour of manganese–magnesium alloys in sea-water is shown in photomicrographs, and the causes of the observed phenomena are briefly discussed.—A. R. P.

***A New Method for the Investigation of Corrosion-Resistance (Corrosion of Zinc and of a 1% Copper–Zinc Alloy).** E. V. Zehnovizer (*Zhurnal Fizicheskoy Khimii* (*J. Phys. Chem.*), 1934, **5**, 607–616).—[In Russian.] The corrosion of zinc and of a 1% copper–zinc alloy has been followed by measurements of the electrical conductivity of the solutions produced by their slow dissolution in 0·1 and 0·01*N* sulphuric acid; in this way observations can be made uninterruptedly of the induction period and the temporary passivity of the metal. The corrosion-resistance of the alloy is considerably lower than that of pure zinc. Preliminary experiments on the corrosion of zinc in distilled water show that zinc hydroxide is formed; the increase in conductivity of the water corresponds with a solubility of 0·0014 grm./litre of hydroxide.—N. A.

***Study of the Topography of Certain Surfaces According to Their Coefficient of Light Diffusion. Applications to Corrosion.** François Canac (*Compt. rend.*, 1934, **199**, 1117–1118).—The coeff. of diffusivity has been experimentally studied on surfaces in the form of juxtaposed hemispherical hollows and mounds, of which the brightness is independent of the angle of incidence and inversely proportional to the cosine of the angle of diffusion. A frequently observed case, in particular for a corroded surface, is that in which the surface consists of a large number of hemispherical cups made larger by little hemispherical hollows on their surfaces. It can easily be shown that the useful surface capable of reflecting in the direction, ε, is: $S = AR^2(\pi - \frac{5}{3} - \frac{3}{3}\varepsilon)$. As the cups increase in size, the diffusion continues to increase to a maximum. It is observed that: (1) this is attained at the same moment as the angle of illumination, and (2) the value of the diffused light decreases linearly as the incidence increases.—J. H. W.

***The Action of Solutions of Nitrocellulose on Different Materials.** S. I. Sklyarenko and A. B. Pakshver (*J. Chem. Ind.* (*U.S.S.R.*), 1934, (7), 47–50; *C. Abs.*, 1935, **29**, 102).—[In Russian.] Tin, aluminium, acid-resisting steels, and those containing a large amount of carbon are corroded only slightly or not at all by EtOH–Et_2O or EtOH–Me_2CO solutions of nitrocellulose. Iron, copper, lead, zinc, bronze, and steel containing little carbon are corroded by such solutions. The action is due entirely to traces of sulphuric and nitric acids in the nitrocellulose, and is increased somewhat by the presence of increased amounts of water. Nitrocellulose itself exerts a protective action against the corrosion.—S. G.

Corrosion in the Chemical Industries.—VI. O. A. Knight (*Mineral Ind., Pennsylvania State Coll.*, 1934, **3**, (7), 4).—General.—S. G.

†**Internal Corrosion of Natural-Gas Transmission Lines.** Elmer F. Schmidt and Thomas S. Bacon (*Gas Age-Record*, 1934, **74**, 531–534, 536).—Causes and effects of the internal corrosion of natural-gas transmission lines are reviewed. —J. S. G. T.

***The Limiting Current in Anodic Polarization of Metals in Aqueous Solutions.** Erich Müller and Kurt Schwabe (*Z. Elektrochem.*, 1934, **40**, 862–870).—The limiting current in the electrolysis of the aqueous solutions of a number of lead salts using anodes of an alloy containing lead 99, gold 1% has been investigated.—J. H. W.

V.—PROTECTION

(Other than Electrodeposition.)

(Continued from pp. 20–21.)

***Surface Treatment and Surface Protection of Aluminium and Aluminium Alloys.** H. Röhrig (*Korrosion u. Metallschutz*, 1934, **10**, 135–142; and (translation) *Light Metals Rev.*, 1934, **3**, 85–92).—The rate of corrosion of aluminium and its alloys is considerably influenced by the nature of the surface, being much greater with a rough surface than with a smooth surface, thus the loss in weight of aluminium after 40 hrs. in 1% sodium chloride solution containing 1% of hydrogen peroxide is: sand-blasted surface, 17·2; surface polished with steel wool, 4·2; scratch-brushed surface, 2·5; surface pickled in 5% sodium hydroxide solution at 50° C., 8·7; surface pickled in 20% hydrochloric acid at 20° C., 3·7; as rolled surface without any treatment, 2·2; surface protected by M.B.V. treatment, 0·46; surface treated by the Eloxal process, 0·1 grm./m.^{2}. Curves are given showing the rate of attack in 1·5*N*-hydrochloric acid of bright-rolled, oxidized, oxidized and steam-treated, and oxidized and impregnated (fat) aluminium, Lautal, and Silumin surfaces; in all cases the resistance to corrosion is greatest with the last-named treatment. Bright aluminium surfaces may be kept in this condition by cleaning with dilute hydrochloric acid containing certain resins as inhibitors; this treatment is recommended for cleaning brewery vats, &c., in preference to the usual nitric acid treatment. —A. R. P.

The Application of Anodized Aluminium and Its Alloys. G. O. Taylor (*Metallurgia*, 1934, **11**, 15–16).—A description of the application of the anodizing process for improving the corrosion-resistance of aluminium and certain of its alloys, to the aircraft, automobile and cycle, building, chemical, electrical, and photographic industries.—J. W. D.

Metallization. —— Cauchetier (*Bull. Soc. Ing. Soud.*, 1934, **5**, 1247–1268; and (abstract) *Machine moderne*, 1934, **28**, 395).—The construction and handling of the Schoop spraying pistol are described. The characteristics of sprayed coatings and the reasons for their porosity are explained. Several methods are suggested for improving the corrosion-resistance of such coatings. In the case of zinc, for example, treatment with brine forms a resistant film of oxychloride. The economics of the process and many applications are discussed.—H. W. G. H.

Sprayed Molten Metal Coatings. E. V. David (*J. Amer. Weld. Soc.*, 1934, **13**, (9), 16–20; and (abstract) *Iron Age*, 1934, **134**, (15), 38).—A review of the spraying process, with particular reference to its applications.—H. W. G. H.

Durability of Aluminium Paints. Fr. Kolke (*Farbe u. Lack*, **1934**, 473–474; *C. Abs.*, 1935, **29**, 359).—The exterior durability of aluminium paints depends more on the leafing properties of the aluminium-bronze than on the durability of the vehicle.—S. G.

VI.—ELECTRODEPOSITION

(Continued from pp. 21–22.)

***Theory and Practice of Chromium Plating.—I.** N. D. Biriukov, S. P. Makarieva, and A. A. Timohin (*Vestnick Metallopromishlennosti* (*Messenger Metal Ind.*), 1934, **14**, 118–134).—[In Russian.] Baths containing chromic acid 300 grm./litre and sulphuric acid 4·4 and 8·8 grm./litre have been operated for 30–35 amp.-hrs. with varying intervals of several hrs. and determinations made after each run, of the weight of chromium deposited, the amounts of hydrogen and oxygen evolved, and the amounts of Cr^{II}, $\Sigma Cr^{III} + Cr^{VI}$ in the bath. The chromium deposition reaches a maximum of 35% current efficiency after a definite number of amp.-hrs. depending on the SO_4'' and Cr^{III} concentrations. Oxidation at the anode corresponding to the difference between total consumption of current and that consumed in oxygen evolution, after 25–30 amp.-hrs. is due not only to the reaction $Cr^{III} \longrightarrow Cr^{VI}$ but also to the formation of perchromic acid and its salts. Increase in concentration of Cr^{III} with decrease in free SO_4'' lowers the deposition of metallic chromium. For every equivalent of chromium deposited, an equivalent of Cr^{VI} is reduced to Cr^{III}.—D. N. S.

***Theory and Practice of Chromium Plating.—II.** N. D. Biriukov, S. P. Makarieva, and A. A. Timohin (*Vestnick Metallopromishlennosti* (*Messenger Metal Ind.*), 1934, **14**, 103–120).—[In Russian.] In operating the sulphuric-chromic acid plating bath with a high current density, the cathode yield is increased by intermittent working since the interruptions afford time for the complex $Cr_2(CrO_4)_2SO_4$ formed during the electrolysis to decompose again into sulphuric acid and chromium bichromate. The voltage changes at the electrode terminals are also affected by interruptions, the difference between the initial and final values being considerable after a long interruption. The curves showing the initial voltages in the individual experiments of a series against the life of the bath in amp.-hrs. always exhibit several maxima corresponding neither with the time of interruptions nor with the sulphuric acid concentration. The expression $K = \dfrac{\%\text{ current for depositing metallic chromium}}{\%\text{ current for reducing } Cr^{VI} \text{ to } Cr^{II} \text{ and } Cr^{III}}$ approaches a constant value of nearly 2 after the bath has been used for a definite number of amp.-hrs. depending on the concentration of sulphuric acid. Variation in the values of K are regular and the maxima correspond to maxima on the voltage curve. The rate of hydrogen evolution depends on the surface condition of the cathode and on the intervals between the experiments; after a long interruption, the rate alters in an ascending curve.—D. N. S.

***Influence of Temperature on Efficiency of Chromium Plating.** R. J. Piersol (*Metal Cleaning and Finishing*, 1934, **6**, 353–356; *C. Abs.*, 1935, **29**, 53).—The effect of the temperature on the rate of deposition of hard, thick, impervious chromium deposits for wear- and corrosion-resistance at elevated temperatures was investigated. The experimental findings for efficiencies of 5–40% for temperatures between 24° and 68° C. and current densities up to 20 amp./in.^{2} show the general tendency of high efficiency at high current densities and low temperatures. At any given temperature there was the same % increase in efficiency for a doubling of the current density regardless of the value of current density used as reference.—S. G.

***Influence of Current Density on Chromium Hardness.** R. J. Piersol (*Metal Cleaning and Finishing*, 1934, **6**, 453–455; *C. Abs.*, 1935, **29**, 53).—Experimental results show the interrelation of the current density, and iron and Cr^{III} concentrations in the hardness of chromium electrodeposits.—S. G.

On the Determination and Removal of Faulty Chromium Plating from Sheet Metal. Werner Frölich (*Metallbörse*, 1934, **24**, 1049–1050).—The copper

sulphate and ferroxyl tests are the best methods of detecting porosity in chromium plate direct on a ferrous metal base. When a nickel undercoat has been used, however, these reagents are useless, and the only satisfactory test comprises immersion of the article in 1 : 1 ammonia containing 2 grm. of dimethylglyoxime per litre for 12–24 hrs., the pores being indicated by the development of red spots or streaks where the nickel is exposed. Faulty chromium plate strips readily in hydrochloric acid, but it is difficult to recognize the point at which stripping is complete, and too prolonged pickling spoils the base metal surface for further plating. A better procedure comprises anodic dissolution of the chromium in 3·5–4% caustic soda at 80°–95° C.; this treatment has no deleterious effect on iron-, nickel-, or copper-base metals.
—A. R. P.

Concentrated [Copper] Cyanide Plating Baths. L. C. Pan (*Monthly Rev. Amer. Electroplaters' Soc.*, 1934, **21**, (5), 16–20; discussion, 19–20).—A reprint of a previous paper, but includes a discussion. See *Met. Abs.*, 1934, **1**, 596.
—A. R. P.

Copper Cyanide Solution and Its Idiosyncrasies. Elmer Woodmansee (*Monthly Rev. Amer. Electroplaters' Soc.*, 1934, **21**, (5), 7–15).—The causes of some faults frequently met with in copper-plating with a cyanide bath are discussed, and practical hints are given for obtaining good results with the bath. Efficient degreasing is essential to obtain good adherence and a smooth plate; electrolytic cleaning in an alkaline phosphate bath gives the best results.—A. R. P.

***Electrodeposition of Copper–Nickel–Iron Alloys.** H. Paweck, J. Bauer, and J. Dienbauer (*Z. Elektrochem.*, 1934, **40**, 857–862).—Experiments were undertaken to determine whether, and under what conditions, the cathodic deposition of an alloy of copper, nickel, and iron, especially that having a composition approximating to that of Monel metal, is possible without using a cyanide electrolyte. It was established that the deposition of such ternary alloys was practicable from solutions of the single metal sulphate to which nickel citrate had been added. By varying the composition of the electrolyte and the current density, alloys of given compositions were obtained, and the conditions were determined under which alloys corresponding with Monel metal were deposited. The effect of the addition of the citrate on the production of these ternary alloys was investigated.—J. H. W.

Brass Plating. M. de Kay Thompson (*Metal Cleaning and Finishing*, 1934, **6**, 449–452; *C. Abs.*, 1935, **39**, 53).—A series of investigations on the maintenance of cyanide brass-plating solutions during electroplating and the factors which affect the composition of the deposits are discussed.—S. G.

Faults in Brass Plating and Their Prevention. Robert J. Snelling (*Chem.-Zeit.*, 1934, **58**, 680–681).—A discussion of the various types of faults which occur in brass plating, and practical hints for their prevention.—A. R. P.

Gold Plating of Aluminium. Werner Frölich (*Metallbörse*, 1934, **24**, 1146–1147, 1179; and (translation in abstract) *Light Metals Rev.*, 1934, **1**, 122–126).—The articles are first degreased in a hot solution (90°–93° C.) containing borax 15, soda 8, caustic soda 2, and ammonium chloride 2 grm./litre, then pickled in a 1 : 1 mixture of sulphuric and nitric acids containing 7·5 grm./litre of ferrous sulphate. After washing, the articles are plated with brass from a cyanide bath or with nickel from a boric acid–nickel chloride bath, and finally gold-plated in the usual cyanide bath.—A. R. P.

Bright Nickel. L. Eckelmann (*Monthly J. Amer. Electroplaters' Soc.*, 1934, **21**, 18–28; discussion, 28–35; and *Met. Ind.* (*N.Y.*), 1934, **32**, 416–418).—A description is given of the results obtained with a new bright-nickel plating bath (composition not given). It is claimed that the bath gives deposits with a high gloss, is stable, operates at p_H 2–6 at 30°–55° C., and can be operated with current densities up to 200 amp./ft.^{2}. Brilliant deposits can be obtained up to ½ in. thick having a mirror-like finish. The throwing power of the bath is better than that of the ordinary nickel bath, and the deposit has the property of increasing the throwing power of chromium over it.—A. R. P.

Rapid Nickel Plating. James A. Rabbitt and Takashi Okamoto (*Japan Nickel Information Bureau Working Instructions*, **C-17**, 1934, 117 pp.).—S. G.

Faults in Nickel Plating and Their Prevention. Robert J. Snelling (*Chem.-Zeit.*, 1934, 58, 860–862).—The various faults met with in nickel plating are described, their causes are indicated, and means for their prevention are outlined.—A. R. P.

Applications of Nickel in Metal Finishing. O. B. J. Fraser (*Metal Cleaning and Finishing*, 1934, **6**, 461–462, 472–474; *C. Abs.*, 1935, **39**, 53).—The uses of nickel compounds in electroplating and metal finishing, production of pigments, paints, varnishes, lacquers, and enamels are discussed.—S. G.

What Effect Has the Shape of the Electroplated Article on Throwing Power? —— Hay and —— Lockerbie (*Monthly Rev. Amer. Electroplaters' Soc.*, 1934, **21**, (5), 21–28).—The use of auxiliary anodes for copper- and nickel-plating deeply recessed parts of an automobile radiator shell in order to get efficient throws is described in detail.—A. R. P.

New Results in the Field of Electrodeposition. A. Pollack (*Chem.-Zeit.*, 1934, 58, 997–1001).—A review of recent patent literature on plating.
—A. R. P.

VII.—ELECTROMETALLURGY AND ELECTROCHEMISTRY

(Other than Electrodeposition.)

(Continued from pp. 22-23.)

***Electrolytic Alloying of Iron [with Aluminium] in Molten Mixture.** V. A. Plotnikov, N. N. Grazianski, and K. P. Makovey (*Vestnick Metallopromishlennosti* (*Messenger Metal Ind.*), 1934, **14**, 88–94).—[In Russian.] The specimen to be alloyed is made the cathode in a molten 3 : 1 molecular mixture of sodium and aluminium chlorides, containing as anode an aluminium rod or molten aluminium. The depth of diffusion, microstructure, and heat-resisting properties of the alloyed iron have been studied in relation to the temperature, time of electrolysis, and current density. The best results are obtained at 600°–800° C., with a cathode current density of 0·5 amp./dm.^{2} for 3 hrs. The depth of diffusion is 1·5 mm.—D. N. S.

IX.—ANALYSIS

(Continued from pp. 23–26.)

***Quantitative Spectrographic Analysis of Light Alloys.** J. A. Kliachko (*Legkie Metalli* (*Light Metals*), **1934**, (1), 29–36).—[In Russian.] Values obtained spectrographically for Mg and Mn in Duralumin are compared with those found by chemical analysis. A brief *exposé* of the theory and practice of spectrographic analysis is given.—D. N. S.

Sources of Error in the Fire Assay of Gold and Platinum and Their Avoidance. K. W. Fröhlich (*Mitt. Forschungsinst. Edelmetalle*, 1934, **8**, 39–46).—In the determination of Au and Pt in alloys by inquarting with Ag and parting in H_2SO_4 serious errors may occur even under carefully controlled conditions, since Pt dissolves to some extent in the H_2SO_4 if the temperature rises too high and some Ag is retained by the cornet when the temperature is too low. These errors may be obviated by using H_2SO_4 containing 0·5% As; the acid is prepared by dissolving 10 grm. of As_2O_3 in 1500 grm. of H_2SO_4 at 200° C. The following procedure for the determination of Au and Pt is recommended: a preliminary trial is made to ascertain roughly the Au and Pt ratio; if this is less than 10 : 1 the requisite amount of carefully weighed fine Au is added to the assay trials to make this ratio and the metal together with 3–4 times its weight of Ag is cupelled with 1 grm. of Pb foil, finishing at 1150° C. The bead is flattened, annealed, rolled into a cornet, and heated with the As-H_2SO_4 at 280°–300° C. until evolution of SO_2 ceases, the acid is decanted and the cornet boiled gently for 20 minutes with a second lot of acid, and finally this is replaced with a third lot and the heating continued for 20–30 minutes. After washing, drying, and annealing the residual metal is weighed as Au + Pt; it is again inquarted with Ag and the bead parted in HNO_3 as usual to remove the Pt, leaving a residue of pure Au.—A. R. P.

The Recognition of Gold. K. Bihlmaier (*Mitt. Forschungsinst. Edelmetalle*, 1934, **8**, 85–91).—Rapid tests for Au in alloys, residues, jewellery sweepings, plating solutions, and compounds are described and tabulated.—A. R. P.

The Recognition of Silver. K. Bihlmaier (*Mitt. Forschungsinst. Edelmetalle*, 1934, **8**, 47–53).—Tests are given for the detection of Ag in metals, alloys, residues from metal working, plating solutions, and various compounds. The quickest test for finished articles consists in making a streak on the usual touchstone and moistening it with a solution of 3 grm. of $K_2Cr_2O_7$ and 2 c.c. of H_2SO_4 in 32 c.c. of water; if the article is Ag or Ag-plated the streak becomes bright red after subsequent washing with water.—A. R. P.

***Separation of Beryllium from Aluminium and Iron.** E. A. Ostroumov (*Redkie Metalli* (*Rare Metals*), 1933, **2**, (5), 25–29).—[In Russian.] After the separation of SiO_2 and sulphides the solution is boiled and $Fe^{\cdot\cdot}$ is oxidized with bromine. After neutralization with Na_2CO_3 a few drops of HCl are added, and Al and Fe are precipitated with a 3% solution of tannin in a saturated solution of CH_3COONH_4. The solution to be analyzed must be added to the boiling solution of tannin. The filtrate is evaporated with HNO_3 until it clears and $Be(OH)_2$ is precipitated with NH_4OH.—D. N. S.

Determination of Small Quantities of Alkali Metals in Magnesium. August Rauch (*Z. anal. Chem.*, 1934, **98**, 385–396).—A reagent for Na precipitation is prepared by mixing with an equal volume of 96% C_2H_5OH a 1 : 1 mixture of (*a*) 100 grm. of $(CH_3{\cdot}CO_2)_2UO_2$ and 60 grm. of glacial $CH_3{\cdot}CO_2H$ in 1 litre of H_2O, and (*b*) 333 grm. of $(CH_3{\cdot}CO_2)_2Mg$ and 60 grm. of $CH_3{\cdot}CO_2H$ in 1 litre of H_2O; the mixture is set aside overnight and filtered before use. For the determination of Na in Mg 20 grm. of metal are dissolved in 1 : 1 HCl, the solution diluted to 500 c.c., and 100 c.c. evaporated to crystals; 50 c.c. of C_2H_5OH are added, and the solution evaporated to dryness. The residue is stirred up with 100 c.c. of the above reagent and after 6 hrs. the precipitate is collected on a glass filter, washed with a few c.c. of the precipitant, then with 96% C_2H_5OH, dried at 110°–120° C. for 1 hr. and weighed; the weight × 0·375 = % Na in the metal. K may be determined in Mg by a similar method using $Na_3Co(NO_2)_6$ as the precipitant and eventually titrating the precipitate with $KMnO_4$.—A. R. P.

Colorimetric Determination of Aluminium Oxide in Metallic Aluminium. V. P. Okhotin and N. N. Zubareva (*Zavodskaya Lab.*, 1933, **2**, (6), 18–19; *C. Abs.*, 1935, **29**, 78).—[In Russian.] Dissolve 1 grm. Al in a mixture of 2 c.c. of 5% $Hg(NO_2)_2$ and 70 c.c. of tartaric acid, filter, wash, remove any Hg from the precipitate in the filter, ignite in a Pt crucible, fuse with 6 parts of $Na_2CO_3 + K_2CO_3$ (1 : 1), dissolve in 50–60 c.c. of hot H_2O, filter off the residue, wash, unite the filtrate and wash H_2O, make slightly acid with HCl and dilute to 100 c.c. Prepare 2 portions of a solution from 5 c.c. of 0·05% of Na alizarinsulphate by adding 5 c.c. of saturated NaCl solution, 5 drops of 4% NH_3 and H_2O to 18–20 c.c.; add to one portion a standard solution containing 0·01 mg. Al_2O_3 in 1 c.c., and to the other dropwise the tested solution until the colour shade of the 2 solutions is matched. The accuracy is within 0·01–0·02%.
—S. G.

The Precipitation of Aluminium with 8-Hydroxyquinoline in the Presence of Iron, Nickel, Cobalt, Copper, Chromium, and Molybdenum. Theodor Heczko (*Chem.-Zeit.*, 1934, **58**, 1032).—For the determination of Al in Al-bronze, Ni and Cr alloys, the alloy is dissolved in HCl or HNO_3 or a mixture of both, the solution evaporated to dryness, and the residue dissolved in HCl. The solution is treated with tartaric acid, NH_4OH in slight excess, KCN until the blue colour disappears, and H_2S until a clear solution is obtained with only a trace of turbidity. If the alloy contains Cr, this must be oxidized to CrO_3 before the above treatment by adding H_2SO_4 in the first stage and subsequently boiling with $(NH_4)_2S_2O_8$. The clear solution is treated with a 10% alcoholic solution of 8-hydroxyquinoline, which precipitates the Al in a form which can be weighed after drying at 105° C.—A. R. P.

***A Volumetric Method for the Determination of Beryllium in the Presence of Fluor.** V. M. Zvenigorodskaya and A. A. Gayguerova (*Redkie Metalli (Rare Metals)*, 1933, **2**, (5), 29–31).—[In Russian.] To 100 c.c. solution of $BeSO_4$ containing 0·04 grm. of Be are added 20–30 c.c. of 20% $CaCl_2$, and the whole is titrated with 0·1*N* NaOH using phenolphthalein as indicator. This method is good for the rapid determination of Be.—D. N. S.

***Estimation of Small Amounts of Bismuth in Presence of Much Copper and Chloride.** Naoto Kamehama and Shōji Makishima (*Kōgyō Kwagaku Zasshi (J. Soc. Chem. Ind. Japan)*, 1933, **36**, (6); *C. Abs.*, 1933, **27**, 4498).—[In Japanese, with English summary in supplemental binding, pp. 364–365.] To the neutral solution containing considerable Cu and little Bi, add, at 80° C., NH_4OH until a permanent turbidity of basic Cu salt appears; then add a little 5% $MnSO_4$ solution and boil. To the boiling solution add 0·5–2·0 c.c. of *N*-$KMnO_4$ dropwise with stirring. Filter off the precipitate of MnO_2 and adsorbed basic Bi salt and repeat the treatment with $MnSO_4$ and $KMnO_4$. Dissolve the filtered precipitate in H_2SO_4 and H_2O_2 and determine Bi colorimetrically with KI, filtering off any Cu_2I_2 that may form, and reducing any free I_2 by cautious addition of Na_2SO_3.—S. G.

On a New Volumetric Method for the Determination of Cadmium. G. Spacu and M. Kuraš (*Z. anal. Chem.*, 1934, **99**, 26–28).—The Cd is separated from other metals in the usual way and the CdS is dissolved in HNO_3. The solution is neutralized and the Cd precipitated as $Cd(C_5H_5N)_2(CNS)_2$ by addition of C_5H_5N and KCNS, and the excess of the latter is titrated with $AgNO_3$ using diphenylcarbazone as indicator (violet end-point).—A. R. P.

Use of Potassium Chlorostannite in the Volumetric Determination of Copper. Emm. Voyatzakis (*Bull. Soc. chim. France*, 1934, [v], **1**, 1356–1357).—The metal is dissolved in HNO_3, the solution evaporated with H_2SO_4 until fumes of SO_3 are evolved, and after cooling 200 c.c. of 1 : 1 HCl are added. The cold solution is treated with a weighed amount of $K_2SnCl_4,2H_2O$ which reduces the $CuCl_2$ to Cu_2Cl_2; the excess of $Sn^{\cdot\cdot}$ is then titrated with I_2. The method is quicker and cheaper than the usual KI method, and only metals reducible by $SnCl_2$ interfere.—A. R. P.

The Application of Electrolytic Reduction Methods in Analytical Chemistry. III.—Direct Determination of Copper and Iron by Electrolytic Precipitation and Reduction. G. Galfajan (*Z. anal. Chem.*, 1934, **99**, 32–34).—The H_2SO_4 solution of the two metals is diluted to 10–20% H_2SO_4 and electrolyzed in the cathode compartment of a divided cell having a rotating Pt cathode. All the Cu is deposited on the Pt, and the Fe in solution is reduced to $FeSO_4$ ready for direct $KMnO_4$ titration. As, Sb, and Sn are not deposited under these conditions.—A. R. P.

Determination of Iron and Copper in Chromium Plating Baths. N. I. Surenkov (*Zavodskaya Lab.*, 1933, **3**, (6), 17–18; *C. Abs.*, 1935, **29**, 73).—[In Russian.] Dilute 10 c.c. of the liquor to 100 c.c., add 10 c.c. HCl and 10 c.c. EtOH, boil to expel alcohol, cool, add gradually a small excess of cupferron, let stand 20 minutes, filter, wash the precipitate free from HCl, dissolve the Cu compound and excess of cupferron on the filter with dilute NH_3, and ignite the Fe compound to Fe_2O_3. Determine Cu in the NH_3 solution as usual. Accuracy is within 0·02–0·03%.—S. G.

Quantitative Precipitation of Copper with Tannin. M. B. Darbinian and A. G. Kankanian (*Z. anal. Chem.*, 1934, **99**, 29–32).—Tannin precipitates Cu completely from a feebly acid solution containing $CH_3{\cdot}CO_2NH_4$ as a voluminous cuprous complex which yields CuO on ignition. The method is useful for the rapid gravimetric determination of Cu in alloys containing metals which cannot be precipitated by tannin.—A. R. P.

On a New Volumetric Method for the Determination of Lead [in Bearing Metals]. I. Tananaeff (*Z. anal. Chem.*, 1934, **99**, 18–22).—The alloy (0·5–1·5 grm.) is dissolved in HNO_3 and the solution filtered into a 100-c.c. flask, neutralized with NaOH (methyl orange indicator), treated with an excess of a 2*N*-solution of NaCl and NaF and diluted to the mark. The Pb is thereby precipitated as PbClF; a filtered portion of 20–50 c.c. of the solution is titrated with $AgNO_3$ (fluorescein indicator) to determine the excess of NaCl from which the Pb is readily calculated. The analysis can be made in less than 30 minutes.
—A. R. P.

Use of 8-Hydroxyquinoline in the Analysis of Light Alloys [Estimation of Magnesium]. V. A. Taler (*Zavodskaya Lab.*, 1933, **2**, (6), 10–12; *C. Abs.*, 1934, **29**, 70).—[In Russian.] Directions are given for determining Mg with "oxine."—S. G.

The Colorimetric Determination of Small Amounts of Magnesium. C. Ingham Cox (*Chem. Eng. Min. Rev.*, 1934, **27**, 60).—A letter. Mg is quantitatively precipitated as $MgNH_4PO_4$ according to the method of Denis (*J. Biol. Chem.*, 1922, **52**, 411). The $MgNH_4PO_4$ is dissolved in dilute HCl, and the phosphoric acid so liberated is estimated by the colorimetric method of Fiske and Subbarow (*J. Biol. Chem.*, 1925, **66**, 375).—J. H. W.

Alkalimetric Determination of Mercury by the Aid of Amido Salts. S. Škramovský and R. Uzel (*Coll. trav. chim. Tchécoslov.*, 1934, **6**, 435–444).—[In French.] See *Met. Abs.*, 1934, **1**, 609.—A. R. P.

Determination of Small Quantities of Tin in Anodic and Cathodic Copper. S. Yu. Faĭnberg and M. I. Troitzkaya (*Zavodskaya Lab.*, 1934, **3**, 126–129; *C. Abs.*, 1935, **29**, 75).—[In Russian.] The method depends on precipitating hydrated SnO_2 and MnO_2 from dilute HNO_3 solution of the alloy, dissolving the precipitate in dilute HNO_3 and H_2O_2, and precipitating hydrated SnO_2 by boiling with NH_4NO_3 solution. The precipitate is fused with Na_2O_2, the melt leached with water and dilute HCl, and the solution analyzed for Sn by the usual iodometric method.—S. G.

Determination of Tin in Sludges. M. I. Shubin (*Zavodskaya Lab.*, 1934, **3**, 216–222; *C. Abs.*, 1935, **29**, 75).—[In Russian.] Mix in a Ni crucible 1 grm. (2 grm. for samples containing less than 1% Sn) of finely powdered sludge with a mixture of 3 grm. anhydrous Na_2CO_3 and 4 grm. Na_2O_2, cover up with 1 grm. of the mixture, heat carefully to liquefaction within 15 minutes and then 15 minutes longer, allow to cool, dissolve in dilute HCl and determine Sn by the usual iodometric method.—S. G.

On the Oxidimetric Determination of Tin. S. Ferjančič (*Z. anal. Chem.*, 1934, **98**, 246–248).—After reduction in the usual way the Sn solution is treated with 10 c.c. of 0·1*N*-KI and a slight excess of 0·1*N*-$KBrO_3$, the excess being then measured by titration of the liberated I with $Na_2S_2O_3$.—A. R. P.

X.—LABORATORY APPARATUS, INSTRUMENTS, &c.

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

(Continued from pp. 26–27.)

***An Ultra-Violet Microscope for the Examination of Opaque Objects [Reflecting Power of Metals and Alloys in the Ultra-Violet].** B. K. Johnson (*J. Sci. Instruments*, 1934, **11**, 384–394).—Describes the construction of an ultra-violet microscope for opaque objects, designed to avoid the defect of loss of light by back reflection from the lens system. The increased contrast obtained by the use of ultra-violet light is illustrated by photographs of aluminium alloy containing magnesium, copper, and silicon, in which two constituents could be distinguished in ultra-violet, but not in visible light. In order to find a suitable substance for the mirrors in the microscope, the reflecting powers in the ultra-violet region were determined for the following metals and alloys: mercury, mercury–tin amalgam, silver, Magnalium, and an "aluminized surface."—W. H.-R.

***A New Recording Dilatometer of High Sensitivity.** A. Goetz, J. W. Buchta, and T. L. Ho (*Rev. Sci. Instruments*, 1934, [N.S.], **5**, 428–431).—A recording dilatometer designed for investigating details of the thermal expansion of crystals over small temperature intervals, *e.g.* for investigating the nature of the pseudo-allotropic transformation of bismuth at about 75° C., and employing adjustable optical and electrical amplification as high as 10^5–10^6, is described. The rate of change of temperature is adjustable and reproducible.—J. S. G. T.

Apparatus for Making Permeability–Tension Tests. G. A. Kelsall and H. J. Williams (*Rev. Sci. Instruments*, 1934, [N.S.], **5**, 437–440).—Apparatus for determining the permeability of ferromagnetic materials, in the form of a tape bent into triangular form, under tension is described. Results relating to Perminvar in fields of strengths up to 3·5 oersteds are briefly referred to.
—J. S. G. T.

Apparatus for Distilling Mercury Under Reduced Pressure. Henry Vogels (*Bull. Soc. chim. Belg.*, 1934, **43**, 327–330).—A glass apparatus for the purification of mercury by distillation *in vacuo* is described with reference to a diagrammatic illustration.—A. R. P.

***Glass-To-Metal Seals.** Albert W. Hull and E. E. Burger (*Physics*, 1934, **5**, 384–405).—Equations are derived for the stresses in cylindrical seals in terms of the difference of expansion of metal and glass, and the calculated stresses are compared with those observed photoelastically in carefully annealed test-seals. Two new sealing alloys are described: (1) Fernichrome (Fe 37, Ni 30, Co 25, Cr 8%), which matches, for sealing purposes, lead glass, and (2) Fernico (Fe 54, Ni 28, Co 18%), which matches Corning glasses G–71 and G–705 AO. Seals made with these combinations are practically free from strain.—J. S. G. T.

***Measurement of Absolute X-Ray Intensities and Absolute X-Ray Sensitivity of X-Ray Film with a Geiger–Müller Counter.** Gordon L. Locher and Donald P. Le Galley (*Phys. Rev.*, 1934, [ii], **46**, 1047–1051).—W. H.-R.

***The Use of Lithium for an X-Ray Window.** R. E. Clay (*J. Sci. Instruments*, 1934, **11**, 371–372).—A note. The low absorptive power of lithium makes it suitable for X-ray windows, and simple means of preventing oxidation are described.—W. H.-R.

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

(Continued from pp. 27–28.)

***Determination of Initial Stresses by Measuring the Deformation Around Drilled Holes.** Josef Mathar (*Trans. Amer. Soc. Mech. Eng.*, 1934, **56**, 249–254; and *J. Amer. Weld. Soc.*, 1934, **13**, (7), 24–29).—A method for determining internal stress consists of drilling a hole between the two gauge-points of an extensometer and measuring the change in distance caused by drilling. The method has been used to determine the internal stresses in castings and in welded seams.—W. P. R.

Free-Bend Tests on Welds. F. S. Mapes and F. Howenstein (*J. Amer. Weld. Soc.*, 1934, **13**, (10), 28–30).—An improved method of testing is described, by which it is ensured that bending takes place in the weld metal.—H. W. G. H.

Note on the Fatigue Testing of Welds. J. H. Zimmerman (*J. Amer. Weld. Soc.*, 1934, **13**, (9), 13–15).—Full-scale tests are compared with tests on small machined specimens. A special form of specimen is recommended for the rotating beam test on welded joints, in which the final machining marks are in a longitudinal direction. The effect of surface condition is thus greatly reduced. A short *bibliography* is given.—H. W. G. H.

A Fatigue Testing Machine. Anon. (*Engineer*, 1934, **158**, 167–168).—Illustrated description of the Haigh–Robertson machine for testing wire, which enables tests to be carried out rapidly, as many as 28 million reversals of stress being readily applied in 24 hrs. It can very conveniently be used for corrosion-fatigue experiments.—W. P. R.

***Allowable Working Stresses Under Impact.** N. N. Davidenkoff (*Trans. Amer. Soc. Mech. Eng.*, 1934, **56**, 97–107).—The tensile strength, and especially the yield-point, are higher under impact than under static tests. Variations in conditions of test, such as sharpness and depth of notch, speed of impact, temperature, will cause material to rupture sometimes in a brittle, and sometimes in a ductile, manner. Although iron and steel are brittle at low temperatures, copper, brass, and aluminium and the alloys of the latter are not brittle at low temperatures, and Duralumin shows an increased ductility at low temperatures. In the discussion, *R. V. Southwell* describes an impact machine designed to eliminate errors caused by energy absorption by the anvil in the Izod and Charpy impact tests.—W. P. R.

Hardness Testing with a Pendulum Hammer. Richard Walzel (*Stahl u. Eisen*, 1934, **54**, 954–957).—Describes a machine for dynamic hardness tests. In this a steel ball is mounted on a heavy pendulum and driven into the test-piece by the fall of the pendulum, and the angle of rebound is noticed. The general arrangement is much like that of the Izod notched-bar impact tester, and the machine can be used for both dynamic hardness and notched-bar tests.—W. H.-R.

XII.—TEMPERATURE MEASUREMENT AND CONTROL

(Continued from p. 29.)

Thermometer Controller. Anon. (*J. Sci. Instruments*, 1934, **11**, 399).—In this apparatus, every 6 seconds a motor-driven control table tilts a mercury switch from one side to the other according to the relative position of the pointer or pen and a control setting. The temperature variation can be recorded on a chart, and the instrument can be adapted for the control of pressure, liquid level, &c., as well as of temperature.—W. H.-R.

***The Sensitivity of Thermopiles, Micro-Radiometers, Radiometers, and Bolometers.** C. Hawley Cartwright (*Z. Physik*, 1934, **92**, 153–171).—A criterion for the comparison of the sensitivities of radiometric instruments is proposed and discussed. The results show that vacuum thermopiles can possess a greater sensitivity than that of radiometers or micro-radiometers in air; their anticipated sensitivity is that of vacuum micro-radiometers and vacuum bolometers. The best vacuum thermopiles, employing bismuth alloys, are only about twice as sensitive as iron–Constantan thermopiles. Thermodynamical considerations suggest that, using ideal thermoelectric metals, the sensitivity of the thermopile can be increased five-fold.
—J. S. G. T.

XIII.—FOUNDRY PRACTICE AND APPLIANCES

(Continued from pp. 29–30.)

The Foundries of the Kcharkoff Tractor Works. L. M. Marienbach (*Liteinoe Delo* (*Foundry Practice*), **1933**, (8), 27–32).—[In Russian.] A description of the non-ferrous foundry of the tractor works.—N. A.

The Foundries of the Gorkovsk Automobile Works of the Name of Molotov. V. M. Shestopal (*Liteinoe Delo* (*Foundry Practice*), **1933**, (6), 27–30).—[In Russian.] A description of the non-ferrous foundry and other workshops of this concern.—N. A.

Use of Long-Time Creep-Test Data in the Design of Heat-Enduring Castings. B. J. Sayles (*Indust. Heating*, **1934**, (Oct.), 41–46).—The best basis for designing high-temperature alloy structures is found in the use of long-time creep-test values. The daily melt of the foundry should be closely controlled to the analysis of the creep-test specimens, otherwise the commercial castings will not uniformly possess the physical properties ascribed to them.—W. A. C. N.

The Fight Against Fine Porosity in Aluminium Castings. A. M. Brezgunov (*Liteinoe Delo* (*Foundry Practice*), 1934, **7**, 15–20).—[In Russian.] The porosity of aluminium castings can be intercrystalline as a result of the shrinkage of metal and the escape of gases. The following factors which are of importance in the prevention of the porosity are considered: design of castings, control of the casting temperature, rate of cooling of the castings in sand-moulds, regulation of cooling time by artificial cooling, speed of pouring of metal into the mould, absorption of gases from unsatisfactory mould materials, absorption of furnace gases, moulds and reactions inside the molten metal, fluxes, double melting.—N. A.

Aluminium Alloys and Improved Methods of Manufacture. W. C. Devereux (*Metallurgia*, 1934, **11**, 49–52).—An article similar to that noted in *Met. Abs.*, this volume, p. 29. Views expressed by D. at a joint meeting of the Institute of British Foundrymen and the Institute of Aeronautical Engineers are dealt with. Improved methods of manufacture for cast and wrought alloys and the co-operation necessary between designer and material supplier to effect good results are discussed.—J. W. D.

The Causes of Waste (Rejects) and the Fight Against It in the Casting of Aluminium Alloys in Metal Moulds. P. E. Liamin and A. F. Komarov (*Liteinoe Delo* (*Foundry Practice*), **1934**, (9), 11–16).—[In Russian.] Discusses the causes of waste in metal-mould casting due to porosity, cracks, and cavities. The authors emphasize the great importance of temperature control and rate of casting.—N. A.

Apatite-Nephelinic Ore in Foundry Production [Deoxidation of Copper]. S. E. Noskov (*Liteinoe Delo* (*Foundry Practice*), **1933**, (8), 19–20).—[In Russian.] Apatite–nephelinic ore can be used for the deoxidation of copper and for protecting the metals from loss by volatilization.—N. A.

The Application of Khibinsk Apatites in the [Armature] Casting of Non-Ferrous Metals. L. G. Ardashnikov and V. N. Bacharov (*Liteinoe Delo* (*Foundry Practice*), **1933**, (7), 15–18).—[In Russian.] As a result of 10 trial melts with tin–bronze and with addition of apatite ore, the authors conclude that the deoxidizing action of the latter and the quality of metal produced are satisfactory.—N. A.

Aluminium-Bronze—A Method of Quality Control. Anon. (*Machinery* (*Lond.*), 1934, **45**, 455–459).—The characteristics of any portion of a casting of " aluminium–bronze " depend on the speed of cooling. Moulding methods and the use of chills thus need careful consideration. By means of routine microscopic examination of sections cut from castings and cast-on test-pieces close control can be maintained on the output of the foundry. Typical structures are illustrated and discussed.—J. C. C.

Melting of a Copper–Nickel Alloy. Gustav Schüle (*Giesserei*, 1934, **21**, 520–521).—A procedure is given for melting an alloy of nickel 15, lead 17, zinc 20, tin 3, and copper 45% in 100 kg. lots. The nickel and copper are first melted under a glass flux in a plumbago crucible by rapidly heating to 1400° C., the tin is then added, followed by 80 grm. of magnesium and 3 cubes of 12% phosphor–copper to deoxidize the melt. The crucible is then removed from the furnace, the lead added as a 50 : 50 zinc–lead alloy (molten) followed by the remainder of the zinc. Castings of this alloy do not segregate, have a yield-point of 30 kg./mm.^{2}, a tensile strength of 52 kg./mm.^{2}, and an elongation of 15–18%. Contamination with arsenic and antimony must be avoided, otherwise the metal becomes very brittle.—A. R. P.

The Production of Special Bronzes. A. P. Smiriagin (*Liteinoe Delo* (*Foundry Practice*), **1933**, (4), 23–26).—[In Russian.] A general discussion of the melting and casting of special bronzes.—N. A.

The Casting of Bronze Bushes in Metal Moulds. A. A. Lunev (*Liteinoe Delo* (*Foundry Practice*), **1934**, (9), 17–20).—[In Russian.] The need for exact fulfilment of the proper conditions during the casting of bronze bushes in metal moulds is indicated.—N. A.

Silicon–Bronzes and Brasses. A. P. Smiriagin (*Liteinoe Delo Foundry Practice*), **1933**, (4), 27–31).—[In Russian.] The results are given of an investigation of the production of silicon–bronzes and brasses at the Moscow Brake Works. Silicon–bronzes and brasses with a content of 2–5% silicon and from 0·2 to 0·9% of iron, possess a high breaking stress, low elongation, and normal hardness, as compared with tin–bronzes. Their fluidity is very high. Anti-friction properties of silicon–bronzes and brasses are not high. The simplest and most economical method of producing these alloys is by the solution of ferro–silicon in copper.—N. A.

Melting of Magnesium Alloys. P. S. Mayboroda (*Liteinoe Delo* (*Foundry Practice*), **1933**, (5), 25–26).—[In Russian.] The refining action of fluxes during the melting of magnesium is disputed. Metal stirred during melting with the fluxes had larger quantity of impurities. It is recommended that the flux be introduced after melting and in quantity sufficient to cover the metal. Stirring is done after removal of the flux from the surface of the metal, the flux being added again before casting.—N. A.

Production of Sound Castings of Magnesium Alloys. A. S. Lugaskov (*Liteinoe Delo* (*Foundry Practice*), **1933**, (5), 21–25).—[In Russian.] The melting and casting of magnesium alloys are discussed. The alloys AZF (Al 4, Zn 3, Mn 0·3%) and AZG (Al 6, Zn 3, Mn 0·3%) are recommended.
—N. A.

[Pressure] Casting into Metal Moulds. P. M. Potapov (*Vestnick Elektropromishlenosti* (*Messenger Elect. Ind.*), **1934**, (1), 25–28).—[In Russian.] Pressure casting in a Russian works and the properties of castings obtained are described.—N. A.

The Problem of Pressure-Casting of Articles with High Mechanical Properties. V. M. Pljazkiy (*Liteinoe Delo* (*Foundry Practice*), **1933**, (8), 21–24).—[In Russian.] For the pressure-casting of aluminium alloys, piston-machines are recommended because of the higher mechanical properties of the manufactured articles. The conditions of working and compositions of alloys are given.—N. A.

The Compression Chambers in Modern Pressure-Casting Machines. P. E. Liamin (*Liteinoe Delo* (*Foundry Practice*), **1933**, (5), 27–28).—[In Russian.] A review of data given in the literature.—N. A.

Investigations of Foundry Sands. L.-F. Girardet (*Bull. Assoc. Tech. Fond.*, 1934, **8**, 265–276).—Reviewing the fundamental factors influencing the properties and behaviour of foundry sands, G. concludes that the adhesive properties of the agglomerants (colloidal substances) depend on their degree of flocculation, which in turn varies with the nature and amounts of salts present in the temper water. Generally deflocculating agents reduce adhesion, and *vice versa.* The ions are absorbed by the agglomerant with their water of hydration, the more hydrated they are the more liquid the agglomerant and the more dispersed it becomes. For the same kind of ion the degree of hydration depends on the concentration of the saline solution containing it. Suggested methods of estimating the physical constitution of sand are described, and the effect of variations of the physico-chemical properties on the foundry properties are discussed.—R. B. D.

Why Not Green-Sand Cores? Frank Whitehouse (*Iron Steel Ind.*, 1934, **8**, 95–97, 98).—Although dealing essentially with cores for the iron foundry, this article is also of interest to the non-ferrous founder. After describing the core irons, core boxes, and the time factor required in the manufacture of various types of castings, answers are given to such questions as the relative cost of green-sand and mass-produced oil-sand cores, the extent to which construction or accuracy of shape is affected by using green-sand cores, dangers from washing in intricate castings, and the most suitable temperatures for casting.—J. W. D.

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

On the Reworking of Copper Scrap. Werner Frölich (*Chem.-Zeit.*, 1934, **58**, 920–921).—In remelting scrap copper wire all tinned and soldered parts should be removed and the remainder cut into 50–60 cm. lengths and bundled in a press. Deoxidation with 0·1% of 15% phosphor–copper is recommended just before pouring. Scrap containing aluminium and silicon can be refined by stirring it with copper oxide residues (hammer scale) at 1200° C. under a sodium carbonate slag which dissolves the silica and alumina formed. Scrap containing tin, lead, or zinc is suitable only for making bronze or brass.
—A. R. P.

†**Remelting of Brass Scrap and Residues in Reverberatory Furnaces.** Karlheinz Herbert (*Metallbörse*, 1934, **24**, 1081–1082, 1113–1115, 1147, 1177–1178, 1209–1210, 1241–1242, 1274–1275, 1402–1403, 1433–1434, 1497–1498, 1531).—Modern practice in Germany, England, and America in the remelting and refining of brass scrap in reverberatory furnaces is critically reviewed, and the value of this type of furnace is compared with that of various types of electric furnaces from the economic point of view. Precautions to avoid loss and contamination of the metal and methods of removing objectionable impurities are also discussed.—A. R. P.

On the Working-Up of Silver Residues. P. Köhring (*Metallbörse*, 1934, **24**, 1082–1083, 1115).—Hints on the recovery of silver from waste produced in silver-mirror manufacture and from old plating solutions are given.—A. R. P.

XV.—FURNACES AND FUELS

(Continued from pp. 30–31.)

Aluminium Alloys Aged in a Recirculating Oven. C. F. Mayer (*Indust. Heating*, **1934**, (Oct.), 69–71).—A portable electric-type oven has been replaced by one using the direct gas-fired air-heater principle. The air heater is a refractory-lined combustion chamber, enclosed in an insulated steel housing. A low-pressure gas-burner is at one end. At the discharge end of the heater is a heat-supply fan that removes the heated air from the air-heater and distributes it to the supply ducts in the oven. Heating of the stock is, therefore, more by convection, due to the rapid movement of large volumes of air, than by radiation or conduction. Treatment time is said to be diminished and the temperature to be more uniform and under closer control.—W. A. C. N.

Melting Precious Metals with Gas. Anon. (*Gas World* (*Indust. Gas Suppl.*), 1934, **6**, (12), 8).—The use of crucible furnaces fired with high-pressure towns' gas for melting old gold and silver, and plant for the recovery of these metals from jewellers' floor sweepings are briefly described.—J. S. G. T.

Combustion Research with Gas Burners of Different Mixing Characteristics. M. H. Mawhinney (*Indust. Heating*, **1934**, (Nov.), 119–122, 152, (Dec.), 175–194).—A summary of a paper by *R. Pistor* (*Mitt. Wärmestelle Verein. deut. Eisenhüttenleute*, Nr. **151**). The tests were intended to fix a relationship between the method of mixing various gas-air ratios and flame length, temperature and composition of the combustion gases through the length of their travel in the furnace. It was shown that a larger amount of hydrogen was in the waste gases when the proportion of air in the original mixture was low, and that as the latter increased the amount of hydrogen decreased. The carbon monoxide content increased with the air supply until the ratio between actual air and theoretical air required became 0·5. After that the amount of carbon monoxide decreased. With increasing air supply the heavy carbohydrates and methane decrease steadily. Different types of burners are discussed. It was shown that the speed of combustion is not higher in a hot furnace than in a cold one, although the rate of ignition is greater.—W. A. C. N.

Fundamental Studies on the Industrial Furnace. I.—A New Relation Between the Gas Temperature and Wall Temperature (Preliminary Report). Sakae Yagi (*Kōgyō Kwagaku Zasshi* (*J. Soc. Chem. Ind. Japan*), 1934, **37**, (4); *C. Abs.*, 1934, **28**, 5151).—[In Japanese, with English summary in supplemental binding, pp. 159–162.] From data reported by E. Schulze (*Mitt. Wärmestelle Düsseldorf*, 1928, (**118**)), Y. has developed a relationship which is practically independent of the nature of the gas and the tube diameter. The function is $K = (T_G/100)^3/(t_G - t\omega)$, where T_G = true gas temperature in ° K., and t_G and $t\omega$ are gas and wall temperatures, respectively. K changes regularly with the gas velocity ω. It changes greatly with the thermal insulation of the furnace wall, and it is roughly constant within moderate temperature ranges. Plots of K and heat transfer coeff. *versus* ω are presented.—S. G.

XVI.—REFRACTORIES AND FURNACE MATERIALS

(Continued from p. 31.)

New Products of Sinter-Corundum. Anon. (*Siemen's Review*, 1935, **11**, 27–28).—Outlines the useful properties of Sinter-Corundum (99·7% Al_2O_3). It softens at 1730° C. under a load of 2 kg./cm.^{2}. Particular applications are combustion boats, crucibles, mortars with pestle, and gas-tight furnace vessels.—R. Gr.

XVII.—HEAT-TREATMENT

(Continued from p. 31.)

Trend in Brass Mill Annealing Practice. P. E. Petersen (*Indust. Heating*, **1934**, (Oct.), 13–18).—Modern demands are for closer annealing control on finished metal and better surface finish. Bright-annealing and controlled-atmosphere furnaces are now standard. Copper is bright-annealed in atmospheres of steam, nitrogen, hydrogen, or the products of combustion of any of the commercial gases that have been freed from oxygen and sulphur. Brass may be best treated in propane, butane, or methanolated flue gases, using a short-time cycle. Illustrations and descriptions of modern electric and gas-fired furnaces are given.—W. A. C. N.

XVIII.—WORKING

(Continued from pp. 31–32.)

The Flow of Metals During the Extrusion Process. C. E. Pearson (*Machinery* (*Lond.*), 1934, **45**, 401–405).—Read before the Sheffield Local Section of the Institute of Metals. The flow of metal in direct and inverted extrusion is illustrated by a number of sections cut through partially extruded billets. These include composite billets of plasticine or metals and billets cut before extrusion through an axis of symmetry and marked on the cut faces with a scribed or ink pattern. The factors which influence extrusion pressure are discussed, and experiments on the pressure required to extrude tin through dies of various shapes described. These indicate that a slight reduction in pressure is obtained with a die angle of 45°.—J. C. C.

Manufacture of Lead Sheath in Electric Cables. J. Mahul (*Aciers spéciaux*, 1934, **9**, 269–272).—The lead sheaths for electric cables are made in the same way as extruded lead pipes, except that the sheath requires accurately fitting over the cable. The lead is extruded at a temperature of 200°–250° C. under a pressure of 4 tons/in.^{2}. Since the lead chamber is generally too small to complete the sheath, new metal is added from time to time, and care must be taken to ensure that the new and old charges mix perfectly. The interposition of a film of oxide or impurities results in defects in part of the sheath which must be cut out and rejected. The flow of the lead in the extrusion has been studied experimentally.—J. H. W.

The Manufacture of Copper Firebox Plates.—Discussion. (*J. Inst. Locomotive Eng.*, 1934, **24**, 128–141).—A discussion in Perth, Western Australia, of paper by *W. F. Brazener* (see *J. Inst. Metals*, 1933, **53**, 104). Many speakers suggested that pre-war copper was superior to present-day product. In reply, *B.* pointed out the change in the British Standard Specification raising purity since 1924 from 99·0 to 99·2% copper as a minimum. Attention was also directed to the greater severity of modern demands in service and to the absence of any difference in the mechanical test results in records extending over 40 years. Other points discussed included the formation of scale on arsenical copper, the effect of furnace atmosphere on oxygen content, and the importance of avoiding tool marks and scratches.—J. C. C.

The Brittleness of Sheets. N. A. Kalashnikov (*Vestnick Ingenerov i Tehnikov* (*Messenger Engineers and Technol.*), **1934**, (10), 473–474).—[In Russian.] —N. A.

Further Improvements in Seamless Tube Manufacture. Gilbert Evans (*Met. Ind.* (*Lond.*), 1934, **45**, 339–341).—The Foran process of seamless tube manufacture is described and compared with older methods, and a brief reference is made to the Roeckner tube-rolling process.—J. H. W.

***Composite Bearings ("Rahmenlager") with Pressure Lubrication for Rolling Mills.** Hans Weinlig (*Stahl u. Eisen*, 1934, **54**, 801–806).—Details are given of the performance, durability, and cost of different kinds of bearings in the rolling mills of the Röckling Iron and Steel Works at Völklingen a.d. Saar. These illustrate the advantages of composite bearings with pressure lubrication.—W. H.-R.

The Roughing of Grooves in Ingot and Rough Rolls. Carl Holzweiler (*Stahl u. Eisen*, 1934, **54**, 853–854).—A note on the method by which rolls are made to grip metal by means of ridges on the surfaces of the roll instead of by grooves.—W. H.-R.

Working and Heat-Treatment of Aluminium and Its Alloys. Anon. (*Illust. Zeit. Blechindustrie*, 1934, **63**, 1283–1285).—A discussion of the appropriate conditions for the drawing, deep-drawing, die-casting, forging, and annealing of aluminium and light alloys in various initial states, with special reference to the obviation of grain-growth.—P. M. C. R.

***Forging Certain Copper Alloys.** E. Berthelman (*Metallurgia*, 1934, 11, 45–48).—Translation of a paper presented to the Mechanical Engineers of Poland. Five copper alloys are discussed, and include tin-bronze containing 4·5–6% tin; 3 "aluminium-bronzes" containing aluminium 9–11, nickel 2·5, iron 2, and manganese 1%; aluminium 9–9·8, nickel 1–2·5, and iron 1–2%; and aluminium 9·8–11, and nickel 1·5%, respectively; and a special brass containing zinc 30–40, manganese 4–5, aluminium 1–1·5, and copper 53·5–57%. The microstructure, both cast and forged, the forging or casting temperatures, and the average mechanical properties are given and are considered in detail, with special reference to the operations of forging and stamping and to the influence of the various constituents.—J. W. D.

Turning of Light Metals. A. von Zeerleder (*Berg.- u. Hüttenw. Jahrb. Montan. Hochschule, Leoben*, 1934, 82, 144–147).—Suitable cutting and drilling tools for working aluminium alloys are described, and working procedures are recommended.—A. R. P.

Working of Aluminium. I. S. Beljov (*Vestnick Ingenerov i Tehnikov* (*Messenger Eng. and Technol.*), 1934, (6), 289).—[In Russian.] Hints are given on turning, drilling, and milling.—N. A.

***Performance of Cutting Fluids When Sawing Various Metals.** O. W. Boston and C. E. Kraus (*Trans. Amer. Soc. Mech. Eng.*, 1934, 56, 527–531).—The influence of various fluids on the rate of wear when sawing 8 different metals has been investigated. Cutting fluids produced a wide variation in cutting time when cutting steels, but had little influence when cutting aluminium or brass.—W. P. R.

XIX.—CLEANING AND FINISHING

(Continued from p. 32.)

A New Process for the Cleaning of Metals. U. C. Tainton (*Wire and Wire Products*, 1934, 9, 399–400).—Abstract of a paper read before the Wire Association. For the electrolytic galvanizing of steel, it is of special importance to have the cathode surface scrupulously clean. This is effected by causing nascent metallic sodium to be liberated at the surface of the article to be plated by electrolysis in a bath of fused sodium salt. This sodium will reduce the oxide on any ordinarily oxidized metal surface, regardless of its composition, and will produce a completely continuous metal surface with no non-metallic inclusions.—J. H. W.

XX.—JOINING

(Continued from pp. 32–33.)

Influence of Foreign Constituents on the Technological Properties of Common Solder. Edmund Richard Thews (*Metallbörse*, 1934, 24, 1593–1594, 1625–1626).—After a description of the characteristic properties of soft solders, the effect of various impurities on the strength and resistance to corrosion of soft-soldered joints is considered. Antimony in excess of 0·65% for every 10% of tin tends to produce brittle joints, which are further weakened by exposure to damp air or steam. Copper up to 0·05% appreciably increases the strength of the joints, and up to 3% copper is advantageous in solders used for joining zinc and galvanized metals. Even as little as 0·01% zinc tends to spoil the adhesion of soft solders and to produce subsequent disintegration of the solder. Arsenic is also a very objectionable impurity.
—A. R. P.

****A Method of Soldering Molybdenum to Copper.** A. Müller and R. E. Clay (*J. Sci. Instruments*, 1934, **11**, 405).—A note. The molybdenum is first covered with a layer of sodium nitrite, which is gently warmed to dispel water. A small chip of silver is then placed on top of the nitrite, and the temperature raised until the reaction between the molybdenum and the nitrite begins. The heat of the violent reaction is sufficient to melt the silver which flows over the surface, and can then be soldered in the ordinary way. The method is suitable for pieces about 1 cm.^{2} in area by 0·3 mm. thick.—W. H.-R.

Brazing of Stainless Steel Articles with Silver Solder. Edmund T. Richards (*Metallbörse*, 1934, **24**, 1627).—In brazing stainless steels with silver solders the solder should have a melting point of above 850° C., and the steel should be heated to 875°–900° C. so as to avoid the bad effects of heating at 750°–850° C. on the rust-resisting properties of the steel. To obtain good adhesion of the solder a flux of borax with 10–20% of boric acid and 10–15% of zinc chloride is recommended. A cheap but good solder consists of silver 10–15, copper 50–60, nickel 3% and the rest zinc.—A. R. P.

The Repair of Aluminium Alloy Crankcases by Oxy-Acetylene Welding. R. Meslier (*Rev. soudure autogène*, 1934, **26**, (249), 2–4).—Complete removal of grease and dirt is essential. Contraction stresses and distortion must be avoided by careful preheating in special furnaces designed for the purpose. Aluminium–copper or aluminium–silicon filler rods are usually employed.
—H. W. G. H.

The Construction of Light Boats by Blowpipe Welding. P. Modro (*Rev. soudure autogène*, 1934, **26**, (249), 8–9).—Oxy-acetylene welded canoes and out-board motor-boats are described. They are made from either "G.7"—an aluminium–manganese alloy of the Duralumin type, or Thalassal (silicon 0·8, magnesium 2, manganese 1·4, antimony 0·2%), both of which are said to be readily weldable and very resistant to sea-water corrosion.—H. H.

An Electric-Arc Process for Welding Aluminium. Anon. (*Welding J.*, 1934, **31**, 330).—A carbon-arc method for welding aluminium alloy castings is announced. No details of plant or technique are given.—H. W. G. H.

Welding Non-Ferrous Process Piping. G. E. Deatherage (*Heating, Piping, Air-Conditioning*, 1934, **6**, 14–16).—Describes various methods for joining aluminium and copper pipes by soldering or welding.—W. P. R.

†**Autogenous Welding of Copper.—V.** Anon. (*Cuivre et Laiton*, 1934, **7**, 579–582).—A description of electric welding of copper by (1) resistance methods; (2) arc process; and (3) the use of atomic hydrogen. In the first, both linear and spot welding are discussed. Owing to the high electrical and thermal conductivity of copper, large localized currents have to be employed and special electrodes, *e.g.* beryllium–copper, are recommended. The insertion of a piece of high-resistance material, such as phosphor–bronze, between the parts to be welded is suggested. The advantage of arc-welding lies in the localization of the generated heat. The advantages and disadvantages of metallic and carbon electrodes are discussed. The application of atomic hydrogen welding to copper is still a matter of controversy, some saying that the metal is thereby maintained in a deoxidized condition, whilst others state that copper is prone to dissolve hydrogen and that its mechanical properties are thus impaired.—W. A. C. N.

The Welding of Copper Sheets, Plates, and Tubes. Herbert Herrmann (*Welding Ind.*, 1934, **2**, 307–312).—Recommendations on technique are given.
—H. W. G. H.

Automatic Arc Welding in Industry. R. Sarazin (*Bull. Soc. Ing. Soud.*, 1934, **5**, 1269–1296; also *Métallurgie et la construction mécanique*, **1934**, Special No., 46–49; and (abstract) *Machine moderne*, 1934, **28**, 371–373).—A description is given of an automatic welding head which can be used for metallic-arc or carbon-arc welding. In the latter case, the arc is stabilized by a magnetic field round the electrode, and provision can be made for welding in a neutral or reducing atmosphere: in the former, a flux-coated electrode is recommended in which electrical contact is made with the core wire by a metallic sheathing and a spirally-wound wire, between the turns of which the flux is pasted. The relative merits of the two processes and their spheres of application are discussed.—H. W. G. H.

Remarks on the Article by H. v. Conrady, Entitled " Atomic-Physical Bases for the Phenomena of the Welding Arc." R. Seeliger (*Elektroschweissung*, 1934, **5**, 197–199).—See *Met. Abs.*, 1934, **1**, 325. A criticism of the article and reply by H. v. C.—H. W. G. H.

Spot Welding. Lawrence Ferguson (*Bell Lab. Record*, 1934, **13**, 109–112).—The operation of spot-welding is discussed, and a chart given of the welding characteristics of 250 combinations of metals. These are classified as yielding good, brittle, or poor welds or as unweldable.—J. C. C.

Spot-Welding in Aero- and Automobile Construction. K. Ruppin (*Z.V.d.I.*, 1934, **78**, 1389).—Various methods of spot-welding are described, with their application to the welding technique of light metals.—K. S.

Size and Spacing of Spot-Welds. R. L. Briggs (*J. Amer. Weld. Soc.*, 1934, **13**, (11), 25–30).—The factors which influence the size of spot produced are explained, so that the best ratio of spot diameter to thickness of material can be chosen, with reference to electrical capacity requirements, life of contact points, and strength of welds.—H. W. G. H.

Thermal Study of Oxy-Acetylene and Electric-Arc Welding. A. Portevin and D. Séférian (*Rev. soudure autogène*, 1934, **26**, (247), 6–7).—A note by Henry Le Chatelier, based on the paper by P. and S. presented to the Rome Congress of the International Acetylene Association.—H. W. G. H.

Recent Developments in Atomic Hydrogen Welding. J. A. Dorrat (*Welding J.*, 1934, **31**, 306–312).—Recent advances in plant and technique are described. Automatic welding by this process has been developed, a unit being employed in which 3 stable atomic flames are produced close together.—H. W. G. H.

Resistance of Welds to Corrosion. André Leroy and Maurice Bonnot (*Welding Ind.*, 1934, **2**, 281–283, 321–322).—The effects of welding methods and after-treatments are discussed in a general way. Aluminium and copper, and their alloys are briefly mentioned.—H. W. G. H.

Stress Measurements on Welded Circular Seams. —— Ebel and —— Reinhard (*Autogene Metallbearbeitung*, 1934, **27**, 305–310).—Two steel cylinders 2 ft. 6 in. in diameter, were made with a central circumferential seam welded by oxy-acetylene. In one cylinder, the seam was annealed by the blowpipe, step by step, and, in the other, the whole seam was annealed at once by a ring burner. The weld stresses were calculated from measurements with a Siebel extensometer. In the first case, they were found to be large, and, in the second, almost negligible.—H. W. G. H.

***Notched Impact Strength of Welded Metals in the Temperature Range of — 195° to + 200° C.** Franz Zimmermann (*Inst. Mech. Tech. u. Materialkunde, Tech. Hochschule, Berlin*, **1934**, (4), 1–52).—Tests have been made on cast iron, steel, aluminium, and Silumin. Whereas fracture did not occur in any of the tests on unwelded 99% aluminium, all the welded pieces broke giving values for the impact strength which increased with the testing temperature to a maximum at — 60° to 0° C. This difference is attributed to internal stresses and large silicon inclusions as well as to the coarse crystal structure of the weld. Hammering the weld reduced the impact strength by a further 40% owing to its effect in increasing internal stress and reducing the capacity to deformation. With Silumin, welding reduced the impact strength by about 15% since the grain-size and internal stress both increased.—A. R. P.

Qualification of Welding Equipment Operators. Harry W. Pierce (*J. Amer. Weld. Soc.*, 1934, **13**, (9), 26–28).—A plea for a simplified and standardized procedure for checking a welder's qualifications.—H. W. G. H.

Thyratron Tube Control of High-Speed Resistance Welders. Warren C. Hutchins and O. W. Livingston (*J. Amer. Weld. Soc.*, 1934, **13**, (11), 19–21).—The application of electronic control to increase the speed of welding is described. A welding period as short as a half-cycle can be obtained, with consequent increase in the temperature gradient through the metal. This reduces oxidation at the surface, prevents distortion, increases the life of contact points, and permits the welding of alloys for which ordinary welding methods are detrimental.—H. W. G. H.

Evolution of Welding-Generator Design. K. L. Hansen (*Welding Eng.*, 1934, **19**, (8), 22–25; (9), 38–41; (10), 24–25).—The development of the modern generator is traced from the days of the series-resistance and constant-potential machine. The production of a drooping characteristic, and various methods of stabilizing, with both separate- and self-excitation, are explained. —H. W. G. H.

Prevention of Possible Accidents in Opening Drums of Calcium Carbide. R. Granjon (*Rev. soudure autogène*, 1934, **26**, (249), 12–13).—Many accidents are said to have taken place due to sparks caused in cutting open the tops of carbide drums and consequent explosion of an air–acetylene mixture in the drums. It is suggested that drums should be employed which can be opened without cutting, or that cutting instruments of bronze should be used. —H. W. G. H.

XXI.—INDUSTRIAL USES AND APPLICATIONS

(Continued from pp. 34–37.)

History, Properties, and World Production of Aluminium. H. Ruderer (*Berg.- u. Hüttenw. Jahrb. Montan. Hochschule, Leoben*, 1934, **82**, 84–85).—Production statistics for 1929 of the principal world producers of aluminium and a brief account of the properties of the pure metal are given.—A. R. P.

Technical Uses, Surface Protection, Soldering, and Welding of Aluminium. H. Ruderer (*Berg.- u. Hüttenw. Jahrb. Montan. Hochschule, Leoben*, 1934, **82**, 158–162).—A review.—A. R. P.

The Light Metal Industry in Austria. R. Mitsche (*Berg.- u. Hüttenw. Jahrb. Montan. Hochschule, Leoben*, 1934, **82**, 85–89).—Statistics of the production, import, and export of aluminium as regards Austria, and a brief account of the domestic industry.—A. R. P.

Aluminium in the Gas Industry. F. Delarozière (*Rev. Aluminium*, 1934, **11**, 2445–2451; and (abstract) *Light Metals Rev.*, 1934, **1**, (5), 90–91).—In gas works and gas distributing systems, the three impurities, hydrogen sulphide, ammonia gas, and hydrocyanic acid, which occur freely, especially in the unpurified gas, and their products of combustion, exert a strong corrosive action on iron and lead containers and pipe-lines. Aluminium, on the other hand, resists this corrosion very satisfactorily. The applications of aluminium in the gas industry are described. The Gas Society of Paris, for instance, recommends pipes and bends to be made of aluminium of 99·5% purity, assembled by autogenous welding, and aluminium of at least 99% purity has a high resistance to ammonium sulphocyanide. In Germany, Alpax (Silumin) has similar applications.—J. H. W.

The Austrian Light-Metal Electric Motor. Johann Brazda (*Berg.- u. Hüttenw. Jahrb. Montan. Hochschule, Leoben*, 1934, **82**, 89–98).—Numerous types of electric motors made almost entirely of aluminium and its alloys are described and illustrated, and their advantages over the usual types are discussed.—A. R. P.

Aluminium as a Constructional Material for the Electrical Equipment of Tramways. W. Benninghoff (*Z.V.d.I.*, 1934, **78**, 1385–1386).—Researches are described on the use of aluminium for various tramway accessories, such as coils.—K. S.

Aluminium Alloy Cylinders. Anon. (*Light Metals Rev.*, 1934, 1, 196–204).—The advantages to be gained are briefly discussed together with the main design features. The properties desirable in the aluminium alloy are considered, and silicon alloys are stated to give the best results.—R. B. D.

The Importance of Aluminium in Textile Technology. Arthur H. Pettinger (*Amer. Dyestuff Reporter*, 1934, 23, 605–607; *C. Abs.*, 1935, 29, 349).—A discussion of applications of aluminium and its compounds in the textile industries. Aluminium paint has been used for covering woodwork or metal, and on pipes and tanks.—S. G.

The Lightening of Dead Weights and the Circulation of Heavy Weights. J. Bally (*Rev. Aluminium*, 1934, 11, 2577–2592).—The use of light alloys in easing the loads to be carried by road transport vehicles and the dead weight of bridges is discussed with numerous illustrations.—J. H. W.

Aluminium in Shipbuilding. Anon. (*Overseas Eng.*, 1934, 8, 42–45).—The special applications of aluminium and aluminium alloys in shipbuilding are outlined from data supplied by the British Aluminium Co., Ltd., London, and the mechanical properties of the cast and the heat-treated material are compared with those of other non-ferrous alloys, steel, and wood.—J. H. W.

Craft Built of Light Alloy. Anon. (*J. Commerce Ship. and Eng. Edn.*, 1934, Nov. 29, 5).—A description of a small 55-ft. Diesel-engined cruiser built throughout of Birmabright. The frames, main hull plates, deck and bulkhead plates, and rivets were all manufactured of this alloy, as well as such parts as propeller brackets, rudders, compass equipment, davits, and many other parts in the form of castings.—J. W. D.

Metallic Insulation. G. P. Crowden (*J. Inst. Heat. Ventilating Eng.*, 1934, 2, 427–448; discussion, 449–457).—Owing to their high reflectivity and low emissivity for radiant heat, aluminium and tin-foil are especially valuable for heat insulation. A number of experiments showed the very varied applicability of aluminium foil for this purpose, and its use in practice is fully described. A *bibliography* of 29 references is appended.—J. H. W.

["Federal Mogul" Tests] Efficiency of Copper Alloy Cylinder Heads. Anon. (*Automotive Ind.*, 1934, 71, 474–475).—Comparative tests using varying speeds and fuels would appear to demonstrate that the use of a copper alloy (composition not stated) results in higher mileage per gall., horse-power, and compression ratio than with light alloy or cast-iron cylinder heads. Graphs based on experimentally obtained values are reproduced.—P. M. C. R.

The Value of Nickel from a Food Hygiene Point of View According to the Literature. W. Schreiber (*Korrosion u. Metallschutz*, 1934, 10, 205–212, 229–235).—A review of the behaviour of nickel vessels for domestic cooking purposes with especial reference to the effect of various foodstuffs on the metal. A *bibliography* of 111 references is given.—A. R. P.

Modern Extensions of the Field of Technical Alloys. W. Guertler (*Chem.-Zeit.*, 1934, 58, 969–970).—The modern use of lithium, beryllium, calcium, barium, cerium, indium, thallium, and tellurium in alloys is briefly outlined.
—A. R. P.

Metals and Alloys in Dentistry. Oscar E. Harder (*Metals and Alloys*, 1934, 5, 236–241).—A review of the uses of amalgams, gold and its alloys, platinum, palladium, and nickel in modern dental practice.—A. R. P.

Metallurgical Advances Reflected in Engineering Design. Robert W. Carson (*Metals and Alloys*, 1934, 5, 217–220).—The use of corrosion-resisting alloys in chemical plant construction and the like is briefly reviewed.—A. R. P.

†Condensing Plant and Condensate Economy in Ships. D. Schäfer (*Z.V.d.I.*, 1934, 78, 1369).—The life and smooth working of ships' condensers are dependent on the resistance to corrosion of the materials of which they are constructed. Tubes of copper–nickel alloys with 20–30% nickel or of aluminium–brass fulfil all the requirements, but efforts to replace these materials with tinned 60 : 40 brass or with lead-coated steel tubes have proved abortive. K.S. Seewasser alloy is also unsatisfactory.—K. S.

The Use of Metals and Alloys in the Sulphuric Acid Industry. Bruno Waeser (*Metallbörse*, 1934, **24**, 1289–1290, 1321–1322, 1353–1354).—A review of recent work on the behaviour of various grades of lead, cast iron, and nickel-chromium alloys towards sulphuric acid of different concentrations.
—A. R. P.

The Rare Metals in 1932. A. Likhachev (*Redkie Metalli* (*Rare Metals*), 1933, **2**, (5), 38–39).—[In Russian.] Deals with world production statistics for lithium and beryllium, ore deposits, and prices for the metal and ores.
—D. N. S.

On New Sources of Economy of Non-Ferrous Metals in Electrical Installations. L. P. Podolskiy (*Vestnick Elektropromishlenosti* (*Messenger Elect. Ind.*), **1934**, (2), 28–29).—[In Russian.]—N. A.

More About Economy of Non-Ferrous Metals in Electrical Installations. L. B. Gayler (*Vestnick Elektropromishlenosti* (*Messenger Elect. Ind.*), **1934**, (2), 29–31).—[In Russian.] Questions raised in the article of L. P. Podolskiy (preceding abstract) are discussed.—N. A.

Non-Ferrous Metals—Past and Future. Zay Jeffries (*Iron Age*, 1934, **134**, (19), 20–23, 77).—Read before the Metropolitan Section of the American Society of Mechanical Engineers. A discussion of the current uses of non-ferrous metals, their individual qualities which fit each for a specific purpose, and what may be expected from common and less common metals in the future.
—J. H. W.

XXII.—MISCELLANEOUS

(Continued from p. 37.)

Non-Ferrous Metallurgical Development During the Past Five Years. Sam Tour (*Metals and Alloys*, 1934, **5**, 213–216).—A brief account is given of the outstanding advances made in the metallurgy of aluminium, copper, lead, magnesium, nickel, and zinc, during recent years.—A. R. P.

Aluminium and Magnesium Industries in Japan. Harushige Inoue (*Kōgyō Kwagaku Zasshi* (*J. Soc. Chem. Ind. Japan*), 1934, **37**, (3)).—[In Japanese, with English summary in supplemental binding, pp. 111–112.] Aluminium is used in Japan for the most part in the manufacture of cooking utensils and tableware, which account for about 60% of the total demand. The remainder is consumed in the manufacture of electric cables, aeroplanes, automobiles, telephones, and other machinery. Details are given of the imports and their use in 1928. Figures for Japanese exports of manufactured goods in 1929, 1930, and 1931 are given. In recent years the annual demand for magnesium was 40–50 tons, one half of this amount being supplied by a Japanese concern. The Nichi-Man Magnesium Co. was formed in 1933, and a modern plant is being installed for an output of 350 tons of magnesium per annum.—S. G.

Creation of a U.S.S.R. Beryllium Industry. V. I. Spizin (*Redkie Metalli* (*Rare Metals*), 1933, **2**, (5), 7–13).—[In Russian.] A record of laboratory and semi-technical scale work on the production of beryllium at the experimental factory. Description of treatment of the ore and deposition of the metal by electrolysis.—D. N. S.

***Economic Storing Arrangements in Metallurgical Works.** Wilhelm Schug (*Stahl u. Eisen*, 1934, **54**, 1030–1035).—Discusses the general problem of storage of materials required in metallurgical works, the amounts to be kept in stock, the ordering of new supplies, &c. Methods of recording the stock in hand, accounting, and book-keeping are dealt with.—W. H.-R.

The Story of Early Metallurgy. XI.—Copper and Bronze: The Questions of Priority and the Mineral Sources. R. T. Rolfe (*Met. Ind.* (*Lond.*), 1934, **45**, 563–565, 576).—See *Met. Abs.*, this volume, p. 37. Conclusion. The claims of South and Central Africa, of Crete and the Ægean, and of China to be the first smelters of copper and the earliest users of bronze are discussed. In summing up, R. concludes that much more research is necessary before definite decisions on these matters can be made.—J. H. W.

***Adsorption of Mercury Vapour by Certain Absorbents and Catalysts and Manganese Dioxide Amalgam [Mercury Poisoning].** E. W. Alexeewsky (*Zhurnal Obschtei Khimii* (*J. General Chem.*), 1933, [A], 3, (65), 360–366).—[In Russian.] The danger of mercury-vapour poisoning has rendered necessary investigation of means of adsorbing it. A series of adsorbents, such as activated charcoal, clay, metal powders, and oxides, were examined. The highest activity was shown by manganese dioxide, which adsorbed 41·5% of mercury over a period of 5 years. The activated manganese dioxide easily forms an amalgam even on mere mixing with mercury, the composition of which varies with the concentrations of the two substances. The mercury can be recovered from the amalgam, and, therefore, the activated manganese dioxide can be used both as a protective medium in masks and as a means of mercury recovery.—M. Z.

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[Includes 4 specifications and 1 recommended practice for zinc-coated steel articles; 1 for pig lead; 8 for aluminium and its alloys; 6 for magnesium and its alloys; 7 for copper and its alloys; 3 for die-castings (Al, Mg, and Zn-base); 2 for electrical heating and electrical resistance alloys; and 8 on testing of metallic materials. In addition a number of tentative revisions of standard specifications are published.]

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[A most useful publication, giving information and data on: physical, mechanical, and electrical constants of aluminium; wire and sheet gauges; useful factors and formulæ; physical properties of various metals; ingots and billets; rods; bar and strip; foil; wire; stranded conductors; British Standard specifications for aluminium and its alloys; alloys—Birmabright, D–2 and MG 7, Duralumin, R.R., Al–Mg-Si, Al–Si, Al–Cu, Al–Cu–Zn, "Y," Al–Mn; sheet, strip, and circles; matting; expanded sheet; rivets; wood screws; tubes and pipes; sections; collector bows; annealing; heat-treatment; mixing, melting, and casting; panel forming; press work; spinning; machining; forging; welding and soldering; riveting; polishing; cleaning; matt finish; anodizing; painting.]

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[See *Met. Abs.*, 1934, 1, 391.]

XXIV.—BOOK REVIEWS

(Continued from p. 40.)

Handbuch der Metallphysik. Herausgegeben von G. Masing. Band I: *Der Metallische Zustand der Materie,* Erster Teil, *Gitteraufbau Metallischer Systeme.* Von U. Dehlinger. 1935. Leipzig: Akademische Verlagsgesellschaft m.b.H.

The application of the methods of X-ray crystal analysis to the study of metals and alloys has resulted in a great accumulation of data, and many metallurgists must have felt the need of books in which attempts were made to reduce the facts to order. This volume by Professor Dehlinger is, therefore, greatly to be welcomed, and should be read by all those who are interested in the structure of metallic substances. The first 40 pages give a brief survey of the elements of crystal structure and symmetry, and of the different methods of X-ray crystal analysis. In the next 30 pages the structures of all the metallic elements, and of a very large number of intermediate phases and intermetallic compounds are tabulated systematically, the values of the lattice parameters being given in many cases. The extent of the ground covered may be judged from the fact that no less than 1017 papers are referred to in this section alone. The next section deals with the relations which have so far been found between the different structures, and which are the first steps towards an exact chemistry of metallic substances. The next section deals with the thermodynamic stability of metallic structures, and this is followed by an exceedingly interesting section on the kinetics of changes in the solid state. This includes the factors affecting the velocity of precipitation from solid solutions, the changes from the ordered to the disordered state, and changes from one structure to another involving intermediate forms such as martensite. The work described here is drawn almost entirely from German sources, and should be of great interest to English readers who have not read the original papers. The reviewer would offer the comment that there is perhaps a tendency to accept the X-ray results a little too readily, for although the methods are of great delicacy, the results are often difficult of interpretation, and in many cases it is far from easy to control the other factors entering into the problem. The recent results of Dr. Bradley on anomalous lattice spacings in solid solutions have shown, for example, how even in the apparently simple process of the determination of solid solubility limits, misleading results may easily be obtained. In more complex problems further difficulties may well be expected, and this book serves to show how wide a field is being explored.—W. HUME-ROTHERY.

Distortion of Metal Crystals. By C. F. Elam (Mrs. G. H. Tipper). Med. 8vo. Pp. xiii + 182, with 94 illustrations in the text and 5 plates. 1935. Oxford: Oxford University Press (Humphrey Milford). (15*s.* net.)

Dr. Elam's name is so well known in connection with work on the formation and deformation of single crystals that we looked forward to having the whole of this complicated subject clearly explained to us at last. Whilst the book contains a very valuable summary of the mass of experimental work carried on since the War, we are definitely disappointed in the result. We had hoped that Dr. Elam would have allowed her own view of an admittedly controversial subject to predominate, and thus give us a picture of the whole subject as she sees it. Her attitude of impartiality is adopted, she states in the preface, so that the reader can reach his own conclusions, but most metallurgists would have preferred a clear picture of the views held by at least one authority. We were particularly disappointed in the last chapter, "Theoretical Discussion and Summary," where we hoped to find some unification, but the card-index was still in evidence, and every proposed hypothesis, dignified by the name of theory, is recorded. The chief errors are in punctuation. The description of the Pintsch process for making single crystals (p. 5) is entirely wrong; the process as described could not possibly work. There is a misprint in the footnote on p. 160. We are still uncertain if there is a subtle difference between slipping on slip-planes and gliding on glide-planes, these terms being used indiscriminately.

The book is well produced, but we must protest against the archaic method of referring to footnotes by means of different forms of sign. Is a sentence that begins like this (p. 108) necessary "Bismuth,†† cadmium,‡‡§§ and zinc§§‖‖. . . ." Fortunately, the attempt was abandoned on p. 20, where there are 46 references.—C. J. SMITHELLS.

État Actuel de l'Essai de Fragilité des Métaux. Par P. Dejean and S. Gerszonowicz. (Pp. iii + 103, with 63 illustrations. 1934. Paris: Dunod. (20 francs.)

The quality of "brittleness" (Fr. *fragilité*) as a property of engineering materials is now almost always assessed by some form of bending impact test on some form of notched specimen. In their review of the present position with regard to the notched-bar test, MM. Dejean and Gerszonowicz survey the various researches that have been carried out, and describe the attempts that have been made to determine the effect of such factors as size of test-piece, size and shape of notch, temperature of test, and type of machine used. On the evidence of the results of several different researches, the authors conclude that the value of the energy absorbed is extremely sensitive to small variations of these factors within the ranges commonly employed, so that in many cases, even in carefully controlled research tests, a wide scatter of results is to be expected. For this reason, that the exact value of practically any of the major factors affecting the test may be extremely critical, the authors strongly advocate the adoption of an international standard test; they suggest that for this purpose, the Charpy test-piece is preferable to the Izod, because the diameter of the hole in the former can be reproduced with more certainty than the radius at the bottom of the notch in the latter. Although the authors are apparently resigned for the present to regard the notched-bar impact test simply as an *ad hoc* test, their well-balanced appraisal of the present state of knowledge suggests several directions along which research might proceed. There is clearly much to be done before the energy absorbed by a notched specimen tested in impact can be regarded as a physical property of the material; but the authors are to be congratulated on their clear presentation of the real significance of the test as it is at present made.

The diagrams reproduced are uniformly bad, and Figs. 58 and 59 were apparently too bad to print at all; but, fortunately, the diagrams need be regarded as little more than sketches. In all other ways, the printing and general exposition are excellent.—H. L. Cox.

Introduction à l'Étude des Traitements Thermiques des Produits-Métallurgiques. Par A. Portevin. 4to. Pp. 120, with 66 illustrations. 1934. Paris: Aciers Spéciaux Métaux et Alliages, 4 Rue Férou. (20 francs.)

This is an excellent introduction to the detailed study of the thermal treatment of metals and alloys. The major portion of the book is devoted to iron and steel, however, and but a small part deals with the treatment of aluminium alloys. Following each chapter an auxiliary one embodying details of experimental work in the same connection is inserted. Although the discussions deal mainly with ferrous materials, the principles involved and the relevant experimental details may be read with advantage by those whose interests are principally non-ferrous. A final chapter deals with (1) the analogies and differences between the thermal treatment of steel and light alloys; (2) structural transformation by precipitation; (3) heat-resistant alloys; and (4) general conditions for the transformation of alloys in the solid state.—W. A. C. Newman.

A Short History of Pewter and Its Manufacture. By Elsie Englefield. Med. 8vo. Pp. 85, illustrated. 1933. London: Brown and Englefield, 1 Little James St., Gray's Inn Rd., W.C.1. (3*s.* 6*d.* net; 4*s.* post free.)

This little book will appeal primarily to the lover of genuine pewter, and includes some useful hints to collectors. It is written in simple, non-technical language, and contains a fair amount of interesting information. Allusion is made to the control of the pewterer's craft, formerly exercised by the Worshipful Company of Pewterers, but perhaps the predominant feature is the intimate account of an old-established London business. The constitution and metallurgy of the alloy, however, receive scant treatment, the processes of manufacture being dismissed in two short pages.—F. Orme.

Who's Who, 1935. An annual Biographical Dictionary with which is incorporated "Men and Women of the Time." Eighty-seventh year of issue. Post 8vo. Pp. xviii + 3694. London: A. & C. Black, Ltd. (60*s.*)

"Forty thousand 'tabloid' biographies of living notabilities." In that sentence is summed up the contents of one of the most indispensable books that appear year by year for the information and guidance of busy men and for the intriguing of others who may be fortunate enough to become possessed of a copy of this wonderful volume.

From Aaron to Zwemir there passes a pageant of the illustrious—or the merely industrious—in every branch of human activity and in every part of the world. Among them Members of Council of the Institute of Metals figure prominently, and the records of their birth, training and achievement, of their families, hobbies, and clubs—to mention only a few of the particulars generally given—cannot fail to interest every member who would know more of the men by whom he is represented on the Council.

One could wish that commercial considerations did not spoil the opening pages of the book, in which a collection of beautifully reproduced photographs of members of the Royal Family is marred—with the single exception of that of Princess Elizabeth—by being set to face pages of advertising matter. It is not fair that our thoughts in viewing an inspiring photograph of His Majesty should be distracted by the flaring announcement of a railway company that one would have expected indignantly to reject the idea of seeking publicity in such juxtaposition.
—Ed.

PRINTED IN GREAT BRITAIN BY RICHARD CLAY AND SONS, LTD., BUNGAY, SUFFOLK.