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

Vol. 1. Part 9.

2566 III Lcz.

The Monthly Journal of the
INSTITUTE OF METALS

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and

METALLURGICAL ABSTRACTS

SEPTEMBER, 1934

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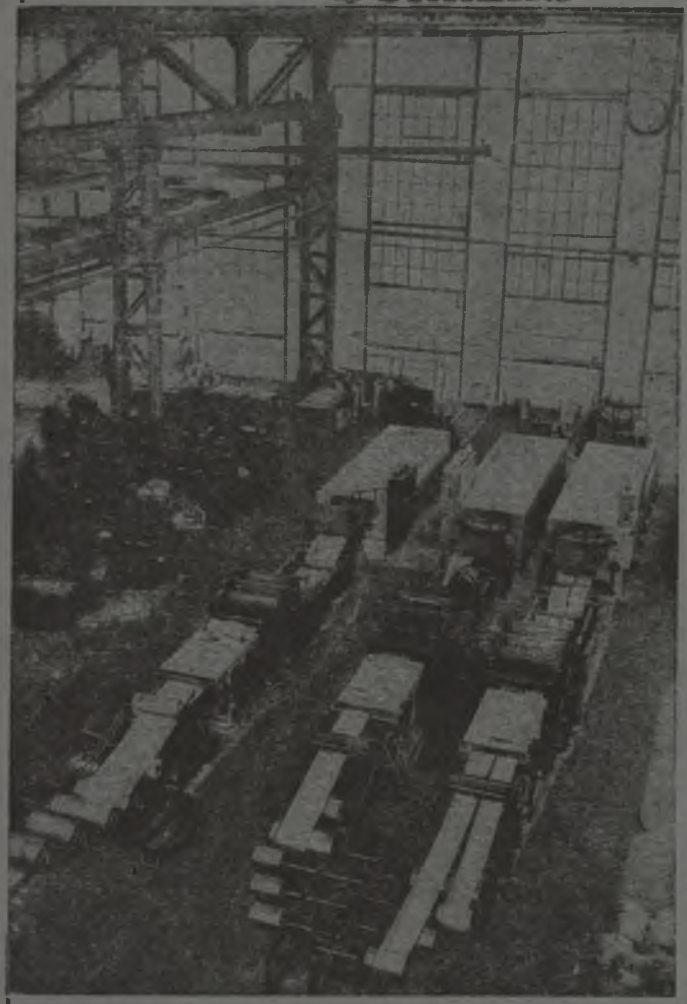

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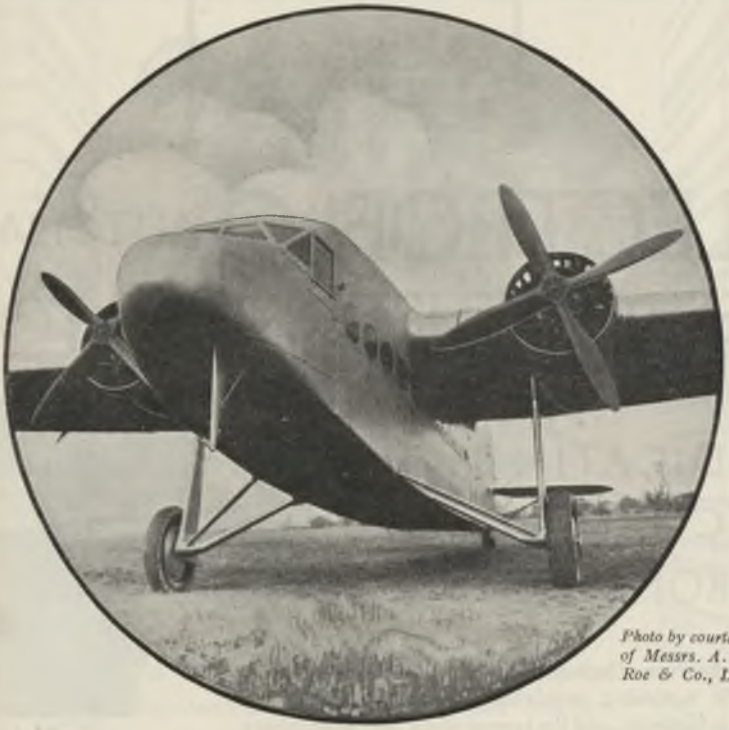

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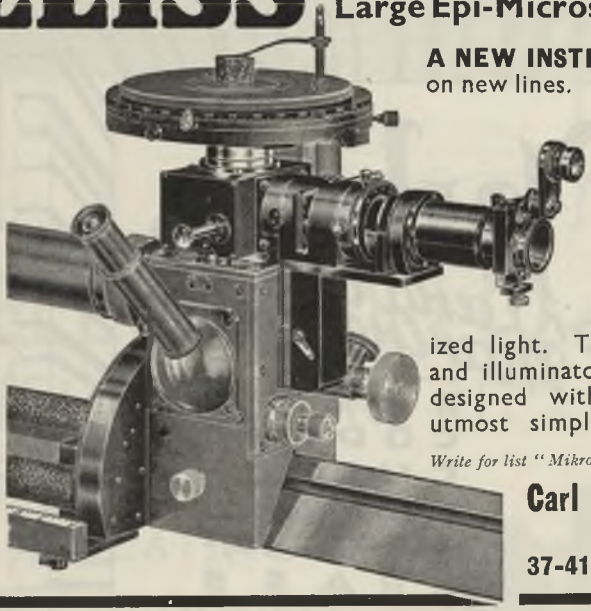

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"Brass World." Volumes 1–6.

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. Volumes 1–3 incl.

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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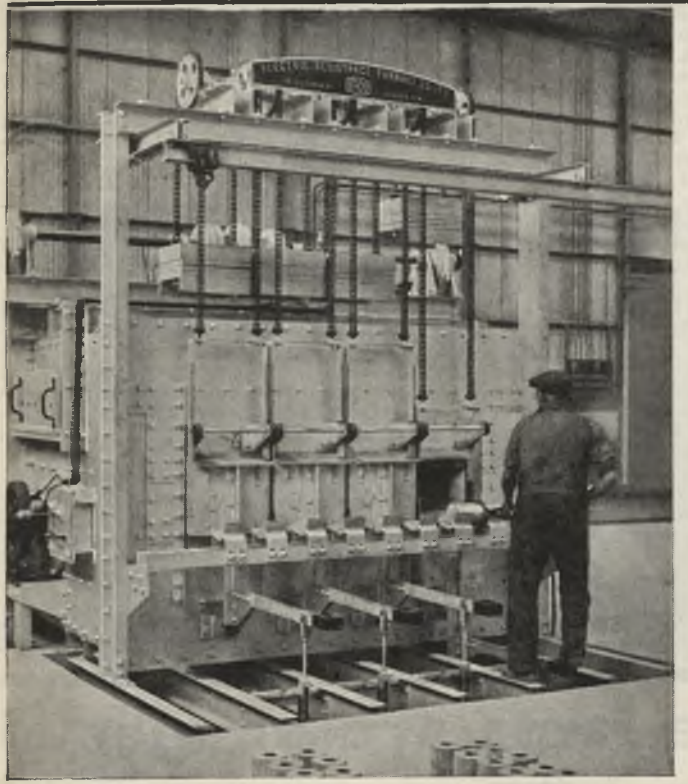

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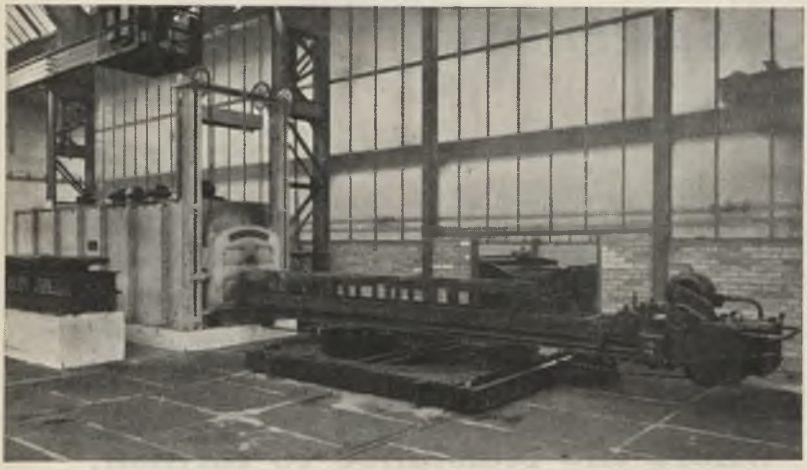

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Volume 1 SEPTEMBER, 1934 Part 9

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The monthly issue of *Metallurgical Abstracts* may be cut up for card indexes, as members will receive early in 1935 the year's abstracts in bound form.

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INSTITUTE NEWS AND ANNOUNCEMENTS

Autumn Meeting, Manchester.

THE Twenty-Sixth Annual Autumn Meeting was successfully held in Manchester from September 3 to 6, and was well attended. The excellent arrangements made by the Local Reception Committee for the entertainment and convenience of members were much appreciated. The papers discussed at the meeting were previously printed in the *Monthly Journal* (May–August issues) and written discussion on any of them may be sent to the Secretary not later than October 1 next, for inclusion in the bound volume of the *Journal* which will be issued in December, 1934. In this volume will be reproduced all the papers that were presented at the Manchester meeting, as well as the three papers dealing with spectrographic analysis and the paper on ancient copper-coated silver coins of Cyprus that are included in this issue. These papers were presented but not discussed at the Manchester meeting.

The general principle of the Institute is not to publish spectrographic papers of an analytical character; but it is held that the subject of spectrographic analysis of metals is so new as to justify, for the present, the inclusion of such papers in the *Journal*, provided that they contribute to the knowledge of the application of this method of investigation. At a later date it will probably be necessary to deal with communications on spectrographic analysis as with other analytical papers.

Nomination of Officers for 1935–1936.

At the Manchester meeting the Secretary read the following list of members nominated by the Council as Officers for the year 1935–1936 :—

President :

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

Vice-Presidents :

W. R. BARCLAY, O.B.E.

CECIL H. DESCH, D.Sc., Ph.D., F.R.S.

Members of Council :

Lieutenant-General Sir RONALD CHARLES, K.C.B., C.M.G., D.S.O.

Engineer Vice-Admiral Sir ROBERT DIXON, K.C.B., D.Eng.

R. GENDERS, M.B.E., D.Met.

A. H. MUNDEY.

The Hon. R. M. PRESTON, D.S.O.

H. B. WEEKS.

Biographical details of three of the above-mentioned members who are newly nominated to the Council, and reproductions of their photographs, are given on the following two pages.

Educational Tour.

It has been suggested that in view of the success that attended the Institute's first Educational Tour last spring, when a party of 40 visited Belgium, another Continental tour should be arranged to take place shortly after Easter, 1935, visiting the Rhineland of Germany. Any of the younger members of the Institute who are interested in the proposed tour should communicate with the Secretary.

Overdue Subscriptions.

Members who have not yet paid their annual dues (the amount is £3 3*s*.), which became payable *on or before July 1 last*, are asked by the Finance Committee to be good enough now to forward the necessary remittance, **thus enabling their names to be retained on the list of those entitled to receive this Journal month by month as issued.** Cheques should be made payable to the Institute of Metals and crossed "Lloyds Bank, Victoria Street." The Secretary will be glad to supply specially printed banker's order forms to those members who desire to pay their subscriptions by this simple and economical means. *Already 550 members use Banker's Orders.*

[*Vandyk*.

Lieutenant-General Sir Ronald Charles, K.C.B., C.M.G., D.S.O.

Born June 26, 1875. Second son of the late T. Edmondston Charles, M.D., Honorary Physician to H.M. the King. Educated at Winchester (Scholar) and Royal Military Academy, Woolwich.

Joined the Royal Engineers as Second Lieutenant, August, 1894. Served in South African War, 1899–1900; Queen's Medal with 4 clasps; despatches twice and D.S.O.

Served in India from 1901 to 1914, during which time he saw active service twice, gaining two mentions in despatches and the Indian Frontier Medal, 1908, with clasp; passed through the Quetta Staff College and served on the Staff at A.H.Q. India.

Went to France with the Indian Army Corps in September, 1914, and served there continuously in various capacities for the rest of the Great War, finishing up in command of the 25th Division. Mentioned in despatches five times, decorated with C.B., C.M.G., and Legion d'Honneur (Officier); received brevets of Lieut.-Colonel and of Colonel.

After the War served on the Directing Staff of the Camberley Staff College, 1919–1921; at Army Headquarters, India, 1921–1923; commanded the Waziristan Force, 1923, and received a mention in despatches and a clasp to his frontier medal. Was Commandant of the Royal Military Academy, Woolwich, from 1924 to 1926, Director of Military Operations and Intelligence at the War Office, 1926 to 1931. Master General of the Ordnance and Member of the Army Council from 1931 to 1934. Retired from the Army in May, 1934, and joined the Board of The British Aluminium Company, Ltd.

R. Genders, M.B.E., D.Met., F.I.C.

Dr. Genders, who has been a member of the Institute of Metals since 1919, is Deputy Director of Metallurgical Research at the Research Department, Woolwich. He was born in 1891, and had his metallurgical training at Sheffield University. He was subsequently an assistant in the research laboratories of Messrs. Cammell Laird and Messrs. Brown Bayley, and metallurgist to Messrs. Moses Eadon & Sons, Sheffield, working on alloy and special tool steels.

In 1914 he joined the staff of the Research Department, Woolwich,

under Dr. H. Moore, was later head of the section dealing with non-ferrous metallurgy, and among other researches carried out the investigations which led to the introduction of the "inverted" extrusion process. More recently, he was associated with the British Non-Ferrous Metals Research Association in extensive work on the casting and die-casting of copper alloys, and was joint author (with G. L. Bailey) of a book on the casting of brass ingots. His metallurgical interests have been necessarily of a wide character, including both steel and non-ferrous metals, and he has carried out many researches on alloy steels and on new applications of some of the rarer metals.

Dr. Genders has published much scientific work, including a number of contributions to the Institute of Metals dealing with the extrusion process and with various problems connected with the solidification of metals and alloys, segregation, and macrostructure. He has also given many lectures on these and other subjects, and takes an active part in the meetings of the Institute. He was for some years lecturer in chemistry and metallurgy at the Dartford and Northampton (London) Technical Institutes.

The Hon. R. M. Preston, D.S.O.

Born, 1884. Royal Military Academy, 1901–1903. Joined Royal Artillery, 1903. Served in the War in the Honourable Artillery Company, 1914–1918.

After the War was engaged in the coal-mining, coking and by-product industry and in shipping in the North of England. Managing Director of Rio Tinto Company Limited. Director of Rhokana Corporation, Ltd.;

Minerals Separation, Ltd.; Marine Insurance Company, Ltd.; British Metal Corporation, Ltd.; Amalgamated Metal Corporation, Ltd., and the British Non-Ferrous Mining Corporation, Ltd.

PERSONAL NOTES

Sir Henry Fowler, K.B.E., LL.D., D.Sc., Past-President, has been appointed by the Minister of Transport as Chairman of a committee of scientists and motor and motor-cycle manufacturers "to consider and report upon the principal causes of noise in the operation of mechanically-propelled vehicles and the steps which can effectively be taken to limit the noise so resulting." Dr. H. J. Gough, M.B.E., F.R.S., Superintendent of the Engineering Department of the National Physical Laboratory and a frequent contributor to the Institute's *Proceedings*, is a member of Sir Henry's committee.

Dr.-Ing. Max Haas, Corresponding Member to the Council for Germany, has been appointed Manager of the Aluminium-Zentrale. His address in Berlin is Potsdamerstrasse 23a, where he will be glad to welcome friends visiting Berlin. He is producing from the offices of the Aluminium-Zentrale this month a new periodical under the title "Aluminium."

Dr. Hugh O'Neill has joined the staff of the Metallurgical Research Laboratory, L.M.S. Railway Company, Derby.

LOCAL SECTIONS

Opening of 1934–1935 Session.

Five of the six Local Sections of the Institute will have held their opening meetings, at most of which Addresses will be given by the respective Chairmen, before the next issue of the *Monthly Journal* appears. Attractive programmes have been arranged for the coming session, as will be noted by members from the green folder cards that will be despatched on September 29 to members resident in the British Isles. With each programme will be sent a post-card that should be returned by every member who desires to receive regular monthly " reminders " of the meetings of his Local Section. For the session 1934–1935 the Council is making to the Local Sections grants totalling £125.

During the coming session it is proposed to print a short synopsis of each Local Section paper in the issue of the *Monthly Journal* that appears in the month previous to that in which the paper is due for presentation. It is hoped that as a result members will be stimulated to attend the meetings and to take part in the discussions.

The meetings to be held next month are as follows :—

Birmingham :			
Open Discussion on " The Production of Brass Ingots."	October 25.	James Watt Memorial Institute.	7 p.m.
London :			
C. J. Smithells, M.C., D.Sc.	October 11.	Society of Motor Manufacturers & Traders, 83 Pall Mall, S.W.1.	7.30 p.m.
North-East Coast :			
W. Richardson, B.Sc.	October 9.	Electrical Engineering Lecture Theatre, Armstrong College, Newcastle-on-Tyne.	7.30 p.m.
Scottish :			
J. W. Donaldson, D.Sc.	October 8.	Institution of Engineers & Shipbuilders in Scotland, 39 Elmbank Crescent, Glasgow.	7.30 p.m.
Sheffield :			
Kenneth Gray.	October 12.	Non-Ferrous Section, Applied Science Dept., The University, St. George's Square.	7.30 p.m.
Swansea :			
Professor L. Taverner, A.R.S.M.	October 9.	Y.M.C.A., Swansea.	6.15 p.m.

Supper-Dance.

As previously announced, the Council is arranging, in co-operation with the London Local Section of the Institute, for a Supper-Dance to be held on Friday, November 30, 1934, at Thames House, Millbank, S.W.1. Dancing will begin at 7.30 p.m. and the function will conclude at midnight. Tickets price 6*s*. each are now available and can be obtained from the Honorary Secretary of any Local Section, or from the Secretary of the Institute of Metals.

It is hoped that members of Local Sections throughout the country will support the London Local Section with their attendance at what promises to be a pleasant and interesting new function.

PAPER No. 680. This paper was presented at a meeting held on September 3–6, 1934, in Manchester, and may be reprinted, wholly or in part, by the technical press, provided that due acknowledgment is given to the Institute of Metals. 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 October 15, 1934.

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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.

THE SPECTROGRAPHIC DETECTION AND ESTIMATION OF MINUTE QUANTITIES OF IMPURITIES IN COPPER.*

By M. MILBOURN, † B.Sc., MEMBER.

SYNOPSIS.

An accurate and convenient method is described for the detection and estimation of small quantities of bismuth, arsenic, lead, iron, nickel, silver, antimony, and tin in copper. Details of technique, sensitivity, and line intensity comparisons are given.

INTRODUCTION.

THE problem which gave rise to this work was the necessity for making spectrographic analyses on small samples of copper, weighing less than 0·5 grm. The usual arc method using copper rods was impossible, and the spark method was unsuitable on account of lack of sensitiveness; it was decided therefore to try a globule method of arcing such as has been described for tin and lead by Smith,[1] Brownsdon and van Someren,[2] and Hitchen;[3] and for copper by Hill and Luckey.[4] Breckpot [5] has also described somewhat similar work in which synthetic samples, consisting of copper oxide with small additions of other oxides, were tested in a graphite arc.

Working on small samples of copper, van Someren made the interesting observation that increased sensitivity to a number of impurity elements occurred when they were examined by the globule method of arcing. The present paper deals with the technique and line intensity comparisons to be used when applying this method to the detection and estimation of minute quantities of impurities in copper.

TECHNIQUE.

The method used is essentially the same as that described elsewhere.[1, 2, 3, 4] An arc 4 mm. long and carrying 5 amp. is passed between a pure copper rod, made the positive electrode, and a small

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† Research Physicist, I.C.I. Metals, Ltd., Witton, Birmingham.

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portion (0·2–0·5 grm.) of the sample to be examined, supported in a shallow cup in the end of a graphite rod (Hilger's H.S. graphite). The piece of sample used is pickled, washed, and dried on filter paper. The voltage across such an arc is generally about 40 v. and does not vary by more than $\pm$ 1 v. for any one sample.

If the sample adheres to the copper rod, or if the arc tends to pass to the graphite, then the electrodes should be manipulated until a suitable, steady arc is obtained. The cup in the end of the graphite rod should be of about 1·5 cm. radius, that is, just sufficiently deep to keep the molten globule in place.

The copper rod used contains the following small amounts of impurities, as estimated from tests in which a small portion of it was made the globule: Lead, slight trace (Pb 2833·1 A. just visible); iron, about 0·001 per cent.; nickel, about 0·0005 per cent.; silver, about 0·002 per cent.; antimony, about 0·001 per cent.; bismuth, arsenic, and tin, not detected.

Using other samples as globules and the above copper rod as anode, spectra are obtained in which lines due to such elements as lead, iron, or silver may be absent; hence these small amounts of impurities are not affecting the spectrum.

Similarly the graphite rod acts merely as a convenient conductor and an easily cleaned support for the globule, and does not enter into the arc. Cyanogen bands and lines due to impurities in the graphite, such as vanadium, titanium, and silicon, do, however, appear when a graphite rod is used as anode instead of the copper rod. For this reason, the copper rod is preferred.

Hilger's medium quartz spectrograph (E.315) has been used throughout the work, with the arc 20 cm. from the slit, and no condensing lens between them. An exposure of 15 seconds was given using Ilford Process Panchromatic plates. This exposure is about half that necessary for a solid electrode arc. The slit width of 0·015 mm. was fixed to give the required resolution.

It has been found that weight of sample, provided that it is between the limits stated, has no appreciable influence on the results.

Exposures made at intervals in the continuous arcing of various globules for 2 to 3 minutes showed that lines due to impurities do not decrease in intensity during the first minute's arcing. Thereafter the arsenic lines decrease somewhat, and there is a slight decrease in the lead, tin, and bismuth lines when the globule has practically boiled away (after about 3 minutes' arcing). The increase in sensitivity with the globule method is therefore not due to distillation of impurities from the copper.

Modifications to the Copper Spectrum.

The copper spectrum obtained from a globule arc is radically different from that given by a solid electrode arc. The spark lines appearing near the poles in the latter are practically suppressed in the former, and many lines absent from or appearing only faintly in the solid electrode arc occur with considerable intensity in the globule arc. The factors, such as temperature and electrical conditions in the arc, which favour the appearance of these lines also enhance the impurity lines. Many of the faint " background " lines are nearly absent from the globule arc; this also assists in the observation of impurity lines. The yellow luminous cone surrounding the arc, as described by W. B. Nottingham,[6] is very pronounced with the globule method.

The state of the globule arc can best be judged from the steady value of the voltage at the time of exposure and from the reversal of the lines Cu 3247·6, 3273·9, 2199·6, and 2293·8 A. and the equality of the lines Cu 2844·2 and 2845·0 A. in the photographed spectrum.

Relative Sensitivity of Globule and Solid Electrode Arcs.

The results of observations on sensitivity to impurities made under identical conditions of amperage and arc length for the two methods of testing copper are given in Table I. Impurity lines which cannot be detected in the solid electrode arc appear with sufficient intensity to allow of comparison with copper lines in the globule arc. The sensitivity to iron and silver, however, is not greatly increased.

Table I.

Element.	Percentage.	Sensitivity in globule arc.	Sensitivity in solid electrode arc.
Bi	0·0002	Bi 3067·7 = Cu 3068·9	not detected
As	0·001	As 2349·8 visible	,,
Pb	0·0004	Pb 2833·1 = Cu 2845·0	,,
Fe	0·002	Fe 2483·3 < Cu 2479·8	Fe 2483·3 visible
Ni	0·0005	Ni 3134·1 = Cu 3135·2	not detected
Ag	0·001	Ag 3382·9 < Cu 3375·7	Ag 3382·9 < Cu 3375·7
Sb	0·002	Sb 2598·1 > Cu 2570·7	Sb 2598·1 barely visible
Sn	0·0005	Sn 2354·8 = Cu 2363·3	not detected

Estimation of Impurities.

The tabular data given below in the form of line intensity comparisons are entirely based on chemically analyzed samples. The range of percentage of impurities studied extended into that which can be covered by the solid electrode arc. It was thus found that the globule method is the more reliable for percentages of impurities which approach the limit of detectability of the solid electrode method. The amounts

of impurities given, therefore, frequently exceed the description "minute quantity." Breckpot [5] gives intensity data for 1, 0·1, 0·01, and 0·001 per cent. of bismuth, arsenic, lead, silver, and antimony.

Bismuth.

Care should be taken to distinguish the line Bi 3067·7 A. from the line Fe 3067·3 A. when iron is present in quantities greater than 0·01 per cent.

TABLE II.

Bismuth, Per Cent.	Bismuth Line. A.	
	2898·0.	3067·7.
0·0002		= } Cu
0·0005		> } 3068·9 < } Cu
0·001	< } Cu	= } 3088·0
0·003	= } 2905·4	> }
0·005	> } < } Cu	
0·01	= } 2911·0	

Arsenic.

Up to 0·05 per cent. of arsenic the globule method may be advantageously used. For the estimation of arsenic in arsenical coppers containing up to 0·5 per cent. arsenic the globule method is not so suitable as the solid electrode method, owing to the fact that there is a comparatively rapid loss of arsenic due to volatilization with the former method. If, however, some estimation of the arsenic content is required when using the globule method on an arsenical copper, then the exposure should be made during the early stages of arcing.

TABLE III.

Arsenic, Per Cent.	Arsenic Line. A.		
	2349·8.	2780·2.	2860·5.
0·001	b.v.	not detected	
0·003	< } Cu	b.v.	
0·01	> } 2363·3		= } Cu
0·03			> } 2862·0 < } Cu
0·05			= } 2874·7

Lead.

The method used by Hill and Luckey,[4] employing a globule arc, the globule being positive, consisted in noting the time for the lead line 4057·8 A. to disappear from a spectrum observed visually. This indicates that under the conditions they used lead was being removed from the copper, whereas such removal was found not to take place within the range studied here.

TABLE IV.

Lead, Per Cent.	Lead Line. A.		
	2614·2.	2833·1.	2873·3.
0·0004 0·001 0·005 0·01 0·03	$\left.\begin{matrix}<\\>\end{matrix}\right\}$ Cu 2627·5 $\left.\begin{matrix}<\\=\\>\end{matrix}\right\}$ Cu 2630·0	$\left.\begin{matrix}=\\>\end{matrix}\right\}$ Cu 2845·0	$\left.\begin{matrix}<\\=\\>\end{matrix}\right\}$ Cu 2874·7

Iron.

Great care in the pickling and handling of the samples is essential if distinctions are to be made in amounts of iron of less than 0·01 per cent.

TABLE V.

Iron, Per Cent.	Iron Line. A.	
	2483·3.	2484·2.
0·002 0·005 0·01 0·02	$\left.\begin{matrix}<\\=\\>\end{matrix}\right\}$ Cu 2479·8	$\left.\begin{matrix}<\\=\end{matrix}\right\}$ Cu 2494·9

Nickel.

The most sensitive nickel line is nickel 3415 A., but the full range of analyzed samples can be followed from the comparisons given below.

TABLE VI.

Nickel, Per Cent.	Nickel Line 3134·1 A.
0·0005	b.v. = Cu 3135·2
0·005 0·01 0·02 0·03 0·06	$\left.\begin{matrix}<\\=\\>\end{matrix}\right\}$ Cu 3131·5 $\left.\begin{matrix}<\\=\\>\end{matrix}\right\}$ Cu 3120·7 $\left.\begin{matrix}<\\>\end{matrix}\right\}$ Cu 3140·3

Silver.

TABLE VII.

Silver, Per Cent.	Silver Line. A.	
	3280·7.	3382·9.
0·001 0·002 0·004 0·006 0·01	b.v. $\left.\begin{matrix}<\\>\end{matrix}\right\}$ Cu 3266·0 $\left.\begin{matrix}<\\=\end{matrix}\right\}$ Cu 3282·7	$\left.\begin{matrix}<\\>\end{matrix}\right\}$ Cu 3375·7 $\left.\begin{matrix}<\\>\end{matrix}\right\}$ Cu 3381·4

Antimony.

At 0·002 per cent., Sb 2598·1 A. > Cu 2570·7 A. < Cu 2577·1 A.

At 0·015 per cent., Sb 2598·1 A. > Cu 2627·5 A. < Cu 2630·0 A.

Tin.

At 0·0005 per cent., Sn 2354·8 A. = Cu 2363·3 A.

At 0·012 per cent., Sn 2421·7 A. = Cu 2479·8 A.

The copper lines used for intensity comparisons all belong to the class which are more intense in the globule than in the normal arc. Many of them are not given in published tables, but their identity has been well established by their constant and regular appearance.

General Remarks.

The globule method of arcing is most suited for the examination of relatively pure coppers. Arsenical coppers can be satisfactorily examined for impurities other than arsenic, but an estimation of the arsenic content may tend to be low owing to the rapid loss of arsenic in the globule arc unless the precaution is taken of exposing the plate during the early stages of arcing.

The quantitative results given with coppers deoxidized with phosphorus are not reliable for lead, tin, and iron, although they are satisfactory for bismuth, arsenic, nickel, silver, and antimony.

It is interesting to note that when arcing a copper containing 0·04 per cent. phosphorus by the globule method an original weight of 0·3 grm. metal loses only about half its weight as the result of arcing for 5 minutes, whereas a similar weight of copper free from phosphorus is almost completely volatilized at the end of 3 minutes' arcing, there being insufficient copper left in the globule to sustain a steady arc.

Conclusion.

For the detection and estimation of minute quantities of impurities in copper the globule method of arcing is more sensitive than the normally used solid electrode method of arcing. Some precautions are necessary, however, when dealing with arsenical and with phosphorus-deoxidized coppers.

Acknowledgments.

The author wishes to express his thanks to the Management Board of I.C.I. Metals, Limited, for permission to publish this paper, and to Dr. H. W. Brownsdon for his valuable suggestions and most helpful guidance.

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[2] Brownsdon and van Someren, *J. Inst. Metals*, 1931, **46**, 97–113.
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THE SPECTROGRAPHIC ANALYSIS OF SOME ALLOYS OF ALUMINIUM.*

By ERNEST H. S. VAN SOMEREN,† B.Sc., MEMBER.

SYNOPSIS.

The paper describes the technique of analyzing aluminium alloys by means of their spark spectra in the ultra-violet, using the method of internal standards.

Tables are given for the estimation of copper, zinc, iron, silicon, manganese, magnesium, nickel, tin, and cadmium; and also for the detection of lead, antimony, chromium, titanium, and bismuth.

A LIST of the aluminium alloys in commercial production would include considerably more than one hundred names, but analysis of samples shows a great deal of duplication in various countries, and the number of essentially different alloys in common use is probably between 40 and 80. An attempt is made in this paper to enable users of a spectrograph to find the approximate composition of any unknown aluminium alloy. With such data, supplemented if necessary by the usual physical tests and metallographic examination, either the alloy can be identified or a similar material prepared.

Previous publications on the spectrographic analysis of aluminium are infrequent; the chief contribution is that of A. Schleicher and J. Clermont,‡ who dealt with titanium, iron, and silicon in their first paper, copper in the second, and zinc in the third. Their method was to photograph the spark spectra, and obtain comparison lines by photographing copper spectra on the same plate with such an exposure as to obtain equality of intensity between specified copper and aluminium lines. The author, with the equipment at his disposal, was not able to reproduce the conditions they laid down, and has consequently not adopted a similar method.

Owing to the instability of the arc between aluminium electrodes,

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† Formerly Spectrographic Investigator to the Nordiske Kabel- og Traadfabrikker, Copenhagen.

‡ *Z. anal. Chem.*, 1931, **86**, 191; 1932, **90**, 1, 321.

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the spark is preferable to the arc for the routine testing of aluminium alloys. With the exception of the alkali metals, no impurity in aluminium is known to be important when present in such a small quantity that it cannot be detected by the spark method. Minute quantities of lithium, sodium, and calcium can best be detected by the arc method, and its application to sodium has been developed in the U.S.A. by A. W. Petrey,* who uses a small piece of aluminium arced between graphite rods. For this purpose a spectrograph covering the visible range only would be more suitable than one for the ultra-violet the dispersion of which in the visible spectrum is small. A quartz spectrograph will always allow the detection of calcium, and can be used for sodium and lithium if panchromatic plates are used.

The data in this paper are based on the spectra of 12 commercial alloys, and about 50 synthetic alloys prepared for this work only. The latter were all made from one strip of commercial Norwegian aluminium (99·6% aluminium) which was selected from material in works production after spectrographic examination of a number of samples. From this metal, with commercial cupro–manganese, commercial magnesium, electrolytic zinc, brass strip, and some soft-iron strip, a few " temper alloys " were made, and these were analyzed.

From these alloys and aluminium strip the other alloys were prepared; melts of from 250 to 750 grm. of material were melted in a small gas-fired furnace, using a little charcoal, but no flux, and were cast in flat cakes in a thick iron mould. As many of the alloys as possible were cold-rolled to strip about 3 mm. thick. Spectrographic testing of the material as cast, and after rolling, produced no evidence of inhomogeneity, except in one or two cases; these samples were discarded.

Five alloy samples were cast and analyzed by the Perry Barr Metal Company.

A small quantity of aluminium containing only 0·1 per cent. each of iron and silicon was obtained from Norway, and was used to prepare two alloys containing abnormally low quantities of these impurities.

The composition of the synthetic samples was checked by chemical analysis for about a third of the material used, so that the tables are based partly on analytical results and partly on synthetic figures.

Electrodes of cross-section about 3×8 mm. were cut from each sample, and the ends filed to a blunt wedge.

The instrument used was a Hilger medium quartz spectrograph (Model E3) giving a spectrum 150 mm. long from 2200 to 4500 A. (All wave-lengths are in International Angstrom units, usually quoted to the nearest integer.)

* *Indust. and Eng. Chem.* (*Analyt. Edn.*), 1932, **4**, 265.

A Hilger spark equipment was used, consisting of auto-transformer and transformer, the input being 1·2 amp. at 220 v., 50 p.p.s. A 4-mm. spark gap was used between two electrodes of each sample, situated 200 mm. from the slit, and aligned slightly off the optic axis of the instrument, so that the light passed through less than half the thickness of the prism. A condenser of capacity 0·014 microfarad was in parallel with the spark, and a self-inductance of 0·2 millihenry in series with it. The condition of the spark is best specified by comparison between certain aluminium lines; Al II 2369 should be slightly weaker than Al I 2378, and Al II 2317 should be slightly weaker than Al I 2319. The second line-pair is given because in some alloys containing copper the strong copper line 2370 makes comparisons with the adjacent aluminium line difficult.

The spark was always run for 5 seconds before starting the exposure, during which time its position was checked by a magnified image thrown on a screen by a lens; then an exposure of 20 seconds was given. Ilford thin film half-tone plates were used because they are remarkably uniform in sensitiveness over the range 2000–4000; they were developed with metolhydroquinone developer. These plates can be developed, fixed, washed, and dried in half-an-hour. Exposure and development were so adjusted that the group of lines at 2312–2322 was visible, but 2315 was very faint.

The slit-width used was about 0·04 mm., being such that the pair of aluminium lines 3064, 3066 appeared just separate. This wide slit made comparison of relative intensities easier; with a narrow slit some comparisons with diffuse lines are impossible. The plates were examined over opal glass with a lens giving a magnification of about 6 diameters.

The aluminium spectrum is not rich in lines, the characteristic pairs of lines are mostly too strong for comparison with impurity lines, but there are two important groups of faint lines, the wave-lengths of which are tabulated below, stating the strongest and faintest line in each group.

2312·4, 12·8	not resolved	3050·1
2313·5		3054·7
2315·0	faintest	3057·2 strongest
2317·5		3059·0 faintest
2319·1		3064·3
2321·6	strongest	3066·2

Although there is some doubt as to the allocation of some of these lines between the arc and spark series of aluminium (Al I and Al II),

some of them have been used as internal standards for analysis, owing to the absence of other lines of suitable intensity.

It would be desirable to follow the example of certain German investigators and use for quantitative analysis only pairs of aluminium and impurity lines which are homologous, *i.e.* lines the relative intensity of which is independent of variations in the condition of the spark. For convenience in the examination of the spectra an arbitrary limit of 20 mm. was taken as the maximum distance between lines to be compared. Spectra of many of the samples were photographed with deliberately varied electrical conditions, various dimensions of sample, various times of running of the spark before exposure, and homologous lines were selected when possible; these are marked H in the tables. To avoid large gaps in the tables other pairs of lines have been included. The spark between aluminium electrodes produces more uniform spectra than that between lead or tin electrodes, and this departure from the ideal is justified in practice by its results.

Care has been taken to avoid using lines which coincide with lines due to common alloying constituents in aluminium; where this is inevitable a note is added to the tables.

Table I gives only the percentages of minor constituent at which the pairs of lines referred to are equal; weight percentages are used throughout. An attempt to expand the Table by including the concentrations at which the impurity line is less than, and greater than, the aluminium line would lead, in the author's opinion, to an illusion of greater accuracy than is warrantable. When interpolating from these tables it should be noted that generally if an impurity line is equal to an aluminium line at x per cent. of the impurity it will be definitely less at $0{\cdot}8\,x$ per cent., and equally definitely greater at $1{\cdot}4\,x$ per cent. ($1{\cdot}3\,x$ per cent. if both lines are very faint). This unsymmetrical nature of the change in relative intensity has been observed by the author when making large numbers of observations on samples of fairly similar composition, and should be borne in mind when interpolating from the Table. It is supported by the fact that the general shape of curves connecting the relative intensity of a pair of lines with the concentration of an impurity (as measured with a microphotometer or wedge sector) is concave towards the concentration axis.

The percentages for equality quoted in the Table do not always correspond with the analysis of an individual sample, but each is the result of a number of observations on the spectra of a few appropriate samples, each photographed at least four times. This method of formulating tables introduces a possible error, which must be added to the uncertainty resulting from occasional reliance on synthetic figures

for the composition of samples. The total uncertainty can be best expressed by stating the result of a spectrographic analysis in the form : the concentration of the impurity *M* lies between *m* per cent. and 2 *m* per cent. In routine analysis of aluminium samples by this method accuracy will be increased by experience, and should, after a few months, be comparable with that of ordinary chemical analysis as practised in an industrial laboratory except for concentrations of more than 2 per cent. of alloying constituents.

Although the proportion of alloying constituents in many aluminium alloys is sufficient to make the aluminium lines in the spectrum fainter than in that of ordinary aluminium (with the same exposure), the lines due to the lesser impurities are also apparently fainter; consequently no appreciable modifications in the Tables appear to be necessary from this cause. This source of error has, however, not been completely explored, and is likely to be significant in some aluminium–zinc casting alloys.

The same aluminium lines are used for comparison with lines of different impurities, and Table I shows certain regularities in the percentages at which equality occurs. This regularity might be made use of in extending the Table to other percentages of impurities—for cadmium, for example. Unfortunately, a change in the author's occupation prevents him from checking the accuracy obtainable in this way.

Certain lines mentioned in Table I are sometimes masked by lines due to other metals, and then may not be used for intensity comparisons. These are set out in the first column of Table II; in the second column follows the symbol for the metal which interferes; and the last two columns specify a line due to that metal, and an aluminium line. If the line in column III is stronger than the line in column IV, then the line mentioned in column I must not be used. Usually comparison may be made by the help of an adjacent aluminium spectrum so exposed that its fainter lines are equal to the same lines in the spectrum of the sample. This is certain to be necessary in the analysis of aluminium containing nickel, where the comparisons marked N in Table I can never be made directly in the same spectrum, on account of other nickel lines.

In Table III are set out the lower limits for the detection of various elements in aluminium under the conditions laid down on p. 411. Two lines are given for each element, in order of sensitiveness. For antimony the only possible confirmatory lines are masked by iron and silicon; for bismuth no second line is likely to occur, and a narrower slit than usual must be used on account of the line Al 3066. For the detection

TABLE I.

		Aluminium Lines.													
		2204.	2315.	2317.	2319.	2322.	2372.	2378.	2460.	2568.	2652.	2669.	2928.	3050.	3055.	3057.
Copper All H	2200	2·8														
	2243		0·1	0·3	0·4	1·2										
	2247		0·05	0·15	0·2	0·5										
	2294		0·5	1·2	1·5	4·5										
	2400			7	9											
	3274													0·1	0·07	
Zinc	2558									5		0·5				
	3076														15	
	3283													H 5		H10
Iron All H	2344			0·22	0·3	0·8										
	2395			0·08	0·13	0·36										
	2663											2·0				
	2740											0·16				
	2743											0·6				
	3020													1 ±		2
Silicon	2435						H 10 ±		1·0		H 2·8					
	2507								0·45		H 0·8					
	2516								0·12		H 10 ±					
	2519											0·12		H 0·6	H 0·45	
	2881															
Manganese	2452								H 1 ±							
	2594											H 0·02				
	2656											H 1·2				
	2673											H 0·7				
	2890															H 5
	2933													H 0·6		H 1·2
	2939												0·08	H 0·4	H 0·25	
	2949												0·05		H 0·15	H 0·7

Magnesium	2777 2783 2803 2852 2937 3097											H 9 H 3 H 0·2	0·6 0·2 H 0·002±		0·5 H 6	0·3 H 3·5	0·9 H 9
Nickel	2316 2438 2473 3100		H 0·05		0·15	0·4 N			H 1·0 H 3±						H 2 N	H 1·2	
Tin	2355 2706 2840 3175							H 2·7					0·5 0·15			H 0·6	
Cadmium	2265 2307 3262		1±	0·1											1·2		

N. See p. 413.

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Table II.

I.	II.	III.	IV.
Al 2928	Mg	2937	2928
Al 2669	Cr	2677	2652
Al 2322	Cd	2313	2313·5
Al 2322	Ni	2316	2319
Al 3050	Ni	3100	3055
Si 2881	Cd	2981	2928
Zn 3076	Ti	3087	3055

of tin, lead, bismuth, and antimony the arc method is at least ten times more sensitive than the spark.

Table III.

Element.	Lower Limit Per Cent.	Lines Used.	
Copper	less than 0·01	3247	3274
Zinc	0·1	3345	3303
Iron	less than 0·02	2382	2740
Silicon	less than 0·02	2516	2881
Manganese	0·004	2594	2606
Magnesium	less than 0·002	2803	2852
Nickel	0·025	2316	3414
Tin	0·1	2840	2863
Cadmium	0·01	2265	2288
Lead	0·1	2833	3684
Antimony	0·2	2311·5	
Chromium	0·1	2836	2843
Titanium	0·03	3350	3361
Calcium	less than 0·01	3934	3968
Bismuth	0·1	3068	

Note to Table III.—Pb 2833 equals Al 2669 at 0·4 per cent.; Sb 2311 equals Al 2315 at 0·3 per cent.

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Thanks are also rendered to Ingeniør Henning Hansen, who analyzed most of the standard samples, to the Superintendent of Research of I.C.I. Metals, Ltd., Birmingham, for two analyses, and to the chief chemist of the Perry Barr Metal Co. (Birmingham) for the provision of five analyzed samples.

PAPER No. 682. This paper was presented at a meeting held on September 3–6, 1934, in Manchester, and may be reprinted, wholly or in part, by the technical press, provided that due acknowledgment is given to the Institute of Metals. 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 October 15, 1934.

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A "SYNTHETIC SPECTRUM" METHOD OF ANALYSIS AND ITS APPLICATION TO THE QUANTITATIVE ESTIMATION OF SMALL QUANTITIES OF BISMUTH IN COPPER.*

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

Synopsis.

A method has been devised for the production of "synthetic" spectra as standards for comparison, the spectrum of a standard alloy being exactly superimposed on that of the pure metal which forms the main constituent. The total time of the two exposures is equal to the normal time of exposure of a sample which is being analyzed, and a series of spectra is obtained in which the impurity lines show a systematic increase in intensity. While the method was originally applied to the checking of the reliability of standard samples, it can be used for the quantitative determination of impurities in metals, once the standard calibration curve has been obtained. The application to the determination of 0·0001 to 0·004 per cent. of bismuth in copper is described.

Introduction.

In the standardization of spectrographic methods for the quantitative determination of minor constituents in metals and alloys, samples are adopted as standards when the intensities of the lines due to the constituents under examination exhibit a systematic increase with increasing content. This applies equally to synthetically prepared and chemically analyzed samples. Where it is possible to obtain numerical values for the intensities, deviations are readily detected in a graph showing the relation between the intensity of the line (using as a standard for reference, that of a line of the main constituent) and the percentage content. With methods of the comparison sample and internal standard type, however, purely visual examination and comparison has to be relied on for the detection of discrepancies.

An attempt has been made, therefore, to devise a means of producing a systematic and easily controlled variation of intensity of a line due to an impurity or alloying constituent which would serve as a standard

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

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for reference. The time of exposure of a standard alloy appeared to be the most suitable variable, since this can be expressed numerically with a known probable accuracy. Since this method promises to be of general application and, so far as the author is aware, has not been described before, the present paper gives the experimental details and the mode of application in the particular case of the estimation of small quantities of bismuth in copper.

Principle of the Method.

The synthetic spectrum is produced by two exposures, one of an alloy containing an accurately known percentage of the constituent under examination, and the other of the pure metal predominating in the alloy, the two spectra being exactly superimposed. In each case the total time of the two exposures is equal to the normal time of exposure of a sample which is being analyzed. As the time of exposure of the alloy is increased in progressive stages, the time of exposure of the pure metal being correspondingly diminished, the intensity of the line or lines due to the impurity or alloying constituent systematically increases. The spectrum of the pure metal is superimposed on that of the alloy in order to obtain the same intensity of spectrum background and of the lines due to the primary constituent in the synthetic spectrum as in the spectrum of the sample under test.

The effect obtained is similar to that of a series of spectra of graded samples containing increasing proportions of the impurity in question, the lines due to the main constituent remaining constant. Once these spectra have been calibrated by means of intermediate samples of known content, analyses of further samples can be carried out by comparison of their spectra with the synthetic spectra.

Spectrographic Detection of Bismuth in Copper.

With the standard conditions previously adopted for the estimation of the usual impurities in copper,* *viz.*, the 3 amp. arc between metallic electrodes, it is difficult to detect 0·001–0·002 per cent. bismuth with certainty on account of the masking of the only bismuth line available, 3067·7 A., by the spectrum background. By increasing the current strength to 7 amp. the intensity of the bismuth line at a given percentage is increased to a greater extent than that of the spectrum background, resulting in greater sensitivity of detection.

The spectra of the various copper samples received were compared with one another, and those showing a systematic increase in intensity of the bismuth line with corresponding increase in percentage content

* Smith, "Metallurgical Analysis by the Spectrograph," London: 1933, p. 93.

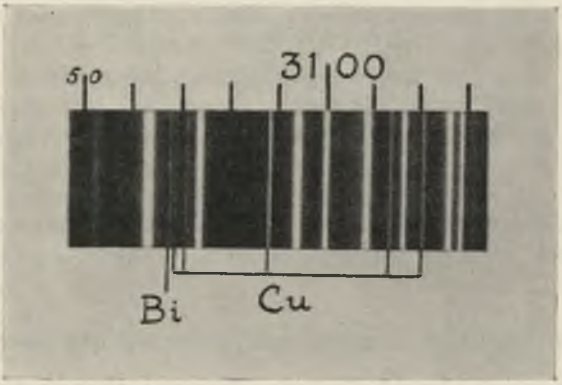

FIG. 1.—Arc Spectrum of Copper Containing 0·001% Bismuth.
(Arc Between Metallic Electrodes.) × 10.

were provisionally adopted as standards. Later samples were then analyzed by means of these standards, the bismuth contents of the provisional standards being either confirmed or modified in accordance with the data thus obtained.

After the examination of numerous spectra, samples containing the following percentages of bismuth were selected as being reliable as standards :

0·0001	0·003
0·0006	0·0035
0·001	0·004
0·0025	

A medium-size spectrograph giving a length of spectrum of about 19 cm. for the region 2100–6000 A. provides adequate dispersion in the region of the bismuth line. With the Hilger E.34 spectrograph, as used in the present work, a smaller diaphragm (oval, $\frac{7}{8}$ in. $\times$ $\frac{3}{8}$ in.) than that generally used was inserted between the camera lenses in order to obtain improved definition and resolution of the lines. A plate was also photographed on a large E.1 (Littrow) spectrograph in the laboratory of Messrs. Siemens Bros., Woolwich, to whom the author is indebted for the facilities placed at his disposal. The spectra obtained on this plate confirmed the results obtained with the medium-size instrument.

Estimation of Bismuth by the Internal Standard Method.

The standardized conditions of analysis adopted for the estimation of 0·0001–0·004 per cent. bismuth in copper, by means of the arc between metallic electrodes, were as follows :

Form of Sample : Two 3 in. length, about $\frac{3}{8}$ in. in diameter, rods or their equivalent, roughly pointed to an angle of about 70°.

Length of Arc : 5 mm. ($\frac{3}{16}$ in.).

Current Strength : 7 amp.

Exposure : After the arc has run for 15 seconds an exposure of 1 minute, of the central part of the discharge, focussed on the slit by means of a spherical lens.

Slit Width : 0·007–0·01 mm.

Photographic Plates : Wellington Antiscreen.

Development : Should be continued until the two faint lines 3069 and 3071 A. are clearly visible on the plate (see Fig. 1, Plate I).

The notation in Table I follows the usual conventions,* " by " indicating that the line is barely visible, the limit of detection having been reached, " $<$," " $=$ " and " $>$ " indicating that the bismuth

* See H. W. Brownsdon and E. van Someren, *J. Inst. Metals*, 1931, **46**, 106.

TABLE I.—*Analytical Table for the Estimation of Bismuth in Copper.*

(Arc between metallic electrodes.)

Bismuth, Per Cent.	3067·7 Bi.			
0·0001		bv <	3069 *	
0·0006		=	and	
0·001	< 3115	>	3071 Cu	
0·0025	=	<		
0·003	> Cu	=	3122	< 3088·5
0·004		>	Cu	= Cu

Note.—With high iron and nickel contents there is the possibility of masking or confusion with the lines 3067·3 Fe and 3064·6 Ni.

* These lines are ascribed to copper, since they appear with constant intensity in all the copper spectra examined, including those of high-grade pure copper. (The wave-lengths are only approximate.)

line is respectively weaker than, equal in intensity to, and stronger than, the copper lines used as internal standards.

CALIBRATION OF THE STANDARD SYNTHETIC SPECTRA.

In the particular case studied, the standard alloy selected was of copper with 0·004 per cent. bismuth (referred to subsequently as sample AFT) and the corresponding times of exposure of this sample and of pure copper are given in Table II. The sample of " pure copper " actually used contained 0·00001 per cent. bismuth by chemical analysis. This amount of bismuth, however, was not detected spectrographically, the most sensitive bismuth line 3067·7 A. being absent from spectrum No. 1. For the purposes of this investigation, therefore, the purity was adequate.

The total time of exposure in each case was 2 minutes, as compared with 1 minute as standardized for the internal standard method. In this way greater accuracy was obtained in the times of exposure of the sample AFT. Moreover, any fluctuations in the running of the arc would be of less consequence than might be the case with shorter exposures. The copper lines in the spectra in both cases were quite uniform in strength.

The apparent percentages of bismuth obtained from these composite or " synthetic " spectra were then determined by means of the internal standard data in Table I and confirmed by direct comparison with the spectra of the standard samples. The results are shown graphically in Fig. 2.

The deviation of the only point not on the curve in Fig. 2, is within the limits of experimental error (the curve giving 0·00365 per cent.

TABLE II.—*Times of Exposure for the Synthetic Standard Spectra.*

Spectrum No.	Sample AFT (0·004% Bi).	Pure Copper.
1	0 seconds	120 seconds
2	20 ,,	100 ,,
3	30 ,,	90 ,,
4	35 ,,	85 ,,
5	40 ,,	80 ,,
6	60 ,,	60 ,,
7	90 ,,	30 ,,
8	120 ,,	0 ,,

bismuth, approximately, as compared with the experimental value 0·0035 per cent. bismuth).

It is interesting to note that, so far as the shape of the curve is concerned, Fig. 2 bears some resemblance to the blackening curves of

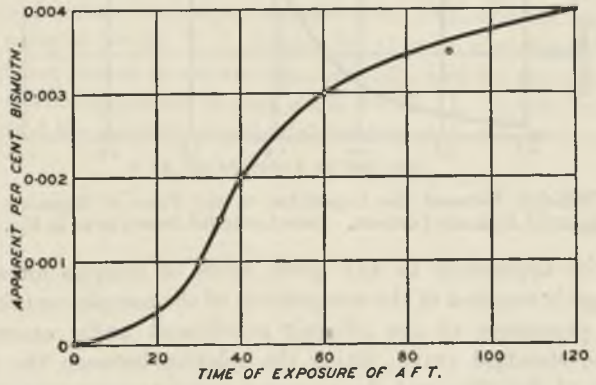

FIG. 2.—Relation Between the Time of Exposure of Sample AFT (Containing 0·004% Bi) and the Apparent Bismuth Content Shown by the Composite Spectrum.

photographic plates (Density $\propto$ log. Exposure). Plotting the percentage of bismuth against the logarithm of the time of exposure of sample AFT, another curve of similar shape is obtained (Fig. 3). A possible explanation may be offered by regarding Fig. 2 as showing the relation between the time of exposure of the bismuth radiation of wavelength 3067·7 A. (which may be regarded, for exposures of 20 seconds or more, as a reasonably constant source of illumination) and the density of the image on the photographic plate (as represented by the percentage

content which would produce it). Until further work is done on this subject it is perhaps premature to arrive at any definite conclusions.

General Application of the Synthetic Spectrum Method.

It is believed that the method will prove to be of quite general application. Its value in the case of small quantities of bismuth in copper, using arc spectra, has been demonstrated, and results have since been obtained showing its applicability to the spark spectra of lead with small quantities of cadmium. Other series of alloys are being investigated with a view to establishing the general utility of the method.

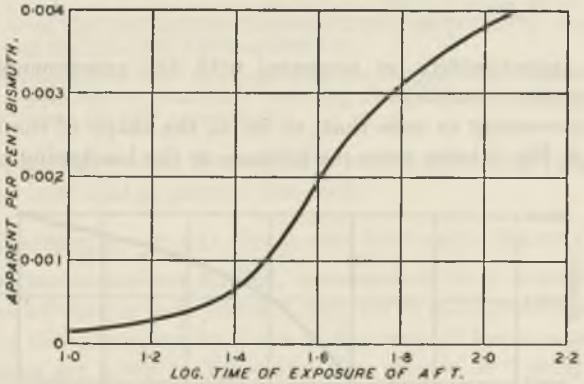

Fig. 3.—Relation Between the Logarithm of the Time of Exposure and the Apparent Bismuth Content. Data Compiled from Curve in Fig. 2.

For its application to any given series of samples an accurate knowledge is required of the composition of the sample containing the highest percentage of the alloying constituent under examination. Once the standard curve, giving the relation between the time of exposure of the alloy and the apparent percentage content given by the synthetic spectrum, has been determined in the manner described, it is available for quantitative determinations.

Comparison would then be made between the spectrum of the sample under test and those obtained by various exposures of the alloy plus the appropriate exposures of the pure metal, *i.e.* the synthetic spectra. From the time of exposure, giving equality of intensity of the impurity line in the two spectra, the corresponding percentage of impurity is then obtained from the graph.

Although no definite tests have yet been made, it is expected that the accuracy of estimation would be of the same order as that obtained by the comparison sample method.

Summary.

The use of "synthetic" standard spectra for the quantitative estimation of impurities in metals is described and illustrated by the particular example of the determination of from 0·0001 to 0·004 per cent. bismuth in copper. Details of the standardization and calibration of the spectra, using the internal standard method of analysis, are given. Further investigations on the application of the principle to both arc and spark spectra are contemplated.

Acknowledgments.

The author desires to record his indebtedness to the Director and Council of the British Non-Ferrous Metals Research Association for permission to publish this paper, and to Mr. B. Drinkwater, B.Sc., A.R.C.S., A.R.S.M., F.I.C., for valuable collaboration and careful chemical determinations of the bismuth contents of the actual copper samples used.

This work has been greatly assisted by the parallel work in the laboratory of Messrs. British Insulated Cables, Ltd., and the supply of standard samples by Dr. F. J. Brislee, F.I.C., who also suggested the use of a higher current in the arc than normally used for the analysis of copper. Acknowledgment is also made to Mr. L. Reeves who has photographed the spectrograms and assisted in their interpretation.

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A NOTE ON SOME ANCIENT COPPER-COATED SILVER COINS OF CYPRUS.*

By STANLEY G. WILLIMOTT,† B.Sc., Ph.D.

SYNOPSIS.

A number of authentic Greek and Roman coins of Cyprus having the appearance of copper or bronze have been found at different times and places. On archæological grounds these coins would have been expected to have been silver, and laboratory investigation proved this to be the case, 92·3 per cent. silver being found in one case and 94 per cent. in another.

The cause of this phenomenon was studied and three possibilities were considered :—(1) galvanic action due to the chance contact of silver coins with a less noble metal, *e.g.* iron, in the presence of water containing copper sulphate as an electrolyte; (2) the electrolytic (cathodic) deposition of copper on silver as a result of contact with an electrolyte charged with copper salts derived from cupriferous pyrites; (3) chemical alteration of the surface of the silver coins by pyro-oxidation of the contained copper as a result of accidental fires.

With regard to cause (1) it was possible to demonstrate this in the laboratory and to coat silver coins with a tenacious film of copper.

AMONGST the many Greek and Roman coins of Cyprus a number of authentic specimens having the appearance of copper have been found at different times and places. On archæological grounds these coins would have been expected to have been of silver. A number of specimens were submitted for laboratory investigation by the Cyprus Museum, Nicosia.

On scraping the surface of the coins, a white metal, suggestive of silver, was in fact revealed, and this supposition was readily confirmed by physical methods of investigation which have the advantage of involving no injury to the object being examined. Such objects, when freshly dug up in excavation, are encrusted with copper salts, and are at first sight suggestive of solid copper or bronze, and, in the absence of other evidence, may be wrongly described and classified. Several such cases, for example, have come to the knowledge of Lucas,‡

* Manuscript received February 14, 1934.

† Government Analyst, Government Laboratory, Cyprus.

‡ A. Lucas, "Antiques : their Restoration and Preservation," Second Edition. London : **1932.**

Note to Abstractors and Other Readers.—This paper will be published, in permanent form, in the *Journal of the Institute of Metals*, Vol. LV, 1934. Reference should accordingly be as follows: *J. Inst. Metals*, 1934, **55** (Advance copy).

who found that when the silver is of poor quality and contains a large proportion of copper the corrosion-product may be of a green colour, and the object may look so like corroded bronze or copper that it will often be mistaken for these metals. The coins examined in this investigation, however, had a high content of silver (94 per cent.) and it appeared to be of some interest, therefore, to study the possible conditions in which silver objects, when buried in the soil, may become coated with a deceptive surface layer of copper and its salts.

Three possible causes suggested themselves as being responsible for the phenomena observed :—

(1) galvanic action due to the chance contact of silver coins with a less noble metal, such as iron, in the presence of water containing copper sulphate as an electrolyte.
(2) the electrolytic (cathodic) deposition of copper on silver as a result of contact with an electrolyte charged with copper salts derived from cupriferous pyrites, the ore body acting as anode.
(3) chemical alteration of the surface of the silver coins by pyro-oxidation of the contained copper as a result of accidental fires.

The first and second causes appear to be the most likely explanations of the observed facts, since such conditions may readily exist in ancient tombs in Cyprus. The copper sulphate electrolyte may be derived either from the breakdown of cupriferous pyrites direct, or by dilute sulphuric acid, also arising from the decomposition of pyrites, acting on a mixed lot of copper and silver coins. In the first cause, copper would then be deposited on the silver if in contact with iron, as, for example, in an iron receptacle. As will be seen later, it was possible to demonstrate this in the laboratory, and to coat silver coins with a tenacious film of copper.

The second suggestion presupposes conditions favourable to the setting up of weak external currents between the silver objects and the surrounding ore or rocks, whereby copper is deposited. This possibility, however, is obviously limited to certain areas where silver objects have been in contact with dilute solutions of copper sulphate derived from the decomposition of cupreous ores. As regards the third possibility, this must be limited to accidental fires, which are exceptional, and further, copper oxide, and not metallic copper, is developed on the surface of silver–copper alloys when exposed to high temperatures. The subsequent action of air and moisture would in time produce a deceptive incrustation of green copper salts.

Experimental.

The 32 copper-coated coins examined were of dates from 411–374/3 B.C. to A.D. 180–192. Many of them were current during the Roman occupation, and were probably struck in Cyprus.

No information was available as regards the exact places in which these coins were originally found. The possibility that they might have been plated with copper by intention was regarded as untenable. Examination of the coins showed that the metallic coating was thin but firmly attached, and could not be removed mechanically. The surface layer of greenish copper salts was satisfactorily removed by the well-known treatment with Rochelle salt solution. To determine the composition of such objects without destruction, two methods are available : (*a*) the quantitative spectrographic method of Hartley, and (*b*) the simple qualitative procedure of determination of the specific gravity. No spectrograph being available, recourse was had to the specific gravity method. It was found that the specific gravity varied between 9·8 and 10·2, a value suggestive of alloyed silver. The thin coating of copper was now removed by gentle treatment of the coins with dilute acid, when silver was revealed in each case. This was confirmed by analysis of two different coins, 94 per cent. silver being found in the one case, and 92·3 per cent. in the other; the remainder being copper and impurities.

Having identified the true nature of these coins, experiments were next undertaken to test as far as possible the theories already advanced. The galvanic theory lent itself more readily to experimental verification, and this was first investigated. An acid solution of copper sulphate does not deposit copper on silver immersed in it, since silver is more noble than copper; hence silver objects buried in tombs could not become plated merely by contact with water carrying copper sulphate as electrolyte. It was found, however, that when a silver object, immersed in an acid solution of copper sulphate, is in contact with a less noble metal than copper—as, for example, iron—deposition of copper immediately commences. Rods of clean iron or zinc were conveniently employed for this purpose. This is simply a form of galvanic action in which the copper sulphate, dissolved in the soil water, has been derived either from the breakdown of cupriferous pyrites direct or by the continuous action of dilute sulphuric acid, also derived from the decomposition of pyrite, on a mixed lot of copper and silver coins. The finding of mixed collections of coins is not unusual in the island.*

* Since the above was written a hoard of several hundred copper-coated Venetian and Turkish silver coins was discovered in March, 1934, during excavations on the ramparts of Nicosia, the capital of Cyprus.

In natural conditions the solutions of copper sulphate would be dilute, and the thickness of the copper film would depend principally on the length of time during which the silver had been exposed to its action.

It is only necessary, then, to suppose that the coins were in an iron receptacle, or simply in contact with an iron object, to have reproduced *in situ* all the conditions necessary for copper to be deposited on the silver coins. Some of the silver coins, which had been freed from copper in the laboratory, were in fact readily replated under these conditions, so as to resemble closely the original specimens after the green incrustation had been removed. The coating of copper was firmly laid on, and could be removed only by chemical treatment. This would seem to be a very probable explanation of the finding of copper-coated coins in Cyprus. Other silver objects may also be found copper-coated; for example, a broken antique bowl, badly encrusted with copper salts, appeared after preliminary cleaning to consist of copper. On investigation it proved to be silver on which had been deposited a definite film of copper and copper salts.

Unfortunately, it was not found possible to investigate experimentally the second suggestion—that the copper-coated coins might be the result of cathodic action between the metallic objects and adjacent ore bodies.

So far as the third cause is concerned—that the copper salts resulted from pyro-oxidation caused by accidental fires—this would seem to be the least likely explanation. In these conditions coins containing about 6 per cent. of copper would develop a film of copper oxide only. Metallic copper would be present only if the coins were subsequently exposed to conditions of reduction.

Experiments showed that gold objects, when exposed to the conditions first considered, also readily take on a deceptive coating of copper. Specimens of copper-coated gold coins have apparently not been found in Cyprus, but some years ago a bowl, found near Athienou, was so corroded with green incrustation as to suggest copper or bronze. When cleaned, the bowl proved to be gold.

Acknowledgments.

I am indebted to Mr. J. A. Bevan, M.Inst.M.M., and Mr. C. P. Manglis for their interest in this work, and to the Curator of the Cyprus Museum, Nicosia, for information regarding the coins and objects examined.

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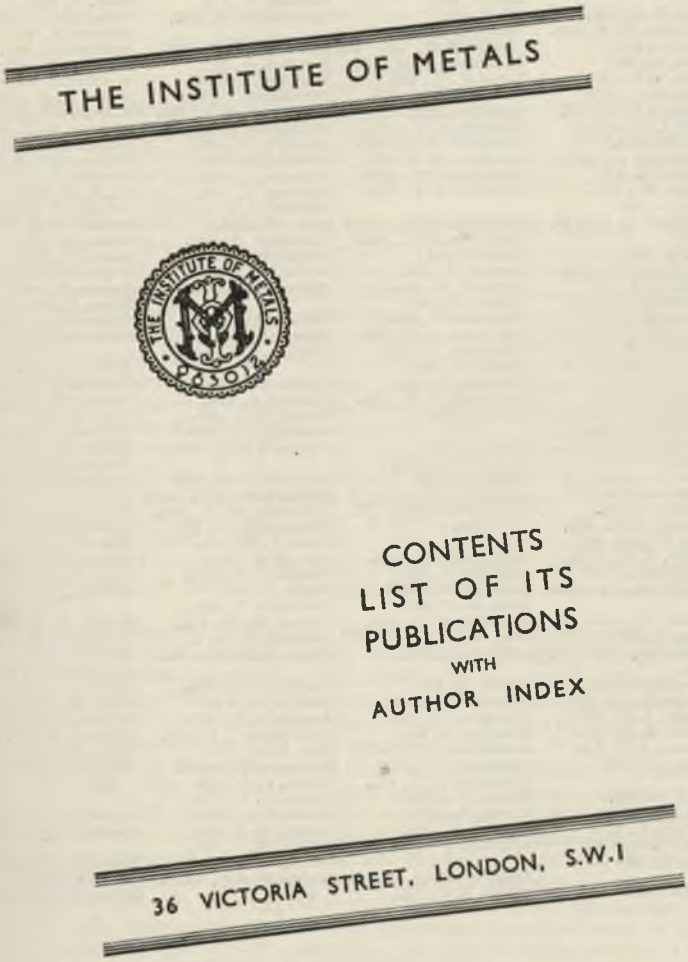

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METALLURGICAL ABSTRACTS

(GENERAL AND NON-FERROUS)

Volume 1 SEPTEMBER 1934 Part 9

I.—PROPERTIES OF METALS

(Continued from pp. 377–380.)

The Mass of Be^9 and the Atomic Weight of Beryllium. K. T. Bainbridge (*Phys. Rev.*, 1933, [ii], **43**, 367–368).—A letter to the Editor. The mass of Be^9 determined spectroscopically is 9·0155 ± 0·0006. If allowance is made for 1 part in 2000 of Be^8 the atomic weight of beryllium is 9·0130 ± 0·0007. The packing fraction of Be^9 is + 17·2.—S. G.

***On the Evaporation, Solubility, and Oxidation of Metallic Mercury.** Alfred Stock (*Z. anorg. Chem.*, 1934, **217**, 241–253).—The amount of mercury which can be taken up by water, aqueous solutions, and air under various conditions has been quantitatively determined. Mercury is appreciably absorbed by blood. The solubility in benzene, white of egg, filter paper, cotton, linen, silk, rayon, and woollen fabrics, and beetroot discs has been measured as well as the absorptive capacity for mercury vapour from air by water, benzene, paraffin oil, glycerin, carbon bisulphide, sulphur monochloride, phenyl mustard oil, milk of sulphur, flowers of sulphur, phosphorus sulphide, silica gel, activated charcoal, and activated carbon impregnated with iodine. Quantitative adsorption was obtained very rapidly with the last-named. Some observations on the volatility of very small mercury globules are included.—B. Bl.

***The Oxidation and Intercrystalline Brittleness of Nickel.** N. W. Ageew (*Trudi Instituta Metallow* (*Trans. Inst. Metals, U.S.S.R.*), 1930, (**7**), 61–79; *C. Abs.*, 1931, **25**, 2960).—[In Russian.] Two grades of commercial nickel showed that nickel is brittle after having been annealed under atmospheric conditions at 800° and 1000° C. Intercrystalline oxidation is the cause of this brittleness.—S. G.

***Positive and Negative Thermionic Emission from Columbium [Niobium].** H. B. Wahlin and L. O. Sordahl (*Phys. Rev.*, 1934, [ii], **45**, 886–889).—The electronic and positive ion emission from thoroughly outgassed niobium have been investigated, and the effect of impurities studied. The work-function for the electrons is 3·96 v. with the Richardson constant A equal to 57 amp./cm.^{2}/degree^2. For the positive ions the work-function is 5·52 v.—W. H.-R.

***On the Mobility of Polonium on and in Silver.** Karl Schwarz (*Z. physikal. Chem.*, 1934, [A], **168**, 241–247).—Volatilization of polonium deposited on silver takes place with measurable velocity only above 350°–400° C.; diffusion within the outer silver layers is appreciable at 300° C. and increases with increase in temperature, although no penetration into the body of the silver is detectable below 500° C. The apparent low-temperature volatilization of polonium is explained as follows: the explosive disintegration of one atom tears off another not yet disintegrated atom from the layer, and this atom is then deposited on another part of the apparatus; this action is independent of the temperature between 100° and 350° C.—B. Bl.

***Action of Water on Selenium and Tellurium.** E. Montignie (*Bull. Soc. chim. France*, 1934, [v], **1**, 507–508).—Grey selenium is unattacked by water even at 160° C. under pressure, but red selenium dissolves slowly at 50° C. and more rapidly at higher temperatures. Tellurium in all its forms dissolves slowly in water at all temperatures giving tellurium dioxide; heat and pressure accelerate the dissolution.—A. R. P.

* Denotes a paper describing the results of original research.

† Denotes a first-class critical review.

***Bactericidal Effect of Metallic Silver; Antiseptic Action According to Vincent; Oligodynamic Action According to Naegeli.** P. Lasseur *et al.* (*Trav. Lab. Microbiol. Fac. Pharm. Nancy*, **1932**, (5), 13; *Zentr. ges. Hyg.*, 1933, **29**, 88; (*U.S.*) *Public Health Eng. Abs.*, 1934, **14**).—A full discussion of earlier work on the bactericidal effect of metallic silver, with accounts of some experiments using B. coli and 3 colour-forming bacteria more sensitive to the action of silver than B. coli. Gentle heating of silver wire increased but strong heating decreased the bactericidal action. Increasing the surface area increased the action. Short times of contact decreased the bacterial content but complete destruction of bacteria was not achieved in 24 hrs.—S. G.

***Colour in Films of Sputtered Tin.** Clarence J. Overbeck (*J. Opt. Soc. Amer.*, 1933, **23**, 109–113).—Films of tin sputtered from circular cathodes in air showed under monochromatic light rings and cycles of colour, probably due to thickness and interference effects. Films produced in nitrogen were brown and opaque. These were found to consist of a tin–nitrogen compound. Heating the nitride film in air produced a transparent film similar to those sputtered in air.—R. G.

***The Rate of Crystallization of and the Number of Nuclei in Tin, Bismuth, and Lead.** G. Tammann and H. J. Rocha (*Z. anorg. Chem.*, 1934, **216**, 17–25).—The rate of crystallization of under-cooled melts is determined by inoculating such a melt in a U-tube in one limb and observing the time taken for the crystallites to reach the meniscus in the other limb or the time taken for a thermocouple in the other limb to show an increase in temperature. A third method consists in determining the grain-size after inoculating the molten metal in a cylindrical container and quenching after the single crystal has reached a certain size, so that the still liquid portion freezes to a finely crystalline aggregate; from the length of the single crystal and the time between inoculation and quenching the rate of crystallization can be deduced. The rate of crystallization of tin, bismuth, and lead has been determined for various degrees of under-cooling by the second and third methods, and from the grain-size of quenched under-cooled melts the number of nuclei present and the influence of the cross-section of the melting tube have been determined.—B. Bl.

***Some Thermionic Properties of Barium Films Adsorbed on Tungsten.** Herbert Nelson (*Physics*, 1931, **1**, 84–93).—A full report of work previously noted in abstract. See *J. Inst. Metals*, 1931, **47**, 326.—S. G.

***The Effect of Alkali Ions on the Photoelectric Emissivity of Tungsten.** A. Keith Brewer (*Phys. Rev.*, 1933, [ii], **44**, 1016–1019).—Known quantities of Na^+, K^+, Rb^+, and Cs^+ ions were deposited on tungsten and the changes in the photoelectric current measured. For wave-lengths below 2800 A. the current increases proportionally to the fraction f of the surface covered as long as f is small. The emissivity for longer wave-lengths is low at first, and then increases sharply beyond some critical value of f, which increases with the wave-length. The results indicate that the work-function is not uniform over these composite surfaces; this makes it important to fix a definite threshold for the various values of f. The emissivity increases with temperature to about 500° C., where fatigue becomes appreciable. As the filament fatigues for photoelectric emission the positive ion emissivity increases reaching a maximum when the threshold returns to that for clean tungsten. The results show that the alkali dissolves so rapidly in the tungsten that the dependence of the work-function on f cannot be determined at temperatures above 500° C.—S. G.

***Photoelectric Properties of Thin Films of Alkali Metals.** S. Asao (*Physics*, 1932, **2**, 12–20).—Measurements are reported on the colour sensitiveness of various photoelectric tubes having cathodes made of alkali metals. A composite surface of R–Ag–RO–Ag of any alkali metal R shows a higher sensitivity over a wider range of wave-lengths than R–RO–Ag and has 2 peaks, one between 330 and 370 mμ and one at about 500 mμ for potassium and 550 mμ

for rubidium and between 700 and 800 mμ for cæsium. If a gas-filled lamp at 2700° K. is used as a light source, photoelectric currents from vacuum phototubes are obtained sometimes as large as 29 μa per lumen for potassium, and 10–15 μa per lumen for rubidium, and 40–50 μa per lumen for cæsium.—S. G.

***Elasticity of Flexure.** A. Jaquerod and H. Mügeli (*Helv. Phys. Acta,* 1931, **4,** 3–30; *Sci. Abs.*, 1931, [A], **34,** 454).—[In French.] As in a previous publication (*ibid.*, 1929, **2,** 419–444) only the data referring to the variation of the first modulus of elasticity with temperature are now published, and this for the following materials: iron, copper, gold, silver, platinum, nickel, silica, and glass. The temperature range was 0° to 140° C. and the temperature–elasticity curves, which are given for each material, are found to be similar to that of steel, *i.e.* parabolic. Silica glass proved to be an exception, since it possessed a positive thermoelastic coeff. and almost a linear variation. Thermal and mechanical treatment generally produces an increase of Young's modulus: iron and silica glass exceptionally showing a diminution. Hooke's law is never completely obeyed even for small deformations. Nickel exhibits interesting phenomena.—S. G.

***The Determination of the Character of Viscous Extension of Metals at High Temperatures.** G. Ranque and P. Henry (*Compt. rend.*, 1931, **193,** 1061–1063).—See *J. Inst. Metals*, 1932, **50,** 149.—S. G.

***The Plastico-Viscous Deformation of Right Circular Cylinders of Soft Metal under Variable Load Axially Directed.** W. E. Grimshaw (*Phil. Trans. Roy. Soc.*, 1934, [A], **233,** 217–245).—Subject to the restriction customarily imposed of an order of strain smallness when stress–strain relationships are being considered, an analysis is developed for the motion of a soft-metal cylinder when subjected to a crushing load directed axially, surface friction being regarded as absent. The metal is considered to be homogeneous, isotropic, and incompressible, and coefficients of plasticity and viscosity are used in the stress–strain relationships. The modifying influence of rate of application of load is examined. Theorems of the analysis are shown to be in accord with conclusions reached from experiments especially from those on the compression of copper cylinders (*Rgs. Dept. Woolwich, R.D. Report,* No. **64,** 1927; London: H.M. Stationery Office).—W. H.-R.

***Mechanism of Plasticity.** N. J. Seljakov (*Z. Krist.*, 1932, **83,** 426–447; *Sci. Abs.*, 1933, [A], **36,** 111).—Cf. *J. Inst. Metals,* 1932, **50,** 597. For rock salt, plastic deformation is accompanied by the appearance of intermediate layers of monoclinic symmetry. The change of symmetry is brought about by simple gliding. The different values of the characteristic angle *a* for the monoclinic layers produces " starring " on the X-ray photographs.—S. G.

Plasticity and Hardening. O. Manfred (*Z. physikal. Chem.*, 1932, [B], **15,** 383–387; *Sci. Abs.*, 1932, [A], **35,** 466).—Evidence is presented to show that plastic distortion of a material is always followed by increase of hardness, whether the material is polycrystalline like a metal or a plastic colloid like rubber. This parallel relation, which seems to be independent of the ultimate structure of the material, may be regarded as a new general principle.—S. G.

The Relation Between Plastic Shortening and Pressure in Compression of Salts and Metals. Karl Przibram (*Sitzber. Akad. Wiss. Wien, Math.-naturw. Klasse*, 1933, Abt. IIa, **142,** 377–380; *C. Abs.*, 1934, **28,** 3633).—The decrease in height of either a metal (lead, copper) or an alkali halide salt crystal with pressure is proportional to the product of the pressure and the width. The plasticity coeff., *b*, of the alkali halide salts depends on the atomic number of the anion and of the cation. Plotting atomic number of anion against *b* gives a straight line.—S. G.

Reactions in Solids. Roland Ward (*Trans. Illinois State Acad. Sci.*, 1933, **25,** 167–169; *C. Abs.*, 1934, **28,** 3634).—A review of the work of van Liempt, Langmuir, Hume and Colvin, Tammann, Hedvall, Sander, and others. Re-

action is initiated by deformation of the crystals through grinding, followed by rearrangements to form more stable products. Higher temperatures increase the diffusion velocities at the crystal interfaces.—S. G.

***Superficial Oxidation of Molten Metals.** R. Delavault (*Bull. Soc. chim. France*, 1934, [v], **1**, 419–424).—Tests made on the oxidation of molten metals in air have confirmed the theory of Pilling and Bedworth (*J. Inst. Metals*, 1923, **29**, 529) that oxidation occurs only when $Wd/wD > 1$, where W is the molecular weight of the oxide, D its density, d the density of the metal, and w the weight of metal in a gramme-molecule of oxide. For magnesium–aluminium alloys at least 40% of aluminium is required to prevent oxidation in air. For melting magnesium, ammonium borofluoride with or without borax affords adequate protection.—A. R. P.

***On Experiments on Hot-Pressing of Highly Dispersed Metal Powders.—III.** W. Trzebiatowski (*Z. physikal. Chem.*, 1934, [A], **169**, 91–102).—Cf. *ibid.*, 1934, [B], **24**, 75, 87. Chemically prepared copper and gold powders were pressed to solid crystalline bodies at 20°–600° C. under 15,000 atm. The density and hardness of the bodies increased up to 200° C. to very high values, and X-ray examination showed strain-hardening. Between 200° and 400° C. the density still further increased, but the hardness decreased, although no grain-growth occurred, the changes being explained as crystal recovery. The maximum density obtained was that of the massive metal, but the hardness at this point was much greater. The specific electrical resistance, and its temperature coeff. corresponded with those of the massive metals. At pressing temperatures of 450°–600° C. the hardness decreased and recrystallization occurred.—B. Bl.

***Ignition Temperatures [of Metals] as a Function of Particle Size.** G. Tammann and W. Boehme (*Z. anorg. Chem.*, 1934, **217**, 225–236).—If small strips or wires of metal are allowed to slide through a laboratory tube furnace a relation can be found between the ignition temperature (t) and the cross-sectional area of the strip (q). For $q = 0{\cdot}02$–$0{\cdot}4$ mm.^{2}, t is given by the following equations: electrolytic iron in air, angular strip, $1015 - t = 4{\cdot}80/q$; electrolytic iron wire, in air, $1128 - t = 3{\cdot}50/q$; electrolytic iron wire in oxygen, $1000 - t = 5{\cdot}80/q$; manganese in air, $1225 - t = 15{\cdot}5/q$; magnesium in air, $630 - t = 0{\cdot}10/q$; cerium in air, $550 - t = 2{\cdot}25/q$. If the iron wire is coated with silver it does not ignite below the melting point of the coating. If the boiling point of the metal is much above the melting point of its oxide, ignition occurs only when the oxide film shrinks or melts. In metals, the vapour pressure of which is appreciable at the ignition temperature but the oxides of which melt much above this point (*e.g.* magnesium), oxidation of the vapour in air is accompanied by the development of smoke. Solid solutions of gold in iron have the same value for t as electrolytic iron, but additions of nickel, silicon, and aluminium tend to increase t for iron. The particles of steel rubbed off by a carborundum disc are partly angular fragments of iron and partly molten spheres of oxide with a diameter of 0·05–0·24 mm. the average value being 0·1 mm. Corresponding figures are given for some steels. The ignition temperatures of the following pyrophoric metals have been determined: iron (reduced in hydrogen at 370° C.) — 11° C. in air, — 15° C. in oxygen; cobalt (reduced in hydrogen at 320° C.) 3° C. in air; nickel (treated in hydrogen at 350° C.) — 6° C. in air, — 9° C. in oxygen; osmium powder (reduced in hydrogen at 200° C.) about 500° C. in air.—B. Bl.

***The Optical Properties of Metallic and Crystalline Powders.** A. H. Pfund (*J. Opt. Soc. Amer.*, 1933, **23**, 375–378).—The procedure developed for the production of very finely-divided bismuth (bismuth black) has been found applicable to a wide variety of metals, including gold, silver, nickel, copper, zinc, and lead. The method consists in the distillation of the metals at high pressure. Measurements of the transparency of the blacks in the infra-red are given.—R. G.

***The Isotopic Constitution and Atomic Weights of the Rare-Earth Elements.** F. W. Aston (*Proc. Roy. Soc.*, 1934, [A], **146**, 46–55).—A provisional survey is given of the isotopic constitutions of all the rare-earth elements. More than 30 new isotopes have been discovered. Estimates of the percentage abundance of each isotope are given and the chemical atomic weights are calculated therefrom. The following values of atomic weight are so derived : lanthanum, 138·91 ± 0·05; cerium, 140·13 ± 0·05; praseodymium, 140·91 ± 0·05; neodymium, 143·5 ± 0·2; samarium, 150·1 ± 0·2; europium, 151·90 ± 0·03; gadolinium, 156·9 ± 0·2; terbium, 158·91 ± 0·05; dysprosium, 162·5 ± 0·2; holmium, 164·91 ± 0·05; erbium, 167·15 ± 0·2; thulium, 168·91 ± 0·05; ytterbium, 173·2 ± 0·2; lutecium, 174·91 ± 0·05. Revision of the international atomic weights is desirable in the case of neodymium, samarium, gadolinium, terbium, thulium, and particularly holmium and erbium.—J. T.

***On the Theory of Electrolytic Transmission and Diffusion in Crystals.—II.** W. Jost (*Z. physikal. Chem.*, 1934, [A], **169**, 129–134).—Mathematical. Cf. Part I, *J. Chem. Physics*, 1933, **1**, 466.—B. Bl.

The Thermionic Work-Function and the Slope and Intercept of Richardson Plots. J. A. Becker and W. H. Brattain (*Phys. Rev.*, 1934, [ii], **45**, 694–705).—(1) The thermionic emission current (i) from a metal can be represented by the Richardson equation $i = AT^2e^{-b/T}$, where T is the absolute temperature, and A and b are constants. This implies that if $\log i - 2 \log T$ is plotted against $\frac{1}{T}$, a straight line is obtained of which the slope is $b/2{\cdot}3$, and the intercept $\log A$. The slope of this line which is sometimes really slightly curved is sometimes called the work-function. (2) Fermi–Dirac statistical theory gives the equation $\log i - 2 \log T = \log U(1 - v) - w/2{\cdot}3T$, where U is a universal constant of value 120 amp./cm.^{2} °K^2, v is the reflection coeff., and w is the theoretical work-function. Consequently A and b in (1) can be identified with U and w in (2) only, if $r = 0$ and w is independent of temperature. The authors show from experimental and theoretical considerations that r is negligibly small, but that in general w varies with temperature, which is to be expected from the Sommerfeld theory, since w depends on the number of free electrons per unit volume, and this varies on account of expansion. Hence A in the empirical equation is not a universal constant. (3) In the thermodynamic theory the so-called heat-function h is defined as $h = \lambda_p/R - 5/2T$, where λ_p is the latent heat of vaporization of electrons per grm.-mol. The authors show that h can be identified with b, and that $h = w - Tdw/dT$. (4) The photoelectric work-function is equal to w, and is consequently not really independent of T, as has sometimes been assumed. The paper is a useful correlation of experiment and theory where confusion has been caused by using the same term with different meanings.—W. H.-R.

Directions of Discontinuous Changes of Magnetization in a Rotating Monocrystal of Silicon Iron [Barkhausen Effect]. L. W. McKeehan (*Phys. Rev.*, 1934, [ii], **45**, 839–840).—A note. In a single crystal of 3% silicon iron, slowly rotated in a magnetic field, almost all of the large Barkhausen changes can be explained as due to simple reversals along one of the directions of easy magnetization here of the form <100>.—W. H.-R.

On the Hypothesis of a Critical Field in Superconductivity. David Rittenhouse Inglis (*J. Franklin Inst.*, 1924, **217**, 227–228).—A brief discussion. —S. G.

II.—PROPERTIES OF ALLOYS

(Continued from pp. 380–383.)

***A Study of the Aluminium-Rich Aluminium–Copper–Silicon Alloys.—III.** Chiuyō Hisatsune (*Suiyō-Kwaishi*, 1929, **6**, (1), 31–34; (2), 199–211; *Japanese J. Eng. Abs.*, 1933, (**9**), 69).—[In Japanese.] Cf. *J. Inst. Metals*, 1933, **53**, 294. Alloys containing copper up to 40% and silicon up to 8% were prepared, quenched at 450°–520° C. and aged at 100°–200° C. The ageing phenomena were observed. The changes of tensile strength and Charpy impact value of wrought and cast alloys due to quenching and artificial ageing were studied, and also the impact hardness at 25°–500° C. The quenched and aged alloys showed the highest values. It was found that 450°–500° C. was the best temperature for forging and that the alloys containing more than 4% silicon and more than 6% copper were unsuitable for this purpose. The mechanical and physical properties are considerably improved by heat-treatment. The alloy containing copper 4 and silicon 2–4% is superior in many respects to the other aluminium-rich aluminium–copper–silicon alloys. —S. G.

***A Study of the Aluminium-Rich Aluminium–Copper–Silicon Alloys.** Chūyō Hisatsune (*Suiyō-Kwaishi*, 1930, **6**, (4), 373–379; *Japanese J. Eng. Abs.*, 1934, (**10**), 48).—[In Japanese.] H. investigated the time required for the dissolution and diffusion of the soluble constituents in the solid solution by measurements of Rockwell hardness and electrical resistance, and by microscopic examination. He also studied the artificial ageing of these alloys; 5 hrs. were found to be sufficient to heat the specimens at 500° C. for the purpose of the so-called solution treatment.—S. G.

Silumin-Gamma, the New Quality Alloy for Heat-Treatment. J. Dornauf (*Alluminio*, 1934, **3**, 68–73).—A small addition of magnesium to Silumin renders it susceptible to great improvements by heat-treatment. The changes in structure and properties produced by various heat-treatments are illustrated.—G. G.

A New Aluminium Light Alloy "Chlumin." Ichirō Iitaka (*Zassan* (*J. Japanese Soc. Naval Arch.*), 1931, **48**, 165–177).—[In Japanese.] See *J. Inst. Metals*, 1932, **50**, 11, 221, 425, 661.—S. G.

***Elastic Hysteresis of Aluminium and Its Alloys.** G. Colonneti and G. M. Pugno (*Atti Pont. Accad. Sci. Nuovo Lincei*, 1930, **14**, 435–488; *Sci. Abs.*, 1931, [A], **34**, 264).—The elastic properties of the alloys of aluminium do not depend only on the chemical composition of the alloy but also, and perhaps more, on the thermal and mechanical treatment that the material has undergone. The following 3 properties which were noted in alloys of copper were found also in aluminium alloys. (1) The irreversibility of the phenomenon of deformation. If a specimen is gradually subjected to a load increasing from zero to an arbitrary value and the load is then gradually decreased the deformations observed on the original process are in general different from those in the reverse process. (2) The adjustment of the cycles. If the operation of loading and unloading is repeated a second time the deformation curve is different in the latter case from that in the first. (3) The modulus of elasticity assumes for each material a value practically constant immediately after every inversion of the sense of variation of the load. In some respects the characteristics of the alloys of aluminium differ from those of copper. Whilst in the case of the copper alloys examined the modulus of elasticity always assumed after every regression a maximum value, with numerous specimens of aluminium alloys the characteristic value of the modulus immediately after a regression was a minimum. Attention is directed to the assymmetry of the bilateral cycles, that is, the diversity of the values

that, other circumstances being equal, the modulus of elasticity can assume according as the experiment is with tension or compression.—S. G.

***The Influence of Temperature on the Elastic Properties of Cast Aluminium Alloys.** M. v. Schwarz and A. Evers (*Z. Metallkunde*, 1934, **26**, 37–39).—Comparative tensile tests on a self-hardening American alloy and on a German alloy showed the former to have the better mechanical properties at high temperatures (up to 250° C.). The Brinell hardness of the specimens was also determined three days after the tensile test. The original must be consulted for details of the results.—B. Bl.

***On the Problem of the Electromotive Force and Electrical Conductivity of Alloys of Antimony and Cadmium.** B. N. Volfson and V. N. Rojdestvenskiy (*Zhurnal eksperimentalnoy i teoreticheskoy Fiziki* (*Journal of Experimental and Theoretical Physics*), 1933, **3**, (5), 447–453).—[In Russian.] Measurements of the thermoelectric power and electrical resistance of antimony–cadmium alloys show the presence of 3 ranges of composition in which these properties reach unstable maxima, indicating the existence of mixtures of compounds which are converted one into the other by heat-treatment in the solid state. The probable compositions of these are Sb_3Cd_5, Sb_5Cd_4, and Sb_5Cd_3.—N. A.

***The Cobalt-Silicon Equilibrium Diagram.** Rudolf Vogel and Kurt Rosenthal (*Arch. Eisenhüttenwesen*, 1933–1934, **7**, 689–691).—The system has been re-investigated between 8 and 32·45% silicon by thermal and micrographic methods. The compound Co_3Si separates from the liquid at 1210° C. and decomposes at 1160° C. The compound Co_2Si melts at 1332° C. and undergoes a transformation at 1320° C.; both forms can dissolve a little silicon but no cobalt, and the silicon-rich β-form decomposes at 1208° C. (20·8% silicon) into α-solid solution with 19·8% silicon and the compound CoSi, which are both stable down to room temperature. The existence of Co_3Si_2 has not been confirmed.—J. W.

***The Binary Systems Iron–Copper and Iron–Antimony.** Rudolf Vogel and Walter Dannöhl (*Arch. Eisenhüttenwesen*, 1934, **8**, 39–40).—In the iron–copper system the closed gap of miscibility extends to 1180° C., and the solubility of copper in γ-iron at 1477° C. is 8% (and not 20%), and at 1094° C. 8·5%. Antimony is soluble in γ-iron up to 2%; in the region 55–65% antimony the results of Hägg obtained by X-rays have been confirmed by microscopic examination.—J. W.

***The Cu_2Mg Phase in the Copper–Magnesium System.** V. G. Sederman (*Phil. Mag.*, 1934, [vii], **18**, 343–352).—The β-phase of this system of alloys at 500° C. is found by X-ray analysis to extend from 84·27% copper to 82·64% copper, whilst at lower temperatures it is considerably less. This extent is somewhat less than that found by Grime and Morris-Jones, *viz.* 2 or 3% on either side of the Cu_2Mg composition. The alloys employed in the investigation were those used by Jones, who found by thermal and microscopic methods no evidence for the existence of a range of solubility at this point (see *J. Inst. Metals*, 1931, **46**, 395).—J. S. G. T.

A New Copper–Nickel–Tin–Iron Alloy. Ivan Čerkesov (*Chem. Obzor*, 1934, **9**, 9–13).—An alloy for high-pressure armatures working in superheated steam consists of copper with nickel 37, tin 9, and iron 7%, is highly resistant to corrosion, and has a high resistance to wear and a small coeff. of friction with water as a lubricant. The alloy has a Brinell hardness of 300 with a tensile strength of 40–50 kg./mm.^{2} in the cast state, and requires no heat-treatment. The method of preparing and casting the alloy is described, and a table of physical and mechanical properties given.—R. P.

The Effect of Silver on the Softening Temperature of Copper. Anon. (*Metallurgist* (Suppt. to *Engineer*), 1934, **9**, 122–123).—A brief review of recent work, mainly summarizing a paper by H. C. Kenny and G. L. Craig. See *Met. Abs.*, this volume, p. 341.—R. G.

***On the Properties of Phosphor-Bronze for Springs.** Mitsugu Tanaka and Toshiichi Ogawa (*Res. Electrotech. Lab. Tokyo*, 1931, (**301**), 1–85; *Sci. Abs.*, 1931, [B], **34**, 593).—[In Japanese.] Particular consideration is given to the properties of phosphor-bronze for springs for use in electrical instruments. Over 400 specimens of different compositions (up to 10% or 12% of tin and 0·5% of phosphorus) were annealed at various temperatures up to 600° C. The test-specimens consisted of a wire rolled and drawn from a chill-cast ingot 1 cm.² in cross-section. When reduced to 2 mm. in diameter all wires were annealed at 600° C. for 30 minutes and then cold-drawn to a diameter of 0·4 mm., thus ensuring uniform annealing of all specimens. Numerous empirical formulæ are given for the various physical and mechanical properties of the material. Details are included of a simple *extensometer* having an accuracy of 0·001 mm. with a dial gauge.—S. G.

***Elastic Fatigue and Creep of Coiled Springs [of Phosphor-Bronze].** W. H. Pielemeier (*Science*, 1933, **78**, 511).—A note. Two ordinary jolly balance springs of phosphor-bronze under a continuous load of 50 grm. showed increases in length of 0·03 and 0·23 cm., respectively, after 6 months, the former being equivalent to about 0·08% of the length of the spring. This creep was much less than that shown by springs made of steel piano wire, which were quite unsuitable for balance springs subjected to continuous loading.—W. H. R.

***Some Investigations on Cast Alloys. V.—Perkins Metal.** Gunji Shinoda (*Suiyô-Kwaishi*, 1929, **6**, (1), 42–47; *Japanese J. Eng. Abs.*, 1933, (**9**), 69).—[In Japanese.] The effect of annealing on the electrical resistance of cast bronzes containing 18–24% of tin was studied. The results reported in a previous paper (*ibid.*, 1928, (**4**), 687) for quenched alloys was also observed for chill-cast alloys, although the phenomena were less remarkable. The specific resistance–concentration curve was obtained; its general shape did not differ essentially from that of Stephen's later experiments, except for a small kink corresponding to Cu_3Sn_2 and CuSn. The electric potential of the tempered alloy containing 24% tin was measured and S. found an intimate relation between this and the microscopic structure due to tempering, *i.e.* he considered the reaction rims surrounding the martensitic needles must be a kind of tin-rich solid solution and that the specific resistance must be less than that of Cu_4Sn. From this point of view S. explains the remarkable minimum at about 340° C. Laue photographs were taken of all the specimens and the change of internal structure was studied. The effect of tempering first appeared at about 200° C. and from 300° C. the structure became fibrous.—S. G.

***The Mechanical Properties of the Copper-Zinc Alloys.** W. Broniewski and S. Trzebski (*Rev. Fonderie moderne*, 1934, **28**, 173–178).—An investigation of the mechanical properties of unoxidized brasses containing up to 44% zinc has been undertaken. In the case of the alloys annealed at 550° C.; the hardness, tensile strength, and elastic limit curves show a horizontal part between 20 and 36% zinc, preceded and followed by rising sections; the elongation has successively a minimum and a maximum towards 13–32% zinc; the reduction of area curve shows a sharp fall beginning at 40% zinc; the elongation and resilience only vary slightly with the composition. Cold-working considerably reduces the elongation and makes it nearly independent of the composition; the hardness and tensile strength are increased, but the curves preserve the general direction of those of the annealed alloys. Oxidation of the alloys affects the mechanical properties of chiefly the 12–35% brasses; the elongation, reduction of area, and resilience are reduced, but the hardness and tensile strength are increased.—J. H. W.

†Bearing Metals on the Railways of the United States of America and Their Recent Development (Satco Metal). Fr. Witte (*Z. Metallkunde*, 1934, **26**, 69–70).—The properties of the lead-base bearing alloy Satco metal are

compared with those of tin, lead, and antimony bearing alloys. Satco metal consists of lead with (preferred composition in brackets) tin 0·5–2 (1), calcium 0·3–1 (0·5), mercury 0·1–0·5 (0·25), aluminium 0·02–1 (0·05), magnesium 0·05–0·1 (0·075), potassium 0·02–0·06 (0·04), and lithium 0·02–0·06 (0·04)%. The bending strength is 1740–1870 kg./mm.², the Brinell hardness 24–27 (20° C.), 17–19 (100° C.), and 10–14 kg./mm.² (150° C.), and melting begins at 315° C. Further information on the tensile strength, elongation, and deformation under load is given. The life of Satco metal bearings is 75,000–300,000 km., compared with 45,000–75,000 km. for ordinary bearings.—B. Bl.

***Some Investigations on Magnesium–Aluminium Alloys.** Shirō Ishida (*J. Mining Inst. Japan*, 1930, **46**, (540), 245–268; *Japanese J. Eng. Abs.*, 1934, (**10**), 45).—[In Japanese.] The solid solubility of aluminium in magnesium was determined by microscopic study and determinations of electrical resistance and thermal expansion. It was found to be about 13% at the eutectic temperature and to decrease to 5% at room temperature. The effect of quenching and tempering was investigated by microscopic examination and the measurement of physical and mechanical properties. The alloys containing more than 7% of aluminium harden by quenching and tempering, and the structures are troostitic. Maximum hardening occurred at 150°–170° C. but the temper-hardened alloys are too brittle to be used under shock. I. recommends that they be cooled in the furnace after heating at higher temperatures.—S. G.

***Solid Solubility of Aluminium and Zinc in Magnesium in Relation to Temperature.** P. J. Saldau and V. S. Sokolov (*Trudi Nauchno-Issledovatelskogo Instituta Legkih Metallov—"NIISALUMINI"* (*Transactions of the Scientific Research Institute for Light Metals—"NIISALUMINI,"* **1932**, (1–2), 57–62).—[In Russian.] From a microscopic examination of alloys annealed for 24 days *in vacuo* at different temperatures and quenched, the limits of solid solubility of aluminium and zinc (1 : 1 weight ratio) in magnesium have been found to be: at room temperature, 1·1 and 1·6; at 250° C., 2·45 and 2·85; at 300° C., 2·30 and 2·75; at 350° C., 4·30 and 4·60; and at 400° C., 3·04 and 4·0%, respectively, whence the values at the eutectic temperature (351° C.) are deduced to be 4·5% for both metals.—D. N. S.

***Solid Solubility of Zinc and Aluminium in Magnesium in Relation to Temperature.** P. J. Saldau and N. I. Korenev (*Trudi Nauchno-Issledovatelskogo Instituta Legkih Metallov—"NIISALUMINI"* (*Transactions of the Scientific Research Institute for Light Metals—"NIISALUMINI"*), **1933**, (3), 60–64).—[In Russian.] Microscopic examination of magnesium alloys (with a 3 : 1 weight ratio of aluminium and zinc) annealed for 24 days and quenched in water, showed the limiting solubility of these metals to be: at 20° C., 3·9 and 1·31; at 250° C., 4·84 and 1·66; at 325° C., 6·57 and 2·14; at 350° C., 7·57 and 2·50%, respectively.—D. N. S.

***An Investigation on Some Magnesium Alloys.** Shirō Ishida (*J. Mining Inst. Japan*, 1929 (**529**), 256–268; (**532**), 611–621; (**536**), 786–790; *Japanese J. Eng. Abs.*, 1933, (**9**), 68).—[In Japanese.] From the results of thermal and microscopic investigations, I. confirmed the constitutions of the magnesium–aluminium, magnesium–cadmium, magnesium–copper, and magnesium–zinc alloys. The limit of solubility of aluminium was found to be about 5% at room temperature and 13% at the eutectic temperature; the solubility of zinc in magnesium was observed to be about 3% at 200° C. and 7% at 300° C. The alloy containing 55% zinc solidified as a white solid solution but transformed a few degrees below the crystallization temperature into a eutectic structure. The systems magnesium–aluminium–cadmium, magnesium–zinc–aluminium, and magnesium–zinc–copper were also studied. In the two latter a ternary compound was found but the formula was not determined. Some experiments were carried out on the melting of mag-

nesium alloys by various methods. It is concluded that magnesium manufactured by the electrolysis of magnesium oxide can be melted without cover, but for magnesium prepared by the electrolysis of magnesium chloride it is better to use a cover such as carnalite or a mixture of carnalite and sodium chloride. The mechanical properties of alloys made by the latter method were always better, but it is necessary to take precautions to prevent the salt from entering the alloy and to protect it from the action of sulphur dioxide.—S. G.

***The Iron Corner of the System Iron–Manganese–Chromium.** Werner Köster (*Arch. Eisenhüttenwesen*, 1933–1934, **7**, 687–688).—Up to 40% manganese and 30% chromium only the α- and γ-solid solutions exist. The equilibrium diagram of this region has been constructed from measurements of the thermal expansion and from micrographic examination.—J. W.

***Forced Life Test of Heating Wires.** Shinji Togō (*J. Illuminating Eng. Soc. Japan*, 1929, **13**, (4), 201–207; *Japanese J. Eng. Abs.*, 1933, (**9**), 34).—[In Japanese.] See *Met. Abs.*, this volume, p. 73.—S. G.

***Life of Resistance Wires for Electric Heaters.** Masaie Horioka, Kenichi Yamamoto, and Komazō Honda (*J. Inst. Elect. Eng. Japan*, 1931, (**518**), 645–654).—[In Japanese.] See *J. Inst. Metals*, 1932, **50**, 298.—S. G.

Remarks on the Equilibrium Diagram of the Iron–Nickel System Below 1000° C. L. Grenet (*Aciers spéciaux*, 1934, **9**, 76–83).—The iron–nickel diagram is critically reviewed and the results of X-ray observations are discussed. It is concluded that it it is difficult to conceive a continuous evolution from the homogeneous α-phase to the homogeneous γ-phase with a crystalline system, as with an amorphous system, or a rapid variation from the cube-centred to the face-centred cube. It is suggested that the notion of phases be separated from the notion of a crystalline state, and the coexistence of individualities and not phases be envisaged. This hypothesis is expanded further and the grounds on which it is based are explained.—J. H. W.

Lines of Research in the Field of High-Resistance and Heat-Resistant Alloys. A. A. Botchvar (*Vestnick Ingenerov i Tehnikov* (*Messenger of Engineers and Technologists*), **1933**, (8), 340–341).—[In Russian.]—N. A.

***On the Absorptive Power of the Palladium–Boron Alloys for Hydrogen.** Adolf Sieverts and Kurt Brüning (*Z. physikal. Chem.*, 1934, [A], **168**, 411–418).—Alloys with up to 6·9 atomic-% boron are homogeneous after heat-treatment, but alloys with 13·8 and 16·6 atomic-% boron consist of two phases; the hardness increases with the boron content at first rapidly then more slowly. The absorptive power of the alloys for hydrogen decreases in all cases with rise of temperature; at constant temperature the amount of gas absorbed is approximately proportional to the square root of the pressure except in the case of alloys low in boron, above 500° C. At 20° and 100° C. the absorptive power of the alloys decreases with increasing boron content. Between 160° and 900° C. the absorptive power increases to a maximum at 7 atomic-% boron, then decreases again. The behaviour of boron–palladium alloys is very similar to that of gold–palladium alloys.—B. Bl.

***Alloys of Palladium with Nickel.** A. T. Grigoriev (*Izvestia Platinago Instituta* (*Annales de l'Institut de Platine*), 1932, (**9**), 13–22).—[In Russian.] The system has been studied by micrographie examination and by measurement of the Brinell hardness and temperature coeff. of electrical resistance. The hardness curve is characteristic of a continuous series of solid solutions, the maximum hardness (156) being reached with 60–64 atomic-% palladium. The structure consists of polyhedral grains typical of solid solutions. The curve of temperature coeff. of electrical resistance has a sharp break at 70·8 atomic-% palladium, corresponding with the transition from magnetic to non-magnetic alloys.—N. A.

***Alloys of Platinum and Cobalt.** V. A. Nemilov (*Izvestia Platinago Instituta* (*Annales de l'Institut de Platine*), 1932, (**9**), 23–30).—[In Russian.] See *J. Inst. Metals*, 1933, **53**, 494.—N. A.

White Bearing Metals. Mark R. Pitt (*J. Inst. Eng. Australia*, 1932, **4**, 430–434).—A review of the tin- and lead-base bearing metals, their structure, properties, and behaviour in service.—R. G.

The White Alloys of Tin. IV.—Britannia Metal. Anon. (*Tin*, **1934**, June, 8–9).—Briefly describes the properties of Britannia metal, Ashberry metal, and "Falun" or Falun Brilliants.—J. H. W.

***The System Iron–Fe_3C–ZrC–Fe_3Zr_2.** Rudolf Vogel and Karl Löhberg (*Arch. Eisenhüttenwesen*, 1933–1934, **7**, 473–478).—The iron–zirconium–carbon system has been investigated up to 6% carbon and 30% zirconium by thermal and micrographic methods. The results are shown in a ternary equilibrium diagram.—J. W.

***Comparative Fluidity Tests.** Ernst Scheuer (*Metallwirtschaft*, 1931, **10**, 884–885; *C. Abs.*, 1932, **26**, 677).—The apparatus used was similar to that developed by Guillet and Portevin, in which the metal is cast under definite conditions at constant hydrostatic pressure into a spiral-shaped mould. The fluidity is measured by the length of the mould which is filled out with the metal. The fluidity of zinc, aluminium, and Silumin increases proportionally with the pouring temperature. Mould temperature has little influence up to 300° C.; above that it increases the fluidity. The smoothness of the mould surface has practically no influence. The fluidity of the binary alloys of aluminium with silicon, copper, zinc, and nickel was investigated. In each case small additions of the respective metals lower the fluidity of pure aluminium. With further additions it increases again, approximately up to the eutectic point, after which it remains almost constant. Additions of cadmium and nickel up to 1·5% to Silumin increase its fluidity by about 10%. Magnesium, copper, zinc, and manganese have little or no effect. Additions of magnesium up to 2% to a 13% aluminium–copper alloy decreases the fluidity slightly, further additions increase it. The decreased fluidity is explained by the formation of a solid solution, and the increase with higher additions by the formation of a eutectic. —S. G.

***Measurement of the Viscosity of Molten Metals and Alloys by the Rotating Cylinder Method.** Daikichi Saitō and Tatsuo Matsukawa (*Tetsu-to-Hagane* (*J. Iron Steel Inst. Japan*), 1931, **17**, (5), 502–532).—[In Japanese.] Cf. *J. Inst. Metals*, 1933, **53**, 435.—S. G.

***Permeability Changes in Ferromagnetic Materials Heat-Treated in Magnetic Fields.** G. A. Kelsall (*Physics*, 1934, **5**, 169–172).—Very high maximum magnetic permeability has been obtained in ferromagnetic alloys by slowly cooling them in a magnetic field. In Permalloy containing 78·5% nickel the permeability has thus been raised above 140,000, *i.e.* to the same order as is obtainable by rapid cooling without an applied field. Similar magnetic heat-treatment is likewise effective in the case of Perminvar containing 45% nickel, 30% iron, and 25% cobalt. The maximum permeability is highest if the testing field is in the same direction as that applied during cooling. In directions at right angles to this, the maximum permeability is decreased. The ratio of these two permeabilities was in one case more than 14 for Perminvar and in another case almost 70 for the same alloy.—J. S. G. T.

***Magnetic Properties and Chemical Compounds in Alloys.** J. G. Dorfman (*Zhurnal eksperimentalnoy i teoreticheskoy Fiziki* (*Journal of Experimental and Theoretical Physics*), 1933, **3**, (4), 293–302).—[In Russian.] See *J. Inst. Metals*, 1933, **53**, 626.—N. A.

III.—STRUCTURE

(Metallography; Macrography; Crystal Structure.)

(Continued from pp. 384–385.)

Some Statistical Properties of an Annealed Alpha-Grain Aggregate.—II. R. G. Johnston and W. G. Askew (*Met. Ind.* (*Lond.*), 1934, **45**, 27–30).—It is shown that the arithmetical grain area or mean grain diameter as a specification of grain pattern is irrational and leads to unreliable and conflicting results when correlating the properties of an α-brass with its grain size. It is suggested that the absolute size of the largest grain to be tolerated be used as a basis of a complete method of specification, perhaps in conjunction with one or more mean quantities.—J. H. W.

Notes on the Metallography of Light Metal Alloys. A. Blumenthal (*Zeiss Nachrichten*, **1934**, April, 28–34; and (translation) *Metallurgia*, 1934, **10**, 83–85).—The technique employed in the metallographic investigation of some light metal alloys including Silumin, K.S.-Seewasser, the Elektron die-casting alloy A.Z. 91, and other casting alloys is described.—J. W. D.

***A Metallographic Investigation of Native Silver.** (Sir) H. C. H. Carpenter and M. S. Fisher (*Trans. Inst. Min. Met.*, 1932, **41**, 382–403; discussion, 403–433).—See *J. Inst. Metals*, 1932, **50**, 362.—S. G.

***On the Twinning of Zinc.** N. N. Davidenkov, A. F. Kolesnikov, and K. N. Fedorov (*Zhurnal eksperimentalnoy i teoreticheskoy Fiziki* (*Journal of Experimental and Theoretical Physics*), 1933, **3**, (4), 350–360).—[In Russian.] When single crystals of zinc are stretched at temperatures between — 185° and + 200° C. under conditions of orientation favourable to twinning the resistance to twinning, manifested as a shear stress along the plane and in the direction of twinning, is 5–11 times the resistance to slip along the basal plane and much less constant. Probably resistance to twinning is affected by the normal extension stresses acting along the twinning plane and arresting the process. Lowering the temperature increases resistance to twinning more than resistance to slip.—N. A.

***Abnormal Structures in Slowly Cooled Alloys of the Eutectic Type.** A. A. Botchvar and K. V. Rusetsky (*Vestnick Metallopromishlennosti* (*Messenger of the Metal Industry*), **1933**, (1), 59–61).—[In Russian.] Abnormal structure of alloys of the eutectic type is characterized by the appearance of "halos" of the second phase, surrounding primary crystals. Both hypo- and hypereutectic alloys of bismuth, cadmium, lead, and tin were investigated. In this series each metal forms halos round the metals which precede it, the further apart the metals in the series the sharper being the halo.—D. N. S.

***On the Crystallization of Ternary Eutectics.** A. A. Botchvar and K. V. Gorev (*Vestnick Metallopromishlennosti* (*Messenger of the Metal Industry*), **1933**, (2), 44–45).—[In Russian.] Cf. *J. Inst. Metals*, 1933, **53**, 238. Experiments are described to ascertain the order in which the different phases crystallize in the ternary eutectics, lead–tin–cadmium, bismuth–tin–cadmium, and bismuth–lead–cadmium. The order of crystallization irrespective of the presence of an excess of one component is cadmium, lead, tin, bismuth.

—D. N. S.

***An X-Ray Investigation of the Arsenic–Tin System of Alloys.** W. H. Willott and E. J. Evans (*Phil. Mag.*, 1934, [vii], **18**, 114–128).—The crystal structures and lattice constants of the complete range of arsenic–tin alloys are determined by X-rays analysis. The results show that the phase from 0 to 29·5% of arsenic is a solid solution, and not a mixture of tin and Sn_3As_2. There is no evidence of the presence of the compound Sn_3As_2. The compound SnAs has a sodium chloride structure, which persists as a homogeneous phase over the

range 34·5–49·0% of arsenic and is accompanied by changes of lattice constant, indicating that the compound SnAs dissolves both tin and arsenic. The sodium chloride structure has a range extending from 29·5 to 68·0% of arsenic, indicating the presence of two mixture phases, one extending from 29·5 to 34·5% of arsenic, and the other from 49·0 to 68·0% of arsenic. The existence of a solid solution of tin in arsenic is confirmed.—J. S. G. T.

***X-Ray Crystal Measurements of Nickel at High Temperatures.** William P. Jesse (*Physics*, 1934, **5**, 147–149).—X-ray powder photographs of an electrically heated nickel ribbon showed no new high-temperature crystal form of nickel between 450° C. and 1200° C. The thermal expansion of the face-centred cubic lattice is in agreement with macroscopic thermal expansion data.—J. S. G. T.

***On Osmiridium. II.—X-Ray Analysis.** O. E. Zviagintzev and B. K. Brunovskiy (*Izvestia Platinago Instituta* (*Annales de l'Institut de Platine*), 1932, (**9**), 49–53).—[In Russian.] Cf. *J. Inst. Metals*, 1933, **53**, 352. Osmiridium of various origins and compositions has a close-packed hexagonal lattice, like osmium: $a = 2{\cdot}620$–$2{\cdot}90$ A., $c = 4{\cdot}235$–$4{\cdot}60$ A., $c/a = 1{\cdot}581$–$1{\cdot}617$. Some of the atoms in the osmium lattice can be replaced by up to 51% of iridium and platinum without altering its character. Osmiridium must therefore be regarded as a solid solution of iridium (and platinum) in osmium.—N. A.

***An Electrochemical and X-Ray Investigation of Solid Thallium–Lead Alloys.** Arne Ölander (*Z. physikal. Chem.*, 1934, [A], **168**, 274–282).—The potential of the cell $Tl_{solid}|(Na, K, Tl)CH_3{\cdot}CO_2|(Tl, Pb)_{solid}$ and its temperature coeff. between 245° and 295° C. has been measured for 41 alloys. The results together with X-ray examination of the alloys indicate that in alloys up to 54·6% thallium the thallium atoms are distributed at random in the lead lattice. Between 54·6 and 92·5% thallium the intermediate phase Tl_7Pb exists. The lattice parameter of the lead-rich phase is given by the expression $a = 4{\cdot}9380$–$0{\cdot}0758[Tl]$, and that of the thallium-rich phase by the expression $a = 4{\cdot}9794$–$0{\cdot}1516[Tl]$, where [Tl] is the concentration of thallium in the lead. These two straight lines intersect at $[Tl] = 0{\cdot}546$.—B. Bl.

***Mechanism of Formation of Hard Alloys in the Light of Modern Crystallographic Chemistry.** V. I. Riskin (*Redkie Metalli* (*Rare Metals*), **1933**, (3), 3–9).—[In Russian.] An account of modern theories of crystal structure and their application to the formation of metal carbides. The relation between the atomic radii of metals and carbon and the crystalline structure of carbides is examined. The results of these calculations are applied to the theoretical selection of new hard carbide alloys.—D. N. S.

***Laminated Fracture in Super-Hard Alloys of the Metallo-Ceramic Type.** N. M. Zarubin and V. I. Tretiakov (*Redkie Metalli* (*Rare Metals*), **1933**, (3), 16–21).—[In Russian.] Discusses the macro- and micro-structures of fractures of the hard alloys Pobedit, Carboloy, and Widia. The laminated fracture is explained primarily by the presence of free carbon in the alloys and the decarburization due to irregularities in the sintering process of production of the alloys.—D. N. S.

***Optical Method of Determining the Orientation of Single Crystal Specimens.** E. S. Yakovleva (*Zhurnal eksperimentalnoy i teoreticheskoy Fiziki* (*Journal of Experimental and Theoretical Physics*), 1933, **3**, (5), 454–459).—[In Russian.] A modification of A. W. Schubnikow's method (*Z. Krist.*, 1931, **78**, 111) is described for the determination of the inclination of any face of a metal crystal to the axis of the specimen and its crystallographic index. The apparatus, preparation of specimens, method of etching, experimental procedure, and calculation of the results are described. The results are accurate to 30′–1°.—N. A.

IV.—CORROSION

(Continued from pp. 385–387.)

Behaviour of Aluminium in Laundry Work. Anon. (*Illust. Zeit. Blechindustrie*, 1934, **63**, 740).—A summary of the work of Bohmer on the attack of aluminium and certain light alloys in soapy and alkaline solutions. It is found that soft aluminium (99·5%) suffers less attack than hard; that alloying increases susceptibility, as does increase in temperature: that the presence of other metals, especially copper and zinc, very greatly increases the speed and violence of attack and that the action is almost completely inhibited if sodium silicate is present in sufficient quantity. As many washing preparations contain sodium silicate it should be possible to utilize aluminium and its alloys in laundry vessels to a greater extent than has hitherto been considered possible. —P. M. C. R.

***Poisoning and Activation of Aluminium and Cadmium During Dissolution in Hydrochloric Acid.** K. Jablczynski and T. Pierzchalski (*Z. anorg. Chem.*, 1934, **217**, 298–304).—Thiocyanates and thiourea retard considerably the rate of dissolution of aluminium in hydrochloric acid, but urea is without effect, and hydrogen sulphide and carbon bisulphide activate the solution. Potassium cyanide reduces the rate of dissolution, whereas iodine activates aluminium. Potassium chloride and sulphate, aluminium, and iron chlorides also assist the reaction. Thiocyanates and thiourea activate cadmium, as also does iodine, but urea and potassium cyanide are inert.—B. Bl.

***Corrosion of the Bimetal "Ferran."** V. S. Zorin (*Trudi Nauchno-Issledovatelskogo Instituta Legkih Metallov—"NIISALUMINI"* (*Transactions of the Scientific Research Institute for Light Metals—"NIISALUMINI"*), **1932**, (1–2), 74–81).—[In Russian.] The corrosion of the bimetal Ferran by sodium chloride, sodium carbonate, and acetic acid solutions, dilute sulphuric acid, tap-water, ammonia gas, hydrogen sulphide, carbon dioxide, foodstuffs, and fish products was investigated. In all cases the aluminium layer was found to be porous, the porosity being inversely proportional to its thickness and giving rise to pitting by all the liquid reagents. Sodium carbonate solution produced stripping of the aluminium layer. The gases gave no corrosion. —D. N. S.

***Plating of Iron with Aluminium.** N. N. Ivanov-Skoblikov (*Trudi Nauchno-Issledovatelskogo Instituta Legkih Metallov—"NIISALUMINI"* (*Transactions of the Scientific Research Institute for Light Metals—"NIISALUMINI"*), **1933**, (5), 3–31).—[In Russian.] "Ferran" has been compared with sheet iron plated with aluminium on one side by rolling together iron and aluminium sheets under certain conditions; these have been critically studied and the products examined under the microscope. "Ferran" is not resistant to corrosion by many reagents, but foodstuff containers made from aluminium-plated sheet showed no corrosion or deterioration of their contents after 2 years' storage.—D. N. S.

***Corrosion of the Bimetal Iron–Copper.** V. S. Zorin (*Trudi Nauchno-Issledovatelskogo Instituta Legkih Metallov—"NIISALUMINI"* (*Transactions of the Scientific Research Institute for Light Metals—"NIISALUMINI"*), **1933**, (5), 44–50).—[In Russian.] Corrosion tests on sheet (1–2 mm.), strip, and various utensils of a composite metal produced by rolling sheet iron between two copper sheets and subsequently tinning, have been made in tap-water and solutions of sodium chloride, sodium carbonate, acetic acid, and malic acid. Owing to its plastic nature, the copper layer (0·08–0·17 mm. thick) is non-porous, and hence does not give an iron–copper couple which promotes corrosion, and does not peel off the iron. The mechanical

properties of the composite sheet are unaltered after the corrosion tests, and it is considered to be a suitable substitute for pure copper in cooking utensils. —D. N. S.

***Corrosion of Lead by Fatty Acids in Presence of Iron.** G. O. Heyer (*Seifensieder-Zeit.*, 1933, **60**, 131–133, 165–167; *Res. Assoc. Brit. Paint Manuf. Rev.*, 1933, (**32**), 88).—A case of corrosion of the lead lining of an iron vessel is described. On removing the corroded lead lining small pits were found on the surface next to the iron and the narrow space between the 2 metals was found to be little-changed fatty acid which had previously leaked into it. On removing the fatty acid, the lead surface was seen to be much corroded. The theory is advanced that the cause of corrosion is to be found in the system lead–iron–fatty acid. Apparatus to investigate the cause of the above corrosion is described. Small lead plates are bent to fit on to similar plates of iron and the metals alone and fitted together are immersed in beakers containing oleic acid and oleic acid + water. Data are recorded to show the loss in weight of the lead plates under the 4 conditions over a period of 9 months. The loss was considerably greater when iron was present than when the lead alone was immersed in oleic acid and the loss is greater still in presence of water. Curves in which loss in weight per unit area is plotted against time are regular and tend to flatten out. The inference is that the lead surface becomes coated by a protective layer and oleic acid attack falls off.—S. G.

Protection Against Lead Poisoning from Water Supplies. J. A. Cancik (*Mem. Soc. Roy. Sci. Bohème*, **1932**, (5), 1; *Zbl. ges. Hyg.*, 1933, **29**, 14; (*U.S.*) *Public Health Eng. Abs.*, 1934, **14**).—Discusses factors favouring the corrosion and erosion of lead and its occurrence in water supplies. Small variations in the properties, particularly the p_H, of a water are always occurring and may cause it to become plumbo-solvent. Individual susceptibility to lead poisoning varies and drinking water should be so far as possible free from lead. Protective measures usually taken are increasing the hardness or alkalinity of the water or lining the pipes, as the coating is easily destroyed and hydrogen sulphide may be formed. A strong lining of tin is the only safe method for protecting the pipes.—S. G.

***The Corrosion and Protection of Magnesium and Its Light Alloys (with Discussion).** Guy D. Bengough and L. Whitby (*Trans. Inst. Chem. Eng.*, 1933, **11**, 176–190).—See *Met. Abs.*, this volume, p. 179.—A. B. W.

The Corrosion of Tin Cans used as Food Containers. S. G. Lipsett (*Canad. Chem. and Met.*, 1933, **17**, 171; *Res. Assoc. Brit. Paint Manuf. Rev.*, 1933, (**35**), 277).—Electrolytic action on the tin–iron junction is reversed in the absence of air, the tin dissolves preferentially in acid solutions. Cans are therefore not especially liable to perforation at pinholes in the tin coating. Lacquered cans are less reliable in this respect.—S. G.

***The Rate of Dissolution of Electrolytic Zinc in Acids.** M. Centnerszwer and M. Straumanis [with Frln. E. Karau] (*Z. physikal. Chem.*, 1934, [A], **167**, 421–430).—The rate of dissolution of chemically pure electrolytic zinc in acids is lower than that of Kahlbaum's zinc and almost the same as that of zinc with 0·2% cadmium. Zinc that has been roughened with emery dissolves at the maximum rate as soon as it is immersed in the acid, but the rate rapidly decreases, and reaches a limiting value characteristic of the acid and the nature of the metal. Chemical activation of the surface is not so effective as mechanical treatment with emery. The reactivity of zinc is not affected by storage in water. The rate of dissolution of electrolytic zinc in hydrochloric acid is a linear function of the concentration up to $2N$, *i.e.* $dv/dt = K(C - C_0)$, where C_0 is the concentration of acid at which dissolution commences, C is the concentration of the acid tested, and K the dissolution constant. In sulphuric acid dissolution is slower than in hydrochloric acid of the same p_H, and in both cases is independent of the current density used

in the preparation of the metal. From the magnitude of the temperature coeff. of the rate of dissolution and from the fact that stirring is without effect, it follows that the reaction is controlled by the chemical partial process and not by diffusion of the acid.—B. Bl.

***On the Corrosion of Electrolytic Zinc and Refined Zinc.** O. Bauer and G. Schikorr (*Z. Metallkunde*, 1934, **26**, 73–80).—Comparative corrosion tests have been made on electrolytic zinc (99·98% zinc) and on two grades of refined zinc (98·86 and 99·00% zinc). Electrolytic zinc is less attacked than refined zinc in neutral waters; in pure water the presence of carbon dioxide to produce a protective film is important. In acid solutions from which zinc liberates hydrogen electrolytic zinc is generally more rapidly attacked than refined zinc, whereas no difference in the behaviour of the three grades can be detected in atmospheric corrosion or in alkaline solutions (soda, Persil). Atmospheric attack is least in pure forest air, increases in the neighbourhood of towns, and is greatest in the ventilator shafts of laboratories. No differences are detectable in the corrosion of sheets hung perpendicular or horizontal except in the moist air of greenhouses, where horizontal sheets were more attacked than vertical ones. All grades of zinc are equally strongly attacked by moist gypsum, but electrolytic zinc is slightly more vigorously attacked by moist cement than is refined zinc. Among moist woods basswood has the greatest corrosive action on zinc and beechwood the least. Moist pinewood attacks electrolytic zinc more strongly than refined zinc.

—B. Bl.

***Internal Corrosion of Zinc.** E. Arendt (*Compt. rend.*, 1934, **199**, 142–143).—Although zinc immersed in an acidified solution becomes passive, if left in sulphuric or hydrochloric acids (the concentration within a large range is immaterial) for some weeks, it becomes corroded internally. The corroded metal in the interior is partly dissolved as the salt and partly oxidized to $Zn(OH)_2$, which fills the cavities formed by the corrosion. The passive film has a metallic appearance on the surface in contact with the solution and the colour of the hydrate on the internal face, and is about 10 μ thick. This effect of the passive film is much more marked in commercial zinc than in the chemically pure metal. The internal corrosion of the metal is facilitated by the difference in chemical properties of the surface films and the interior metal. When the metal is made passive over the whole surface, corrosion is caused by the diffusion of negative ions through the passive film and then reaction with the deeper layers. As a result, hydrogen is liberated and breaks through the film.—J. H. W.

***Alloys Stable in Phosphoric Acid.** O. I. Vehr and M. M. Romanov (*Dokladi Akademii Nauk* (*Compt. rend. Acad. Sci. U.R.S.S.*), **1933**, [N.S.], (3), 111–117).—[In Russian.] The following alloys were found to be resistant to hot and cold phosphoric acid (up to 60%): chromium steel (carbon 0·63, silicon 2·27, chromium 32·92%), chromium–manganese steel (carbon 0·23, chromium 16·45, manganese 11·54%), aluminium–bronze with 0·6% chromium. Aluminium–bronzes containing 0·02–0·67% chromium as well as plain "aluminium–bronze" and "aluminium–bronze" with 3% iron were tested in 80% phosphoric acid at the boiling point and at 135° C., and in technical phosphoric acid at 15° C. All the alloys had previously been heat-treated by quenching from 900° C. and normalizing at 700° C. The influence of chromium is manifested in two ways: by the formation of a protective film by the action of the acid and by a refining of the grain-size. All the "aluminium–bronzes" are resistant at room temperature to pure and commercial phosphoric acid. In 80% acid at 135°–140° C. the bronze containing 0·5% chromium was the most resistant. A bronze containing aluminium 9·46, chromium 0·37, and iron 0·26% prepared by the addition of ferro–chromium to "aluminium–bronze" was highly resistant to boiling 87% acid. The mechanical properties of

" aluminium-bronzes " containing chromium are good; after heat-treatment the tensile strength is 70 kg./mm.^{2} and the elongation 25%.—N. A.

***The Influence of Metals on Milk and of Milk on Metals.** W. Mohr, R. Kramer, A. Burr, —— Osterburg (*Alluminio*, 1934, **3**, 80–82).—Presented at the 10th International Dairy Congress, Rome, 1934. The corrosion of various metals and alloys by milk, and the changes thereby produced in the milk have been studied. Various light alloys, especially those the surfaces of which have been treated by the Eloxal process showed no signs of corrosion. Methods of preventing electrolytic corrosion by contact with other metals and the action of various alloy couples are discussed.—G. G.

***The Corrosive Action of Refrigerating Salt Mixtures on Various Metals.** A. Burr and M. Miethke (*Alluminio*, 1934, **3**, 82–84).—Read at the 10th International Dairy Congress, Rome, 1934. Refrigerating mixtures with a basis of calcium chloride have the most corrosive action even on stainless steel, the least corrosive mixture is a proprietary product containing chromate. —G. G.

***Metals and Wines. Corrosion-Resistance of Metals in Wine Making and Tolerance of Wines for Metals.** H. E. Searle, F. L. La Que, and R. H. Dohrow (*Indust. and Eng. Chem.*, 1934, **26**, 617–627).—Corrosion-resisting metals offer important advantages over the older materials of construction of winery equipment. Tests made to ascertain the resistance of metals to corrosion by wine and their effect on the product, are described. Inconel and 18:8 chromium–nickel steel were almost perfectly resistant under all the conditions studied. Inconel is adequate for all winery uses. The pick-up of iron from 18:8 alloy storage tanks, closed fermenters, and blending tanks may exceed the tolerance of wines for iron; in all other stages of the process this alloy is adequate. Owing to the high tolerance of wine for nickel, this metal may be used almost throughout the winery without affecting the colour, brilliance, flavour, or bouquet of wine. Monel metal, aluminium, and copper may be employed in certain winery equipment, *e.g.* juice tanks, in which the liquid does not remain for long periods. These metals as well as copper alloys are now used in pipe-lines, pumps, filling machines, &c. Tin is the only metal tested which appears to have a very limited application in wineries. Wine will tolerate only small quantities of tin, and the metal has a comparatively high corrosion rate, particularly when exposed to red wine under conditions of low aëration.—F. J.

***Corrosion of Metals by Phenols.** F. H. Rhodes, P. A. Riedel, and V. K. Hendricks (*Indust. and Eng. Chem.*, 1934, **26**, 533–534).—A method for determining the rates of corrosion of various metals and alloys in phenol and the cresols is described. In the stills used for refining these substances the metal of the condenser coils must resist the chemical action of the vapour, and must not discolour the finished product. The corrosive action of the acids on metal is also of importance in connection with the operation of the processes for the purification of petroleum oils by fractional extraction with cresol. The results showed that nickel or the 18:8 chromium–nickel steels should be satisfactory for use in handling and condensing the vapours of phenol or the cresols. Lead is rapidly attacked by the tar acid, and should not be used in handling these materials. The use of copper in phenol stills and containers for phenols at ordinary temperatures should be avoided, both because the copper itself is attacked to a considerable extent and also because the products of the action of the tar acids on copper cause discoloration of the phenol or cresol. Commercial zinc, aluminium, Monel metal, pure electrolytic silver, high-carbon and low-carbon steel, brass, and high-chromium steel were also used in the investigation.—F. J.

Corrosion of [Oil] Production Equipment in the Gulf Coast. S. Gill (*Oil Weekly*, 1933, **69**, 51).—Corrosion of well equipment, which constitutes one

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of the most serious items of trouble and expense in the Gulf Coast area, is discussed.—S. G.

Chemical Injection in Kansas [Oil] Wells Retards Corrosive Action. Anon. (*Oil Weekly*, 1933, **70**, (3), 22; *J. Inst. Petrol. Tech.*, 1933, **19**, 313A).—Difficulty is experienced in one of the Kansas fields through the presence of hydrogen sulphide and a low concentration of salt in the water coming with the oil from the deep producing horizons. Continued pulling of tubing, casing, &c., has been necessary since the oil was discovered in that region. An attempt was made to manufacture some alloy which would not be attacked but these measures failed. Injection of chemicals into the hole was then studied and is now being carried out to retard corrosion.—S. G.

Corrosion Test for Liquid Butane. F. M. Clothier (*Nat. Petrol. News*, 1933, **25**, 22; *J. Inst. Petrol. Tech.*, 1933, **19**, 411A).—This is an adaptation of the corrosion test for gasoline (copper strip) A.S.T.M. D 130–30, and is for the purpose of detecting the presence of free sulphur or corrosive sulphur compounds in commercial butane.—S. G.

Testing of Fuels, Solvents, and the Like for Corrosive Sulphur by Means of Copper. H. Kiemsted (*Brennstoff-Chem.*, 1933, **14**, 284–286).—S. G.

The Phenomenon of Corrosion. J. Liger (*Galvano*, **1934**, (26), 18–20).—A discussion of general principles.—E. S. H.

***The Velocity of Corrosion from the Electrochemical Standpoint.—III.** U. R. Evans and R. B. Mears (*Proc. Roy. Soc.*, 1934, [A], **146**, 153–165).—It is shown that Bengough's "film distribution" view of corrosion has much in common with views published by E. and M., and can be, in part, accepted. Criticisms of the differential aeration theory based on Bengough's linear corrosion–time curves are invalid. In the corrosion of iron immersed vertically in potassium chloride solution below oxygen–nitrogen mixtures, the velocity of corrosion *increases* and the area affected *decreases* with the oxygen concentration, thus confirming Borgmann's results (*Trans. Faraday Soc.*, 1932, **28**, 813). A statistical study of drops of potassium chloride on iron below oxygen–nitrogen mixtures shows that the probability of attack *diminishes* and the conditional velocity of corrosion *increases* with oxygen concentration. This confirms the opinion of Schikorr (*Z. Elektrochem.*, 1933, **39**, 409) that oxygen can be regarded as either a stimulator or inhibitor of corrosion.—J. S. G. T.

Rapid Method of Evaluating Corrosion. C. M. Chapman (*Refiner & Natural Gasoline Manuf.*, 1933, **12**, 153–155; *J. Inst. Petrol. Tech.*, 1933, **19**, 242A).—The exposure and examination of test-specimens inserted in closed vessels under operating conditions may be facilitated by the use of a corrosion tester, which represents a means of introducing and withdrawing specimens without interruption to plant operation. Specimens are attached to the end of a threaded spindle by means of which they are projected through a valve and connection into the vessel for exposure, and withdrawn for inspection by removal of the projecting spindle and yoke attachment from the valve. The exact type and size of the inserted specimens is limited by the diameter of the passage way through the valve and connection ($\frac{1}{16}$ in.) and to a length which allows clearance with the valve gate, about $1\frac{1}{2}$ in. A quick method for determining the relative suitability of metals for corrosion-resistance consists in polishing one or more exposure surfaces of a test-specimen to such a degree as to permit microscopic observation of corrosion. As a highly-polished surface tends to inhibit corrosion the final polish is made with No. 4/0 emery paper, which finish does not inhibit corrosion. In actual tests, specimens thus prepared were exposed to the action of corrosive water for 16 hrs., and the specimens, by microscopic examination, subsequently arranged in the order of resistance, which approximated to the valuation obtained by 2-year service tests.—S. G.

V.—PROTECTION

(Other than Electrodeposition.)

(Continued from pp. 387–389.)

Cinematographic Survey of Anodic Passivity Processes (with Film Production, and Discussion). W. J. Müller (*Z. Elektrochem.*, 1934, **40**, 536).—Read before the Deutsche Bunsen Gesellschaft. A note of an exposition of the phenomenon of passivity of different metals by means of an ordinary cinematograph camera. In the discussion, the passivity of aluminium is described, and it is stated that ferrous sulphate can form a primary film without the presence of a trace of ferric sulphate.—J. H. W.

***Plating of Light Alloys by the Method of Dipping in Fused Salts.** K. P. Lebedev and T. K. Riazhskaia (*Trudi Nauchno-Issledovatelskogo Instituta Legkih Metallov*—"*NIISALUMINI*" (*Transactions of the Scientific Research Institute for Light Metals*—"*NIISALUMINI*"), **1932**, (1–2), 82–86).—[In Russian.] Metal coatings were obtained by dipping aluminium, Duralumin, and Elektron in molten salts of zinc, copper, nickel, cadmium, and chromium. The best results for aluminium and its alloys were obtained by coating it with zinc in a mixture of the chlorides of zinc 75, potassium 12·5, and sodium 12·5% at 425° C. for 3–5 minutes. Copper-plating was unsatisfactory, whilst the other metals require further experiments.—D. N. S.

***Cementation with Aluminium in Works Practice.** V. O. Gess (*Vestnick Metallopromishlennosti* (*Messenger of the Metal Industry*), **1933**, (4), 31–35).—[In Russian.] For the aluminium coating of iron case-hardening boxes the boxes are pickled in sulphuric acid, washed with alkali solution, dried, and coated internally with graphite paint. Aluminium or Lautal is melted in a graphite crucible, 6–8% of iron shavings added, and the boxes submerged in the metal at 790°–800° C. for 40–50 minutes. They are then coated with sodium silicate solution and annealed at 950°–1000° C. for 2 hrs.—D. N. S.

***Hot-Dipped Aluminium Coatings on Iron.** H. Röhrig (*Z. Metallkunde*, 1934, **26**, 87–90; and (translation) *Aluminium Broadcast*, 1934, **4**, (29), 1–7).—Hot-dipped aluminium coatings on iron consist of three layers: (*A*) the iron–aluminium solid solution immediately above the iron core, (*B*) a brittle intermediate zone of $FeAl_3$, and (*C*) an outer surface of aluminium penetrated with $FeAl_3$ crystals. The increase in the thickness of *B* is greater with rise in temperature than with an increased time of immersion. The total thickness of the deposit increases rapidly with rise in temperature and time of immersion. The aluminium grips the iron by penetration into those constituents for which it has the greatest affinity. Addition of silicon to the aluminium bath reduces the thickness of the $FeAl_3$ layer by up to 50%. Before immersion in the aluminium the iron should be pickled in a salt-bath, preferably after being coated with a non-hygroscopic film of zinc ammonium chloride. Methods of testing aluminium-coated wires are described; they are similar to those used for zinc-coated wires.—B. Bl.

***Preece Test (Copper Sulphate Dip) for Zinc Coatings.** E. C. Groesbeck and H. H. Walkup (*U.S. Bur. Stand. J. Research*, 1934, **12**, 785–802; *Research Paper* No. **688**).—The Preece test is in common use for inspection purposes to determine the uniformity of galvanized coatings, even though the results are sometimes erratic. An experimental study made with wires with different types of zinc coating and with wires consisting of commercially pure zinc and iron indicates that the p_H value of the copper sulphate solution, the rate of solution of the zinc coating, and the cleanness of the test-specimens are important factors in the Preece test. The use of cupric hydroxide instead of cupric oxide for neutralizing the copper sulphate solution is recommended, since a stable p_H is much more quickly reached by its use. Electroplated and

sprayed zinc coatings dissolve more rapidly in the copper sulphate solution than do hot-dipped or galvannealed coatings. Pure zinc coatings showed, during their solution, a " potential minimum " (with respect to a copper wire) which was practically absent with coatings that contain iron, such as on galvannealed wires and the inner layer of hot-dipped galvanized wires. This minimum may be caused by the delayed coagulation of basic zinc compounds, which coagulation may be accelerated by the presence of iron. The causes and remedies of premature and delayed end-points are explained. A method for measuring the thickness-distribution of the zinc-coating by the use of a suitably acidified copper sulphate solution is suggested.—S. G.

Corrosion of Oil Well Tubing [Use of Galvanized Tubing]. W. F. Rogers (*Oil and Gas J.*, 1933, **32**, (1), 61; *J. Inst. Petrol. Tech.*, 1933, **19**, 259A).—From records of a large number of tube failures the results show that the most common occur in the joint ends either from corrosion at the back of the threads, thread breaks, or split joints. Corrosion of the joints is a particularly bad form of attack. Where severe corrosive conditions prevail the use of galvanized external upset seamless steel tubing is advocated.—S. G.

Combating Rust with Metallic Finishes. H. Chase (*Synthetic and Applied Finishes*, 1933, **4**, (37), 3; *Res. Assoc. Brit. Paint. Manuf. Rev.*, 1933, (**33**), 143).—Samples of steel coated with metallic finishes and exposed to external weathering in New York have been weighed every 2 months. Cadmium coatings weathered at twice the rate of zinc coatings. In these conditions salt-spray tests showed zinc coatings to be much inferior. Nickel and Monel metal failed in less than 2 months, sprayed lead was better, but not so good as sprayed aluminium. Hot-dipped lead coatings show no sign of pinhole corrosion.—S. G.

Resisting Corrosion. J. Winning (*Mech. World*, 1934, **95**, 599).—A letter to the Editor advocating cadmium plating as a protection for iron and steel and enumerating some of its advantages.—F. J.

Rapid Testing of the Characteristics of Metallic Coatings. Alexander Glazunov (*Iron Age*, 1934, **134**, (1), 12–14).—A known length of wire, coated with metal is exposed to electrolytic action under given conditions. If e = the electro-chemical equivalent of the metal, A = the current intensity in amperes, t = the time in seconds, s = the specific gravity, l = the length of the wire exposed, and r = its radius in cm., then the thickness of the surface layer, $d = \frac{e \times A \times t}{s \times l \times 2\pi r}$ cm.—J. H. W.

Metal Spraying in the Petroleum and Natural Gas Industries. H. B. Rice (*Refiner & Natural Gasoline Manuf.*, 1933, **12**, 148–152).—S. G.

Lacquering Cast Aluminium. H. Gge (*Indust.-Lackier-Betrieb*, **1933**, (5), 59; *Res. Assoc. Brit. Paint Manuf. Rev.*, 1933, (**32**), 89).—Cheap cast aluminium articles may be lacquered satisfactorily if they are first boiled in caustic soda for a short time in order to form a " passive " layer of aluminate. They should then be well washed and dried, when, if they show a grey appearance, they should be further treated with nitric acid and very carefully washed and dried. Costly articles should be dipped in solutions to give a metallic undercoat (of brass or pure copper or zinc).—S. G.

[Protection of Cans for] Canning Fruit and Vegetables. G. Cadbury (*Synthetic and Applied Finishes*, 1934, **4**, 302; *Res. Assoc. Brit. Paint Manuf. Rev.*, 1934, (**37**), 18).—Tins for fruit should be coated internally with a double layer of varnish; a single layer is less effective than no varnish since rapid corrosion occurs at any cracks in the coating. For vegetable tins a special sulphur-resisting varnish containing zinc is used.—S. G.

Varnishes and Temperatures for Tin Containers. Anon. (*Mod. Lith. and Offset Printer*, 1933, **29**, 186; *Res. Assoc. Brit. Paint Manuf. Rev.*, 1933, (**36**), 308).—Lacquers for food containers must be formulated with special regard to

the conditions to which they are subjected. It is essential that the temperature of baking ovens be carefully regulated. A device for measuring the temperature of tinplate at various points in an oven is described.—S. G.

Rust-Proofing of Tinned Objects. F. Hth (*Indust.-Lackier-Betrieb*, **1933**, (27), 319; *Res. Assoc. Brit. Paint Manuf. Rev.*, 1934, (**38**), 152).—A thick tin coating is essential; where thin spots occur exposure to a flame may cause melting of tin or exposure of the iron. This can be avoided by coating the tin surface with a " bronze "; for the latter any heat-resistant varnish or lacquer may be used, *e.g.* one containing cellulose acetate or bitumen. For storm lanterns aluminium–bronze is best, as copper and brass are liable to discoloration.—S. G.

Varnishing of Galvanized Iron Objects. F. Hth (*Indust.-Lackier-Betrieb*, **1933**, (27), 320; *Res. Assoc. Brit. Paint Manuf. Rev.*, 1934, (**38**), 98).—A composition is used containing copal or synthetic resin with 0·6–1% formic or butyric acid, which removes any trace of oxide from the surface. Owing to crystallization, the zinc surface is sufficiently rough to hold the varnish.—S. G.

Anti-Rust Preparations. S. Salm (*Allgem.-Oel u. Fett Zeit.*, 1933, **30**, 87–88; *Res. Assoc. Brit. Paint Manuf. Rev.*, 1933, (**32**), 88).—Lanoline or vaseline containing 10% lanoline, dissolved in solvent such as white spirit, are useful preparations. Schürer recommends the following: for metal articles, 125 grm. lard melted with 20 grm. camphor to which graphite is added. For *nickel* articles, 50 kg. stearin oil are stirred with sal ammoniac and 250 grm. benzine and 375 grm. vinegar added.—S. G.

Painting on Aluminium and Aluminium Alloys. —— Eckert (*Angew. Chem.*, 1933, **46**, 784; *Res. Assoc. Brit. Paint Manuf. Rev.*, 1934, (**37**), 14).—Preliminary roughening and removal of grease are important for adherence in the painting of aluminium. With otherwise faultless painting adherence often may be greatly decreased by the formation of pores, possibly submicroscopic. Correct choice of pigment and correct amount of dilute avoid this. Aromatic compounds permit of better adsorption than aliphatic. Basic pigments are suitable, but cannot be worked with every binder. Very finely ground aluminium is an excellent pigment. The synthetic resins from phthalic acid and from formaldehyde have a good adherence, hardness and elasticity, only 1 coat is required, no roughening and no priming, but the technical advantage of this valuable stoving varnish is decreased by the high baking temperature (150°–180°), which promotes intercrystalline corrosion and spoils the adherence properties. For all these alloys a 5-hr. baking at 200° is the maximum possible. —S. G.

Painting Aluminium Alloys. Anon. (*Indust.-Lackier-Betrieb*, **1933**, (12), 144; *Res. Assoc. Brit. Paint Manuf. Rev.*, 1933, (**34**), 213).—All parts of aircraft motors were coated with Japan or enamel before assembly. A black japan was sprayed on to the cylinders and a grey enamel on to the other parts. In the Wright factory (U.S.A.) the cylinders were put into a 2-chambered furnace and brought to a temperature of 233°; other parts were heated in an electric furnace to 121°.—S. G.

Surface Preparation and Corrosion-Resistance of Aluminium. Anon. (*Indust.-Lackier-Betrieb*, **1934**, (1/2), 12; *Res. Assoc. Brit. Paint Manuf. Rev.*, 1934, (**38**), 151).—For paint to adhere, the surface should be made passive by anodic oxidation. A suitable priming coat is given by $ZnCrO_4$ or aluminium in oil. Various electrolytes are used, *e.g.* chromic, sulphuric, and oxalic acids. Flawless surfaces result from anodic treatment of aluminium–silicon, zinc–copper, and copper–aluminium alloys. Oil or wax is used for final treatment. After treatment with sulphuric or oxalic acid the resulting coatings are mechanically and chemically highly resistant.—S. G.

VI.—ELECTRODEPOSITION

(Continued from p. 389.)

***Electrolytic Deposition of Aluminium From a Molten Medium.** V. Plotnikov, N. Gratsiansky, and Z. Demtshenko (*Legkie Metalli* (*Light Metals*), **1933,** (2–3), 27–31).—[In Russian.] Good deposits of aluminium on copper can be obtained from a 3 : 2 molecular mixture of aluminium and sodium chlorides; for iron a 2 : 1 mixture is better. The optimum temperature is 200°–250° C. and current density 1 amp./dm.^{2}.—D. N. S.

The Theory of Chromium Plating. Erich Müller (*Z. Elektrochem.*, 1934, **40,** 344–352).—Cf. *Met. Abs.*, this volume, pp. 352–353. The explanation of M.'s theory of chromium plating is concluded.—J. H. W.

***Rapid Electrographic Differentiation of Chromium-Plated and Nickel-Plated Goods.** Alexander Glazunov and J. Krivohlavý (*Chem. Obzor*, 1933, **8,** 175–177).—A spot test and an electrographic method of identifying electrodeposits on metals are described. For nickel an acetic acid alcoholic solution of dimethylglyoxime is used, and for chromium a sulphuric acid solution of diphenylcarbazide.—R. P.

Gold Electroplating. Paul A. Oldam (*Monthly Rev. Amer. Electroplaters' Soc.*, 1934, **20,** (10), 27–34).—Notes on the preparation, operation, and control of gold-plating solutions, especially those used for the deposition of alloy deposits of various colours.—A. R. P.

Recent Developments in the Electrodeposition of Nickel. A. W. Hothersall (*Met. Ind.* (*Lond.*), 1934, **45,** 109–121, 157–159).—Reproduced from a booklet issued by the Mond Nickel Co., Ltd.—J. H. W.

Peeling of Nickel–Chromium Deposits. André Darlay (*Galvano*, **1934,** (25), 17–20).—Faults in degreasing and in the electroplating process, which lead to subsequent peeling, are discussed.—E. S. H.

***On the Question of the Electrodeposition of Iron–Nickel Alloys.** F. Marschak, D. Stepanow, and C. Beljakowa (*Z. Elektrochem.*, 1934, **40,** 341–344).—The electrodeposition of iron and nickel from a mixture of the solutions of the simple salts in the presence of colloids and conducting salts has been investigated and the simultaneous deposition of iron and nickel on the cathode has been obtained. These deposits have a quite uniform and fine crystalline structure, and adhere strongly to the base; when thin they are elastic. From the earlier investigations it appears that the nickel content of the deposit increases with longer periods of electrolysis of solutions which have lower nickel concentrations and decreases in the course of time with electrolytes having higher concentrations of nickel.—J. H. W.

Electrolytic Deposits of Rhodium. J. Milinaire (*Galvano*, **1934,** (25), 23–24).—A brief discussion of recent developments and applications.—E. S. H.

Notes on Cyanide Solutions [Silver Plating Baths]. Richard M. Wick (*Monthly Rev. Amer. Electroplaters' Soc.*, 1934, **20,** (10), 10–15; discussion, 15–16).—Decomposition of cyanide plating baths proceeds chiefly by hydrolysis and oxidation. At room temperature hydrolysis produces hydrocyanic acid, which is partly lost by evaporation, and alkali hydroxide, which is slowly converted into carbonate; at higher temperatures, especially above 45° C., alkali formate is formed, which may be anodically oxidized to alkali carbonate. At high current densities cyanate is formed at the anode, and this may be hydrolyzed to carbonate and ammonia, the latter then forming urea with unchanged cyanate. Since the presence of argenticyanide in cyanide solution restrains loss of hydrocyanic acid when air is bubbled through, it is probable that more complex compounds than $KAg(CN)_2$ are present in silver plating baths.—A. R. P.

***Examination of Electrolytic Silver Deposits by X-Rays.** G. R. Levi and M. Tabet (*Atti R. Accad. Lincei* (*Roma*), 1934, **18**, 463–467; *C. Abs.*, 1934, **28**, 3003).—Bright deposits of silver were examined. The silver is deposited in isodiametric particles, whereas chromium is deposited as plates (*Met. Abs.*, this volume, p. 299). This is proof that plate structure is not a necessary condition for producing bright deposits.—S. G.

Acid Tin Plating. P. R. Pines (*Monthly Rev. Amer. Electroplaters' Soc.*, 1934, **20**, (10), 49–52).—A sulphate bath containing free sulphuric acid 6–8 and stannous sulphate 6 oz./gall., together with certain addition agents (nature not stated), gives bright adherent tin deposits with nearly 100% current efficiency when operated at 25°–30° C. with 5–50 amp./ft.^{2} and gentle agitation. At 40 amp./ft.^{2} a thickness of 0·001 in. is deposited as a bright silver-white plate in 11½ minutes. The throwing power is in excess of 200% on Pan's cavity scale.—A. R. P.

***The Throwing Power of Zinc Plating Solutions. II.—The Relation Between Current Density and Cathodic Polarization Potential of Zinc Sulphate Solutions.** Masami Nakajima (*J. Electrochem. Assoc.* (*Japan*), 1934, **2**, 72–75; *C. Abs.*, 1934, **28**, 3307).—[In Japanese.] Cf. *Met. Abs.*, this volume, p. 309. The relation between current density and cathodic polarization potential has been worked out with 0·5–2·5-*N* zinc sulphate solution (p_H 3·4–1·6). The polarization potential is increased with an increase in current density and is decreased with an increase in zinc sulphate concentration. In a zinc sulphate solution of the same concentration, this potential tends to be increased with a decrease in p_H value, and the lowest potential has been attained in 0·5 and 1·5-*N* solutions with p_H 2·8, and in 2·5-*N* solution with p_H 3·4 at lower current density and with p_H 2·2 at higher current density. Change in p_H does not greatly affect the polarization; the greatest effect is observed in 0·5-*N* concentration; it decreases with an increasing zinc sulphate concentration.—S. G.

***On the Structure of a Cathodic Deposit.** A. Glazunov (*Z. physikal. Chem.*, 1934, [A], **167**, 399–406).—A very elegant apparatus is described for following under the microscope the course of crystallization in the cathodic deposition of metals; the number of nuclei (KZ) and the rate of crystallization parallel (KG_1) and perpendicular (KG_2) to the lines of current increase with rise in current density. KG_1 and KZ decrease with increasing concentration of electrolyte, whilst KG_2 increases. The nature of the deposit (dense or powdery) depends on the ratio KG_2 : KZ; if KG_2 is small and KZ large the deposit is powdery, and if KG_2 : KZ is large a smooth mirror-like deposit is obtained. A high value of KG_1 produces a dendritic deposit with a rough surface.—B. Bl.

Protective Value of Plated Coatings on Non-Ferrous Metals [with Interpolated Discussion]. Wm. Blum (*Monthly Rev. Amer. Electroplaters' Soc.*, 1934, **21**, (1), 14–23).—A progress report and discussion of research on plated coatings now being carried out by the A.E.S. Most of the discussion is concerned with the value of a sodium nitrate stripping bath for removing nickel plate from steel by anodic treatment. The bath is unsuitable for high-carbon steel, and occasionally causes pitting or serious corrosion of low-carbon steel the reason for which is still obscure.—A. R. P.

†What is Under the Plate. George B. Hogaboom (*Monthly Rev. Amer. Electroplaters' Soc.*, 1934, **21**, (1), 5–13).—The importance of correct treatment, especially as regards cleaning and polishing, of the base metal prior to electroplating is stressed, and recent work on the subject is critically reviewed.
—A. R. P.

Some Further Electrochemical Principles Applied in Electrodeposition. I.—Secondary Electrodes. Samuel Field (*Met. Ind.* (*Lond.*), 1934, **45**, 61–63).—The use of copper and lead as secondary electrodes and the mechanism of the process are described.—J. H. W.

VII.—ELECTROMETALLURGY AND ELECTROCHEMISTRY
(Other than Electrodeposition and Electro-Refining.)

(Continued from pp. 354–355.)

***On Potentials in the Electrolytes of Foreign Ions.** O. Essin and M. Lozmanowa (*Z. physikal. Chem.*, 1934, [A], **167**, 209–220).—The potentials of gold in copper sulphate, copper nitrate, and silver nitrate solutions have been measured and compared with those of copper in copper sulphate and nitrate, and of silver in silver nitrate solutions. The gold potential is in all cases a linear function of the potential of the metal that forms the cation of the electrolyte: $E_{Au/MeX} = a + b \cdot E_{Me/MeX}$. In addition, there is a logarithmic relation to the activity of the cation of the electrolyte. The results can be explained by adsorption phenomena.—B. Bl.

***The Electrolytic Potential of Nickel.** L. Colombier (*Compt. rend.*, 1934, **199**, 273–275).—The electrolytic potential of nickel in 3 forms: massive (small cubes cut from a commercial plate), electrolytic (deposited at high current density), and reduced (by hydrogen), has been determined in a normal solution of pure nickel sulphate. The potentials were measured with calomel electrodes and calculated for the normal hydrogen electrode. The value found for the potential under these conditions was: $E_h = -0{\cdot}227 \pm 0{\cdot}002$ volt at 20° C.

—J. H. W.

Mechanical Activation of Electrode Surface. K. M. Gorbunova and A. T. Vagramyan (*Dokladii Akademii Nauk, U.R.S.S.* (*Compt. rend. acad. sci., U.R.S.S.*), 1934, [N.S.], **1**, 127–128 (in Russian); 128–129 (in French); *C. Abs.*, 1934, **28**, 3666).—A silver cathode submerged into 3-*N* silver nitrate solution remains passive at polarization up to $0{\cdot}6 \times 10^{-2}$ v. Increase of polarization up to $1{\cdot}7 \times 10^{-2}$ v. results in the formation of microscopic crystals which are capable of growth at lower potentials. A scratch made on the surface of the electrode enables crystals to form at much lower potentials. Scratching increases the number of active places due to freeing of microcrystalline surfaces where localized separation of metal takes place.—S. G.

***Antimony Electrodes.** Arvid Holmquist (*Svensk Kem. Tids.*, 1934, **46**, 2–10; *C. Abs.*, 1934, **28**, 3005).—The potentials of antimony rods are very different from antimony powder and these electrodes in HBr or HCl are not like those in H_2SO_4 or $HClO_4$. Plotting p_H against acid concentration gives different types of curves. There are tables giving oxidation–reduction potentials for Sb^{III} and Sb^{IV}, also partition data for $SbCl_3$ in $H_2O|Et_2O$.—S. G.

***Rate of Crystallization in the Electrolysis of Cadmium Acetate and Nitrate. [Electrolysis Under the Microscope.—VI.]** Alexander Glazunov and B. Kouřil (*Chem. Listy*, 1933, **27**, 489–493).—Numerous figures are given for the rate of crystallization of electrolytic cadmium deposits from nitrate and acetate baths. Photomicrographs are given showing characteristic structures obtained at various current densities and at various concentrations of the electrolyte.

—R. P.

***The Number of Crystallization Centres in the Electrolysis of Copper from Copper Sulphate Solutions. [Electrolysis Under the Microscope.—VII.]** Alexander Glazunov and J. Janoušek (*Chem. Listy*, 1933, **27**, 457–461).—The cathodic deposition of copper has been studied photomicrographically, and the number of crystallization centres has been determined from electrolytes of various concentrations and at various current densities. High current densities increase the number of centres, but high concentration of the electrolyte reduces the number and results in a dense cathodic deposit.—R. P.

IX.—ANALYSIS

(Continued from pp. 389–391.)

New British Chemical Standard Aluminium–Silicon Alloy "B." —— (*Met. Ind.* (*Lond.*), 1934, **45**, 87).—Aluminium–silicon alloy "B" contains: silicon 12·74, iron 0·34, manganese 0·005, zinc 0·020, titanium 0·006, copper 0·010%, and is believed to be the only standard of its kind issued in Great Britain, U.S.A., or the Continent.—J. H. W.

***Parting Loss in the Gold Assay.** August Hackl (*Z. anal. Chem.*, 1934, **97**, 411–415).—In the parting assay of Au errors of up to 0·2‰ may arise due to solubility of the Au in the parting HNO_3. These errors may be avoided by addition of 0·1 vol.-% of CH_3OH to the acid or by the use of Cd (5 times the weight of the Au) for inquartation instead of Ag.—A. R. P.

***The Volumetric Assay of Gold.** W. Branch Pollard (*Trans. Inst. Min. Met.*, 1932, **41**, 434–454; disc., 454–457).—See *J. Inst. Metals*, 1932, **50**, 365.—S. G.

***Technique of Amalgam Assaying of Platinum.** I. N. Plaksin and S. M. Shtamova (*Izvestia Platinago Instituta* (*Annales de l'Institut de Platine*), 1933, (**11**), 141–157).—[In Russian.] To prepare successfully an amalgam of native platinum containing iron the superficial film of iron oxide must first be removed by agitating the metal in 0·37–0·63% sulphuric acid for 12 hrs., and then setting the mixture aside for 1–2 days. From 90 to 97·1% of the platinum is amalgamated.—N. A.

The Polarograph: A Valuable Tool in Quantitative Chemical Analysis. John Herman (*Eng. & Min. J.*, 1934, **135**, (7), 299–300).—Describes an analytical instrument working on the basis of the difference in decomposition voltage of chemical compounds, and the direct relations between electrical effect and the concentration of a compound in a solution. Can be used for detection of impurities and stated to have a sensitivity of 1 p.p.m.—R. Gr.

***On Colour Reactions of the Rare-Earths with Pyrogallol, Cerium Reactions with Pyrogallol, and Reactions of Thorium, Lanthanum, and Elements of the Third Analytical Group with Pyrogallol.** F. M. Schemjakin (*Z. anorg. Chem.*, 1934, **217**, 272–276).—With NH_4OH and 1% pyrogallol solution, $Fe^{\cdots}$ gives brown hydroxide flocks, $Cr^{\cdots}$ green $Cr(OH)_3$, K_2CrO_4 a reddish-brown solution, $(CH_3{\cdot}CO_2)_2UO_2$, $Al^{\cdots}$, $Mn^{\cdot\cdot}$, $Ni^{\cdot\cdot}$, $Zn^{\cdot\cdot}$ a brownish solution. $Co^{\cdot\cdot}$ a lilac brown solution which becomes darker on keeping, TiO_2 an ochre-brown precipitate stable on boiling or keeping, and $Ce^{\cdots}$ and Ce^{IV} a characteristic blue precipitate. —B. Bl.

***A New Method for the Separation of Lead from Zinc and Their Subsequent Estimations.** Kishori Mohan Sil (*J. Indian Chem. Soc.*, 1933, **10**, 137–141).—A quantitative precipitation of lead is given by H_2O_2 and NH_4OH. The precipitate, a mixture of PbO and PbO_2 varying according to the concentration of NH_4NO_3, when heated gently or in a "crucible bath," gives a residue of pure PbO. Zinc is not precipitated, and can be estimated by the usual method.—R. G.

***Separation of Nickel and Cobalt by Means of Alkaline Phosphates.** H. Wunschendorff and (Mme.) P. Valier (*Bull. Soc. chim. France*, 1934, (v), **1**, 85–90).—In solutions of p_H 5·5 buffered with a mixture of alkali phosphates neutral solutions of Co salts give a blue precipitate, whereas Ni solutions give no precipitate. The test is carried out at 100° C. by adding the Co–Ni solution drop by drop to the phosphate solution.—A. R. P.

***Contributions to the Potentiometric Determination of Ions of Heavy Metals with Sodium Sulphide.** W. Hiltner and W. Grundmann (*Z. physikal. Chem.*, 1934, [A], **168**, 291–307).—By titrating rapidly with 0·1*N*-Na_2S solution using a tube potentiometer and a Ag_2SO_4 electrode, Ag can be determined in the presence of Cu and Cd, Cu and Pb, and of Cu and Zn; Cd can be similarly deter-

mined in the presence of Zn. The heavy metal sulphides do not form solid solutions with one another, but precipitate one after the other. Bi, Pb, Ni, Co, Mn, Sb, and As cannot be determined by this method, since either the rate of formation of the sulphides is too small or the adsorption of sulphide ions is too great.—B. Bl.

***A New Method of Determining Aluminium Oxide in Aluminium and Its Alloys.** J. Kliachko (*Legkie Metalli* (*Light Metals*), **1933**, (9), 44).—[In Russian.] The powdered metal (3 grm.) is dissolved in 50 c.c. of H_2O and 120–150 c.c. of saturated $CuCl_2$ solution, 25 c.c. of HNO_3 (1 : 5) are added, the insoluble Fe_2O_3, Al_2O_3, and SiO_2 are collected, the SiO_2 is volatilized with HF, and the residue fused with $K_2S_2O_7$. In the aqueous solution of the melt the H is removed with NaOH solution and the Al is recovered from the filtrate in the usual way.—D. N. S.

***An Indirect Method for the Potentiometric Determination of Cadmium.** G. Spacu and P. Spacu (*Z. anal. Chem.*, 1934, **97**, 263–266).—The Cd is precipitated with an excess of standard KCNS in the presence of C_5H_5N, and after filtering off the crystals of $Cd(C_5H_5N)_2(SCN)_2$ the excess of KCNS is titrated with $AgNO_3$. —A. R. P.

***Volumetric Determination of Cerium by the Aid of Induced Oxidation of Cerous Salts by Chromic and Arsenious Acids.** Rudolf Lang (*Z. anal. Chem.*, 1934, **97**, 395–401).—The solution containing all the Ce as $Ce^{\cdots\cdot}$ is acidified with 5–30 c.c. of HCl, HNO_3, or H_2SO_4 per 200 c.c., treated with 4–5 grm. of HPO_3 and 3 drops of diphenylamine solution (1 grm. in 100 c.c. of syrupy H_3PO_4), then with 30 c.c. of $K_2Cr_2O_7$ solution (15 grm./litre) and 35–40 c.c. of As_2O_3 solution (15 grm. of As_2O_3 and 10 grm. of $NaHCO_3$/litre), shaken for ½ minute, and titrated with 0·1*N*-$FeSO_4$, solution until the blue colour becomes grass-green.—A. R. P.

Volumetric Estimation of Copper. Erich Boye (*Ber. deut. chem. Ges.*, 1934, [B], **67**, (66), 1119–1121).—Thiocyanate estimation methods are reviewed. A criticism by Henriques of Volhard's methods is followed by a summary of Theodor's procedure of back-titrating excess of thiocyanate in faintly acid solution with $AgNO_3$. B. suggests heating the cupric water–alcohol solution almost to boiling with hydroxylamine sulphate in a stream of N_2 or CO_2, and titrating direct with $AgNO_3$. Suitable concentrations and detailed directions are given. Concordant results, closely approaching theoretical values, are claimed for many copper salts.—P. R.

***Quantitative Spectrographic Analysis of Metals in Small Proportions in Light Alloys. A New Method of Determining Magnesium in Aluminium and Duralumin.** Henri Triché (*Bull. Soc. chim. France*, 1934, (v), **1**, 495–505).—The method described gives the Mg content of Al and Duralumin with an error of ± 10%, but is much more rapid than chemical analysis. The original must be consulted for details.—A. R. P.

The Volumetric Determination of Tin. Use of Potassium Iodate. J. B. Ramsey and J. G. Blann (*J. Amer. Chem. Soc.*, 1934, **56**, 815–818).—Determination of Sn by direct titration of air-free stannous solution with KIO_3 was found to give uniform results over a range of acid concentration up to 1·5–2·0*N*, and to be therefore superior to the use of I_2 in KI solution. The effect of the presence of other elements is shown.—R. G.

Determination of Small Quantities of Zinc with Dithizone. Hellmut Fischer and Grete Leopoldi (*Z. anal. Chem.*, 1934, **97**, 385–395).—The method proposed by Rienäcker and Schiff (*ibid.*, 1933, **94**, 409–415) is subject to many sources of error. F. and L. recommend that Cu, Hg, Ag, Au, and Pt be first removed by boiling with H_3PO_2, and that the dithizone test for Zn be then made in a well-buffered acetate solution. Details of the recommended procedure are given in the paper.—A. R. P.

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

(Continued from pp. 392–394.)

Engineering Problems in Aviation. Alexander Stoneman (*J. Inst. Eng. Australia*, 1933, **5**, 368–377).—A review of S.'s experience. Inspection methods for detecting cracks in aluminium alloy pistons consisted of either pickling in caustic soda, and then in nitric acid or in dipping in hot kerosene containing a little oil, wiping dry, and covering with French chalk to show seepage of oil from any cracks.—R. G.

A Mechanical Testing Machine. R. C. Gale (*J. Sci. Instruments*, 1934, **11**, 209–214).—Describes a small mechanical testing machine suitable for industrial, experimental, and educational work. The machine is of the horizontal type, and the stress is applied by the rotation of a capstan-headed screw, and is balanced by the compression of a stiff helical spring, the load being read on a dial gauge reading up to 600 or 1200 lb. By means of suitable holders, which are described and illustrated, the machine can be used for tensile, compression, bending, indentation, and cupping tests.—W. H.-R.

Metal Fatigue and Methods for Its Measurement. R. Cazaud (*J. Aeronaut. Sci.*, 1934, **1**, 137–143).—An illustrated account is given of some typical fatigue failures, and the rotating flexure test, described in detail, is recommended as a standard method of determining fatigue strength. Results of this test are tabulated for a series of steels and for the following non-ferrous alloys: sand-cast and die-cast aluminium–copper (8 and 12% copper, respectively), die-cast aluminium–silicon (silicon, 5, 12, and 18%), drawn and heat-treated Duralumin, drawn magnesium–aluminium (aluminium 6%), drawn magnesium–aluminium–copper (aluminium 9, copper 3%). Types of test-piece for initial and inspection tests are illustrated, and the influence of holes, threading, and abrupt alterations in cross-section is discussed.—P. M. C. R.

†**Bendability.** W. Burggaller (*Draht-Welt*, 1934, **27**, 195–197, 211–213).—A critical discussion of to-and-fro bending tests embodying the findings of Sachs and Sieglerschmidt, Schuchard, and Herbst, as well as results from B.'s own dissertation. It was found that logarithmic plotting of bending number B_Z and bending grade $B_G = \frac{2R}{d} + 1{\cdot}65 + 0{\cdot}05d$, where R is the mandrel radius and d the wire diameter (both in mm.), gave straight lines of uniform slope of 2 for different materials. Thus $B_Z \propto B_G^2$. The bendability B_F is defined as the bending number for $B_G = \sqrt{10}$, so that it can be derived from $B_F = 10\frac{B_Z}{B_G^2}$. Tables exemplifying these relations are given as well as a nomogram for determining the bendability from bending number, mandril radius, and wire diameter.—A. B. W.

Ductility Testing. Anon. (*Met. Ind.* (*Lond.*), 1934, **45**, 99–100).—A description is given of the Olsen cupping machine, in which the depth of the cup at fracture, the maximum load required, and also the depth of the cup and the corresponding load applied at any time during the progress of the test are registered.—J. H. W.

Elasticity Tests. G. Colonneti and G. M. Pugno (*Atti Pont. Accad. Sci. Nuovo Lincei*, 1931, **84**, 525–530; *Sci. Abs.*, 1932, [A], **35**, 5).—Points out a source of systematic error in the use of testing machines. The elasticity of constructional materials does not work out at the same values when the tests are taken with increasing weights as with decreasing weights.—S. G.

Standard Methods of Tension Testing of Metallic Materials (E 8–33). —— (*Amer. Soc. Test. Mat. Standards*, **1933**, (I), 949–964).—S. G.

Standard Method of Test for Thermoelectric Power of Electrical Resistance Alloys (B 77–33). —— (*Amer. Soc. Test. Mat. Standards*, **1933**, (I), 895–897). —This method is intended for testing the thermoelectric power of a metal with respect to copper when the temperatures of the junctions lie between 0° and 100° C.—S. G.

XII.—TEMPERATURE MEASUREMENT AND CONTROL

(Continued from p. 363.)

A Connector for Wires—Particularly for the Cold-Junctions of Thermocouple Wires. R. J. M. Payne (*J. Sci. Instruments*, 1934, **11**, 231–232).—Describes a split screw brass connector. When used for the cold-junction of a thermocouple the copper lead is soldered to the connector, which is screwed up so that the thermocouple wire is pinched tightly. In this way the thermocouple wires can be unscrewed for threading through apparatus.—W. H.-R.

A Precision Couple for Measuring Gas Temperatures. E. E. O. Mattock (*Metal Progress*, 1934, **26**, (1), 37–40).—Working ranges and most favourable atmospheres are tabulated for copper–Constantan, iron–Constantan, Chromel–Alumel, Chromel–X–Copel, and platinum/platinum–rhodium couples. Errors arise mainly from the variety of methods by which heat is transmitted to the point of measurement. In gas thermometry, an equilibrium reading is often taken as the true temperature. Radiation errors and their correction are discussed, the method adopted by the American Gas Association being described in detail.—P. M. C. R.

***Response of Thermocouples.** N. P. Bailey (*Mech. Eng.*, 1931, **53**, 797–804; *Sci. Abs.*, 1932, [B], **35**, 121).—An account of research on effects of temperature gradients in the hot-junction, effects of varying temperatures on the indications of a thermocouple, and methods for predicting the performance of any couple of cylindrical form. The seat of the thermo-e.m.f. of a couple is the surface of contact, and 3 types of temperature gradient are possible: along the surface, normal to it, and across it. Each was studied separately. General conclusions include the fact that only the temperature of the contact surfaces affects the developed e.m.f., and that in a long junction it is the temperature (or temperatures) at the point of separation which is involved. Various experiments on the lag of couple e.m.f.'s behind a change of temperature, together with theoretical investigations, lead to a series of curves showing for a given diameter of wires forming the couple the lag due to various rates of change of ambient temperature. Curves and oscillograms illustrate the experimental results.—S. G.

***Establishment of a Scale of Colour Temperature.** H. D. Wensel, D. B. Judd, and Wm. F. Roeser (*U.S. Bur. Stand. J. Research*, 1934, **12**, 527–536; *Research Paper* No. **677**). A number of 400-watt projection lamps were colour matched with black bodies immersed in freezing platinum, rhodium, and iridium. From these lamps working standards of colour temperature were prepared, interpolation between the 3 fundamental points being accomplished by making use of the systematic difference between the colour temperature of the lamp and the brightness temperature of the inside of a particular turn of the coiled tungsten filament. These working standards embody a reproducible scale of colour temperature which is consistent with the International Temperature Scale within 5° K. everywhere in the range from 2000° to 2800° K. The new scale assigns higher values to any given source than the scale previously used at the Bureau of Standards, and which was supposed to be the same as the Nela scale of colour temperature. The differences are 22° K. at the platinum point and 14° K. at the rhodium and iridium points.—S. G.

XIII.—FOUNDRY PRACTICE AND APPLIANCES

(Continued from pp. 394–395.)

The Practice of Art Casting. Erich Becker (*Z. ges. Giesserei-Praxis: Das Metall*, 1934, **55**, 307–309).—The devices and methods used in moulding for the production of art castings are described.—J. H. W.

Aluminium and Special Alloys. M. Bocahut (*Rev. Fonderie moderne*, 1934, **28**, 205–210, discussion, 210–211).—Read before the Association Amicale et Mutuelle de Fonderie. Commonly occurring defects in aluminium castings and the methods of obviating them, the choice of primary materials, sand-casting, and the melting and casting of aluminium alloys are described. The composition, properties, and details of casting alloys of aluminium and zinc, copper, silicon, magnesium, nickel, and iron are given.—J. H. W.

Properties of Metals Cast under Pressure. A. P. Gulyayev (*Vestnick Ingenerov i Tehnikov* (*Messenger of Engineers and Technologists*), **1933**, (8), 350–353).—[In Russian.] Casting under pressure gives castings which are insufficiently dense (large cavities and blowholes), but by taking suitable precautions (low pouring temperature, thin stream of liquid metal, convenient arrangement of cores, insertions and other obstacles in the path of the flowing metal) this porosity may be, if not entirely avoided, at least considerably reduced. The portions without cavities show a dense and extremely fine-grained structure. Yield-point and hardness are always greater in pressure castings than those produced by other methods, but usually the toughness is somewhat lower, especially Silumin and copper–aluminium alloys. The 12% copper–aluminium alloy used in aero-engine pistons has the best properties after pressure casting.—N. A.

***Hot Mechanical Treatment of Light Alloys (Investigation of Sand-Castings).** V. M. Aristov and N. I. Korneyev (*Niimash* (*Bulletin of the Scientific Research Institute of Machine-Building and Metal Treating*), **1933**, (6), 28–33).—[In Russian.] Aluminium alloy castings with clearly marked defects (*e.g.* continuous porosity, cavities, axial friability) are unsuitable for hot-working.

—N. A.

***The Thermal Preparation of Silumin Alloys and the Technique of Such Alloy Production.** V. N. Verigin (*Trudi Nauchno Issledovatelskogo Instituta Legkih Metallov*—"*NIISALUMINI*" (*Transactions of the Scientific Research Institute for Light Metals*—"*NIISALUMINI*," **1933**, (4), 39–54).—[In Russian.] The preparation of Silumin by fusing aluminium with an alloy of 20% silicon and 80% aluminium in a rocking Morgan crucible furnace heated by petroleum residues is described. The alloy was obtained by melting aluminium with silico–aluminium containing 70% silicon. The temperature conditions and nature of fluxes to be used have been elucidated.—D. N. S.

***The Effect of Chloride Fluxes on Aluminium Alloys.** Eiichirō Itami (*Tetsu-to-Hagane* (*J. Iron Steel Inst. Japan*), 1931, **17**, (12), 1288–1335; *Japanese J. Eng. Abs.*, 1934, (**11**), 56).—[In Japanese.] The effects of various chloride fluxes on the properties of aluminium alloys are described. To prevent the formation of pinholes in cast aluminium alloys, chloride fluxes must be added at about 750° C.; among the various chlorides, $SiCl_4$, $TiCl_4$, and $ZnCl_2$ are the most effective for the improvement of the mechanical properties of the alloys, but $SnCl_4$ has sometimes an adverse effect. The quantity to be added need not exceed 1%. The addition of $SiCl_4$ does not affect the composition of the alloys, but tin, titanium, and zinc are dissolved in the alloy from the chlorides, and the magnesium content of "Y" alloy and Duralumin is decreased by this treatment. The changes in microstructure are discussed.—S. G.

Difficulties in the Production of "Aluminium–Bronze" Castings. E. T. Richards (*Z. ges. Giesserei-Praxis: Das Metall*, 1934, **55**, 265–267).—One of

the chief difficulties in casting " aluminium–bronze " is the change in structure that takes place during the long solidification interval. This can be obviated by casting the metal in iron moulds, by sand-casting and removing the casting as soon as it is solid, or by the addition of 3–4% iron or nickel. A casting temperature of 1200° C. and a mould temperature for iron moulds of 250° C. are recommended. Allowance must be made for the high shrinkage of the alloy.—J. H. W.

Bohn Solves Difficult Production Problems to get Quantity Output of Copper–Lead Bearings. A. F. Denham (*Automotive Ind.*, 1934, **71**, (1), 14–16).—The development of copper–lead bearings demanded careful control of heating technique and solidification conditions, owing to the high casting temperature and great solidification range of the material, and to the need for securing a copper–iron bond with the casing. Conditions of production are discussed, and the advantages of copper–lead bearings are summarized.—P. M. C. R.

Elektron. E. Player (*J. Coventry Eng. Soc.*, 1933, **14**, 59–67).—A lecture describing mainly the technique of casting the magnesium-base alloys known as Elektron. Castings are made in green sand, porous and low in clay content, containing sulphur and boric acid. Moulding practice follows ordinary lines, and the casting is preferably bottom run. Die-casting of the alloys has been developed. Various questions of interest are dealt with in the discussion of the lecture.—R. G.

***Melting of Magnesium Alloys.** P. S. Mayboroda (*Legkie Metalli* (*Light Metals*), **1932**, (10–11) 26–28).—[In Russian.] Experiments have been made to determine whether the use of fluxes in melting magnesium alloys serves not only to protect the metal from oxidation, but also to remove impurities by absorption. The results indicated that on mixing metal and flux the latter is occluded in the metal and causes cavities in the castings.—D. N. S.

Slush Casting Aluminium Spouts. E. Stevan (*Machinist* (*Eur. Edn.*), 1934, **134**, 410–411E).—The mould preparation and the method of slush casting aluminium kettle-spouts are described.—J. H. W.

Zinc-Base Pressure Die-Castings. Anon. (*Metallurgist* (Suppt. to *Engineer*), 1934, **9**, 119–120).—A summary and discussion of a paper by D. L. Colwell in *Metal Progress*, 1933, **24**, (6), 19–23. See *Met. Abs.*, this volume, p. 98.—R. G.

Improved Technique Gives Die-Casting Process New Applications. Herbert Chase (*Automotive Ind.*, 1934, **71**, (1), 18–20, 30).—The cost of dies for intricate castings is in many cases justified by the precision with which the work can be executed, obviating expensive machining and finishing. Some cases in point, notably of die-cast zinc alloys, are discussed and illustrated.—P. M. C. R.

***On the Properties of Moulding Sands at High Temperatures.** Tokushichi Mishima (*Tetsu-to-Hagane* (*J. Iron Steel Inst. Japan*), 1929, **15**, (11), 949–962; *Japanese J. Eng. Abs.*, 1933, (9), 67).—[In Japanese.] M. measured the change of volume and weight on heating of 4 kinds of loams usually employed in Japanese foundries and made some chemical analyses; by these means he was able to explain the irregular changes of properties. Similar investigations were carried out on silica sand, ordinary moulding sand, and sand for steel casting.
—S. G.

XV.—FURNACES AND FUELS

(Continued from pp. 395–396.)

Standard Methods of Laboratory Sampling and Analysis of Coal and Coke (D 271–33). —— (*Amer. Soc. Test. Mat. Standards*, **1933**, (II), 269–308).
—S. G.

XVI.—REFRACTORIES AND FURNACE MATERIALS

(Continued from p. 396.)

Standard Method of Test for Porosity and Permanent Volume Changes in Refractory Materials (C 20–33). —— (*Amer. Soc. Test. Mat. Standards*, **1933**, (II), 176–178).—S. G.

Standard Method of Test for Softening Point of Fire-Clay Brick (C 24–33). —— (*Amer. Soc. Test. Mat. Standards*, **1933**, (II), 184–186).—S. G.

XXI.—INDUSTRIAL USES AND APPLICATIONS

(Continued from pp. 398–399.)

***Aluminium Vessels and Food Contamination.** C. A. Dunbar Mitchell (*J. Roy. Army Medical Corps*, 1933, **61**, 99–107, 193–201; (*U.S.*) *Public Health Eng. Abs.*, 1933, **13**).—Surveys of the physiological effects of aluminium have shown that no ill effects of any kind were produced by daily doses of alum up to an equivalent of 200 mg. of aluminium per diem. M. deals primarily with the chemical phase of the problem and attempts to measure the increase of aluminium content arising after foods have been cooked in aluminium vessels in the way that would normally be employed in the household. The results of various investigations show that with neutral foods there is no appreciable removal of aluminium. If cooked in bright pans, acid juices remove small amounts varying from 1–13 p.p.m. and in dark pans the amounts removed increase to from 16–41 p.p.m. Various methods for measuring aluminium content are described. The total amount of aluminium obtained when foods are cooked in aluminium vessels is 12 mg. per diem. Cooking in aluminium vessels removes daily quantities which are minute in comparison with those that can be administered without harm to normal adults. It is concluded that aluminium utensils can be used for storing water, for use as water-bottles, for frying or boiling or otherwise cooking foodstuffs, for heating or holding acid liquids or milk, without absorption of harmful amounts of the metal.—S. G.

***Report on Canned Fish in Aluminium Containers.** Chemical Laboratories, Royal Institute of Public Health, London (*J. State Medicine*, 1933, **41**, 487–489; (*U.S.*) *Public Health Eng. Abs.*, 1933, **13**).—Chemical examination of various fish products packed in hygienic aluminium containers disclosed that no aluminium could be detected. A similar examination of fish products in tin containers resulted in a finding of from 0·1 to 0·75 grain of tin per lb. This amount, however, is well below the limit of 2 grains per lb., at which stage toxic symptoms may develop. Opposition to the use of aluminium and aluminium utensils in contact with food is decried. From a study of the literature on the subject the following conclusions are reached: (1) aluminium is not a poisonous metal and there is no scientific evidence of its relationship to disease; (2) aluminium utensils are very resistant to corrosion by foostuffs cooked therein; (3) aluminium does not accelerate the destruction of vitamins or other food substances during cooking.—S. G.

On the Uses of Aluminium in the Dairy Industry. —— Camponaro (*Alluminio*, 1934, **3**, 75–79).—Presented at the 10th International Dairy Congress, Rome, 1934. An illustrated review.—G. G.

The Use of Aluminium in the Cheese Industry. —— Bonin (*Alluminio*, 1934, **3**, 74–75).—Presented at the 10th International Dairy Congress, Rome, 1934. The uses of light metals in various branches of the cheese industry are dealt with.—G. G.

Light Alloy [25 S] Forgings and Stampings. —— (*Provisional* (*British*) *Air Min. Aircraft Specification* No. **D.T.D. 106,** 1930, 3 pp.).—Covers the alloy known as 25 S.—S. G.

Light Alloy Airscrew Forgings (Fairey Reed Type). —— (*Provisional* (*British*) *Air Min. Aircraft Specification* No. **D.T.D. 147,** 1930, 3 pp.).—S. G.

Light Alloy [Duralumin] Airscrew Forgings and Stampings (Detachable Blades and Complete Airscrews). —— (*Provisional* (*British*) *Air Min. Aircraft Specification* No. **D.T.D. 150,** 1930, 3 pp.).—Covers Duralumin.—S. G.

Aluminium Alloy [Hiduminium R.R.] Forgings (For Sealing Rings of Cylinders). —— (*Provisional* (*British*) *Air Min. Specification* No. **D.T.D. 128,** 1930, 1 p.).—Covers Hiduminium R.R. alloy.—S. G.

Aluminium Alloy [Hiduminium R.R. 53] Die-Castings (Suitable for Pistons, &c.). —— (*Provisional* (*British*) *Air Min. Aircraft Specification* No. **D.T.D. 131,** 1930, 2 pp.).—Covers the alloy Hiduminium R.R. 53.—S. G.

Aluminium Alloy [Hiduminium R.R. 56] Forgings (Not Suitable for Pistons). —— (*Provisional* (*British*) *Air Min. Aircraft Specification* No. **D.T.D. 130,** 1930, 2 pp.).—Covers the alloy Hiduminium R.R. 56.—S. G.

Aluminium Alloy [Hiduminium R.R. 59] Forgings (Suitable for Pistons). —— (*Provisional* (*British*) *Air Min. Aircraft Specification* No. **D.T.D. 132,** 1930, 3 pp.).—Covers the alloy Hiduminium R.R. 59.—S. G.

Wrought Light Aluminium Alloy [Hiduminium R.R. 56] Tubes. —— (*Provisional* (*British*) *Air Min. Material Specification* No. **D.T.D. 220,** 1934, 4 pp.).—Covers the alloy Hiduminium R.R. 56; sp. gr. 2·75.—S. G.

" Y " Aluminium Alloy Piston Forgings and Stampings. —— (*Provisional* (*British*) *Air Min. Aircraft Specification* No. **D.T.D. 58A,** 1932, 2 pp.).—S. G.

Aluminium-Copper-Silicon Light Alloy Castings. —— (*Provisional* (*British*) *Air Min. Aircraft Specification* No. **D.T.D. 84,** 1929, 1 p.).—S. G.

Aluminium-Silicon Alloy Sheets. —— (*Provisional* (*British*) *Air Min. Specification* No. **D.T.D. 50,** 1929, 1 p.).—The sp. gr. of this alloy is approx. 2·68.—S. G.

Hard Aluminium-Magnesium Alloy Sheets. —— (*Provisional* (*British*) *Air Min. Aircraft Specification* No. **D.T.D. 170,** 1931, 2 pp.).—The sp. gr. of this alloy is 2·68.—S. G.

Half-Hard Aluminium-Magnesium Alloy Sheets. —— (*Provisional* (*British*) *Air Min. Aircraft Specification* No. **D.T.D. 175,** 1931, 2 pp.).—The sp. gr. of this alloy is 2·68.—S. G.

Soft Aluminium-Magnesium Alloy Sheets. —— (*Provisional* (*British*) *Air Min. Aircraft Specification* No. **D.T.D. 180,** 1931, 2 pp.).—The sp. gr. of this alloy is 2·68.—S. G.

Standard Specifications for Fire-Refined Copper Other than Lake (B 72–33). —— (*Amer. Soc. Test. Mat. Standards,* **1933,** (I), 577–579).—Cover fire-refined copper, other than Lake, and not usually electrolytically refined. The material is intended for use in rolling into sheets and shapes for mechanical purposes, and is not intended for electrical purposes or for wrought alloys.—S. G.

Standard Specifications for Copper Bars for Locomotive Staybolts (B 12–33). —— (*Amer. Soc. Test. Mat. Standards,* **1933,** (I), 676–678).—Cover two grades—arsenical and non-arsenical.—S. G.

Standard Specifications for Copper Plates for Locomotive Fireboxes (B 11–33). —— (*Amer. Soc. Test. Mat. Standards,* **1933,** (I), 713–715).—Cover two grades—arsenical and non-arsenical copper, fire-refined or electrolytic, and hot-rolled from suitable cakes.—S. G.

Standard Specifications for Seamless Copper Boiler Tubes (B 13–33). —— (*Amer. Soc. Test. Mat. Standards,* **1933,** (I), 679–682).—Cover two grades—arsenical and non-arsenical.—S. G.

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