Vol. 3 Part 6

The Monthly Journal of the INSTITUTE OF METALS

and

METALLURGICAL ABSTRACTS

CONTENTS

JUNE 1936

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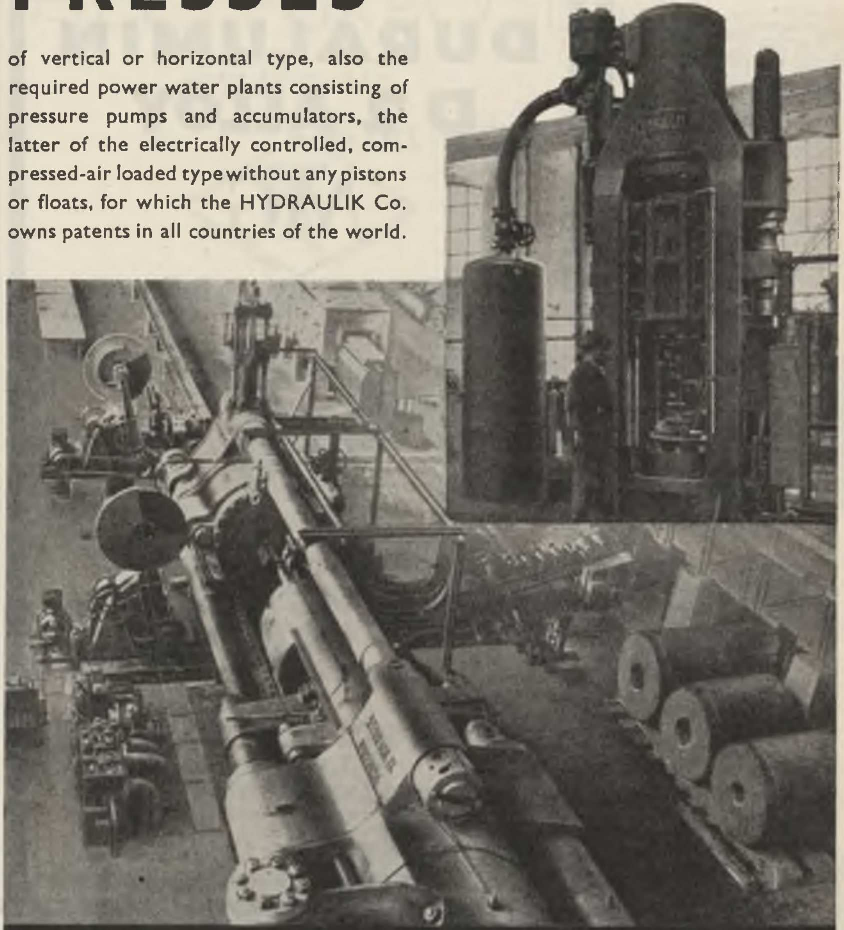


THE GAS INDUSTRY

—AN INDEX TO TRADE RECOVERY

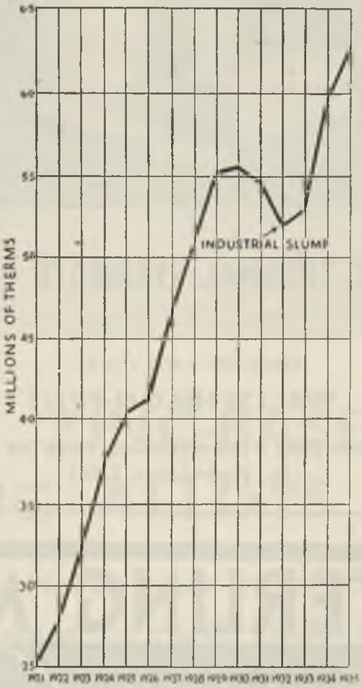
THE yearly statistics published by the gas industry are a useful guide to the state of trade in this country. When times are bad and factories are closed down or not working fully, the sales of gas to industry are low, rising as industrial prosperity returns. The marked increase then during the last year in the industrial sales of gas is a reliable pointer to better times ahead. It not only shows which industrial centres have been quickest to shake off the depression of the last few years, but affords evidence too of the movement of trade from one district to another.

In 1934, for instance, 56 per cent. of the total gas sold in Sheffield was bought for industrial purposes; last year the percentage had risen to no less than 62. Rotherham can show equally striking figures, while increases in the amount of gas taken by industries in almost every important town in Lancashire reflect the healthier condition of that County's trades.

A similar story is told by recent statistics from the busy manufacturing centres in the Midlands. Coventry, the home of motor-car manufacture and a huge consumer of gas, shows a rise in the percentage of gas sales to industry during the last two years of from 30 to 35; in Derby the corresponding percentage in 1934 was 28, which rose to 35 in the year that has just closed; Stoke-upon-Trent and the Potteries, West Bromwich, Smethwick, Leicester and Wolverhampton also show that, with increasing prosperity, trades of all kinds turn to the gas industry to supply them with a fuel suitable for modern methods of manufacture. Industries in all these towns bought last year a fifth of more of the total gas sold.

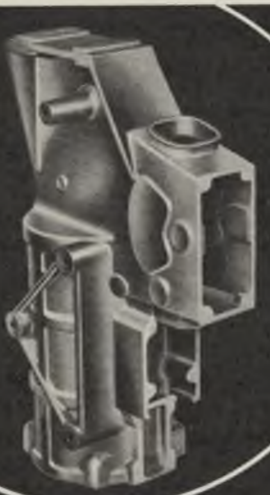
The Move Southwards

A sharp rise in the industrial sales of many gas undertakings in or near London shows that the trend of industry southwards continues. In the areas covered by the Watford and Maidstone gas undertakings the proportion of sales for industrial purposes last year was approximately double the 1934 figure, rising in the former case from 9 to 17, and in the latter from 8 to 17 per cent. At Slough the percentage has increased from 28 to 32, almost a third of the total annual sales of gas now going to industry; while in London itself, the two largest gas undertakings disposed of almost one-tenth of their total annual sales last year to trades of various kinds, and one-fifth of the yearly sales of a third London undertaking now go to industry.



Increase of gas sold for industrial purposes by one large gas company.

Issued by the British Commercial Gas Association, 28 Grosvenor Gardens, London, S.W.1.

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

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Mineral Industry. Issues since 1932 (incl.).

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

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

Journal of the Russian Physico-Chemical Society. (Chemical Part.) 1930, Volume 62, Part 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.)

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Volume 3 **JUNE, 1936** **Part 6**

CONTENTS

METALLURGICAL ABSTRACTS

The monthly issue of *Metallurgical Abstracts* may be cut up for card indexes, as members will receive early in 1937 the year's abstracts in bound form.

INSTITUTE NEWS AND ANNOUNCEMENTS

Autumn Meeting in Paris.

The Twenty-Eighth Autumn Meeting of the Institute will be held in Paris, from September 14 to 18, by the kind invitation of the Bureau International des Applications de l'Aluminium with the cordial co-operation of the Chambre Syndicale des Métaux à Paris.

The headquarters of the Institute, and the office of the Honorary Local Secretary, will be in a very attractive building, the Maison de la Chimie, 28 Rue St. Dominique, Paris, where all the meetings, and a banquet, will be held.

An influential Reception Committee (of which the Honorary Secretary is Monsieur J. S. Douchement, a member of the Institute) has been formed to carry out the necessary arrangements. Already the programme of the meeting is practically complete; it will be issued to all members shortly after the appearance of this issue of the *Monthly Journal*, together with the usual reply forms.

A special feature of the meeting will be an optional tour, to be made on Friday, September 18, to Rouen, its neighbourhood, and Havre, which will give members an opportunity of visiting a town famous in French history as well as modern metallurgical and engineering works in another part of France.

Arrangements have been made with Messrs. Thos. Cook & Son, Limited, to issue a "Travel" circular, which will accompany the Institute's forthcoming "Meeting" circular, giving details of tours from England to Paris and back in connection with the meeting at inclusive prices ranging from £8 15*s*.

The meeting will open on Monday, September 14, with the delivery of the Fifteenth Annual Autumn Lecture by Professor P. A. J. Chevenard (Corresponding Member to the Council for France) on "The Scientific Organization of Factories." This will be followed by an informal gathering of members, light refreshments, and a display of cinematograph films of metallurgical interest.

An official welcome will be extended to members in the Amphitheatre of the Maison de la Chimie in the morning of Tuesday, September 15, before the beginning of the first session for the discussion of papers. Afterwards ladies will have an opportunity of making morning visits to places of interest and will later join members at lunch at the Hôtel Palais d'Orsay (tickets 4*s*. each). In the afternoon members and ladies will make visits to works, and in the evening a Banquet will be given by the Bureau International des Applications de l'Aluminium.

On Wednesday, September 16, the discussion of papers will continue in the morning (arrangements being made for the entertainment of the ladies meanwhile), and lunch will be served as on the previous day. In the afternoon further visits will be paid, concluding with a Civic Reception at the Hôtel de Ville by the Municipal Council of Paris. In the evening there will be a Dance at the Pré Catelan, Bois de Boulogne.

Thursday will be devoted to an all-day motor excursion to Versailles, visiting the Château, gardens, and other features of interest. The charge for the excursion will be 15*s*. per person inclusive of luncheon, tea, admission fees, and transport back to the hotels, where members are due to arrive about 6 p.m., thus leaving the evening free.

The previously mentioned tour to Rouen, Havre, and neighbourhood (the charge for which will vary from £1 7*s*. to £1 14*s*. according to places visited) will conclude the meeting on Friday, September 18, when members will be due back in Paris between 7 and 8 p.m. A party will return to England on Saturday morning, September 19; another party will proceed to Düsseldorf for the Autumn Meeting of the Iron and Steel Institute.

It is anticipated that there will be a large attendance of members from all parts of Europe. Those members who expect to take part are asked to return as soon as possible the reply forms that will shortly be in their hands, thus greatly facilitating the completion of arrangements by the Committee in Paris.

Institute News and Announcements

Committees of the Institute.

The Committees appointed by the Council for the year 1936–1937 are as follow :

Finance and General Purposes Committee.

Charles, Lieut.-General Sir Ronald.
Clarke, H. W.
Dixon, Engineer Vice-Admiral Sir Robert (*Chair*).
Greenly, Lieut.-Colonel J. H. M.
Morcom, E. L. (*Vice-Chairman*).
Mundey, A. H.
Preston, Lieut.-Colonel the Hon. R. M.
Seligman, Dr. R.
Turner, Professor T.

Ex-Officio :

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Chairman, Publication Committee.

Local Sections Committee.

Andrew, Professor J. H.
Brownsdon, Dr. H. W.
Gray, Kenneth.
Greer, H. H. A.
Griffiths, W. T.
Hanson, Professor D. (*Chair*).
Haughton, Dr. J. L.
Mundey, A. H.
Thompson, Professor F. C.

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Local Reception Committee's Representative.
Chairman and Secretary of :
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  London Local Section.
  North-East Coast Local Section.
  Scottish Local Section.
  Sheffield Local Section.
  Swansea Local Section.

Meetings Committee.

Andrew, Professor J. H.
Brazener, W. F.
Brownsdon, Dr. H. W. (*Chair*).
Dorey, Dr. S. F.
Gwyer, Dr. A. G. C.
Hanson, Professor D.
Haughton, Dr. J. L.
Weeks, H. B.

Ex-Officio :

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Immediate Past-President.
Chairman, Membership Committee.
Chairman, Publication Committee.
Local Reception Committee's Representative.
Local Sections Committee's Representative.

Membership Committee.

Andrew, Professor J. H.
Charles, Lieut.-General Sir Ronald.
Genders, Dr. R.
Gray, Kenneth (*Chair*).
Macnaughtan, D. J.
Morcom, E. L.
Mundey, A. H.
Seligman, Dr. R.
Weeks, H. B.

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Immediate Past-President.
Local Sections Committee's Representative.

Publication Committee.

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

Ex-Officio :

The President.
Immediate Past-President.
Chairman, Finance and General Purposes Committee.

Membership.

As only members are permitted to take part in the social functions and works' visits connected with the Paris meeting, an election is being arranged on July 2 for the benefit of those who desire to participate in the Autumn Meeting, but are not yet members of the Institute. The Council expects that as this election occurs at the beginning of a new financial year, there will be many membership applications to be considered at its meeting. The Secretary will be glad to forward particulars of the Institute, and, if desired, a specimen copy of the *Monthly Journal*, to any potential member, on receipt of name and address.

Local Sections.

At the annual meeting of the Local Sections Committee, held in London on May 6, the reports of the sections for the past session were presented and programmes for the coming session were submitted. The completion of a useful year's work was indicated by the reports, and the programmes suggest that a further period of activity is in prospect for the coming session.

In order to maintain the correctness of records of membership of the Local Sections, members who remove from one Local Section area to another are asked to notify their changes of address to the Secretary, who will then inform the appropriate Honorary Secretary so that members will receive notices of meetings in their new locality.

The officers of the several Local Sections for 1936–1937 are:

Birmingham Section.

Chairman: W. F. Brazener.
Hon. Secretary: J. W. Jenkin, B.Sc., Ph.D.
Hon. Treasurer: G. Bill-Gozzard.

London Section.

Chairman: H. J. Gough, M.B.E., D.Sc., Ph.D., F.R.S.
Hon. Secretary: S. V. Williams, B.Sc.
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North-East Coast Section.

Chairman: H. Dunford Smith, M.Sc.
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Sheffield Section.

Chairman: Professor J. H. Andrew, D.Sc.
Hon. Secretary: H. P. Gadsby, Assoc.Met.
Hon. Treasurer: Frank Mason.

Swansea Section.

Chairman: Roosevelt Griffiths, M.Sc.
Hon. Secretary and Treasurer:

PERSONAL NOTES

MR. F. A. CHAMPION, B.Sc., A.R.C.S., has recently taken up an appointment in the Corrosion Department of the Research Laboratories of The British Aluminium Company, Limited, Warrington.

MR. F. DICKINSON, B.Sc., has left the Research Department, Woolwich, for an appointment with The Mond Nickel Company, Limited, in their Research and Development Department, Thames House, Millbank, London, S.W.1.

MR. J. E. JENKINS has left Merthyr Tydfil as he has recently been appointed to the Spelter Laboratory of the National Smelting Company, Ltd., Avonmouth Works, Avonmouth, Bristol.

DR. A. G. RAMSAY, B.Sc., has been appointed Deputy Production Manager of I.C.I. Metals, Ltd., Kynoch Works, Witton, Birmingham.

DR.-ING. PAUL ROSBAUD, until recently director of the technical science section of *Metallwirtschaft*, joined Verlag Julius Springer on May 1. His new address is Linkstr. 22–24, Berlin W.9; telephone B 1 Kurfürst 8111.

MR. A. J. G. SMOUT has been appointed Group Chairman of the Metal Section of Imperial Chemical Industries, Ltd.

MR. T. D. WELBY is on a visit to England from Calcutta, India, and correspondence may be addressed to him c/o Messrs. Lloyds Bank Limited, G.3, 6 Pall Mall, London, S.W.1, until September 13, 1936.

Birth.

HAAS. To Dr. Max and Frau Haas, on May 3, 1936, a son, Hans Max.

Loose Copies of Papers.

Members are reminded that, for the convenience of members attending the Institute's general meetings, the Council has authorized the supply of special loose prints of the papers. Orders for complete sets of reprints of all papers appearing for one year in the *Monthly Journal*, from April, 1936, to March, 1937, should now be sent to the Secretary. The annual charge is 5*s*., post free.

Annual Subscriptions, 1936–1937.

Members and student members are reminded that their annual subscriptions of £3 3*s*. and £1 1*s*., respectively, become payable, according to the Rules, "*in advance on July* 1." If they will be good enough, therefore, to send their remittances to the Secretary, the Institute will be saved the expense of forwarding "reminders," which cost a substantial sum each year and involve much clerical labour that might be more usefully employed. Delay in the payment of subscriptions is not only unnecessarily costly to the Institute, but it also prevents members from receiving their *Monthly Journals* promptly. The Institute's publications are not sent to members whose subscriptions are in arrear.

The use of Banker's Orders for the payment of subscriptions is strongly urged on members by the Finance Committee. There are already nearly 600 members who issue these orders, with resulting appreciable saving in time and money to themselves and to the Institute. Printed Banker's Order forms are available, and may be obtained from the Secretary.

PAPER No. 737. This paper is copyright. It may be reprinted, wholly or in part, in the Press (with due acknowledgment) after the Annual Autumn Meeting of the Institute to be held in Paris from September 14 to 18, 1936. 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 1, 1936.

A NOTE ON THE INFLUENCE OF SALT-BATH HEAT-TREATMENT ON THE CORROSION-RESISTANCE OF DURALUMIN SHEET.*

By A. J. SIDERY,† Assoc.Met. (Sheff.), MEMBER, and B. EVANS,‡ B.Sc.

SYNOPSIS.

Some experiments were carried out to provide information as to whether the use of a nitrate salt-bath as the medium in the final heat-treatment of Duralumin has any deleterious effect on the corrosion-resistance of the material as compared with that of material which has been heat-treated in an electric furnace. Further, the influence of salt residues on the surface of the sheet during prolonged storage was investigated.

It was found that the use of nitrate salt-baths in the heat-treatment operation has no deleterious effect on the corrosion-resistance of Duralumin, but that salt residues are liable to foster local surface pitting of the material during storage.

IN view of the extensive use of salt-baths in the commercial heat-treatment of Duralumin, it was considered desirable to investigate the influence of this method of heat-treatment on the corrosion-resistance of the material as compared with that of heat-treatment in air at the same temperature. Two series of tests were made.

For the first series a supply of Duralumin that had not been in contact with salt at any stage of its manufacture was procured. Samples were heat-treated at 490° C. in pure sodium nitrate, in salt mixtures, and in salts supplied and as used by four aircraft contractors, *viz.* Messrs. James Booth & Co. (1915) Ltd., Fairey Aviation Co., Ltd., Hawker Aircraft, Ltd., and Supermarine Aviation Works (Vickers), Ltd. The heat-treatment was followed by quenching in cold water, or in some cases, in cold dilute solutions of the salts employed in heat-treatment. These variously heat-treated samples were then subjected to immersion tests and to intermittent sea-water spray tests for appropriate periods. The corrosion-resistance was investigated by visual and microscopical observations and also by mechanical tests.

In the second series of tests an attempt was made to examine the

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* Manuscript received April 18, 1936.

† Scientific Officer, Royal Aircraft Establishment, South Farnborough.

‡ Technical Assistant, Royal Aircraft Establishment, South Farnborough.

Note to Abstractors and Other Readers.—This paper will be published, in permanent form, in the *Journal of the Institute of Metals*, Vol. LIX, 1936. Reference should accordingly be as follows: *J. Inst. Metals*, 1936, **59** (Advance copy).

corroding effect of adhering salt from the heat-treatment bath during subsequent storage of the material.

DESCRIPTION OF EXPERIMENTS.

SERIES I.

The materials used in the experiments consisted of 20- and 15-S.W.G. Duralumin sheets, the analyses of which are given in Table I.

TABLE I.

	20-S.W.G.	15-S.W.G.
Copper, per cent. . . .	4·46	4·47
Silicon, ,, . . .	0·28	0·24
Manganese, ,, . . .	0·62	0·63
Iron, ,, . . .	0·47	0·56
Magnesium, ,, . . .	0·55	0·44
Aluminium, ,, . . .	remainder	remainder

Samples measuring 10 × 2·5 cm. were cut in the direction of rolling and subjected to heat-treatment for 15 minutes at 490° C. as follows:

(*a*) Heated in pure sodium nitrate and quenched in cold water.

(*b*) Heated in pure sodium nitrate and quenched in a 1 per cent. aqueous solution of the salt.

(*c*) Heated in eutectic mixture of sodium and potassium nitrates and quenched in cold water.

(*d*) Heated in eutectic mixture of sodium and potassium nitrates and quenched in a 1 per cent. aqueous solution of the salt mixture.

(*e*) Heated in salt supplied and as used by aircraft contractor " A " and quenched in cold water.

(*f*) Heated in salt supplied and as used by aircraft contractor " B " and quenched in cold water.

(*g*) Heated in salt supplied and as used by aircraft contractor " C " and quenched in cold water.

(*h*) Heated in salt supplied and as used by aircraft contractor " D " and quenched in cold water.

(*j*) Heated in an electric furnace and quenched in cold water.

After being allowed to age for 7 days the specimens were subjected to the following corrosion tests:

(i) Water-line immersion test for 28 days in normal sodium chloride solution acidified with 1 per cent. by weight of hydrogen chloride, equivalent to 29·4 c.c. of hydrochloric acid of sp. gr. 1·15, or 27·4 c.c. of hydrochloric acid of sp. gr. 1·16, per litre.*

(ii) Water-line immersion test in sea-water for 28 days.

(iii) Sea-water spray test for 6 months.

In the sea-water spray test the samples were exposed to the open air, but protected from rain, and were sprayed with sea-water from the English Channel three times during each working day at intervals of approximately 3 hrs. The sea-water was directed at the specimens in the form of a fine mist by means of compressed air.

Sufficient samples were heat-treated to provide duplicates in all conditions.

"*Water-Line*" *Immersion Tests.*

Superficial observations: All the samples immersed in the acidified sodium chloride reagent behaved similarly, slight effervescence being observed soon after immersion. This activity increased to a maximum intensity after 2 days and then slowly subsided. A loose dark-brown coating accumulated on the immersed surfaces and surface pitting occurred. The samples immersed in sea-water were apparently all corroded to the same extent. The degree of attack, however, was not comparable with that obtaining in the acid sodium chloride solution. A white gelatinous deposit appeared at the water-line in increasing quantities as the test proceeded and small centres of surface attack became perceptible.

Microscopical observations: Sections across the water-line were prepared from the various samples and examined microscopically. It was found that most of the corrosion took the form of surface pitting. The sections from the specimens immersed in the acidified sodium chloride solution were irregularly and deeply pitted, but no intercrystalline channels had developed except in two cases, where minute traces of this form of penetration were observed. One case was on a section taken from a sample that had been heat-treated in an electric furnace and quenched in cold water, while the other case was on a section taken from a sample that had been heat-treated in a sodium nitrate salt-bath and quenched in water, any adhering salt being completely removed by washing. It is considered that the extent of these intercrystalline channels would not justify any importance being attached to their occurrence. Examination of the sections from the various samples immersed in sea-water did not reveal any appreciable variation in the degree of attack. Some irregular surface pitting was observed,

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* This reagent has proved of service in producing intercrystalline corrosion consistently in samples of Duralumin susceptible to this type of corrosion. Sidery, Lewis, and Sutton, *J. Inst. Metals*, 1932, **48**, 168.

TABLE II.—*Mechanical Test Results on Samples Exposed to Sea-Water Spray Test for 6 Months.*

Treatment.	Uncorroded.		Corroded.																	
	Heated in Electric Furnace, Quenched in Cold Water.		Heated in Electric Furnace, Quenched in Cold Water.		Heated in $NaNO_3$ Bath, Quenched in Cold Water.		Heated in $NaNO_3$ Bath, Quenched in 1% Soln. of Salt.		Heated in $K/NaNO_3$ Bath, Quenched in Cold Water.		Heated in $K/NaNO_3$ Bath, Quenched in 1% Soln. of Salt Mix.		Heated in Salt from Mnfr. "A," Quenched in Cold Water.		Heated in Salt from Mnfr. "B," Quenched in Cold Water.		Heated in Salt from Mnfr. "C," Quenched in Cold Water.		Heated in Salt from Mnfr. "D," Quenched in Cold Water.	
	20 S.W.G.	15 S.W.G.	20 S.W.G.	15 S.W.G.	20 S.W.G.	15 S.W.G.	20 S.W.G.	15 S.W.G.	20 S.W.G.	15 S.W.G.	20 S.W.G.	15 S.W.G.	20 S.W.G.	15 S.W.G.	20 S.W.G.	15 S.W.G.	20 S.W.G.	15 S.W.G.	20 S.W.G.	15 S.W.G.
Limit of proportionality, tons/in.^{2} .	10·9	8·7	10·2	9·4	11·0	10·3	8·9	9·6	9·2	11·7	10·6	11·9	11·8	9·2	9·9	10·2	10·0	11·5	10·5	11·6
0·1% Proof Stress, tons/in.^{2} . .	15·9	15·1	16·5	15·5	16·0	16·1	16·5	15·3	16·2	16·3	16·3	15·9	16·4	15·5	17·0	15·4	17·1	15·5	16·6	15·5
0·5% Proof Stress, tons/in.^{2} . .	18·2	17·0	18·4	17·4	18·1	17·9	18·1	17·3	17·8	17·9	18·2	17·4	18·3	17·2	18·6	17·2	18·9	17·2	18·4	17·2
Ultimate Stress, tons/in.^{2} . .	28·0	27·0	26·3	26·4	26·8	26·6	25·5	26·5	26·2	26·9	26·9	26·0	25·5	26·6	26·8	26·5	27·3	26·0	25·9	26·4
Elongation, per cent. on 1 in. . .	19·0	19·0	13·0	17·0	14·0	14·5	10·0	16·0	11·5	16·0	14·0	14·0	9·0	16·0	12·0	15·0	11·5	14·0	11·5	14·0
"E" $\times 10^{-6}$, lb./in.^{2}	10·2	10·9	10·6	10·5	10·1	10·1	10·6	10·5	10·5	9·6	10·3	10·3	10·2	10·3	10·7	10·2	10·5	9·9	9·8	9·7

but no trace of intercrystalline corrosion was detected in any of the samples.

Sea-Water Spray Tests.

It was considered that the determination of the tensile strength after six months' exposure to the sea-water spray test would afford a convenient means of measuring the relative corrodibility of the variously treated samples.

The dimensions of the individual samples were determined prior to the test and the stress values after exposure calculated accordingly. The mean results of duplicate tests, together with the values for the uncorroded material, are given in Table II.

The tensile values obtained do not indicate that heat-treatment in nitrate salt-baths is deleterious, nor does there seem to be any disadvantage, from the point of view of corrosion-resistance, in the use of such media in comparison with heating in an electric furnace. In fact, there was no marked margin of variation in the values as a whole.

SERIES II.

Ordinary commercial British Duralumin in three thicknesses, 16, 18, and 24 S.W.G., was obtained for this part of the work. The results of chemical analysis of samples of each gauge of material are given in Table III.

TABLE III.

	16-S.W.G.	18-S.W.G.	24-S.W.G.
Copper, per cent. .	3·82	4·11	4·17
Silicon, ,, .	0·55	0·36	0·23
Manganese, per cent. .	0·51	0·58	0·60
Magnesium, ,, .	0·79	0·59	0·66
Iron, per cent. .	0·38	0·57	0·45
Aluminium (by difference), per cent. .	93·95	93·79	93·89

Strips measuring 2 ft. long by 2 in. wide were cut from the respective sheets. Five lengths of each thickness were taken and assembled to form three coils having an outside diameter of 5 in. Each coil consisted of about eight turns or laminations and the clearance between successive laminations varied to a maximum of 0·006 in. In addition to these coils, strips measuring 1 ft. long by 2 in. wide were prepared from each of the three sheets.

The coils and strips were then heat-treated in a commercial salt mixture having a melting point of about 180° C. The mixture consisted essentially of sodium and potassium nitrates and solidified from the liquid state to form a hard, dense mass which did not dissolve very rapidly in still cold water. A qualitative analysis indicated the presence of considerable amounts of nitrites, while chlorides were also present in small quantity.

The heat-treatment temperature employed was again 490° C. The coils were held in the bath for 30 minutes and the strip samples for 20 minutes before they were quenched in cold water. The water was allowed to drain away from the samples, which were then dried off normally without any other treatment. The amount of salt entrapped at the interfaces of the laminations in the coils was, of course, much greater than that which remained on those samples heated and quenched as single strips.

The treated coils and strips were then stored in an unheated building for a total period of twelve months. Superficial observations were made at intervals, while at the end of the test period a thorough superficial and microscopical examination was made.

Results of Tests.

Superficial observations : Examination of the coiled material showed that considerable quantities of salt still remained on the sheet surfaces corresponding with the interfaces of successive laminations. Where the salt had been entrapped there was a large amount of greenish-grey deposit, which was fairly adherent, on the surface of the sheet. When this deposit was removed pronounced pitting as well as more general surface etching was in evidence. In the case of the single strip specimens, isolated spots of white deposit were fairly general over the surfaces. Very small surface corrosion pits were observed on all the strip samples and there was no appreciable difference in the appearance of the sheets in the three gauges.

Microscopical observations : Sections were prepared from the lower edges of the inner, middle, and outer lengths of strips in the coils. There was a tendency for the entrapped salt to be more plentiful in the regions chosen than on the other portions of these strips.

Numerous corrosion pits were observed on all the sections examined. The actual depth of these pits, however, was surprisingly small and none more than 0·005 in. deep were detected.

There was no trace of intercrystalline corrosion on any of the sections examined. The complete absence of this type of corrosion from the sections taken from the middle strip in the different coils was also surprising, inasmuch as it would be expected that these would have had a higher susceptibility towards intercrystalline penetration, by virtue of the lower rate of cooling on quenching from the salt-bath during heat-treatment, than the more exposed strips on the outside or inside of the coils.

It appears possible that heat-treatment in a nitrate salt may have a slight tendency to inhibit the development of intercrystalline corrosion.

GENERAL DISCUSSION OF RESULTS.

The water-line immersion tests indicated that the mode of heat-treatment and/or the quenching medium employed had not introduced any variation in either the nature or degree of attack. Negligible traces of intercrystalline corrosion were observed on a few samples immersed in the acidified sodium chloride reagent. No attack of this nature occurred on immersion in sea-water. A considerable amount of superficial pitting developed on all the test-pieces. This was, of course, very much more severe in the acidified sodium chloride solution than in normal sea-water.

The mechanical test results obtained on the series subjected to the sea-water spray test did not reveal any marked margin of variation and there was no evidence of any unfavourable influence arising from the use of any one salt or salt mixture as compared with material heat-treated in an electric furnace in air.

Incomplete removal of nitrate heat-treatment salt from Duralumin sheets after quenching resulted in the development of surface pitting when the latter material was subsequently stored. There was, however, no tendency towards intercrystalline corrosion of the material under these conditions. Apart from the tendency of salt residues present as a result of inadequate washing to cause superficial corrosion on subsequent storage, such residues are objectionable on surfaces to be enamelled or varnished without prior anodic treatment.

These observations are in agreement with the conclusion reached by Rawdon,* namely, that, from the point of view of causing intercrystalline corrosion in Duralumin, nitrates are not as dangerous as chlorides.

ACKNOWLEDGMENTS.

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The authors desire to express their thanks to the Director of Scientific Research, Air Ministry, for permission to publish the paper and also to the Aircraft Contractors who co-operated by supplying samples of the salt mixtures employed at their works.

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* (*U.S.*) *Nat. Advis. Cttee. Aeronautics, Tech. Note* No. **283**, 1928, p. 34.

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A FURTHER STUDY OF THE CONSTITUTION OF THE CADMIUM–TIN ALLOYS.*

By Professor D. HANSON,† D.Sc., Vice-President, and
W. T. PELL-WALPOLE,‡ B.Sc., Student Member.

Synopsis.

A further study (cf. *J. Inst. Metals*, 1935, **56**, 165) has been made of the constitution of the tin-rich cadmium–tin alloys by means of detailed thermal and microscopical analyses, and by electrical resistivity measurements.

A peritectic reaction occurs at 223° C. with a formation of a new phase, β, which undergoes eutectoid decomposition at 127° C. on cooling, producing the well-known transition at this temperature. The limits of the α and β phases have been accurately determined, and the equilibrium temperature of the eutectoid transition is shown to be 133° C.

The earlier diagrams by the authors and by Matuyama can be explained partly as representing metastable conditions which are very easily produced in these alloys, both on heating and on cooling; thus the peritectic reaction is only observed on cooling curves taken at very slow rates of cooling.

The solidus and solid solubility lines of tin in cadmium have been determined accurately, and the results are in agreement with those of Stockdale.

Introduction.

The constitution of cadmium–tin alloys has been investigated recently by the present authors [1] who confirmed that the general form of the system is eutectiferous, as shown by previous investigators. Their determination of the eutectic point agreed fairly closely with that of a very detailed investigation by Stockdale.[2] The authors showed that after annealing for 1 week at 160° C. there was no eutectic present in alloys containing 5 per cent. or less of cadmium, and that the transition at 127° C. gave a maximum thermal effect at 5 per cent. of cadmium, which was associated with the formation of a eutectoid structure at that composition.

On the evidence of certain thermal effects and the microstructures of quenched alloys, the authors presented a diagram (Fig. 1) for tin-rich alloys which agreed substantially with that previously published by Matuyama,[3] which was based on electrical conductivity measure-

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Note to Abstractors and Other Readers.—This paper will be published, in permanent form, in the *Journal of the Institute of Metals*, Vol. LIX, 1936. Reference should accordingly be as follows: *J. Inst. Metals*, 1936, **59** (Advance copy).

ments. This incorporated a theory that the tin-rich solid solution separates at 130° C. into conjugate solid solutions, of which the one richer in cadmium decomposes at 127° C. into a eutectoid consisting of α (tin-rich) and β (cadmium-rich). During the discussion of the authors' paper this diagram (Fig. 1) was criticized on theoretical grounds.

The authors had not determined the solidus lines of the system, their approximate positions being indicated in the diagram by broken lines. Stockdale,[4] however, in the discussion of the paper, gave results, hitherto unpublished, of his determination of the solidus lines. The α solidus fitted into the authors' diagram quite well, but the solidus of the cadmium-rich alloys differed seriously from the authors' estimation, although the microscopic work was in close agreement. The difference arose from the interpretation by the authors of certain thermal effects which were observed on these alloys.

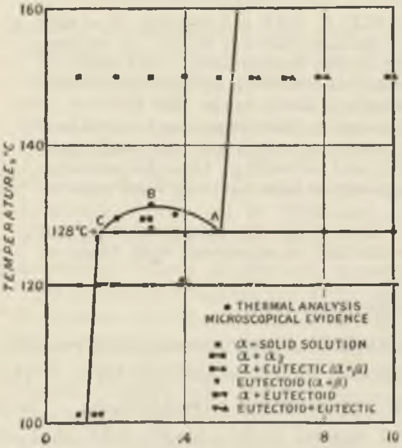

Fig. 1.

In reply to the correspondence on the paper, the authors stated that more recent work on the effect of small additions of a third metal to the cadmium–tin alloys had revealed the existence of a peritectic reaction at 223° C. in these alloys which is easily suppressed by rapid cooling. This discovery led to a more detailed investigation of the tin-rich alloys, including the determination of the solidus by micrographic methods. The solidus of the cadmium-rich alloys also has been determined in order to discover the cause of the apparent discrepancies between the previous thermal and microscopic results.

The present paper gives an account of these additional investigations and their relation to the previous work.

PART I.—TIN-RICH ALLOYS.

Preparation of the Alloys.

The alloys were prepared from Chempur tin (99·992 per cent. pure) and Tadanac cadmium (99·95 per cent. pure), as described previously.

All alloys were analyzed and the results, together with intended compositions, are shown in Table I.

Table I.—*Results of Thermal and Chemical Analyses.*

Alloy. Cadmium, Per Cent.	Analysis Cadmium, Per Cent.	Arrest Temperatures, ° C.							
		Unannealed Alloys.				Annealed Alloys.			
		Cooling Curves.				Cooling.	Heating.		
		1.	2.	3.	4.	1.	1.	2.	3.
0·5	0·5	230	223·2	...	...	...	...	...	226·0
1·0	1·01	228·9	223·1	...	124·5	...	...	...	223·0
1·25	1·24	...	...	...	...	126·0	140·5	162	222·0
1·5	1·50	227·7	223·2	174·0	125·5	126·5	141	167	222·0
2·0	1·97	226·2	223·0	174·0	125·5	126·5	139	165	220·0
2·5	2·47	225·3	223·0	175·2	126·0	127·0	139	160	216·0
3·0	3·00	224·2	222·8	175·5	127·7	127·0	140·0	158	213·0
3·5	3·52	223·5	...	175·8	126·5	127·0	139·0	165	208·0
4·0	3·98	222·4	...	175·8	126·4	127·2	140·0	160	204·0
4·25	4·26	...	...	...	...	127·5	140·0	160	201·0
4·5	4·52	...	...	...	...	128·0	140·0	...	197·0
4·75	4·74	...	...	...	...	127·0	140·0	...	193·0
5·0	5·01	219·8	...	176·0	125·5	127·0	140·0	...	188
5·25	5·27	...	...	...	...	127·0	139·0	...	184
5·5	5·60	...	...	...	...	127·5	140·0	...	178
5·75	5·75	...	...	176·0	125·5	127·5	140·0	...	176
6·0	6·00	217·5	...	176·0	...	126·5	140·5	...	176
8·0	8·00	214·0	...	176·2	...	127·0	140·0	...	176
10·0	10·04	209·5	...	176·0	...	127·0	140·0	...	176

THERMAL INVESTIGATIONS.

During the previous work, cooling curves were taken at a rate of cooling of 2° C. per minute, and readings were plotted at intervals of 0·05 mv. (1° C.) on a Rosenhain chronograph. This method gave no arrests between the liquidus and eutectic temperatures, but during a similar investigation of tin-rich antimony–cadmium–tin alloys, a series of arrests was found which appeared to indicate a peritectic reaction at or near to 233° C. Repeated determinations with the original binary alloys at slower rates of cooling gave very slight arrests in the case of two alloys only (1 and 2 per cent. cadmium) at 223° C. These arrests were very near to the liquidus arrest, so that undercooling, which is difficult to prevent with these alloys, could completely mask the slight thermal effects concerned.

The alloys prepared for the present investigation were of closer compositions, and a slower rate of cooling (1° C. per minute) was used. The difficulty of interpretation arising from the close proximity of the liquidus and supposed peritectic arrests on the cooling curves was overcome by taking advantage of the retarded rate of cooling which follows the commencement of the liquidus arrest. This permitted readings to be plotted at intervals of 0·4° C. instead of 1° C., thus widening the scale of the vertical ordinate on the chronograph drum. The combination of the slower rate of cooling and the more sensitive recording was completely successful, and gave a definite second arrest at 223° C. (± 0·3° C.) for compositions 0·5–3·0 per cent. cadmium. After the second arrest, the rate of cooling increased, so that it was necessary to revert to plotting at intervals of 1° C., which was maintained to the end of the curve (100° C.).

On completion of the cooling curves for a specimen, it was remelted and cast into a cylindrical chill mould of $\frac{1}{2}$ in. diameter. A 30-grm. sample taken from the resulting ingot was drilled to take the bare junction of the thermocouple, annealed for 7 days at 170° C., and cooling curves were repeated over the range 165°–100° C. The specimen was contained in a Salamander pot in a larger crucible which was heated to 170° C. in an oil-bath, kept at that temperature for 30 minutes, and then allowed to cool. These conditions gave a rate of cooling of 1·5° C. per minute, and were kept constant throughout the work. This method has distinct advantages over heating in an electric furnace in that the temperature lag between the specimen and its surroundings is very much less, so that the maximum temperature to which the specimen is heated can be controlled more accurately.

Heating curves were taken for the same specimens from 100° C. to the solidus of each alloy, the rate of heating being 0·5° C. per minute.

In addition to plotting the curves on the Rosenhain chronograph, the durations of the eutectoid arrests on cooling were measured by means of a metronome, and each specimen was weighed so that the arrest time per unit weight for each alloy could be obtained.

Results of Thermal Analysis.

Some typical curves are shown in Fig. 2. The liquidus arrests are in close agreement with those previously obtained, but the investigation of alloys at closer compositions reveals a slight break in the liquidus curve at 3·7 per cent. cadmium, 223° C. The peritectic arrests occur at 223° ± 0·2° C. for alloys containing 0·5–3·5 per cent. cadmium, giving a horizontal which intersects the liquidus at the slight inflection.

The temperatures of the eutectic arrests found in the case of alloys containing more than 1 per cent. cadmium are in agreement with those in the earlier investigation, showing undercooling in alloys containing 1–5 per cent. cadmium.

Only one series of arrests was observed in solid alloys, corresponding to the well-known transition at 125°–130° C. These arrests occur at temperatures approximately 3° C. lower than were found in the earlier investigations, but the differences are probably connected with the different masses of metal and the different cooling conditions. In the case of alloys containing 2–3·5 per cent. cadmium, the arrests occur at a slightly higher temperature than the average, but no additional arrests were recorded, so that although there appears to be some peculiarity for this range of composition, there is no evidence in these results for an additional line such as that shown in the authors' previous diagram.

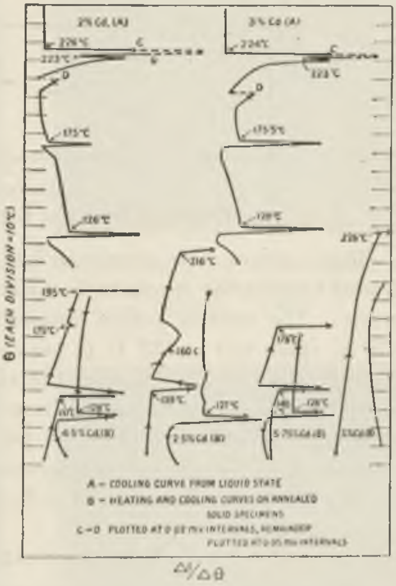

Fig. 2.—Typical Heating and Cooling Curves.

In confirmation of the earlier work, the slow-rate cooling curves for annealed specimens showed that the eutectoid transition occurs at 127° ± 1° C. in alloys containing 1·25 per cent. or more of cadmium. Again, there are no additional arrests at 130°–131° C. in alloys containing 2–3·5 per cent. cadmium, but with the slower rate of cooling employed there are very frequent minor disturbances of the curves between 160° and 130° C. The arrest time per grm. for each alloy is shown graphically in Fig. 3. There is a sharp maximum at 5 per cent. cadmium, confirming that this is the composition of the eutectoid. Theoretically, the curve on either side of the maximum should be linear, and the values for alloys containing 1·5–3·5 per cent. cadmium, are therefore greater than the theoretical values. These effects are discussed later in connection with the results of microscopical analyses.

The heating curves for annealed solid specimens of alloys containing 1·25–10 per cent. cadmium, show arrests corresponding to the eutectoid transition, commencing at 138°–140° C., but these are less sharply defined than those on cooling curves, and extend over a wider range of temperature. The curves for alloys containing 1·25–4·25 per cent. cadmium show a further interruption over the range 160°–167° C.

The maximum effect occurs in the 3 per cent. cadmium alloy, and an explanation of these "arrests" is offered later. Alloys containing 3–5·5 per cent. cadmium give a very slight but sharp arrest at or near to the eutectic temperature (176° C.), but since the authors have shown previously that for equilibrium conditions the eutectic is only present with more than 5 per cent. cadmium, these minor arrests must be due to non-equilibrium conditions, and can be attributed to the lack of complete absorption of the cadmium-rich phase at the transition or during subsequent heating, causing the formation of a small amount of metastable liquid phase at 176° C.

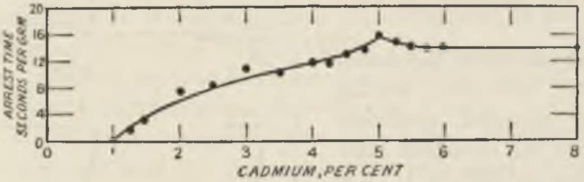

Fig. 3.—Thermal Intensity of Eutectoid Transition on Cooling.

These curves were continued until melting commenced, when the rate of heating the specimen became very slow, producing a prolonged arrest. The melting points obtained indicate a sloping solidus from 232° C. (pure tin) to 223° C. (1 per cent. cadmium), a constant temperature reaction at 223° C., over the range 1–2 per cent. cadmium, and a second solidus curve falling from 223° to 176° C. at 5·5 per cent. cadmium. With more than 5·5 per cent. cadmium, melting always commences at the eutectic temperature, 176° C.

The results are summarized in Table I.

Microscopical Analysis.

Chill-cast specimens, such as those used for the previous microstructural investigations, do not show the type of structure which is normally associated with a peritectic reaction, but this is in agreement with the present thermal investigations, which show that the reaction at 223° C. only occurs with very slow rates of cooling. In order to obtain microscopical evidence of the reaction, a series of specimens was cooled slowly in an electric furnace (under the same conditions as those used for cooling curves) from the liquid state to 160° C. and quenched in water. These specimens were prepared for examination by methods described previously, and were etched in a 2 per cent. solution of nitric acid in alcohol.

Alloys which show the arrest at 223° C. on cooling curves, all have a similar structure (Fig. 4, Plate I), consisting of primary α grains

PLATE I.

FIG. 4.—3·5% Cd. Slowly Cooled from Melt. Primary α (light), Peritectic β (half tone), Traces of Eutectic (dark). × 50.

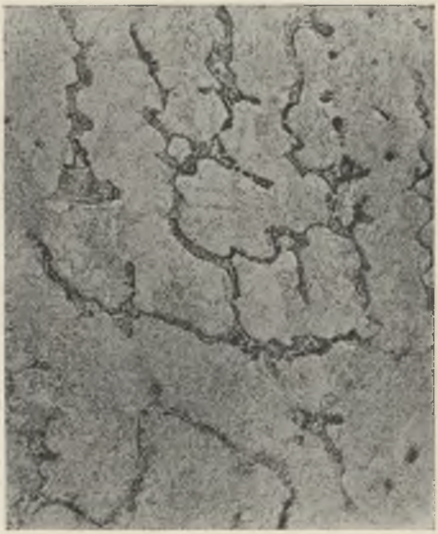

FIG. 5.—10·0% Cd. Slowly Cooled from Melt. Primary β (partially decomposed) and (β + γ) Eutectic. × 200.

FIG. 6.—5% Cd. Quenched at 170° C. Recrystallized β, Showing Incipient Decomposition. × 400.

FIG. 7.—Same as Fig. 6. Structure of β. × 1500.

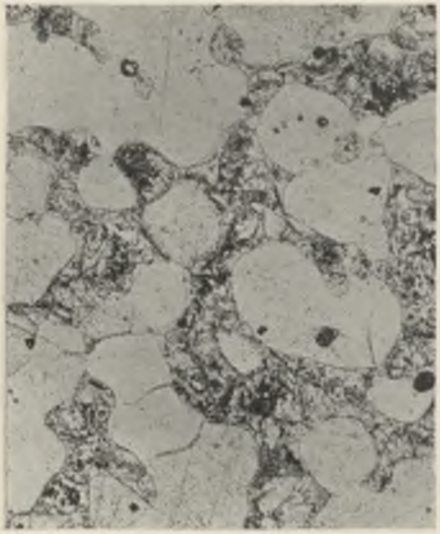

FIG. 8.—2% Cd. Quenched at 160° C. α (white) + Recrystallized β (half tone). × 200.

FIG. 9.—4·5% Cd. Quenched at 195° C. Recrystallized β. × 100.

FIG. 10.—3·5% Cd. Quenched at 205° C. Recrystallized β. × 400.

FIG. 11.—50% Cd. Quenched at 135° C. Decomposed β. × 500.

PLATE III.

Fig. 12.—4·5% Cd. Quenched at 150° C. Traces of α (light) in Decomposing β (dark). × 400.

Fig. 13.—1·5% Cd. Quenched at 220° C. α (light) + β (dark). × 50.

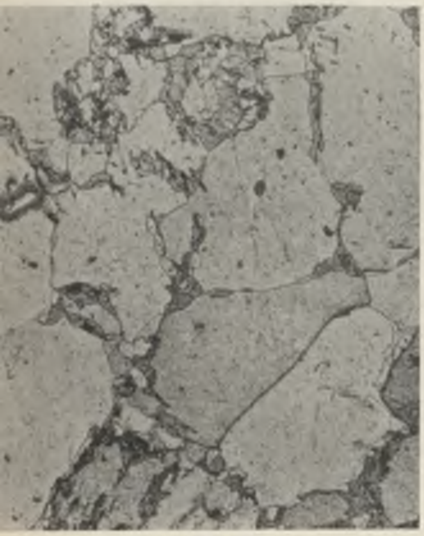

Fig. 14.—1% Cd. Quenched at 220° C. α (light) + β (dark). × 50.

Fig. 15.—5·6% Cd. Quenched at 160° C. β + Intergranular γ. × 400.

PLATE IV.

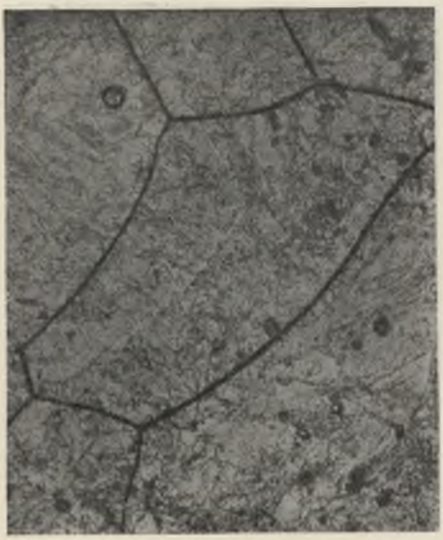

FIG. 16.—3·5% Cd. Quenched at 210° C. Recrystallized β + Quenched Liquid (dark). × 50.

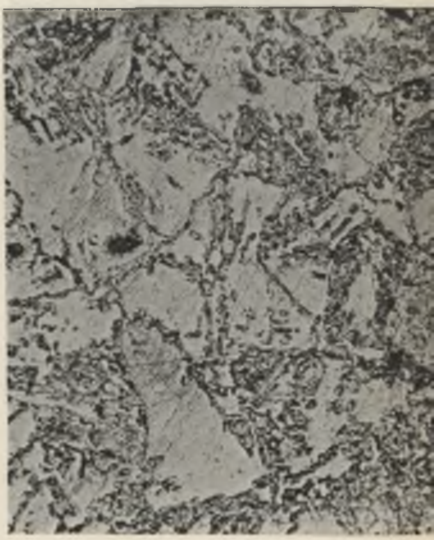

FIG. 17.—4% Cd. Heated Slowly to 140° C Quenched Immediately. Formation of (dark) from Eutectoid (matrix). × 100.

FIG. 18.—Same as Fig. 17. α (light) + β (dark) Eutectoid (half tone). × 500.

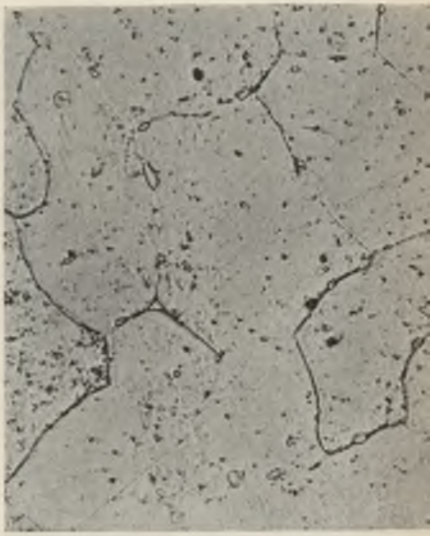

FIG. 19.—99·7% Cd. Quenched at 178° and Re-Prepared. Traces of Quenche Liquid in γ. × 200.

(light etching) with a peritectic fringe of a darker constituent, which shows signs of incipient decomposition, and traces of eutectic. The alloys containing 4 per cent. or more of cadmium consist of the dark constituent as the primary separation with well-developed eutectic at the grain boundaries (Fig. 5, Plate I). The intermediate constituent has a structure similar to that previously observed in tin-rich alloys which had been quenched after annealing at 160° C.

In order to obviate confusion it is necessary to re-name the cadmium-rich phase γ (previously called β), the intermediate phase now being called β and the tin-rich phase α as before.

Figs. 4 and 5 show clearly that the eutectic consists of $\beta + \gamma$.

To investigate the equilibrium conditions of these alloys, two series of specimens, chill-cast and slowly cooled, respectively, were annealed at 170° C. in an electric furnace under thermostatic control. The specimens were quenched and examined periodically until no further changes of structure occurred. It was found that whilst chill-cast specimens reached equilibrium after 6–7 days' annealing, it took 14 days for the slowly-cooled specimens to do so.

The structures of the annealed alloys after cooling slowly in the furnace are very similar to those described and illustrated in the authors' previous paper; thus, alloys containing up to 1 per cent. cadmium are uniform α; with 1·25–4 per cent. cadmium there is an increasing amount of eutectoid ($\alpha + \gamma$) in an α matrix; the 5 per cent. cadmium alloy is completely eutectoid, whilst with more than 5 per cent. cadmium there is an excess of γ at the grain boundaries. The proportion of eutectoid present in each alloy corresponds to the intensity of the thermal effect at 127° C., shown in Fig. 3.

During the previous investigations certain tin-rich alloys were quenched from 160° C. and also from 170° C., after a preliminary annealing for 7 days at 160° C. The structure of the 1 per cent. cadmium alloy was that of a simple homogeneous solid solution, but alloys containing 1·5–5 per cent. cadmium consisted of the α phase (light etching) with increasing proportions of dark etching areas which showed a somewhat " martensitic " structure. The 5 per cent. cadmium alloy consisted entirely of the " martensitic " structure, whilst with 6 per cent. or more of cadmium, eutectic was present around the grains. The " martensitic " areas were approximately proportionate to the amount of eutectoid in the corresponding slowly-cooled alloy, but in alloys containing up to 5 per cent. cadmium they were not separated from the light areas by definite boundaries. On this evidence, the authors considered that at 170° C., the α phase extended to 5·5 per cent. cadmium, but that quenching did not suppress the eutectoid transition entirely. An alloy containing 3 per cent. cadmium was etched in the furnace at 130° C., and quenched : this alloy consisted of two definite constituents in approximately equal amounts; the darker constituent was found to undergo decomposition at room temperature (15°–18° C.), producing a structure very similar to the eutectoid present in slowly cooled alloys.

These results were in agreement with the thermal evidence available at that time, apparently indicating that the primary tin-rich phase separates at 131° C. into conjugate solid solutions, of which the one richer in cadmium undergoes eutectoid decomposition at 127° C. The authors' diagram (Fig. 1) was very similar to the earlier one published by Matuyama,[3] which was based on electrical resistivity measurements.

The discovery of the peritectic reaction at 223° C. during the present thermal investigations, and the peritectic structures of the slowly-cooled alloys (Figs. 4 and 5) suggests another explanation of the transition at 127° C., *viz.* the eutectoid decomposition of the intermediate phase β which is produced by the peritectic reaction. If this is the true explanation, then the " martensitic " structure previously observed in quenched alloys, represents a distinct β phase, and in spite of the incipient decomposition of such a phase on quenching, a suitable etching reagent should reveal the grain boundaries. Experiments to this end were carried out, therefore, on the 5 per cent. cadmium alloy (which on quenching consists entirely of the " martensitic " structure). Several etching reagents were tried, including those used in the previous investigations. The most satisfactory results were obtained with a 5 per cent. solution of nitric acid in alcohol, which revealed the grain boundaries clearly but showed that the specimen had recrystallized on quenching, since it consisted of very coarse grains, each of which was composed of many small grains showing the " martensitic " structure (Figs. 6 and 7, Plate I). The experiment was repeated several times, the specimen being quenched from 160° C. and from 170° C., into cold water (15° C.) or a freezing mixture of ice and ammonium nitrate (— 5° C.), but the same structure was obtained each time.

The recrystallization is not caused by polishing, since the specimen was prepared very carefully, and the flowed layer removed by etching and light repolishing, before quenching. Moreover, the results of mechanical tests published in the previous paper showed that this alloy as quenched from 160° to 170° C., is very much harder than the 1 per cent. cadmium alloy, which consists entirely of α, yet the latter never has a recrystallized structure provided that the specimen is prepared with reasonable care. It was concluded that the structure of the 5 per cent. cadmium alloy confirms the existence of an intermediate phase β, which recrystallizes and partially decomposes on quenching.

One chill-cast specimen and one slowly-cooled specimen of each alloy in the range 0·5–10 per cent. cadmium were then re-annealed for 1 day at 160° C., quenched in water, and etched in a 5 per cent. solution of nitric acid in alcohol. Alloys containing up to 1 per cent. cadmium consisted entirely of a simple homogeneous solid solution α; with 1·25–4·25 per cent. cadmium there is an increasing amount of the recrystallized suppressed β in α matrix (Fig. 8, Plate II); with 4·5–5·25 per cent. cadmium the alloys are entirely β (as Fig. 6), whilst with 5·5 per cent. or more of cadmium the γ phase (cadmium-rich) is present around the coarse β grains. Throughout the series the β phase is recrystallized and " martensitic," as described in the preliminary experiments on the 5 per cent. cadmium alloy, whilst the α phase is light etching and has no substructure. The only difference between the chill-cast and slowly-cooled specimens is that in all cases the grain-size of the former is much finer.

Quenching experiments were then carried out from a series of temperatures, as required, to determine the phase boundaries.

The range of composition of the β phase changes considerably with temperature but the structure is always similar (Figs. 9, 10, and 11, Plate II), although at higher temperatures (190°–200° C.) the " martensitic " structure becomes less pronounced, whilst quenched from temperatures below 160° C., it becomes increasingly difficult to suppress the eutectoid decomposition (Fig. 11).

With alloys containing 3·5–2 per cent. cadmium it was found that on annealing at temperatures at which they are almost entirely β (195°–220° C.), very coarse grains develop, and the quenched specimen has a " rumpled " surface, so that it must be completely re-prepared for microscopic examination. This caused considerable difficulty in obtaining the true structures, and very light polishing was essential. The structures were also more difficult to etch satisfactorily, but when developed, the β was found to differ very little from that of the higher cadmium alloys quenched from lower temperatures (Fig. 10).

In alloys which contain considerably more β than α when quenched from 140° to 200° C., the α appears as light rounded pools in the β (Fig. 12, Plate III), but when alloys containing 1–1·5 per cent. cadmium are quenched from temperatures near to that of the peritectic reaction (215°–223° C.) the (α + β) structure is more angular and the β which forms at these temperatures tends to produce a Widmanstätten structure (Figs. 13 and 14, Plate III).

When the γ-phase is present in quenched specimens, it always occurs around the coarse β grains (Fig. 15, Plate III).

The limits of the peritectic reaction, and the positions of the α and the β solidus, were determined from microstructures of quenched specimens. When a specimen appeared to contain quenched liquid, it was sectioned and a face prepared at right angles to the original one; microstructurally, the quenched liquid appears as a very fine eutectic round the grain boundaries and as globules within the grains (Fig. 16, Plate IV).

An attempt was made to determine the mode of formation of β from the eutectoid mixture of $(\alpha + \gamma)$. Specimens of alloys 4–5 per cent. cadmium were annealed at 170° C., slowly cooled at 120° C., and annealed at that temperature for 1 day so that eutectoid structure was well developed. They were then heated very slowly to 140° C. (temperature of eutectoid arrests on the heating curves) and quenched after 2 minutes at that temperature. The structures obtained from this treatment are similar in each alloy, consisting of a dark etching constituent around the grain boundaries, and as bars across the grains (Fig. 17, Plate IV). At a higher magnification the light etching matrix has a eutectoid structure preserved (Fig. 18, Plate IV). It appears that the β is formed in visible amounts first along the original grain boundaries, and in certain preferred positions in the matrix. It is probable, however, that the apparent residual $(\alpha + \gamma)$ eutectoid structure consists actually of three phases, $\alpha + \beta + \gamma$, the β-phase being formed by reaction as a fringe between the lamellæ of $\alpha + \gamma$. The rather indefinite merging of the light (α) and dark (γ) lamellæ in Fig. 18, as compared with the appearance of the stable eutectoid of the slowly-cooled alloy appears to confirm this possibility, but the β if present in this form is not clearly distinguished.

The equilibrium temperature of the eutectoid transition cannot be determined accurately from thermal analysis owing to the severe hysteresis which occurs, the difference between arrests of heating and cooling being 10°–13° C. The results of prolonged annealing experiments showed that the eutectoid structure $(\alpha + \gamma)$ is stable up to 133° C., since specimens quenched from this temperature contain a coarse mixture of α and γ, whilst quenching from 135° C. produces the very fine structure of β which has decomposed during quenching (Fig. 11, Plate II).

The results of the microscopical investigations are incorporated in Fig. 20.

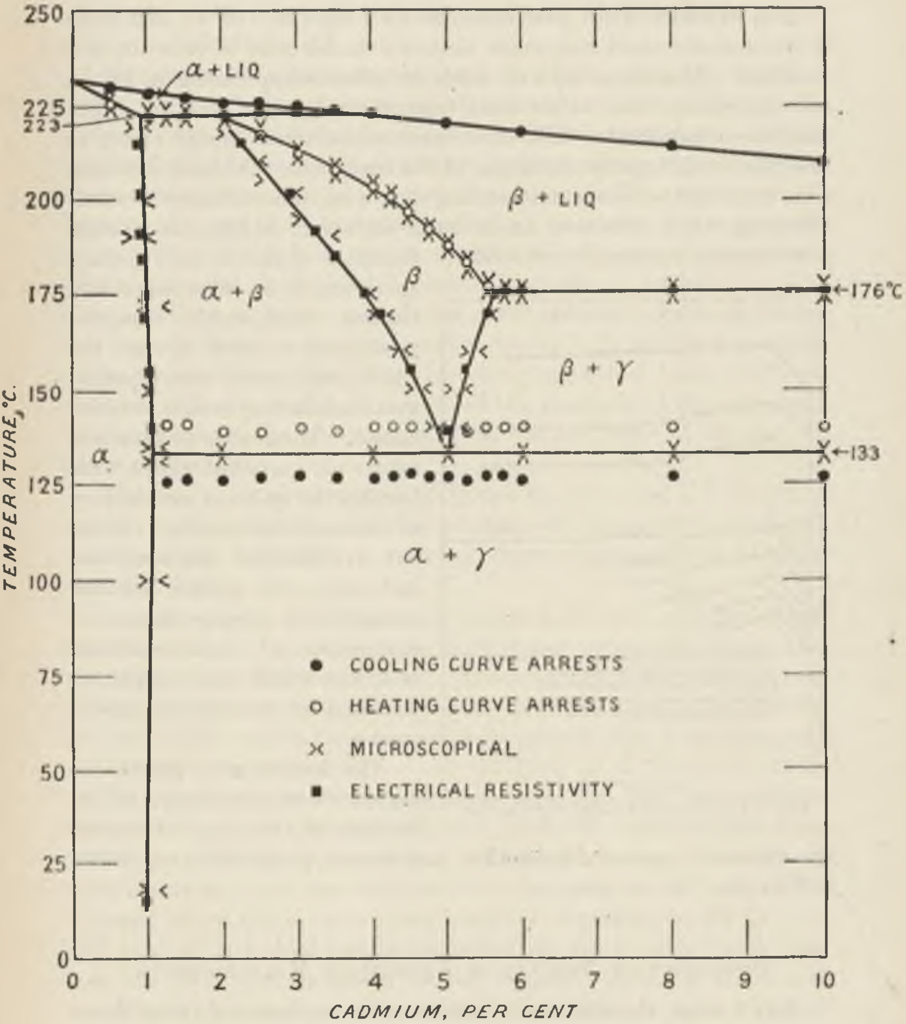

Fig. 20.—Tin-Rich End of the Cadmium–Tin System.

Electrical Resistivity Measurements.

A portion of each cooling curve alloy was cast into a cylindrical chill mould of ½ in. diameter, and specimens 1 in. long were taken from the resulting ingots, the outer skin being removed in a lathe. The specimens were then extruded at 150° C. through a 0·1 in. die under a load of 3000 kg., applied on an Avery Brinell machine.

The extruded wires were annealed for 7 days at 170° C., and resistivity measurements were made against a similar wire of pure tin as a standard. Measurements were made on quenched specimens at 18° C., and in certain cases at elevated temperatures in an oil-bath. Considerable experimental difficulties were encountered chiefly owing to low rigidity and coarse grain-size of the specimens. A slight deformation, such as the accidental bending of a wire, was sufficient to cause twinning, which produced an irregular surface in addition to causing a temporary change in resistivity. Readings obtained on duplicate specimens of an alloy sometimes showed considerable disagreement, but in such a case the whole experiment was repeated until satisfactory results were obtained. The results of measurements on quenched alloys were found to be quite as satisfactory as those of measurements carried out at elevated temperatures, and since the former method permitted a greater degree of uniformity of heat-treatment and was much more rapid, it was used for most of the experiments.

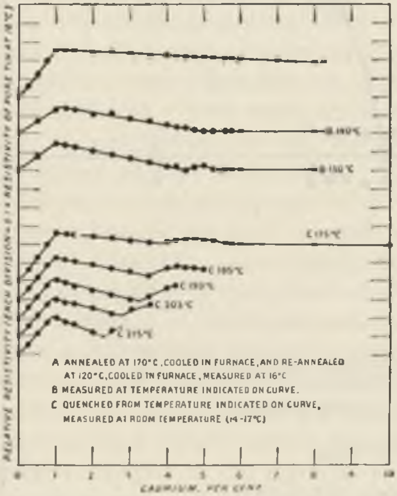

Fig. 21.—Typical Resistivity Curves.

The results were plotted as graphs of the ratio of the resistivity of the alloy to that of the standard, against composition, and some typical curves are shown in Fig. 21.

Discussion of Results of Resistivity Measurements.

In all cases, the addition of cadmium to tin causes a sharp linear increase in the resistivity to a maximum, which corresponds with the limit of the α solid solution. The maximum is sharp and is followed by a linear decrease, so that at each temperature the α phase boundary is determined quite accurately. The inflections of the curve which indicate other phase boundaries are not so definite.

In the case of alloys which are in equilibrium at room temperature, the maximum is at 1·0 per cent. cadmium, and is followed by a gradual linear decrease to 10 per cent. cadmium; the second portion of the curve represents the resistivity of a mixture of the phases α (tin-rich) + γ (cadmium-rich).

The curve for measurements made at 150° C. (Fig. 21) shows a similar increase to a maximum at 1·0 per cent. cadmium, followed by a steep linear decrease to 4·5 per cent. cadmium; from 4·5 to 5·25 per cent. cadmium there is a shallow curve, convex upwards, and a further linear relation from 5·25 to 10 per cent. cadmium. The curved portion, between 4·5 and 5·25 per cent. cadmium indicates a homogeneous phase field, and this is in agreement with the microstructures of these alloys quenched from 150° C., which consists of uniform β. The linear portions on either side of this curve indicate regions of heterogeneous equilibrium and correspond to the (α + β) and (β + γ) phase fields, respectively. The curve for alloys quenched from 150° C. is identical with the former in respect of the positions of the inflections which determine the phase boundaries, but the slope of the (α + β) line is not so steep.

The results for alloys quenched from 160°, 170°, and 175° C. are all similar to the foregoing, but the positions of the inflections change systematically, indicating a widening range of composition of the β field (Fig. 21).

Quenching from 140° C. did not suppress the eutectoid transition, but the results of measurements carried out in an oil-bath at this temperature are shown in Fig. 21. The branches of the curve corresponding to the α, (α + β), and (β + γ) phase fields are quite distinct, but the β field at this temperature is so narrow that it includes only the 5 per cent. cadmium alloy.

The results obtained from specimens quenched from temperatures above 180° C., were more satisfactory, probably owing to the more perfect preservation of the β-phase. These curves are all similar in form, showing (1) a linear increase to a maximum at the limit of the α phase; (2) a fairly steep linear decrease, representing the (α + β) field, and (3) a curved portion representing the β field, which rises from the (α + β)–β boundary to the boundary between the β and (β + liquid) phase fields. Alloys which were annealed in the (β + liquid) field usually broke on quenching due to the presence of a continuous intercrystalline liquid film.

In spite of the somewhat unsatisfactory character of some results of the earlier experiments, the positions of the phase boundaries as determined from the curves of resistivity are in close agreement with the results of microscopical analysis, and are considered to be reliable (Fig. 20).

CONCLUSIONS: CORRELATION OF RESULTS OF THERMAL AND MICROSCOPICAL ANALYSES.

Heating and cooling curves revealed a constant temperature transition at 223° C., indicating a peritectic reaction and the appearance of a new phase. A further invariant transition which occurs at 127° C. on cooling curves of annealed specimens containing more than 1 per cent. cadmium and at 138°–140° C. on heating curves, has been shown previously to be connected with the formation of a eutectoid structure in these alloys.

The present microscopic investigations have confirmed that a secondary phase β is formed at 223° C. by a peritectic reaction between α containing 0·9 per cent. cadmium and liquid containing 3·7 per cent. cadmium. The limits of the α and of the β phase fields have been determined by microscopic examinations and measurements of electrical resistivity, the two methods giving concordant results (Fig. 20). The limits of the α phase change very slightly with temperature, but the β phase which appears at 1·9 per cent. cadmium at 223° C., widens in composition range with decreasing temperature, becoming richer in cadmium and poorer in tin, until 176° C. is reached (eutectic temperature), where the β field extends from 3·9 to 5·7 per cent. cadmium, the latter being the concentration which is present in the $\beta + \gamma$ eutectic. Below 176° C. the solubility of β for both tin and cadmium decreases continuously to 133° C., at which it decomposes to form a eutectoid of α (tin-rich) and γ (cadmium-rich) at 5 per cent. cadmium.

In addition to the eutectoid arrests, certain minor evolutions of heat were noted on the cooling curves of annealed alloys of 1·25–4·5 per cent. cadmium, and these are probably connected with the decreasing solubility of tin in β. The separation of α from β does not take place completely or uniformly at the rate of cooling used, so that at the commencement of the eutectoid transition the β in these alloys is supersaturated with respect to tin. It is probable that the sudden separation of this excess tin as α causes the thermal effects recorded to be greater than the theoretical values (Fig. 3). The microstructures of the cooling curve specimens confirm this explanation, since for the compositions 2–4 per cent. cadmium, there is a greater amount of the fine duplex structure $(\alpha + \gamma)$ than would be present for equilibrium conditions.

During the earlier work of similar nature, a more rapid rate of cooling (2° C. per minute) was used, so that the suppression of the separation of α from β during cooling would occur in greater degree. The authors consider that the minor arrests which were recorded on the curves of alloys containing 2–3·5 per cent. cadmium at 129°–131° C., are caused by a sudden separation of the excess tin from the supersaturated β. The line *ABC* (Fig. 1) joining these arrests therefore represents a metastable position of a portion of the boundary between α + β and β fields (see Fig. 20), but it should not rejoin the transition line at 128° C.

Heating curves of alloys containing 1·25–4·25 per cent. cadmium show additional arrests extending over the range 160°–167° C., but microstructures show no evidence of a transformation in either α or β at these temperatures, and since the compositions concerned come within α + β field at 160° C., the arrests may again be attributed to a hysteresis effect in connection with absorption of α by β during heating.

The positions of the solidus lines as determined microscopically are in close agreement with the results obtained from heating curves except in the case of alloys containing 1·5–3 per cent. cadmium: the solidus arrests of these alloys occur at 1°–3° C. lower than the positions which are determined from the structures of specimens quenched after annealing at the temperatures concerned. The explanation is similar to that advanced for the other anomalies observed, *i.e.* that the rate of heating (1·5°–2° C. per minute) is insufficiently slow for the alloy to remain in equilibrium. Thus, if the β which is formed from α + γ at 140° C. on heating does not absorb α at the rate required for the alloy to remain in equilibrium, then there will be a concentration gradient in the β-phase, some of which will be richer in cadmium than the average composition of the alloy and will commence to melt before the true solidus temperature of the alloy is reached.

The complete revised equilibrium diagram for alloys containing up to 10 per cent. cadmium is given in Fig. 20.

PART II.—CADMIUM-RICH ALLOYS.

In the authors' diagram of the cadmium–tin system,[1] a transition line was shown at 170° C. on the evidence of arrests which occurred at that temperature on cooling curves of alloys containing 40–95 per cent. cadmium. Alloys containing 97–99·5 per cent. cadmium gave only one arrest in the vicinity of 170° C., the temperature decreasing to 164° C. with 99·5 per cent. cadmium. From the apparent absence of the eutectic arrest (176° C.) in these alloys, the authors concluded that the solubility of tin in cadmium was of the order of 3 per cent. at 176° C., but this was not checked microscopically, nor was the solidus of the cadmium-rich phase determined. The microstructures of these alloys contained a precipitate of the tin-rich phase when quenched from between 120° and 170° C., and also when slowly cooled, but the solubility at 170° C. was shown to be less than 0·2 per cent. tin. The sudden change of solubility indicated between 170° and 176° C., was considered to be the cause of the arrests at 170° C., since there was no evidence either of a phase change at that temperature or of a polymorphic transformation in the cadmium-rich solid solution. Similar effects have been observed by Haughton [5] in the copper–tin system, and by Rosenhain and Tucker [6] in the lead–tin system.

During the discussion of the authors' paper, Stockdale [4] proposed a solidus for the cadmium-rich phase as determined by a recent investigation. This indicated a solubility of 0 25 per cent. tin in cadmium at 176° C. He stated that the 95 per cent. cadmium alloy gave only one arrest, at 172° C. on heating, whilst the authors' results from cooling curves showed arrests at 176° C. (eutectic) and at 170° C. (solubility change).

The present investigations, which include a repetition of the authors' previous thermal work on these alloys, with additional heating curves, and a microscopic determination of the solidus, were undertaken to determine the cause of the above-mentioned discrepancies.

EXPERIMENTAL.

Alloys containing 60–99 per cent. cadmium were prepared from Chempur tin and Tadanac cadmium, as described previously.

Cooling curves were taken on 200 grm. samples, under the same experimental conditions as those used for the tin-rich alloys, whilst heating curves were taken for specimens which had been annealed for 1 month at 170° C., cooled in the furnace, and reannealed for 3 days at 120° C.

Microscopic examinations were confined to alloys containing 95–99 per cent. cadmium. Specimens were chill-cast, annealed for 1 month at 170° C., and examined after quenching from a series of temperatures at 5° C. intervals from 170° to 265° C., and also after cooling in the furnace. Specimens were prepared by the methods described previously, and were etched in 2 per cent. nitric acid in alcohol. When a specimen had been taken apparently above its solidus temperature, it was sectioned, and re-prepared.

Analyses of alloys used for microstructural investigations are given in Table II.

TABLE II.—*Analysis of Cadmium-Rich Alloys.*

Intended Composition, Tin, Per Cent.	Analysis, Tin, Per Cent.	Intended Composition, Tin, Per Cent.	Analysis, Tin, Per Cent.
0·1	0·099	1·0	0·98
0·2	0·22	2·0	2·03
0·3	0·29	4·0	3·90
0·5	0·51		

DISCUSSION OF RESULTS OF THERMAL ANALYSIS.

The results of the cooling curves are not presented in detail as they agree closely with the authors' previous results.

Alloys containing 60–90 per cent. cadmium show four arrests corresponding to the liquidus eutectic (176° C.), solubility change (170° C.), and eutectoid transition (128° C.). With 97–99·5 per cent. cadmium, only one arrest occurs between the liquidus and eutectoid arrests, whilst with more than 99·5 per cent. cadmium the liquidus arrest alone is present. In all cases the actual figures agree to within 1° C. with those given in the authors' previous paper.

Heating curves did not give very satisfactory results, owing to the fact that the arrests are not so sharply defined as in cooling. The eutectoid arrest occurs throughout the range of alloys examined at 137°–142° C., but only one arrest was obtained at higher temperatures, commencing at 172°–173° C. and extending over a wide temperature range to 178°–180° C. This appears to confirm the result obtained by Stockdale[4] for the alloy containing 95 per cent. cadmium, and is probably caused by a tendency for the solubility change at 170° C. to take place at a higher temperature on heating, and to occur more slowly than on cooling. This would cause the thermal effect to be prolonged, so that it might not be completed before the eutectic arrest commences at 176° C. A further factor which would have the same effect is the temperature lag between the specimen and its surroundings which is generally greater during heating than during cooling.

RESULTS OF MICROSCOPICAL ANALYSIS.

The structures of specimens which had been annealed for 1 month at 170° C. were very similar to those obtained previously consisting of primary γ (cadmium-rich phase previously called β)[1] with the tin-rich α-phase at the grain junctions and as a precipitate through the γ grains; except in the case of the alloy containing 99·9 per cent. cadmium, which was homogeneous γ.

After annealing for 1 week at 178° C. (2° C. above the eutectic temperature), all alloys containing less than 99·8 per cent. cadmium show the presence of the quenched liquid phase (Fig. 19, Plate IV). The alloy containing 99·8 per cent. cadmium is homogeneous from 172° to 210° C., when the first traces of liquid appear, while the 99·9 per cent. cadmium alloy is homogeneous when quenched from between 120° and 265° C., indicating no change of structure until melting commences.

The solidus of the cadmium-rich γ phase, as determined from these results, is shown in Fig. 22.

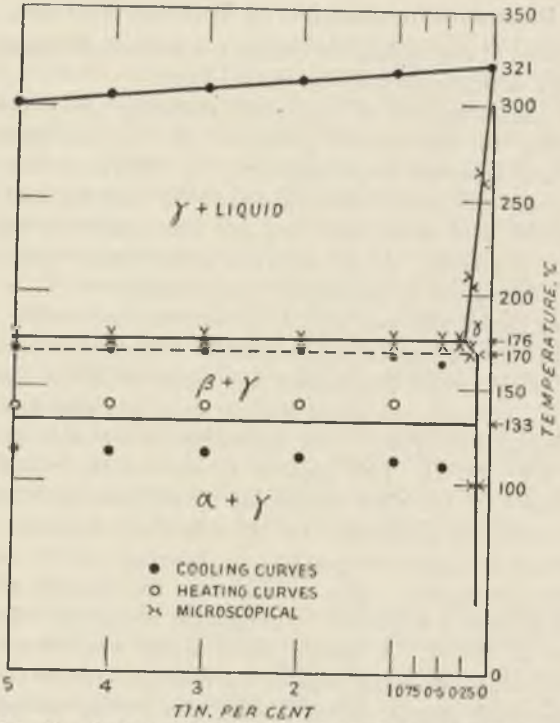

Fig. 22.—Cadmium-Rich End of the Cadmium–Tin System.

Conclusions.

The results of microscopic analyses show that the solubility of tin in cadmium is 0·25 per cent. at 176° C., which is in close agreement with Stockdale's [4] determination. This indicates that the single arrest points obtained on the cooling curves of alloys containing 97–99·5 per cent. cadmium must be regarded primarily as eutectic arrests, showing considerable undercooling.

The arrests recorded at 170° C. in the case of alloys containing 60–90 per cent. cadmium are not associated with a phase change, and are probably caused by the sudden solubility change at 170° C., as suggested previously, whilst in the alloys containing more than 97 per cent. cadmium the severe under-cooling of the eutectic probably masks the minor arrest.

The authors agree with Haughton [4] that a line such as that shown in Fig. 22 at 170° C., should not be considered as part of the equilibrium diagram, since it does not indicate a change of phase. It is included

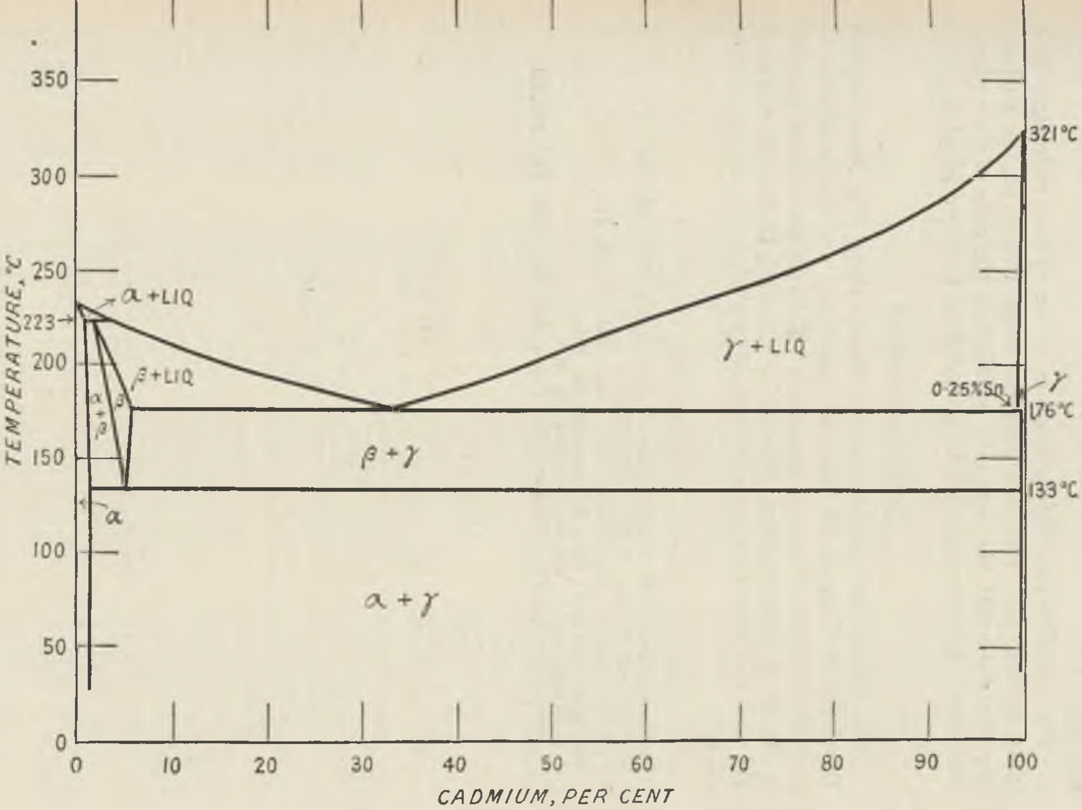

Fig. 23.—Constitutional Diagram of the Cadmium–Tin System.

in the diagram as a fine broken line, since it always occurs on cooling curves, and the authors can think of no more simple way of recording this fact.

The complete equilibrium diagram of the system cadmium–tin is given in Fig. 23. This embodies the main results of the authors' previous work with the necessary revisions at the ends of the system. Stockdale's figure for the eutectic composition has been adopted.

ACKNOWLEDGMENTS.

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AUTHOR INDEX TO ABSTRACTS

METALLURGICAL ABSTRACTS

(GENERAL AND NON-FERROUS)

Volume 3 JUNE 1936 Part 6

I.—PROPERTIES OF METALS

(Continued from pp. 141–146.)

***Compression of Aluminium and Aluminium Alloys.** A. von Zeerleder, R. Irmann, and E. von Burg (*Aluminium*, 1936, **18**, (2), 41–48).—The behaviour of aluminium and various binary and polynary aluminium alloys under compression in the Amsler machine (static) and under the drop-hammer (dynamic) at various temperatures and at various rates of compression is shown graphically, and compared with that of various other metals and alloys. The force required in kg./mm.^{2} to produce a reduction of 50% by compression is as follows for the temperatures given: 99·5% aluminium, 1·3–0·8 (500°–550° C.), brass 2·0–0·8 (700°–800° C.), Anticorodal 2·8–1·9 (450°–500° C.), copper 4·0–2·6 (700°–800° C.), Avional D 4·1–3·8 (420°–440° C.), Peraluman 2 4·8 (420°–440° C.), iron 5·0–4·0 (1000°–1100° C.), and Peraluman 7 5·0 (420°–440° C.).—A. R. P.

***Photoelectric Effect of Aluminium Films Evaporated in Vacuum.** E. Gaviola and John Strong (*Phys. Rev.*, 1936, [ii], **49**, (6), 441–443).—Aluminium films were prepared in a high vacuum, and their photoelectric properties were studied. The photoelectric threshold was determined as 2830 A., and a selective maximum found near 2700 A. The longer wave-lengths of previous values for the threshold are probably due to the presence of oxide films, but the present values cannot be considered as characteristic of pure aluminium, since iron was present in the evaporated film to the extent of at least 0·2% by weight.—W. H.-R.

†**Beryllium.** R. Gadeau (*Rev. Aluminium*, 1936, **13**, (77), 17–24).—See *Met. Abs.*, this vol., p. 74.—J. H. W.

Velocity Distribution of Photo-Electrons Emitted by Composite Cæsium Cathodes. A. I. Pjatnitzki and P. W. Timofeew (*Physikal. Z. Sowjetunion*, 1936, **9**, (2/3), 187–197).—[In German.] The velocity distribution of photo-electrons emitted by oxygen–cæsium and sulphur–cæsium photo-cathodes due to the incidence of monochromatic light is found to depend on the wave-length of the light and on the structure of the cathode.—J. S. G. T.

***Revision of the Atomic Weight of Germanium. II.—Analysis of Germanium Tetrachloride.** O. Hönigschmid and K. Wintersberger (*Z. anorg. Chem.*, 1936, **227**, (1), 17–24).—Cf. *Met. Abs.*, this vol., p. 31. The value found was 72·59.
—A. R. P.

The Properties and Uses of Lead [continued]. R. S. Russell (*Modern Engineer*, 1935, **9**, (11), 499–500; (12), 555–557; 1936, **10**, (1), 39–40).—See also *Met. Abs.*, 1935, **2**, 658. The chief problems of the lead industry are thought to be intercrystalline cracking and the need for better physical testing methods, for better understanding of methods of casting and working, and for a more extensive knowledge of the alloys of lead. Each of these problems is briefly discussed. Intergranular failure is said to be due to fatigue, stress-corrosion, or stressing after high-temperature annealing. The types of physical test which are proposed for development are creep tests, grain-size measurement, and determination of tendency to recrystallize. Casting temperature, pouring technique, and deoxidation are the important factors in casting lead. Rolling at temperatures above 150° C. is not recommended,

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* Denotes a paper describing the results of original research.

† Denotes a first-class critical review.

but extruding dies are kept at 150°–200° C. The most important alloys are the binary combinations with copper, silver, and tellurium, and the recently developed ternary alloys with antimony and cadmium, and tin and cadmium. The properties of these alloys are briefly described.—H. W. G. H.

***The Properties of Heusler's Alloy, and the True Specific Heat of Manganese and Its Discontinuity.** J. R. Ashworth (*Proc. Phys. Soc.*, 1936, **48**, (3), 456–468).—Values of the density, intensity of magnetization, critical temperature, Curie's constant, electrical resistivity and its temperature coeff., thermoelectric power, and mean and true specific heat were determined at certain temperatures up to about 500° C. A large discontinuity is found in the value of the true specific heat of manganese at about 350° C., which is nearly the critical temperature of the Heusler alloy (360° C.). The heat capacity of the alloy is the sum of the heat capacities of its constituents both below and above the critical temperature.—J. S. G. T.

***Surface Tension of Mercury in the Presence of Nitrogen, Hydrogen, and Carbon Dioxide.** Marie Kernaghan (*Phys. Rev.*, 1936, [ii], **49**, (5), 414).—Abstract of a paper read before the American Physical Society. The surface tension of mercury was again checked and found to be 476·5 dynes/cm. at 20° C. The results obtained in the presence of the gases are summarized in a table.—S. G.

***Adsorption of Gases on Mercury.** R. S. Burdon (*Proc. Phys. Soc.*, 1935, **47**, (3), 460–470).—Adsorbed carbon dioxide or hydrogen to the extent of a monomolecular layer are retained by a mercury surface on evacuation. The adsorption is readily observed when the mercury surface is formed in a gas, but not when the gas is admitted to a surface which has been formed in a vacuum. It seems more probable that this is due to something acting as a contamination than to some inherent property of the mercury causing changes in the transition layer at the surface. If more than a single layer of gas molecules condenses on the surface, the subsequent layers are lost on evacuation. No single theory explains the complex phenomena observed.—S. G.

***Adsorption of the Heavier Rare Gases by Mercury.** Hans M. Cassel and Kurt Neugebauer (*J. Physical Chem.*, 1936, **40**, (4), 523–529).—The surface tension of mercury in contact with either krypton or xenon was determined at temperatures between 235° and 293° K. Values of the heats of adsorption of the respective gases were derived as follows: krypton, at 239° K., 2700 cal.; xenon, at 245° K., 345° cal.; at 263° K., 3350 cal.; at 283° K., 3400 cal. —J. S. G. T.

***The Change of Electrical Resistance of Nickel with Temperature.** S. Velayos and H. Bittel (*Bol. acad. cienc. exactas, fis. quim. nat.* (*Madrid*), 1935, **1**, (3), 5–9; *C. Abs.*, 1936, **30**, 2819).—The electrical resistance of nickel was measured from − 190° to 570° C. by using a Wolff precision potentiometer. The precision is 1 : 10,000 in the region of the Curie point, which is 353·6 ± 0·3° for carbonyl nickel. Measurements on ordinary nickel agree when corrections for purity are made.—S. G.

Curie Ferromagnetic Point of Thin Layers of Electrolytically Deposited Nickel. St. Procopiu and T. Farcas (*Ann. sci. Univ. Jassy*, 1935, **20**, 75–82; *C. Abs.*, 1936, **30**, 2438).—The Curie point is 17° higher for thin layers of nickel than for thick layers. This increase is attributed to the internal pressure of the thin layers. This pressure increases the number of atoms which surround the magnetic atom so that the energy of cohesion of the magnetic atom is increased. The Heisenberg formula explains the experimental results fairly well.—S. G.

***On the Change of Thermal Energy Due to Magnetization in Ferromagnetic Substances [Iron, Nickel, Cobalt, Steels, Nickel–Iron Alloy].** Tosihiko Okamura (*Sci. Rep. Tôhoku Imp. Univ.*, 1936, [i], **24**, (5), 745–807).—[In English.] The absorption or evolution of heat accompanying the magnetization of iron, nickel, cobalt, steel, K.S. magnet steel, nickel–iron alloy, and iron single crystals was determined. The thermal phenomenon comprises two types of heat change, one reversible (the magneto-caloric effect), the other irreversible (due to magnetic hysteresis). These two have been separated from one another. In initial magnetization, irreversible heat curves are similar to each other and to the magnetization curve. The reversible heat curves, plotted against the magnetic field, are all similar for iron, the steels, and nickel–iron alloy. In weak fields, heat is absorbed; the amount increases at first, reaches a maximum, then decreases, and finally changes to evolution. In cobalt, heat absorption alone is observed. In the case of cyclic magnetization starting from maximum fields, irreversible effects appear only as the field approaches zero value. When the field assumes negative values, heat evolution is conspicuous.—J. S. G. T.

***The Ferromagnetism of Nickel.** J. C. Slater (*Phys. Rev.*, 1936, [ii], **49**, (7), 537–545).—Theoretical. The calculations of Krutter (*ibid.*, 1935, [ii], **48**, 664) for electron energy bands in crystals of copper are extended, and applied by extrapolation to the next element nickel, which has the same (face-centred cubic) structure. The results show that a ferromagnetic state is stable for nickel. Further extrapolation into the iron group is more speculative, but indicates that ferromagnetism will persist only for a few elements, and that the change to a non-magnetic metal will occur near to the position in the Periodic Table occupied by iron; the actual change occurs between iron and manganese. The criterion for ferromagnetism is the existence of inner incomplete electron shells (the 3*d* shell for the iron group) which are small compared with the distance between the atoms. The calculations are made from the general point of view of the Bloch theory with the electrons traversing the whole crystal, and S. doubts whether the Heisenberg type of theory depending on wave functions surrounding the individual atoms could account for the facts in any simple way.—W. H.-R.

Magnetic Viscosity [in Nickel and Iron]. C. W. Heaps (*Phys. Rev.*, 1936, [ii], **49**, (5), 409).—Abstract of a paper read before the American Physical Society. Barkhausen jumps of magnetization in nickel and iron may continue to occur for 20 or 30 seconds after the magnetizing force has become constant. This phenomenon appears to be a type of magnetic viscosity which cannot be caused directly by eddy currents. A possible explanation is given. —S. G.

***Comparison of the Velocities of Diffusion of Hydrogen and of Deuterium Through Heated Platinum.** René Jouan (*J. Phys. Radium*, 1936, [vii], **7**, (2), 101–106).—The velocity of diffusion of heavy hydrogen through heated platinum is found to be $\frac{3}{4}$ of that of ordinary hydrogen at all temperatures between 450° and 950° C.—J. S. G. T.

***The Photo[-Electric] Effect in the Case of Selenium Blocking Layers.** P. Görlich (*Z. tech. Physik*, 1935, **16**, (9), 268–271).—Conditions necessary for the production of the maximum current by selenium blocking layers are investigated. The most satisfactory thickness of the semi-conducting layer is about $0·08 \pm 0·01$ mm. The formation temperature is, in the case of pure selenium, about 218°–219° C. Preferably the blocking layer electrode should not make complete superficial contact with the selenium film, but there should be between them regions of high resistance due to the presence of gaseous atoms. —J. S. G. T.

***An Abnormal Electrical Conductivity in Powdered Tellurium.** C. Hawley Cartwright (*Phys. Rev.*, 1936, [ii], **49**, (6), 443–448).—Pure tellurium powder contained in a capillary glass tube was mechanically compressed between two steel pistons. At a pressure of 1000 kg./cm.^{2} the specific electrical conductivity of the powder is about ten times greater than that of a single crystal under the same pressure. This anomalous conductivity of the compressed powder is much less marked in impure tellurium. The effects of particle size, surface conditions, surrounding medium, and length of specimen were examined, and possible explanations are discussed.—W. H.-R.

Titanium and Its More Useful Compounds. Robert M. McKinney and Willard H. Madson (*J. Chem. Education*, 1936, **13**, (4), 155–159).—Describes the history and occurrence of titanium, the more important methods for the detection and quantitative determination of the metal, its chemistry and recent developments, and the applications of its compounds.—J. H. W.

***Contact Potential Measurements on Tungsten Filaments.** David B. Langmuir (*Phys. Rev.*, 1936, [ii], **49**, (6), 428–435).—Changes in contact potential of the surface of a tungsten filament have been estimated from emission data obtained from a tube containing two filaments. The effects of temperature and the amount of thorium on the surface were studied. Both activated and deactivated thoriated tungsten surfaces show an increasingly negative contact potential (increasing work-function) with increase of temperature, but pure tungsten seems to show a temperature coeff. of opposite sign.—W. H.-R.

***An Electron Microscope for Filaments: Emission and Adsorption by Tungsten Single Crystals.** R. P. Johnson and W. Shockley (*Phys. Rev.*, 1936, [ii], **49**, (6), 436–440).—An electron microscope is described for small cylindrical filaments. The wire is mounted in the axis of a glass tube with fluorescent material on its inside wall. The emitted electrons are drawn to the wall so rapidly that their initial non-radial velocity components cause little deviation from a strictly radial path, and the fluorescent lining produces an electron image of the wire magnified radially, but not longitudinally. Drawn wires always show prominent die marks unless the surfaces have been smoothed. The emission from single crystals depends systematically on crystal orientation. The results confirm that drastic heat-treatment is necessary before characteristic results are obtained. Experiments are described with thoriated tungsten wires, and with wires activated in cæsium and potassium vapours. —W. H.-R.

***Measurement of the Saturation Current of High-Emission Incandescent [Tungsten] Cathodes.** Emerich Patai and Gábor Frank (*Z. tech. Physik*, 1935, **16**, (9), 254–262).—Apparatus for determining the saturation current of high-emission incandescent cathodes is described. Preliminary determinations of the Richardson constants of tungsten over a temperature range up to 2600° (abs.) agree with results obtained by Langmuir and Jones.—J. S. G. T.

***Brittleness [Cold-Shortness] of Metals at Low Temperature.** Yoshio Fujii (*Japan Nickel Rev.*, 1936, **4**, (2), 371–375).—[In English and Japanese.] Summary of a paper previously published in Japanese only (see *Met. Abs.*, 1935, **2**, 369).—S. G.

***A New Attack on the Problem of Fatigue of Metals Using X-Ray Methods of Precision.** H. J. Gough and W. A. Wood (*Proc. Roy. Soc.*, 1936, [A], **154**, (883), 510–527).—The characteristics, as revealed by precise X-ray analysis, of normalized mild steel, after its subjection to cycles of safe and unsafe ranges of (1) alternating torsional fatigue stresses, and (2) direct stresses (tension and compression) are investigated. The torsional tests show that the application of stress cycles of ± 9·7 tons/in.^{2} results in a progressive change of structure. The change involves a dislocation of the grains into components which are tilted by amounts up to 2° (approx.) from the parent grain. In addition, finely-divided crystallites of sizes of the order 10^{-4} cm. are produced and are oriented at random. These changes are not a secondary effect of the large fatigue cracks. The dislocation of the grains into small units, which reflect independently an incidental X-ray beam, distinguished quite sharply the unsafe from the safe range of stress when cycles of reversed torsional stress are applied. Similarly in the direct stress tests, the unsafe range is distinguished from the safe range by changes of grain structure affecting the X-ray spectrum.

These changes start with the dislocation of the grains and end in their complete breakdown to a degree depending on the applied range of stress. The changes are similar to those recorded for the torsional tests but show a slower gradation with increasing ranges of stress; this is probably due to the value of the fatigue limit being, relatively, more removed from the static yield point in direct stress than in torsion.—J. S. G. T.

***The Solubility of Metals in Crystals of Their Halogen Compounds.** G. Tammann (*Light Metals Research*, 1936, **4**, (19), 320).—Abbreviated translation from *Z. anorg. Chem.*, 1935, **226**, (1), 93; see *Met. Abs.*, this vol., p. 112.—J. C.

The Calculation of Atomic Weights from Nuclear Reaction Energies. H. A. Wilson (*Proc. Roy. Soc.*, 1936, [A], **154**, (883), 560–563).—It is shown that atomic weights (with $O^{16} = 16$) can be calculated from nuclear reaction energies without making use of atomic weights obtained by other methods. The atomic weights of 18 light elements, including lithium and beryllium isotopes, are derived in this manner and agree closely with those obtained by Bethe and by Oliphant, Kempton, and Rutherford from mass spectrograph data.—J. T.

***The E.M.F. of Movement of Metals in Water and Their Electrokinetic Potential.** Stefan Procopiu (*Compt. rend.*, 1936, **202**, (16), 1371–1373).—It has been shown (*J. Chim. phys.*, 1930, **27**, 29) that the displacement of a metal in water in which it is immersed gives rise to an e.m.f., e, equal in magnitude and sign to the electrokinetic potential, ζ, of the same metal in water. The sign is determined by the ratio of the solution potential of the metal to that of hydrogen. If $\varepsilon_r =$ the thermodynamic potential of the metal at rest, and $\varepsilon_m =$ that of the metal in movement, then $e = \varepsilon_m - \varepsilon_r = \zeta$. The e.m.f. of movement, negative for silver and copper, and positive for lead, nickel, iron, aluminium, and zinc, has a definite value for a newly-formed cell, but this value tends to diminish with the time after agitation. It increases at first rapidly with the speed of the electrode in water and appears to tend to a limiting value for high speeds. The e.m.f. of movement in aqueous solutions of ordinary sugar does not vary with the time, probably because the sugar protects the metal from oxidation. The dielectric constant of the liquid diminishes with e (and ζ). The gas dissolved in the water affects the e.m.f. of movement and the time during which the movement takes place. This last fact shows that the value of the electrokinetic potential also depends on chemical reactions at the contact of the metallic particles and the liquid.
—J. H. W.

The Theoretical Calculation of Normal Potential of Metals and Henry Constant of Ions. Iturô Uhara (*Phil. Mag.*, 1936, [vii], **21**, (143), 958–976).—The Henry constant is thus defined: the equilibrium vapour pressure of an ion, present in concentration c', in solution, is given by c'/k, where k is Henry's constant. Expressions for the normal potentials of metals in solution are derived thermodynamically, and values calculated from heat of formation and solubility of slightly soluble compounds of metals are compared with values already given in the literature of the subject. Parallelism is found between values of the Henry constant and the heat of hydration of the respective ions.
—J. S. G. T.

Application of Arkadiew's Method for the Elimination of the Skin Effect to the Investigation of Dynamical Magnetization Curves. O. Veletzkaia (*Z. Physik*, 1936, **99**, (7/8), 569–575).—Curves of magnetic permeability taken at acoustic and radio-frequencies are determined and analyzed. The skin effect appears to accompany the incidence of magnetic viscosity. The permeability curves, freed from the skin effect, and the hysteresis losses agree in the case of weak fields with the corresponding curves yielded by the theory of magnetic viscosity.—J. S. G. T.

II.—PROPERTIES OF ALLOYS

(Continued from pp. 146–153.)

***Expansion of Light Metals for the Pistons of Internal Combustion Motors at the Operating Temperature.** C. A. Maresca (*Industria meccanica*, 1936, **18**, 1–5; *C. Abs.*, 1936, **30**, 2892).—The expansion coeffs. of the most used aluminium alloys were measured for the interval + 20° to + 275° C. and are given, together with the nature of the heat-treatment and the Brinell hardness of the material. A modified method for measuring the temperature with the Chevenard instrument is described.—S. G.

***Study of [the Constitution and Properties of] Certain Aluminium–Chromium Alloys.** Soji Hori (*Tetsu to Hagáne*, 1936, **22**, (3), 194–200).—[In Japanese.] See *Met. Abs.*, this vol., p. 147.—S. G.

Bibliography of Literature on the Effect of Aluminium in Cast Iron. R. W. Woodward; annotated by J. W. Bamfylde (*Bull. Brit. Cast-Iron Res. Assoc.*, 1936, **4**, (7), 264–271).—51 references are given.—S. G.

Alumag. Aluminium–Magnesium Alloy Resistant to Corrosion. H. Rogez (*Métaux*, 1935, **10**, (124), 358–368).—The Alumag alloys (aluminium with up to 8% magnesium) are easily worked and have mechanical properties comparable with those of light alloys containing copper, the high-resistance alloy having a breaking stress of 40 kg./mm.^{2} and an elongation of 27–30%, while the values for the low resistance alloy are 32–34 kg./mm.^{2} and 26–28%, respectively, in the annealed state. The methods of working, cleaning, and soldering these alloys, and their applications are described. To secure the desired properties, the alloys must be manufactured and worked under carefully controlled conditions, and only high-purity materials used for their make-up.—J. H. W.

***Compression of Aluminium and Aluminium Alloys.** (v. Zeerleder, Irmann, and v. Burg.) See p. 193.

***The Eutectic Compound of Antimony and Lead.** Otakar Quadrat and Jan Jiříště (*Chem. Listy*, 1935, **29**, 304–308; *C. Abs.*, 1936, **30**, 2537).—Using 3 kg. ingots 110 mm. high containing 19·55, 15·00, and 12·89% antimony, the authors cooled the mixture slowly, measured the temperature changes, and analyzed chemical samples of the alloy from 30 parts of the ingot. Although it was expected to find an accumulation of antimony in the surface layer in the 12·89% antimony alloy, for this is the composition of the eutectic mixture given in the literature and is based on metallographic analysis, a concentration of antimony was found (after chemical analysis) from 17 to 34% in all 3 alloys to about 0·1 of the depth of the ingot; below this level the composition ranged from 11·36 to 11·69% antimony. Photomicrographs of the homogeneous portion of the ingot are given which show that the antimony is completely separated from the pure eutectic. Possible errors in chemical analysis, the presence of impurities in the original metalloids, and the effect of the rate of cooling on the analyses were investigated to account for the discrepancy in the composition of the eutectic. All investigations confirmed the chemical analysis showing a eutectic composition of 11·4–11·5% antimony. The authors urge that the composition of 13% antimony based on metallographic studies be corrected to 11·4% antimony based on chemical analyses.—S. G.

***The Properties of Heusler's Alloy, and the True Specific Heat of Manganese and Its Discontinuity.** (Ashworth.) See p. 194.

***[Contribution] to the Knowledge of Copper–Tin Alloys.** Carl Haase and Franz Pawlek (*Z. Metallkunde*, 1936, **28**, (4), 73–80).—Cold-rolling or drawing of bronze with more than 5% tin followed by a low-temperature anneal leads to decomposition of the solid solution. This effect has not been previously observed since annealed alloys were always used for the test, and even very prolonged low-temperature annealing fails to bring these to a state of equilibrium below 400° C. The course of the precipitation of cold-worked alloys has been followed by determinations of the specific resistance and Brinell hardness, and by micrographic and X-ray methods. The higher the degree of supersaturation the lower is the minimum degree of reduction necessary to produce precipitation, and the higher the degree of reduction above this minimum the more rapid is the rate of precipitation and the shorter the time of incubation. Recovery from the effects of cold-work and recrystallization above 300° C. results in a retardation of the rate of precipitation so that the accelerating effect of the higher temperature is to a large extent nullified. The changes in electrical resistance produced by recovery from cold-work and by precipitation are separately recorded on the annealing curve and show that precipitation is a continuous single-phase process. Very little change in the hardness occurs during precipitation, but characteristic changes in the microstructure can be observed. Measurements of the lattice parameter and of the electrical resistance of alloys subjected to a very prolonged anneal show that the solid solubility of tin in copper is 13·5% at 400° C., 10·9% at 350° C., 5·5% at 300° C., 2·8% at 250° C., and about 1·2% at 200° C. Below 350° C. the precipitated phase is Cu_3Sn, but above 370° C. it is δ ($Cu_{31}Sn_8$) which decomposes below 350° C. into $\alpha + Cu_3Sn$. The Cu_3Sn precipitated at 300° C. has an hexagonal structure with $a = 2{\cdot}7523$, $c = 4{\cdot}3203$ A., $c/a = 1{\cdot}5697$.—A. R. P.

†**On Lead–Bronzes.** Willi Claus (*Z. Metallkunde*, 1936, **28**, (4), 84–91).—The structure, physical, and mechanical properties, and methods of testing lead–bronzes, both simple and special, are dicussed at some length with reference to recent work and patent literature, and an account is given of the theory of segregation in systems which are heterogeneous in the liquid state; an annotated *bibliography* of 30 references is included.—A. R. P.

***Brinell Hardness, Resistance to Wear and Ability to Slide [Brasses and Bronzes].** Fritz Brobeck (*Giesserei-Praxis*, 1936, **57**, (17/18), 191–194).—Read before the Fachgruppenversammlung Giessereimeister. The dependence of resistance to wear on Brinell hardness was investigated by determining the wear on worm wheels, 77 mm. in diameter and having 27 teeth, made of various cast bronzes and brasses, and working against steel worms. Contrary to the widely held belief, it was found that there is no relation between the resistance to wear and the Brinell hardness of these alloys.—J. H. W.

Residual Stresses and Corrosion Cracks in Metals [Brass]. L. Sergeev and F. Vittmann (*Tech. Physics U.S.S.R.*, 1934, **1**, (1), 86–100; *Brit. Chem. Abs.*, **1935**, [B], 361).—[In German.] Etching with mercury salts is not a reliable test for stress, but alternating treatment with water and ammonia vapours shows the presence of stress in the outer layers. The tendency of brass to crack depends on stress, and for a given stress decreases with the degree of stretching.—S. G.

***Study of Corrosion-Resisting Alloys for Marine Propellers.** Yoshiro Fujii (*Japan Nickel Rev.*, 1936, **4**, (2), 337–344).—[In English and Japanese.] English summary of a paper previously published in Japanese only (see *Met. Abs.*, 1935, **2**, 506).—S. G.

Copper Alloys to Meet Severe Requirements. D. K. Crampton (*Metal Progress*, 1936, **29**, (5), 39–43, 100).—The increasing severity of fabrication conditions, which include deep-drawing of thin material combined with increasing complexity in design, demands careful selection of materials, and suitable copper contents are suggested for brasses under various conditions of fabrication. Compositions suited for the manufacture of condenser tubing are discussed in relation to dezincification, honeycomb pitting, impingement attack, and oil–water corrosion.—P. M. C. R.

***On the [Constitution and Properties of] Gold–Copper Alloys.** W. Broniewski and K. Wesolowski (*Ann. Acad. Sci. Tech. Varsovie*, 1935, **1**, 44–69).—[In

French.] A full account is given of work the principal results of which have already been published (see *Met. Abs.*, 1934, **1**, 176). Thermal arrests occur at 403° and 389° C. on heating and at 366° and 371° C. on cooling alloys of the composition AuCu and $AuCu_3$, respectively. The corresponding critical points on the dilatation curves occur at 448° and 436° C. on heating and at 370° and 384° C. on cooling. Tables are given showing the electrical resistance, thermoelectric power, coeff. of expansion, dissolution potential, and mechanical properties of the alloys after various heat-treatments including low-temperature anneals for as long as 1000 hrs.—A. R. P.

***Electrolytic Reductions of Organic Compounds at Alloy Cathodes. I.—Reduction of Aliphatic Ketones to Hydrocarbons at Cadmium Amalgams.** Sherlock Swann, Jr., H. J. Read, and F. C. Howard (*Electrochem. Soc. Preprint*, **1936**, April, 273–278).—The electrolytic reduction of methyl-*n*-propyl ketone to *n*-pentane was studied at a series of cadmium amalgam cathodes, the compositions of which were varied from 100% mercury to 100% cadmium. A curve plotted with the composition of the cathode as abscissa against the yield of pentane as ordinate showed inflections at points corresponding to changes of phase of the amalgam as indicated in the *cadmium–mercury equilibrium diagram*.—S. G.

***The Optical Constants of Liquid Sodium Amalgams.** A. P. Friesen (*Phys. Rev.*, 1936, [ii], **49**, (5), 414).—Abstract of a paper read before the American Physical Society. The optical constants of liquid sodium and of 44 liquid sodium amalgams were determined between 0 and 40% mercury. Large changes in n^2–k^2 and in $2nk$ with change in concentration occurred in the neighbourhood of those concentrations where so-called intermetallic compounds exist. Incidentally, more or less periodic small changes in n^2–k^2 and in $2nk$ were discovered at those concentrations where compounds are not known to exist. Work is in progress to obtain further experimental data that may be useful in the interpretation of these small periodic changes or "ripples."—S. G.

***Magnetic Investigations of the [Precipitation-]Hardening of Nickel–Beryllium Alloys.** Walther Gerlach (*Z. Metallkunde*, 1936, **28**, (4), 80–83).—After subjecting a 2% beryllium–nickel alloy to a quenching and precipitation-hardening anneal the density, saturation, magnetization, remanence, coercivity, and Curie point are all increased to an extent dependent on the degree of hardening produced. The magnetic hardening produced by precipitation is greater the greater the degree of supersaturation of the original solid solution. These results are explained as follows: annealing of the supersaturated solid solution at 500° C. causes the beryllium atoms to leave the solid solution lattice which thus contracts and, being relatively richer in nickel, has a higher Curie point; since the precipitation occurs at a relatively low temperature the gaps in the lattice structure rendered vacant by removal of beryllium atoms are not filled by nickel atoms, and thus the magnetic hardness is increased. The nickel–beryllium compound which separates during hardening stabilizes the incomplete nickel lattice and thus renders the increased hardness relatively insensitive to temperature changes.—A. R. P.

***Study of the Paramagnetism of Some Nickel Alloys.** Charles Manders (*Ann. Physique*, 1936, [xi], **5**, (Feb.), 167–231).—The relation between magnetic susceptibility, χ, and temperature, T, was determined for selected solid solution alloys of nickel with silver, gold, aluminium, titanium, zirconium, silicon, tin, lead, vanadium, arsenic, antimony, chromium, molybdenum, tungsten, manganese, ruthenium, palladium, and platinum. The specimens were cut from ingots melted in a high-frequency furnace, and were annealed for several hrs. at 800° C. and then very slowly cooled. The experimental results are tabulated in full. For most alloys, the susceptibility follows the relation $\chi = \alpha + \frac{C}{T - \theta}$; the values of α, C, and θ being calculated for each alloy.
—J. C. C.

***Magnetic Properties of the Metallic State and Energy of Interaction Between Magnetic Atoms.** Louis Néel (*Ann. Physique*, 1936, [xi], **5**, (Feb.), 232–279).—The results of Manders (see preceding abstract) indicate that the paramagnetism of certain nickel-base alloys consists of two parts; one constant in value and the other dependent on temperature. It is deduced that the number of magnetic electrons of nickel does not change when passing from the ferromagnetic to the paramagnetic states. Calculations are made of the energy of magnetic interaction between two neighbouring atoms. The complicated magnetic properties of platinum are explained on the supposition that there is a coupling between the crystal lattice and the spin responsible for magnetic properties.—J. C. C.

Properties and Fabrication of Inconel. —— (*Met. Ind.* (*Lond.*), 1936, **48**, (17), 495). **Inconel. Some Notes on Its Properties and Applicable Welding Methods.** —— (*Aluminium and Non-Ferrous Rev.*, 1936, **1**, (6), 266–268; and *Welder*, 1936, **8**, (27), 856–858).—An account of the properties, applications, and welding of an alloy containing (approximately) nickel 80, chromium 14, and iron 6%.—J. E. N.

***The Thermal and Electrical Conductivities of Metals and Alloys. II.—Some Heat-Resistant Alloys from 0° to 800° C.** R. W. Powell (*Proc. Phys. Soc.*, 1936, **48**, (3), 381–392).—Values of the thermal and electrical conductivities of F.H. stainless, F.N.C.T., Staybrite, and Era A.T.V. steels, and of Monel metal and of an alloy containing approximately 80% nickel and 20% chromium were determined up to about 800° C. At atmospheric temperature, values of the Lorenz function of these materials range from $0{\cdot}76 \times 10^{-8}$ for the F.N.C.T. steel to $1{\cdot}18 \times 10^{-8}$ for the F.H. stainless steel, and are abnormally high; at 800° C. all values lie between $0{\cdot}62 \times 10^{-8}$ and $0{\cdot}68 \times 10^{-8}$.—J. S. G. T.

K-Monel Metal and Its Technical Properties. Rudolf Müller (*Z. Metallkunde*, 1936, **28**, (4), 97–99).—K–Monel metal containing nickel 63·2, copper 30·8, aluminium 3·5, iron 1·5, manganese 0·5, and carbon, silicon, &c., 0·5% has a lower density, a slightly lower melting point, a much higher electrical resistance, and a much lower magnetic transformation point (below − 40° C.) than ordinary Monel metal; it has also a very high resistance to impact, vibrational stresses, and high temperatures, and can be used for the same mechanical and corrosion-resistant constructions in which Monel metal is used.—A. R. P.

***Electrical Conductivity and Equilibrium Diagram of Binary Alloys. XX.—The Sodium–Lead System.** H. Klaiber (*Z. Elektrochem.*, 1936, **42**, (5), 258–264).—The sodium–lead alloys between 0 and 50 atomic-% sodium were investigated by tracing out the temperature–resistance curves. Lead takes sodium into solution with the formation of the α-solid solution. The saturation composition of this solid solution depends on the temperature; at the eutectic temperature, 304° C., it is 18 atomic-% sodium, at 20° C., 3·5 atomic-%. The solubility at higher temperatures is appreciably greater than that given by earlier workers. The homogeneous range of the β-phase at 20° C. is between 27·7 and 32·5 atomic-% sodium, and at 298° C., between 27 and 32·5 atomic-%. It was shown, in agreement with the X-ray investigations of Zintl and Harder (*J. Inst. Metals*, 1932, **50**, 431), that the compound Na_2Pb_5, assumed by earlier workers, cannot exist, but that, on the other hand, the β-phase as a sodium-rich solid solution is conceivable. The complete equilibrium diagram of the system was constructed from these results. It was also shown by ageing tests that the hardness increases with increasing sodium content, and that cold age-hardening up to 90% of the initial hardness can be obtained by suitable heat-treatment.—J. H. W.

***Electrical Conductivity and Equilibrium Diagram of Binary Alloys. XIX.—The Sodium–Thallium System.** G. Grube and A. Schmidt (*Z. Elektrochem.*, 1936, **42**, (4), 201–209).—The sodium–thallium alloys were investigated by thermal analysis and by tracing out the temperature–resistance curves of the solid alloys, from which the complete equilibrium diagram was constructed. The intermetallic compounds $NaTl_2$, NaTl, Na_2Tl, and Na_6Tl were found. On the thallium side, solid solution occurs over a wide range of composition. The saturation concentration consists of stable β-solid solution at 28 atomic-% sodium at 238° C., and the stable α-solid solution at 22 atomic-% at 222° C. On the sodium side, the range of the δ-solid solution extends from 98·9 to 100 atomic-% sodium at 63·9° C. The crystals NaTl melt unaltered at 305° C. and form with both components the γ-solid solution, whose range of homogeneity was determined. The phase $NaTl_2$ is formed from the α- and γ-solid solutions by reaction in the solid state at 154° C. The compounds Na_2Tl and Na_6Tl occur through a peritectic reaction, the former from γ-solid solution and the melt at 154° C., the latter from the compound Na_2Tl and the melt at 77·4° C. The alloys in the range 17–24 atomic-% sodium can be age-hardened. After annealing at 200° C., quenching and leaving at room temperature, the alloys with 24 atomic-% sodium show an increase in hardness of more than 60%, alloys with 17 and 20 atomic-% sodium an increase of more than 50%.—J. H. W.

***Compressibilities and Electrical Resistance under Pressure, with Special Reference to Intermetallic Compounds.** P. W. Bridgman (*Proc. Amer. Acad. Arts Sci.*, 1935, **70**, (7), 285–317).—The compressibility and electrical resistance under pressure of 20 intermetallic compounds, 3 metallic salts, metallic germanium, and basalt glass were investigated at 30° and 75° C. at pressures up to 12,000 kg./cm.^{2}. The specimens, all of which crystallized in the cubic system, were specially cast in an argon atmosphere. A detailed description is given of the results, which indicate that the calculated compressibility is almost always greater than that actually found; it is not yet possible to correlate this observed lowering with the heat of formation of the compound, and volume contraction on formation appears to bear no relation to compressibility. The specific resistance is nearly always higher than would be calculated from the rule of mixtures. Pressure coeffs. of resistance are almost invariably negative.
—P. M. C. R.

High Permeability and Plastic Flow [of Ferromagnetic Alloys] in Magnetic Fields. Joy F. Dillinger (*Bell Lab. Record*, 1936, **14**, (8), 265–269).—When certain alloys in the nickel–iron–cobalt series are allowed to cool slowly from above the Curie point in a magnetic field, high values of magnetic permeability are developed in the direction of the applied field. A theory is outlined which explains this effect in terms of the domain theory of ferromagnetism. The domains in the alloy are oriented by the applied field, and the stresses set up when they become magnetized on passing through the Curie point are relieved by plastic flow during the slow cooling. See *Met. Abs.*, 1935, **2**, 579.
—J. C. C.

III.—STRUCTURE

(Metallography; Macrography; Crystal Structure.)

(Continued from pp. 153–155.)

The Importance of Metallography in Metallurgy and Mining. A. Glazunov (*Hornický věstník*, 1936, **18**, 25).—A lecture.—S. G.

The Electrolytic Polishing of Certain Metals, and Its Applications. P. Jacquet (*Bull. Soc. franç. Élect.*, 1936, [v], **6**, (68), 547–554).—The polishing of metals by anodic attack is recommended on account of the freedom from smearing or distortion of the finished surface, which is thus suited for metallographic, X-ray, or electron examination. The surface effects of ordinary mechanical polishing are described. Directions are given for the electrolytic polishing of lead, copper, tin, brass, and lead–tin alloys.—P. M. C. R.

***The Crystal Structure of the Compound Fe_3Ti.** Werner Jellinghaus (*Z. anorg. Chem.*, 1936, **227**, (1), 62–64).—Fe_3Ti has a cubic lattice, $a = 5{\cdot}19$ A. with 4 molecules in the unit cell, and $d = 6{\cdot}34$.—A. R. P.

***Graphical Method for Indexing X-Ray Diagrams of Rotation.** N. J. Seljakow and E. J. Sovz (*Soobshenia Zentralnogo Instituta Metallow* (*Communic. Central Inst. Metals*), **1935**, (18), 226–230).—See *Met. Abs.*, 1935, **2**, 101. —N. A.

***On Obtaining Monochromatic Co K_a Radiation.** E. J. Sovz and V. L. Heyfez (*Soobshenia Zentralnogo Instituta Metallow* (*Communic. Central Inst. Metals*), **1934**, (17), 234–236).—See *Met. Abs.*, 1935, **2**, 100.—N. A.

IV.—CORROSION

(Continued from pp. 155–159.)

***Non-Metallic Inclusions in Aluminium and Their Influence on Its Corrodibility.** L. Tronstad (*Norges Tekniske Høiskole, Avhandlinger til 25 års Jubilect*, **1935**, 467–494; and (summary) *Light Metals Research*, 1936, **4**, (14), 232–234).—[In English.] The inclusions found in aluminium are discussed in relation to corrosion properties. Finely dispersed silicon did not cause increased corrodibility, but coarse inclusions affected it. Nitrides, fluorides, and carbides appeared to be present in too small amount to have any appreciable effect. Sulphide and phosphide inclusions appear to be important. Methods of detecting the inclusions are described. Attempts to correlate sulphide prints with anodic points revealed that only about 20% of the sulphide spots were anodic points under the conditions employed. T. concludes that the formation of anodic corrosion pits is controlled by factors other than sulphide inclusions. Mylius tests indicated lower corrodibility of material rolled in strip form under tension than similar material rolled ordinarily. Sulphurous aluminium was much more corrodible than normal metal, and normal metal much more corrodible than metal of 99·99% purity under the Mylius test.—H. S.

***Aluminium, Even Impure, which is Perfectly Smooth and Free from External Dirt Does not Effervesce in Dilute Acids.** Paul Ronceray (*Bull. Soc. chim. France*, 1936, [v], **3**, (2), 206–213).—As is the case with zinc (see abstract, p. 204) perfectly smooth, clean aluminium is attacked by dilute sulphuric acid only extremely slowly, but the metal dissolves rapidly when the surface is dirty or is roughened. Amalgamation of the surface promotes a rapid reaction as the mercury acts both as an extrinsic and as an intrinsic impurity.—A. R. P.

Permanence of Galvanographs and Stereotypes. A. Rovira (*Gac. Artes grafic.*, 1934, **12**, (7), 11–12; *Brit. Chem. Abs.*, **1935**, [B], 637).—Copper galvanographs are attacked by printing colours containing sulphur or mercury. Nickel plating is recommended.—S. G.

The Disintegration and Corrosion of the [Brass] Heating Tubes in Heaters and Evaporating Structures [in the Sugar Industry]. Josef Hamous (*Listy Cukrovar*, 1935, **54**, 36; *Z. Zuckerind. Čechoslovak Rep.*, 1935, **60**, 126–127; *C. Abs.*, 1936, **30**, 2899).—After investigating corrosion in many plants, H. finds that an inadequate copper content of the brass tubes, a variable composition throughout their length, and an uneven thickness of the brass are responsible for corrosion. Within the steam chamber the carbon dioxide and ammonia are the chief agents of disintegration; within the liquor chamber the carbonates, chlorides, ammonia, and nitrates of the liquor are responsible for corrosion. A careless removal of incrustations with hydrochloric acid is often responsible for disintegration. Although steel tubes are cheaper than brass tubes and possess a lower heat transmission coeff., H. examined an evaporator in which the steel tubes had functioned and had not been replaced for 18 years. Mechanical causes which lead to a disintegration of tubes are listed.—S. G.

Failures in Fruit Preserving. W. Friedrich (*Obst- u. Gemüse-Verwertg.-Ind.*, 1934, **21**, 525–526; *C. Abs.*, 1936, **30**, 2655).—A discussion of the causes of corrosion, discolouration, &c., in canning pears.—S. G.

***Zinc Which is Impure but Perfectly Smooth and Free from Surface Dirt Does not Effervesce in Dilute Acids.** Paul Ronceray (*Bull. Soc. chim. France*, 1936, [v], **3**, (2), 206–213).—Commercial zinc with a perfectly smooth surface which has been carefully cleaned to remove all trace of adherent impurity is scarcely attacked by 1% sulphuric acid even after prolonged immersion. The slightest scratch or surface contamination, however, causes bubbles of hydrogen to appear. When hydrogen peroxide is added to the acid the smooth clean surface becomes coated with a black film of lead sulphide, from reaction of the lead in the zinc with the acid, but no gas bubbles appear. It is considered that dissolution of zinc in acids is promoted by extrinsic impurities and continued by the action of local elements set up by the intrinsic impurities.—A. R. P.

***Deposits in White Metal Carburettors.** E. L. Baldeschweiler, G. M. Maverick, and J. E. Neudeck (*S.A.E. Journal*, 1935, **37**, (4), 17–21).—Since the introduction of zinc-base die-cast carburettors cases of stoppage of fuel flow by white powdery deposits have occurred. These deposits contain more than 80% of zinc oxide and are thus caused by corrosion of the die-casting. Tests have shown that this corrosion is not due to the petrol whether it contains lead or not, but is due to the action of water, an action which occurs even in the absence of oxygen. The presence of oxygen and of salts accelerates corrosion, but the presence of petrol retards the corrosion, probably by preventing access of oxygen to the water layer.—A. R. P.

Freezing in Carburettors. Andrew Swan (*Aircraft Eng.*, 1936, **8**, (83), 3–6).—Alcohols used for de-icing carburettors attack magnesium alloys, un-anodized aluminium, and un-anodized Duralumin. Particulars of materials which may be used in contact with various alcohol mixtures are given.—H. S.

***On the Pitting of Rotors and the Trouble of Water Turbines.** Kazuo Kobayashi (*Trans. Soc. Mech. Eng. Japan*, 1935, **1**, (1), 63–70).—[In Japanese, with English summary in suppt., pp. 20–22.] In a report on the results obtained from 167 water turbines over a period of from 10 to 30 years, the effect of the quality of the water on the runners is first dealt with. The waters either contain large quantities of sand and gravel or may show acidity or may include both sand and acid, and sometimes produce severe erosion and pitting, with a serious reduction in the life of the runner. The relation of pitting to specific speed and effective heat is considered for all the turbines, and it is stated that, for a low-speed runner when erosion occurs at the entrance edge, it is suitable to use bronze, and for a high-speed runner, pitting at the outlet vane, cast steel should be used, because it is easily repairable by electric welding. If the pitting and erosion occur at a point which cannot be welded easily the use of phosphor–bronze is recommended.—J. W. D.

Corrosion-Resistant Materials for Gas Appliances. A. L. Ward and W. H. Fulweiler (*Western Gas*, 1935, **11**, (11), 26; *C. Abs.*, 1936, **30**, 1724).—Parts of a pilot valve and thermostats made of brass with less than 63% copper or made with aluminium do not corrode. Brass with more than this % of copper corrodes by forming cupric sulphide—S. G.

***Action of Arsenic Trichloride on the Elements.** E. Montignie (*Bull. Soc. chim. France*, 1936, [v], **3**, 190–191).—Selenium and tellurium are converted into the mono- and tetrachlorides, respectively, by arsenic chloride, lead is superficially coated with arsenic, copper and gold are slowly blackened, and silver is superficially converted into $AsCl_3Ag_3$. Aluminium and bismuth are quite unattacked by the compound.—A. R. P.

The Influence of Acids, Washing Powders, Chemical Sterilizers, and Refrigerating Brines on Metals. O. F. Hunziker (*Proc. 8th Ann. State Coll. Wash. Inst. Dairying*, **1935**, 102–109; *C. Abs.*, 1936, **30**, 2899).—Corrosion problems in the dairy industry are reviewed.—S. G.

***Corrosion of Metals by Oils.** J. Dintilhac (*Métaux*, 1936, **11**, (128), 71–90).—The corrosion of steels, bronzes, regulus, and light alloys by pure mineral oil, castor oil, and stabilized Yacco Aé was investigated on cylindrical specimens half immersed in the oils. The classification for moist oils was: (1) neutral oils, (2) treated mineral oil, (3) acid oil. The attack begins downwards where the moisture starts. The organic acidity of the oil plays a very active part in the presence of water. The attack of steels by the oil appears to compare with that of acid reagents. The action on the bronzes and regulus are identical. Among the light alloys, Duralumin, which is only attacked by alkali reagents, shows no trace of alteration in oils. On the other hand, Elektron, only attacked by acid reagents, is attacked by all the oils. The results are illustrated by 50 photomicrographs.—J. H. W.

***Corrosion of Metals and Alloys in Apiezon Oil [Materials for Oil Diffusion Pump].** Gunji Shinoda (*Nippon Sûgaku Buturi-gakkwai Kizi* (*Proc. Phys. Math. Soc. Japan*), 1935, **17**, 367–368).—[In English.] Low-carbon steel, copper, aluminium, tin, lead, Duralumin, 12%-tin bronze, 40%-zinc brass, Constantan, nickel, and tin–solder were exposed for 1 month to the oil at 170°–175° C., at a pressure of 10^{-2}–10^{-3} mm. Aluminium was most satisfactory on account of the lack of effect on both metal and oil. Steel is best for the outer case of the pump. Solder cannot be used near the heater.—S. G.

***The Corrosive Action on Metals of Solutions of Ammonium Nitrate in Liquid Ammonia.** I. M. Libinson, I. I. Kukushkin, and A. S. Morozova (*J. Chem. Ind.* (*Moscow*), 1935, **12**, 590–597; *C. Abs.*, 1936, **30**, 68).—[In Russian.] Aluminium is not corroded by concentrated ammonia solutions of ammonium nitrate, lead and tin are slightly corroded, iron is severely corroded, and zinc is completely dissolved. The presence of water in the solution increases the corrosion of iron, but when water is entirely removed the vapour pressure of the ammonia becomes too high for practical use. The mechanism of the corrosion is discussed. Oxidation of iron surfaces by such compounds as potassium chromate or coating them with Bakelite lacquers protects the surface. Prevention of dissociation of the ammonium nitrate by addition of calcium chloride or better, $NH_4CO_2NH_2$, also prevents corrosion. The partial pressure of ammonia over solutions containing 70–80% ammonium nitrate at 20° — 6° and 739 — 47 mm. varies from 220 to 450 mm.—S. G.

***Metal Damage by Free Fatty Acids and Leather Damage by Fatty Acid–Metal Compounds.** F. Stather and R. Lauffmann (*Collegium*, **1935**, 541–545; *C. Abs.*, 1936, **30**, 3273).—The loss in weight of metal rings submerged in oleic or stearic acids or train oil fatty acid was measured after various periods up to 60 days. Aluminium, iron, and silver were only very slightly attacked; copper, zinc, and brass considerably.—S. G.

Corrosion-Resisting Materials in the Chemical Industry. Evert Norlin, *et al.* (*Medd. Sveriges Ind.*, 1935, **18**, 68–108).—An introductory address, followed by discussions.—S. G

***Organic Inhibitors of Corrosion.** Charles A. Mann (*Electrochem. Soc. Preprint*, **1936**, April, 353–366).—A theory is presented to explain the mechanism of inhibitor action for organic inhibitors in the acid corrosion of steel.
—S. G.

The Influence of Temperature on the Severity of Corrosion-Fatigue. A. J. Gould (*Engineering*, 1936, **141**, (3669), 495–496).—Includes a description of a constant temperature room 8 ft. long by 6 ft. wide by 6 ft. high.—R. Gr.

***Corrosion and Fatigue. Influence of the Atmosphere.** L. Persoz (*Métaux*, 1936, **11**, (127), 60–65).—The work of Gough and Sopwith (*J. Inst. Metals*, 1935, **61**, 477–506) on the action of atmosphere on the fatigue of metals, and that of Sutton and Taylor on the effect of pickling on the resistance of Duralumin to fatigue are discussed. The resistance of steel and nickel to fatigue under corrosion can be increased by the addition of retarders to the corroding liquid or by surface compression, and also by alternate bending and alternate torsion. (Cf. *Met. Abs.*, 1935, **2**, 229.)—J. H. W.

A Corrosion Test for Cutting Oils. D. Gustav Nolle (*Werkstatt u. Betrieb*, 1936, **69**, (7/8), 93–94).—A simple laboratory method is described of estimating the corrosive properties of cutting oils by exposing to their action strips of polished metal (copper and iron).—P. M. C. R.

The Fight Against Corrosion. II.—Practical Applications. Louis Delville (*Métaux*, 1935, **10**, (124), 285–287).—An introduction to a series of papers on the subject of the corrosion of metals, describing the present state of the question.—J. H. W.

V.—PROTECTION

(Continued from pp. 159–161.)

***The Theory of Passivity. XXIX.—The Theory of the Rectifying Film (Sperrschicht) in Aluminium.** W. J. Müller (*Z. Elektrochem.*, 1936, **42**, (4), 166–175; and *Light Metals Research*, 1936, **4**, (21), 349–367).—Cf. *Met. Abs.*, 1935, **2**, 528. Continues M.'s investigations on passivity. Müller and Konopicky's discovery that an aluminium oxide film is always porous (*J. Inst. Metals*, 1929, **42**, 477) was confirmed by Simon and Jauch (*Z. Elektrochem.*, 1935, **41**, 741). The doubts that S. and J. raise against the electro-osmotic theory of the rectifying effect were proved groundless. The behaviour of aluminium rectifying electrodes of the purest metal (99·998%) in saturated sodium bicarbonate solution was investigated, especially at very low potentials. This behaviour is completely in agreement with the requirements of the electro-osmotic theory. The results are fully discussed.—J. H. W.

Aluminium Coatings in Foundry Practice and Their Testing. J. Teindl (*Hornický věstník*, 1935, **17**, 438).—S. G.

Homogeneous Lead Coating. A. Bilart (*Métaux*, 1936, **11**, (126), 31–37).—Describes in detail the procedure and relative advantages of 2 methods for protecting steels by covering them with a homogeneous coating of lead, using lead foil of the required thickness and a blowpipe. In the most frequently used of these methods a thin layer of a lead–tin alloy (50 : 50 or 40 : 60) is inserted between the steel and the lead, the adherence of the lead being brought about with the blowpipe. This preliminary coating method gives excellent results. The second procedure consists in placing the lead directly on to the steel; although this also gives good adherence, it is less commonly used than the other method.—J. H. W.

†Tinning Copper Wires. C. Bernhoeft (*Wire Industry*, 1936, **3**, (28), 159, 161).—Translated from *Z. Metallkunde*, 1935, **27**, 264–266; see *Met. Abs.*, this vol., p. 10.—W. E. A.

Tinning of Sheet Metal for Manufacture of Gas Meters. J. G. de Voogd and A. van der Linden (*Het Gas*, 1934, **54**, 323–327; *C. Abs.*, 1936, **30**, 2898).—Tinning is not an effective protection against corrosion. Painting with rust-protecting paints is more important.—S. G.

A Review of the Progress in Cleaning, Pickling, Fluxing, and Hot-Dip Galvanizing for the Year 1935. Wallace G. Imhoff (*Amer. Metal Market*, 1936, **43**, (8), 3, 6, 8).—The year's progress in plant and manipulation is reviewed with reference to journal and patent literature.—A. R. P.

Thickness of Hot-Dip Zinc Coatings. Wallace G. Imhoff (*Amer. Metal Market*, 1936, **43**, (67), 3).—The thickness of hot-dip coatings is controlled by the temperature of the bath, the time of immersion, the thickness of the metal being galvanized, the method used in running-off the excess of zinc, the direction and speed of withdrawal from the bath, and the amounts of iron and aluminium in the bath. The effects of all these factors on the thickness of the resultant coating are critically discussed, and methods of controlling them are described.—A. R. P.

Values of Hot-Dip Galvanizing as Protective Coating for Iron and Steel. Wallace G. Imhoff (*Amer. Metal Market*, 1936, **43**, (28), 3–5).—The importance of the hot-dip galvanizing industry is illustrated by statistics of the output of sheet, pipe, wire, hardware and malleable iron castings, and the consumption of zinc in these and ancillary industries.—A. R. P.

Rain from Leaky Roofs and Pickle Fumes Damage Black Stock for Hot-Dip Galvanizing. Wallace G. Imhoff (*Amer. Metal Market*, 1935, **42**, (249), 5–8).—The production of satisfactory galvanized sheets is possible only when the iron is perfectly clean and free from pitting and hence stocks of sheet iron should be stored in a dry place into which rain and pickle fumes cannot penetrate. Some examples are given of the types of damage which can be done to the metal by exposure to drip from leaky roofs and to fume and spray from the pickling tanks.—A. R. P.

***Metallic Cementation. II.—Cementation of Some Metals [Iron and Copper] by Means of Antimony Dust [Continued].** Tsutomu Kase (*Kinzoku no Kenkyu* (*J. Study Metals*), 1934, **11**, (6), 274–282).—[In Japanese.] Continued from *ibid.*, pp. 251–262. See *Met Abs.*, 1934, **1**, 593.—S. G.

***Metallic Cementation. III.—Metallic Cementation [of Iron, Copper, and Nickel] by Means of Aluminium Powder.** Tsutomu Kase (*Kinzoku no Kenkyu* (*J. Study Metals*), 1935, **12**, (2), 120–128; (3), 159–167).—[In Japanese.] Continued from *ibid.*, pp. 49–66 (see *Met. Abs.*, 1935, **2**, 165), and deal, respectively, with the cementation of copper and nickel.—S. G.

***Cementation of Aluminium on Nickel.** Tsutomu Kase (*Japan Nickel Rev.*, 1936, **4**, (2), 345–350).—[In English and Japanese.] Summary of a section of a paper previously published in Japanese only in *Kinzoku no Kenkyu*, 1935, **12**, (3), 159–167 (see preceding abstract).—S. G.

***Metallic Cementation. VII.—Metallic Cementation [of Iron, Nickel, and Copper] by Means of Manganese Powder [Continued].** Tsutomu Kase (*Kinzoku no Kenkyu* (*J. Study Metals*), 1935, **12**, (11), 507–513).—[In Japanese.] Continued from *ibid.*, 478–483. See *Met. Abs.*, this vol., p. 11.—S. G.

Sprayed Metal Coatings. E. L. Mathy (*Metal Progress*, 1936, **29**, (4), 52–56).—The development of the metal-spraying process is described, and the necessary conditions for its successful application (surface preparation, air supply, melting methods) are discussed. The cost and speed of spraying are compared for 9 non-ferrous and 3 ferrous materials, and the mechanical properties of sprayed coatings of zinc, aluminium, copper, tin, lead, and 66 : 34 brass are compared with those of cast and annealed " pure " materials.
—P. M. C. R.

Protection of Alumag in Bimetallic Constructions [by Metallization]. (Mlle.) Nathalie Goldowski (*Métaux*, 1935, **10**, (24), 484).—If Alumag in contact with steel or other metal with a high potential is to be subjected to the action of sea-water, it requires protection. This is best effected by coating the metal with zinc by means of a Schoop pistol.—J. H. W.

***The Metallization of Machine Elements.** W. E. Glidden (*Iron Age*, 1936, **137**, (5), 49–51, 132; (6), 31–33, 53).—The method of coating by metallization, the preparation of the surface, and the characteristics and subsequent treatment of the resulting coating are described. Experiments to determine the tensile strength of sprayed steel are reviewed, and data on the corrosion-resistance of various sprayed metals are given. The order of resistance to corrosion of the coatings tested was: zinc, cadmium, aluminium, lead, tin, stainless steel, copper. The poor behaviour of stainless steel may be due to incomplete covering of the surface by the coating, or to the possible burning out of part of the protective elements in spraying.—J. H. W.

Metallization. M. Cauchetier (*Métaux*, 1935, **10**, (124), 485–487).—Briefly describes the application of metallization for protection under various industrial conditions. See also (Mlle.) S. François, *Met. Abs.*, 1935, **2**, 232. —J. H. W.

Metal Spraying. E. J. Raymond and R. C. Choice (*Modern Engineer*, 1935, **9**, (12), 522–525; **10**, (1), 13–17, 57).—A general account of the process and its applications.—H. W. G. H.

The Painting of Galvanized Iron. J. Stewart Remington (*Paint Manuf.*, 1936, **6**, 94–95; *C. Abs.*, 1936, **30**, 3258).—New galvanized surfaces should be left unpainted for 3–4 months to allow roughening of the surface. Zinc dust paints easily mixed and requiring no subsequent grinding consist of zinc dust 80 and zinc oxide 20%, incorporated with 20% of the mixture: raw linseed oil 80, turpentine 15%, and cobalt lineoleate.—S. G.

Methods of Testing Paints. A. Vila (*Métaux*, 1935, **10**, (124), 491–508).—Describes various methods of testing paints used to protect metals, and the properties of paint films. The tests consist in investigating: (1) the nature of the components of the paint; (2) precautions to be taken during manufacture; (3) the application of a regular, adherent film to the metal. They may be ageing tests, natural or artificially accelerated, or examinations of one particular property of the paint (*e.g.* permeability to water, flexibility, elasticity, hardness, resistance to wear).—J. H. W.

Protection by Tar Paints and Aluminium Powder Against Corrosion of Metal Structures. J. Roux (*Métaux*, 1935, **10**, (124), 509–513).—Describes the methods of testing paint and aluminium powder coatings, their resistance to corrosion, and the conditions under which they are found to be satisfactory. —J. H. W.

VI.—ELECTRODEPOSITION

(Continued from pp. 161–164.)

***Electroplating Aluminium on Metals.—II.** Naoto Kameyama, Tatsuo Yokoyama, Shikao Sato, Tatsuo Inoue, Hiroshi Iida, and Yasuji Torii (*J. Electrochem. Assoc. Japan*, 1935, **3**, 223–232; *C. Abs.*, 1936, **30**, 2498).—[In Japanese.] Cf. *Met. Abs.*, 1935, **2**, 524. The first requisite in aluminium plating is that the metal surface to be plated be free from fats, oils, and rust and highly polished. Deposition is at 90°–130° C., preferably at 110°–130° C. in a closed cell. The electrolyte is mainly aluminium bromide plus 16–18% of potassium bromide and free from iron, at a current density preferably under 1 amp./dm.^{2}, with an aluminium anode. A 10% a.c. superposition on the d.c. favours smooth deposits. The deposition potential is 0·2–0·4 v. Theoretically 335 mg. of aluminium is deposited per amp. hr. A plate of 0·0124 mm. thickness is obtained with 1 amp. hr./dm.^{2}; current efficiency with lead cathode in an iron-free bath is nearly 100%, whereas it decreases to 50–70% when iron is present. Neither organic addition agents nor organic aluminium salts give satisfactory results.—S. G.

***Aluminium Plating from Organic Baths.** R. D. Blue and F. C. Mathers (*Electrochem. Soc. Preprint*, **1936**, April, 257–265).—Aluminium can be electrodeposited, with a cathode efficiency of above 75%, from a bath containing the condensation or reaction products formed when aluminium bromide and aluminium chloride are dissolved in ethyl bromide and benzene. Hydrobromic acid and hydrochloric acid also give condensation products in benzene with aluminium bromide and aluminium chloride, from which aluminium can be electrodeposited. The baths described in this paper are easier to prepare and are less expensive than those described in previous papers.—S. G.

***Electrodeposition of Aluminium Alloys.** R. D. Blue and F. C. Mathers (*Electrochem. Soc. Preprint*, **1936**, April, 267–271).—Most of the heavy metals could be electrodeposited with aluminium as alloys from the aluminium bath (*Trans. Electrochem. Soc.*, 1934, **65**, 25; and preceding abstract) containing aluminium bromide, aluminium chloride, ethyl bromide, benzene, and xylene. The limiting concentration of aluminium for bright deposits varied with the different alloying metals. The deposits generally were dark, granular, and loose, with low concentrations of aluminium. The great number of alloys which could be deposited was due to the fact that the potentials of most of the metals were not far from that of aluminium in the benzene bath.—S. G.

***Electrodeposition of Aluminium in Fused Salts.** S. I. Orlova and V. I. Lainer (*Legkie Metalli* (*Light Metals*), **1935**, (12), 9–17).—[In Russian.] Experiments on the electrolytic deposition of aluminium on iron and copper in fused mixtures of sodium and aluminium chlorides are described. The best results are obtained when the molecular ratio of the chlorides is 1·5–2 : 1, the current density 0·5 amp./dm.^{2}, and the temperature 125°–130° C. When working with double this current density 0·2% of lead chloride is added. The current yield is about 80%.—D. N. S.

Six Years of Observation of Chromium in a Job Shop. William A. Vignos (*Platers' Guide*, 1936, **32**, (1), 11–14).—The causes of failure in chromium plating are briefly outlined, and some practical hints are given for the efficient operation of chromic acid baths to obtain bright plates.—A. R. P.

Calculating Chromic Acid from Hydrometer Readings. Nathaniel S. Hall (*Platers' Guide*, 1936, **32**, (1), 17–18).—A table is given for converting hydrometer readings (in ° Bé) to oz./gall. of chromic acid.—A. R. P.

Modern Organization of a Nickel and Chromium Plating Works. J. Loiseau (*Métaux*, 1936, **11**, (126), 24–30).—Sets out a suitable arrangement of a large plating shop, and describes the equipment and the sequence of operations. —J. H. W.

Nickel and Chromium Coatings of Considerable Thickness. R. de Buyer (*Métaux*, 1936, **10**, (124), 475–479).—Discusses the failure of nickel and chromium coatings and the consideration of 3 factors in electrodeposition: (1) the adherence of the deposit, (2) its thickness, and (3) the shape of the piece coated. The coatings are especially liable to fail in sharp angles if they are not of sufficient thickness. The applications of heavy deposits of nickel and chromium for the protection of machine parts is described. See also Marcel Ballay, *Met. Abs.*, 1935, **2**, 232.—J. H. W.

***The Effect of Oxidizing Agents on Nickel Deposition. II.—Chromic Acid.** A. W. Hothersall and R. A. F. Hammond (*J. Electroplaters' Tech. Soc.*, 1936, **11**, 48–56).—See *Met. Abs.*, 1935, **2**, 606.—S. G.

***Skin Diseases Associated with Nickel Plating.** N. Wedroff (*Arch. Gewerbepathologie u. Gewerbehygiene*, 1935, **6**, 179–196; *Nickel Bull.*, 1936, **9**, (3), 60).—A comprehensive study was made of the nature of the skin diseases produced by contact with the nickel salts used in electrodeposition and of the influence of temperature, concentration, current density, and other variable factors operative in commercial plating. Preventive and remedial measures are discussed, and the importance of mechanization of the process as a means of safeguarding health is emphasized.—S. G.

***Nickel–Cobalt Alloy Plating from Acid Sulphate Solution.** C. B. F. Young and N. A. Gould (*Electrochem. Soc. Preprint*, **1936**, April, 289–298; and *Met. Ind.* (*Lond.*), 1936, **48**, (19), 541–544).—The co-deposition of nickel and cobalt from an acid sulphate solution, using a rotating cathode, was studied. The effects of temperature, agitation, current density, H-ion concentration, and addition agents were determined. Increasing the temperature of the bath resulted in an increase in the cobalt content of the alloy produced. Increasing the speed of rotation of the cathode decreased the nickel content of the resulting plate. A decrease of current density had the effect of decreasing the cobalt content of the alloy deposited. A change in H-ion concentration towards lower acidity resulted in an increase in the nickel content of the alloy deposited. Gelatin added to the solution produced bright deposits at a fairly high current density without noticeable effect on the composition of the alloy.—S. G.

***Alkaline Plating Baths Containing the Ethanolamines. IV.—The Deposition of Nickel–Cobalt Alloys from Solutions Containing Triethanolamine.** C. J. Brockman and J. P. Nowlen (*Electrochem. Soc. Preprint*, **1936**, April, 349–351; and *Metal Cleaning and Finishing*, 1936, **8**, (5), 247–248, 275).—It has been found possible to deposit alloys of nickel and cobalt from solutions containing triethanolamine, nickel chloride, nickel sulphate, cobalt sulphate, and some sodium sulphate. The concentrations of the nickel and cobalt ions may vary within considerable ranges. The current density may vary between 3·4 and 15·5 amp./dm.^{2} (32 and 144 amp./ft.^{2}).—S. G.

***Electrodeposition of Tin Alloys from Alkaline Stannate Baths.** R. G. Monk and H. J. T. Ellingham (*J. Electrodepositors' Tech. Soc.*, 1936, **11**, 39–47).—See *Met. Abs.*, 1935, **2**, 606.—S. G.

***Electrodeposition of Zinc and Cadmium on Aluminium and Aluminium Alloys.** B. K. Braund and H. Sutton (*J. Electroplaters' Tech. Soc.*, 1936, **11**, 57–73).—See *Met. Abs.*, this vol., p. 83.—S. G.

VII.—ELECTROMETALLURGY AND ELECTROCHEMISTRY

(Other than Electrodeposition.)

(Continued from p. 164.)

***Investigation of the Anode Effect.** I. P. Tverdovski and V. G. Zhirov (*Trudi Nauchno-Issledovatelskogo Instituta Legkih Metallov* "*Niisalumini*" (*Trans. Sci. Res. Inst. Light Metals*), **1935**, (10), 33–46).—[In Russian.] The influence was studied of certain admixtures and preliminary treatment of anodes on the value of the critical current density in electrolysis of fused sodium chloride, barium chloride, sodium fluoride, cryolite, and cryolite with 2% of alumina. Addition of up to 2·5% of silica in the electrolysis of sodium chloride, and up to 7% of cupric oxide in cryolite containing 4% of alumina reduced the critical current density from 2·5 to 1·84 amp./cm.^{2} and from 19 to 10 amp./cm.^{2}, respectively, whereas additions of barium oxide and manganese dioxide had little effect. Anodes with a treated surface gave a lower critical current density.—D. N. S.

***Study of the Bismuth Electrode.** D. N. Mehta and S. K. Kulkarni Jatkar (*J. Indian Inst. Sci.*, 1935, [A], **18**, (14), 109–113; *C. Abs.*, 1936, **30**, 1666).—Experiments with the bismuth electrode with interference colours on the surface due to the oxide film show that it may be used to measure p_H within the range 5·0–7·4 only. In the relation $E = E_0 + 0{\cdot}06011\ p_H$ (30°), the average values of E_0 in the useful range for the half cell Bi|Bi oxide|solution with the saturated calomel and normal hydrogen reference electrodes are $-$ 0·2300 and $-$ 0·4737 v., respectively. The temperature coeff. of the Bi|Bi oxide electrode is $-$ 0·0015 v./1°. Energy calculations indicate the existence of Bi_2O in the surface film.—S. G.

VIII.—REFINING

(Continued from p. 165.)

The Refining of Aluminium. R. Gadeau (*Aluminium*, 1936, **18**, (1), 14–18; and *J. Four. élect.*, 1936, **45**, (1), 17–22).—Cf. *Met. Abs.*, 1935, **2**, 365, 497, 655. The production, properties, and uses of aluminium with a purity of 99·99% are described.—A. R. P.

The Rhokana Electrolytic Copper Refinery. Archer E. Wheeler and Henry Y. Eagle (*Bull. Inst. Min. Met.*, 1936, (**379**), 19 pp.; discussion, (**380**), 15 pp.).

IX.—ANALYSIS

(Continued from pp. 165–167.)

Microchemistry : A New Engineering Aid. Charles Van Brunt (*Gen. Elect. Rev.*, 1936, **39**, (2), 88–94).—Deals in a general way with the chemical analytical methods employed when the available material is measured in terms of gammas or micrograms so opposed to what is called the semi-micro or centigramme scale of analysis which can broadly be described as ordinary analysis on a small scale. A gamma is a millionth of a gramme. The method has been found particularly useful for indentifying surface films, and some interesting examples are described.—S. V. W.

***The Assay of the Platinum Metals.** F. E. Beamish and J. J. Russell (*Indust. and Eng. Chem.* (*Analyt. Edn.*), 1936, **8**, (2), 141–144).—When a Ag bead containing 12 times as much Ag as Pt metals is parted in boiling H_2SO_4 most of the Pd and a small part of the Pt, Rh, and Ru dissolve, but the insoluble portion always retains some Pd. The Pd may be recovered by neutralizing the acid to p_H 4 with $NaHCO_3$, boiling with $NaBrO_3$, adjusting the p_H to 6, and boiling for 20 minutes to precipitate PdO_2 which is collected, washed, and dissolved in HCl for precipitation of the Pd with dimethylglyoxime. The residue from the H_2SO_4 parting is digested with 1 : 5 *aqua regia* and, if Au is absent, the solution is diluted and the Pd and traces of Ir and Rh are precipitated by neutralization and $NaBrO_3$ hydrolysis, the precipitate being added to that obtained from the H_2SO_4 solution. The Pt is recovered from the hydrolysis filtrates by boiling with $H{\cdot}CO_2Na$. The insoluble residue from the *aqua regia* treatment is ignited and fused with Na_2O_2 in a Ag crucible. The melt is dissolved in HNO_3 and the solution evaporated to fumes with H_2SO_4. After dilution the Rh and Ir are separated from the Ag (derived from the crucible) by hydrolysis as described for Pd and from one another by Gilchrist's $Ti_2(SO_4)_3$ method.—A. R. P.

Spot and Drop Tests. A Reagent for the Detection of Gold. Luis Rossi (*Quím. e ind.*, 1935, **12**, 277–278; *C. Abs.*, 1936, **30**, 2131).—The reagent is a mixture of equal volumes of a 1% solution of narcotine in concentrated H_2SO_4, a 10% aqueous solution of $SnCl_2$, and a 10% aqueous solution of $FeSO_4$. A drop of the unknown solution is placed on a filter paper and a drop of reagent added. If Au is present a blue-violet to red-violet colour develops. About 0·5 γ can be detected. Cations of the first group interfere by precipitation as chlorides. Pt gives a yellow spot. Sexivalent Mo by reduction gives a blue colour which disappears when H_2O_2 and NH_4OH are added. Other cations do not interfere.—S. G.

Micro-Analysis. II.—Tests for Rare and Common Metals. J. Gordon Pearson (*Chem. Eng. Min. Rev.*, 1936, **28**, (329), 151–154).—Cf. *Met. Abs.*, this vol., p. 165. Describes the solutions required and the methods to be followed in the micro-detection of Mn, Li, Tl, Ta, Ni, Ti, Th, W, Ce, Co, As, $Cu^{\cdot}$, $Cu^{\cdot\cdot}$, formaldehyde, water, nitrites, and F.—J. H. W.

***Distillation and Separation of Arsenic, Antimony, and Tin.** John A. Scherrer (*J. Research Nat. Bur. Stand.*, 1936, **16**, (3), 253–259).—Describes an apparatus and technique for the separation, by distillation, of As, Sb, and Sn from one another and from elements having non-volatile chlorides. The apparatus is made entirely of glass, for it was found that cork and rubber stoppers absorb the vapours to such an extent that significant errors may ensue.—S. G.

***Investigations into the Analytical Chemistry of Tantalum, Niobium, and Their Mineral Associates. XXX.—Observations on Beryllium.** W. R. Schoeller and H. W. Webb (*Analyst*, 1936, **61**, (721), 235–242).—Be is quantitatively precipitated by tannin from alkaline tartrate solutions. U may be separated from Be by precipitation with $K_4Fe(CN)_6$ in HCl solution in the presence of filter pulp. The best separation of Al from Be is effected by fusing the mixed oxides with Na_2CO_3 and extracting the melt with H_2O whereby $NaAlO_2$ dissolves leaving a residue of BeO.—A. R. P.

Quantitative Spectrographic Analysis. Application to the Determination of Chromium [in Chromium-Aluminium Alloys]. Henri Triché (*Bull. Soc. chim. France*, 1936, [v], **3**, 249–254).—The intensity of the Cr lines varies regularly with the concentration from 0·1 to 4% Cr, but with higher Cr contents the results are erratic due to segregation. Under the best conditions the results are accurate to ± 10% of the absolute Cr content.—A. R. P.

***Determining Copper in the Presence of Interfering Elements. A Modified Iodometric Method.** H. W. Foote and John E. Vance (*Indust. and Eng. Chem.* (*Analyt. Edn.*), 1936, **8**, (2), 119–121).—The best results are obtained in a solution of p_H 3·7 containing NaF to prevent the interference of $Fe^{\cdot\cdot\cdot}$ and KCNS to ensure a stoicheiometric reaction. Se, Mn, and As^V do not interfere.
—A. R. P.

Objective Colorimetric Determination of Copper. C. A. Goethels (*Z. anal. Chem.*, 1936, **104**, (5/6), 170–182).—A number of colorimetric methods were tested for sensitivity.—A. R. P.

***Determination of Gold [in Alloys] Without Cupellation.** Julius Donau (*Z. anal. Chem.*, 1936, **104**, (7/8), 257–270).—The alloy is inquarted with the eutectic Zn–Cd alloy at 400° C. in a glass tube through which H_2 is passed. Two inquartations are necessary when the alloy contains Pd. The beads are parted first in 1 : 3, then in 1 : 1 HNO_3. If Sn is present the residual Au is heated with NH_4Cl prior to weighing.—A. R. P.

***Inorganic Complex Compounds in Analytical Chemistry. IV.—Detection and Determination of Mercury.** C. Mahr (*Z. anal. Chem.*, 1936, **104**, (5/6), 241–245).—The solution is made 0·5*N* with HCl and treated with a warm solution of $(NH_4)_2Cr[(NH_3)_2(CNS)_4]_2$ whereby all the Hg is precipitated as $HgCr[(NH_3)_2(CNS)_4]_2$ which contains 23·96% Hg after drying at 105°–110° C. The precipitate can also be ignited to Cr_2O_3 for weighing or the Cr may be oxidized to CrO_3 with H_2SO_4 and $KBrO_3$ for volumetric work. None of the following interfere: Cu, Pb, Bi, Cd, As, Sb, Sn, Mn, Fe, V, Co, Ni, Al, Cr, Zn, Be, Mg, Ca, Sr, Ba. Tl, Au, and Ag are more or less completely precipitated under the same conditions as Hg.—A. R. P.

***On the Oxidimetric Determination of Nickel and Copper as Oximes.** J. Mironoff (*Bull. Soc. chim. Belg.*, 1936, **45**, (1), 1–8).—Ni is precipitated as usual with mono- or di-phenylglyoxime or with benzoinoxime, and Cu with salicylaldoxime; the precipitate is hydrolysed by boiling with $12N$-H_2SO_4 and, after filtration if necessary, the solution is boiled with $Fe_2(SO_4)_3$ and the $FeSO_4$ formed by the reducing action of the hydroxylamine produced by hydrolysis is titrated with $KMnO_4$.—A. R. P.

***On a Volumetric Determination of Palladium by Means of Oximes.** Marcel Gahide (*Bull. Soc. chim. Belg.*, 1936, **45**, (1), 9–14).—The H_2SO_4 solution is treated with a 1% solution of salicylaldoxime and the washed precipitate is boiled with $12N$-H_2SO_4 to hydrolyze the oxime into salicylaldehyde which is expelled by the boiling and $(NH_2OH)_2{\cdot}H_2SO_4$ which is determined by addition of $Fe_2(SO_4)_3$ and titration of the reduced Fe with $KMnO_4$.—A. R. P.

***Contribution to the Microchemical Determination of Silver [in Gold Alloys].** Julius Donau (*Mikrochemie*, 1936, **19**, (2), 108–117).—The alloy is inquarted with the eutectic Zn–Cd alloy (87% Cd) in a current of H_2, the resulting bead is parted in HNO_3 and the Ag precipitated from the solution on a Cu wire, washed, dried, and weighed.—A. R. P.

***The Detection and Colorimetric Determination of Tin by Means of Substituted 1 : 2-Dimercaptobenzenes. A Specific Reagent for Tin.** Robert E. D. Clark (*Analyst*, 1936, **61**, (721), 242–245).—When a solution containing Sn is boiled with thioglycollic acid and a dilute alkaline solution of 4-methyl- or

4-chloro-1 : 2-dimercaptobenzene, a red precipitate is obtained in concentrations of $1{\cdot}2 \times 10^{-7}$ or 5×10^{-7}, respectively.—A. R. P.

***Separation of Stannic Oxide from Various Oxides by Ignition with Ammonium Iodide [and Its Application to the Determination of Tin in Non-Ferrous Alloys].** Earle R. Caley and M. Gilbert Burford (*Indust. and Eng. Chem.* (*Analyt. Edn.*), 1936, **8**, (2), 114–118).—The SnO_2 obtained by dissolution of brasses and bronzes in HNO_3 is always contaminated with small amounts of CuO, PbO, ZnO, Fe_2O_3, and NiO. Correct values for SnO_2 may be obtained by mixing the weighed oxide with 15 times its weight of NH_4I and heating the mixture in an electric furnace at 425°–475° C. whereby the SnO_2 is completely volatilized. The residue is moistened with HNO_3, dried, and cautiously ignited; the difference in weight between this and the original weight represents the true SnO_2. The method is not applicable to material containing As or Sb since both metals are also volatilized by the treatment.—A. R. P.

X.—LABORATORY APPARATUS, INSTRUMENTS, &c.

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

(Continued from p. 167.)

A New Apparatus for Examining Surfaces. A. Salmony-Karsten (*Z. Instrumentenkunde*, 1935, **55**, 502–504; *C. Abs.*, 1936, **30**, 2425).—A diagram and description are given of an apparatus for works' use. The image of a known standard occupies half the field, and the image of the test surface the other half. Photographs indicate its use in examining welds, paints, and varnish surfaces, &c. A photograph shows a special comparison microscope for cylindrical surfaces.—S. G.

***An Electron Microscope for Filaments: Emission and Adsorption by Tungsten Single Crystals.** (Johnson and Shockley.) See p. 196.

A New Small X-Ray Crystal Analysis Unit for 45 Kv. H. J. Zimmermann (*Siemens Rev.*, 1936, **12**, (2), 43–46).—An outline is given of the most important conditions which must be met by an X-ray crystal analysis unit. A description with illustrations is given of a small equipment.—R. Gr.

A New Type of Room Thermostat. W. E. Bardgett and A. H. Jay (*Engineering*, 1936, **141**, (3666), 418–419).—A description is given of a thermostat used in the Research Department of the United Steel Companies, Sheffield, for controlling the temperature of a room where the investigation is undertaken of the creep of metals at elevated temperatures. The sensitive device is a stainless-steel strip 80 ft. long, ½ in. wide, and 0·010 in. thick stretched round the walls of the room, the movement of the strip being magnified. A maintenance of the room temperature to within ± 1° C. or ± 0·2° C. at any particular point is claimed.—R. Gr.

XI.—PHYSICAL AND MECHANICAL TESTING, INSPECTION AND RADIOLOGY

(Continued from pp. 167–169.)

Notes on Inspection of Metals for Artillery and Aircraft Ammunition. J. Purdue (*Modern Eng.*, 1935, **9**, (12), 536–539; discussion, 1936, **10**, (1), 37).—The inspection of steel for shells is described in some detail, and copper, copper alloy stampings, and cartridge brass are dealt with more briefly. Chemical analysis, macro-etching, and the mercurous nitrate test are particularly mentioned.—H. W. G. H.

***The Oxide Film on Aluminium and Its Photometric Test.** Rokuzo Tomii and Yasuichiro Miyakawa (*J. Electrochem. Assoc. Japan*, 1935, **3**, 232–242; *C. Abs.*, 1936, **30**, 2445).—[In Japanese.] The reflectivity of aluminium oxide film formed under different conditions was determined by reading the deflection of a galvanometer put in series with a photocell actuated by the reflected light from the oxide film. The minimum deflection in accordance with the completion of film formation is observed at 15° in 2% oxalic acid, at 30° in 1% chromic acid, and at 50° in 5·5% borax solution with current densities of 8·3, 3·3, and 0·6 ma./cm.^{2}, respectively. In every solution the deflection of the galvanometer decreases rapidly with increase in the duration of electrolysis. However, nearly the same reflection is seen when the amount of electricity passed reaches 200, 80, and 24 ma.-hr. in the respective solutions; this seems to be due to the increase in thickness of the film. This photometric method may therefore be recommended because of its simplicity for the study of oxide films in testing articles with oxide coatings.—S. G.

†**Alloys which are Strong and Non-Oxidizable at High Temperatures.** P. Chevenard (*Chaleur et Industrie*, 1936, **17**, (192), 125–137).—Descriptions are given of equipment for measuring creep at high temperatures, a thermobalance for determining oxidation rate–temperature curves, and a resistivity method for detecting the production of cracks in a sample repeatedly quenched from a high temperature. A review, mainly devoted to ferrous metals, is given of the properties of materials under load at high temperatures. Curves connecting temperature with the mean creep rate between the 25th and 35th hour are given for nickel, a nickel–chromium, and a nickel–chromium–tungsten alloy under various loads.—J. C. C.

Fatigue and Fatigue Testing Machines. —— (*Wire Industry*, 1936, **3**, (27), 115–117).—A short discussion of fatigue as encountered in wire ropes, followed by some general and historical remarks, leads to a description, with diagrams, of a rotating-cantilever testing machine driven by an air turbine, and of an axial-stress (tension compression) fatigue testing machine. The designs are due to H. F. Moore and G. N. Krouse of the University of Illinois. —W. E. A.

RADIOLOGY.

Industrial X-Ray Practice. Robert C. Woods (*Electronics*, 1936, **9**, (2), 7–11).—General.—J. C. C.

***The Protection of Radium Workers from Gamma Radiation. The Protection Afforded by Building Materials.** G. W. C. Kaye, G. E. Bell, and W. Binks (*Brit. J. Radiology*, 1936, **9**, (99), 161–171).—Using up to 7 grm. of radium as the source of radiation, measurements were made of the γ-rays transmitted through from 4 to 23 in. of brickwork, solid steel doors up to 3½ in. thick, and smaller samples of lead, iron, aluminium, coke breeze, and concrete of various thicknesses. The results show that whereas for light materials the absorption is proportional to their densities, when comparing light and heavy elements the relationship requires correction.—S. V. W.

XIII.—FOUNDRY PRACTICE AND APPLIANCES

(Continued from pp. 170–172.)

Castings. W. Machin and M. C. Oldham (*Proc. Inst. Brit. Found.*, 1934–1935, **28**, 361–481; and *Found. Trade J.*, 1935, **53**, (991), 115–117; (992), 135–138, 140; (993), 148–153; (994), 164–168, 170; (996), 209–212; (999), 275–278, 280; (1001), 316–318).—A general survey of foundry practice and the problems encountered in producing large castings in ferrous and non-ferrous alloys. The heat-treatment of castings is discussed, and examples of gun-metal and manganese–bronze castings are considered briefly. Defects of all types are diagnosed and remedies suggested to eliminate them. The necessity for sand control and treatment and the selection of the correct sand for moulds and cores is emphasized. Volume changes between the molten state and the cold solid state call for special consideration in all castings and provide one of the major problems of the moulder. The authors consider that repairs to castings could be carried out more extensively than is at present permitted, and they make a plea for a wider use of established processes for saving castings showing only minor defects. The aim of the paper is the practical consideration of the founders' art, and is instructive.—J. E. N.

Contraction. W. Machin and M. Oldham (*Found. Trade J.*, 1936, **54**, (1028), 343–348).—A study of the causes and elimination of casting stresses in ferrous and non-ferrous castings.—J. E. N.

The Mould-Filling Capacity of Aluminium Castings Alloys. R. Irmann (*Aluminium*, 1936, **18**, (1), 9–13).—Curves are given showing the fluidity, as determined by the spiral casting method, of Silumin, Peraluman 7, Anticorodal, Alufont II, German alloy, and Peraluman 2 at various casting temperatures and mould temperatures. The fluidity decreases in the order given for a casting temperature of 700° C. and a mould temperature of 350° C.—A. R. P.

Aluminium Castings. R. Irmann (*Aluminium*, 1936, **18**, (1), 2–8).—Modern methods of making chill and sand castings of aluminium alloys are described together with several types of electric melting furnaces and a modern coke-fired reverberatory furnace.—A. R. P.

High-Strength Aluminium Casting Alloys. New Materials for Severe Duty. —— (*Met. Ind.* (*Lond.*), 1936, **48**, (16), 458).—An aluminium alloy containing silicon 5, magnesium 0·5, and copper 1·25% is suitable for complicated parts owing to ease of casting, and responds to solution- and precipitation-treatment; is covered by Air Ministry D.T.D. Specifications Nos. 272 and 276. For high strength, the aluminium–copper alloy "N.A. 225" is recommended; this also responds to heat-treatment, but the composition is not stated.

—J. E. N.

The Production of Sound Aluminium–Bronze Castings by the Vacuum Process. Charles O. Herb (*Machine moderne*, 1936, **30**, (327), 137–142).—An illustrated account of the vacuum die-casting of aluminium–bronze pieces.

—P. M. C. R.

On the Preparation of Cold-Rolled Hollander Rails of Phosphor–Bronze. Erich Becker (*Kalt-Walz-Welt*, **1936**, (2), 13–14).—The rolls of the disintegrating mills used in the manufacture of paper are fitted with bronze beating bars or rails 60–120 cm. long, 6–12 cm. wide, and 5–15 cm. thick made of phosphor–bronze containing 7% tin but free from lead and zinc. Ingots for rolling these bars are made by casting the alloy in green-sand moulds containing a small amount of petroleum or coal dust to prevent binding of the sand to the casting. The mould is slightly inclined to the horizontal and is provided with a feeder at the upper end and a riser at the lower, the riser being loosely plugged at the beginning of the casting in such a way that the plug is pushed out by the air pressure when the mould is about one-third full. In this way sound and dense castings are obtained which can be rolled directly to the desired size.

—A. R. P.

The New Barronia [Bronze] Foundry at Gunnersby. —— (*Aluminium and Non-Ferrous Rev.*, 1936, **1**, (7), 320–323).—An illustrated description. Details are included of the characteristics of Barronia bronze and Berdo bronzes Nos. 1, 6, and 7.—J. C. C.

Fifty Rules for the Treatment of Graphite Melting Crucibles in the Foundry. Edmund Richard Thews (*Giesserei-Praxis*, 1936, **57**, (19/20), 211–213).—Fifty rules for the treatment of graphite crucibles are set out in order to obtain: (1) improved quality of product, (2) economy of time, (3) economy of metal, (4) better heat conditions, (5) lower melting loss (through more rapid heating), (6) lower fuel consumption per charge.—J. H. W.

"Questal" Bentonite [Bond for Moulding Sand]. J. N. Wilson (*Aluminium and Non-Ferrous Rev.*, 1936, **1**, (7), 315–317).—Bentonite is a colloidal bond which, when added to moulding sands in amounts up to 3%, increases porosity and strength (green and dry), and reduces the amount of water needed.—J. C. C.

Practical Aspects of Die-Castings. N. D. G. Robertson (*Found. Trade J.*, 1936, **54**, (1027), 317–318; and *Metal Treatment*, 1936, **2**, (5), 29–31, 33).—Read at a joint meeting of the London Local Section of the Institute of Metals and London Branch of the Institute of British Foundrymen. A brief review of the various processes, with recommendations as to choice of die materials and suitability of the alloys to be cast.—J. E. N.

The Production of Zinc Alloy Die-Castings in U.S.A. Herbert Chase (*Met. Ind.* (*Lond.*), 1936, **48**, (19), 529–531).—Zinc-base die-castings are finding increasing applications in the U.S.A. where alloys of great purity are handled with accurate temperature control at high pressures. Careful die design in selected steels reduces trimming costs and wasters. Dimensions are closely adhered to, and distortion eliminated. C. describes the practice at the Schultz factory.—J. E. N.

The Manufacture of High-Purity Zinc and High-Grade Zinc Die-Casting Alloys. D. S. Burwood (*Met. Ind.* (*Lond.*), 1936, **48**, (16), 455–457).—A fractional distillation process yielding zinc of guaranteed purity of 99·99% is described. Control is by comparative spectroscopic analysis, and it is essential that impurities be kept to an absolute minimum. Aluminium and copper are introduced into the alloys as hardeners and magnesium in stick form with special precautions.—J. E. N.

A Brief Study of American Die-Casting Machines. Herbert Chase (*Met. Ind.* (*Lond.*), 1936, **48**, (17), 481–484).—Describes the principles of the most widely used American machines, noting the special features of each, with photographs and diagrams.—J. E. N.

XV.—FURNACES AND FUELS

(Continued from p. 172.)

Industrial Furnace Design. E. F. Baker (*Modern Eng.*, 1935, **9**, (11), 462–465; (12), 526–529).—The relative costs of various fuels are studied, and their application to reverberatory, muffle semi-muffle, and direct-fired furnaces is discussed. The problems of furnace design and construction, and of temperature control, are explained.—H. W. G. H.

Electric Furnace Practice. A. G. Robiette (*Found. Trade J.*, 1936, **54**, (1021), 212–214).—Report of the discussion on a paper by R. See *Met. Abs.*, this vol., p. 129.—J. H. W.

High-Frequency Electric Melting Furnace Equipment. Engineers of the General Electric Co., Ltd. (*G.E.C. Journal*, 1936, **7**, (2), 83–93).—Describes an installation at the works of Jonas & Colver (Noro), Ltd., Sheffield.—S. V. W.

Repairs to Electric Melting Furnaces. Walter Lister (*Metallurgia*, 1936, **14**, (79), 21–23).—Practical methods for repairing the hearth or rebuilding the bottom of an electric furnace are discussed. The making of a non-conductive basic hearth and of an acid bottom are first considered, then two methods are given for the building of a conductive hearth, the first in a Héroult furnace and the second in a Greaves–Etchell furnace.—J. W. D.

Electric Annealing Furnaces and Their Heating Elements. W. Rohn and J. E. W. Ginger (*Metallurgia*, 1936, **14**, (79), 7–9).—For temperatures under 800° C. an alloy consisting of chromium 15–20, nickel 20–30%, and the remainder iron is suitable, whilst for temperatures up to 950° C. a ferro–chrome nickel alloy containing chromium 15–20 and iron 10–20% is usually employed. A nickel–chrome alloy containing nickel 80, chromium 20% and free from iron is adopted for temperatures from 950° to 1100° C., and an alloy consisting of chromium 20–30, aluminium 4–6%, a little silicon, and the remainder iron for temperatures from 1100° to 1250° C. For temperatures between 1250° and 1450° C. ceramic heating elements consisting of silicon carbide are essential. Heating elements give the maximum service in a purely oxidizing atmosphere. Water vapour is not harmful, but carbon and sulphur, especially the latter, are detrimental. Temperature fluctuations reduce the life of the element, and a system of temperature regulation is necessary.—J. W. D.

Electric Furnaces for Bright-Annealing. —— (*Engineer*, 1936, **161**, (4185), 340, 348).—An illustrated description of the Grünewald process. Sealed pots containing the materials to be heated are placed in resistor-type furnaces. A recuperative chamber is used to conserve heat.—R. Gr.

Operating Temperature of Non-Metallic (Carborundum) Heating Elements. Masao Nagai and Kenzo Sumi (*J. Electrochem. Assoc. Japan*, 1935, **3**, 258–261; *C. Abs.*, 1936, **30**, 2497).—[In Japanese.] The temperature that will give good service life is 1400° C., the maximum useful temperature being 1450° C. —S. G.

Use of Pulverized Fuel in Copper Refining. A. G. Mills (*Chem. Eng. Min. Rev.*, 1936, **28**, (328), 94–98).—Discusses the development of the equipment used and the operations carried out in the production of copper wire-bars and refined shapes, using pulverized-coal firing.—J. H. W.

XVIII.—WORKING

(Continued from pp. 174–176.)

†**On the Important Processes and Magnitudes in the Plastic Deformation of Metallic Materials.** Theodor Dahl (*Kalt-Walz-Welt*, **1935**, (11), 81–86; (12), 89–94).—Recent work on the mechanism of plastic deformation of metals is described and critically reviewed.—A. R. P.

Flatting Rolls for Fine Sheet Metal. L. Reichert (*Aluminium*, 1936, **18**, (2), 48–50).—Modern types of flatting rolls are described with reference to illustrations.—A. R. P.

On the Plating of Iron or Steel with All Metals, and on the Use of the Products. Erich von der Neyen (*Kalt-Walz-Welt*, **1936**, (3), 17–20).—Continuous and discontinuous methods of coating iron or steel on one or both sides with corrosion-resistant metals and alloys by welding the two metals together and then cold-rolling the product are described together with the necessary apparatus.—A. R. P.

The Extrusion of Different Metals Resistant to Corrosion. Pierre Roux (*Métaux*, 1935, **10**, (124), 303–304).—Extrusion, even by light passes, enables cast and unworkable aluminium and aluminium alloys to be forged. Copper is extruded into weldless tubes at about 900° C. Tubes of lead, which is the most suitable metal for extrusion, are extruded at 200° C., although lead will flow at 90° C. Zinc, when impure, extrudes badly, and hence the electrolytic metal is always used for extrusion, the temperature being about 150° C. —J. H. W.

The Working of Lead. J. Mahul (*Métaux*, 1935, **10**, (124), 371–390).—Describes in detail the manufacture of lead pipes by extrusion and their applications; also the manufacture of lead foil, and the methods of effecting joins.—J. H. W.

Tellurium–Lead. Société Minerais et Métaux (*Métaux*, 1935, **10**, (124), 391–400).—Tellurium–lead has many advantages over " chemical lead " (lead containing copper), including better mechanical properties and resistance to corrosion. These advantages are set out in detail.—J. H. W.

The Henley Machine for Extruding Lead. P. Dunsheath (*Machine moderne*, 1936, **30**, (326), 107–111).—An illustrated description is given of a machine incorporating a cooling system which ensures a fine and uniform microstructure in the finished product, which is, in addition, free from surface oxidation. The process is especially applicable to comparatively thin sections, *e.g.* of cable-sheathing.—P. M. C. R.

Working Monel Metal. J. Picard (*Métaux*, 1935, **10**, (124), 324–325).—Describes autogenous, arc, spot, and automatic electric welding, tin and silver welding, and brazing of Monel metal, tube-bending and flanging, heat-treatment, cold-working, pickling, and forging. The alloy is either close annealed or air annealed and quenched in water containing 5% of alcohol. When cold-working before annealing does not exceed 20%, subsequent annealing does not completely soften the alloy. More than 20–25% cold-working tends to favour increase in grain-size. The best forging temperature is between 1180° and 1010° C., the period of heating being as short as possible.—J. H. W.

On the Movement of Metal in the Manufacture of Cold-Drawn Hollow Bodies from Plane Sheets. —— Meyer auf der Heyde (*Kalt-Walz-Welt*, **1936**, (1), 1–6; (2), 9–13).—The movement of the metal during deep-drawing processes is determined mathematically and graphically.—A. R. P.

Metallurgical Aspects of Deep-Drawing. II.—Failures and Defects Encountered During Deep-Drawing. J. D. Jevons (*Met. Ind.* (*Lond.*), 1936, **48**, (16), 459–463; (18), 513–517).—See also *Met. Abs.*, this vol., p. 175. Failures and defects in deep-drawing may be metallurgical or mechanical. There has been a growing tendency to use cheaper lower grades of metal than the pressing demands and to reduce the number of draws. Directional distribution of crystal grains and segregates cause failures, whilst correct annealing practice helps in controlling grain-size and finish. Attention to tool design, clearances, and lubrication assist in eliminating other troubles such as fouling, scoring, and buckling. Improvements in casting have reduced faults due to ingot defects. Present causes of difficulty are irregularities of grain-size, in part produced by critical strains and temperatures, and to the use of materials too low in copper content. Alloys containing a trace of beta are especially troublesome, and it is suggested that the " precipitation " of beta in undesirable forms and distribution may produce " waving," and also may lead to a type of " ageing " which initiates season-cracking. [*Note by Abstractor:* The mechanism by which β can be " precipitated " is not stated. The appearance of β as inter-crystalline stringers is not unusual.]—J. E. N.

The Forming of Self-Hardening Aluminium Alloys. H. Hornauer (*Werkstatt u. Betrieb*, 1936, **69**, (9/10), 121–124).—A list of 13 " self-hardening " light alloys is given, with a summary of the ageing conditions for the various alloy series. The influence of storage period and of annealing temperature on tensile strength is shown graphically in the aluminium–copper–magnesium series. Methods of forming certain sections are described and illustrated. Special emphasis is placed on the advantages of salt-bath annealing, precautions regarding which are described. Possible causes of failure are enumerated.—P. M. C. R.

Standard Nomenclature in Stamping Processes Recommended by the A.W.F. [**Ausschuss für Wirtschaftliche Fertigung**]. H. Hilbert (*Werkstatt u. Betrieb*, 1936, **69**, (9/10), 128–130).—A series of definitions of terms in regular use in metal stamping is recommended by the A.W.F.—P. M. C. R.

The Polishing of Hard Metal Dies for Rod and Tube Drawing. Carl Michael (*Draht-Welt*, 1935, **28**, (47), 739–741).—Various methods of polishing and reconditioning hard metal dies are described with reference to diagrams.
—A. R. P.

How Wire is Drawn. A Visit to an English Works. George McDonald (*Wire Industry*, 1936, **3**, (28), 145, 147, 149).—A popular account of a visit to a steel rod-rolling and wire-drawing works.—W. E. A.

Brass Wire Manufacture. A. Walker Fielding (*Wire Industry*, 1936, **3**, (25), 11, 13, 15, 17).—The drawing of brasses in the range 82 : 18 to 60 : 40

presents few difficulties; the higher the copper content the simpler the production of wire. Close temperature control is necessary during casting, and care must be taken, especially with thicker sizes of wire, to guard against the liability to season-cracking. Asbestos wire, used in brake linings, is pot annealed but not cleaned or dipped afterwards. Weaving wire must have a brilliant finish after annealing: continuous tube annealing gives good finish, but the wire is not fully softened and does not weave dead, and F. prefers fully annealed wire cleaned with a dip of potassium bichromate plus nitric acid. Details of the mixture and method of use are given. Centrifugal drying is advised. Stranding wire, for picture cords, &c., may be given a light draft after dipping, using a highly polished diamond and paraffin oil as lubricant. Die angle, lubricant, and annealing furnaces and pans are discussed.
—W. E. A.

†**The Present Position of Fine Mechanical Working [of Metals].** Carl Büttner (*Z. Metallkunde*, 1936, **28**, (4), 91–96).—Modern methods of accurately machining, drilling, threading, and polishing metals and alloys are described.
—A. R. P.

Cutting Speeds in Turning with Hard Metal Tools. —— (*Werkstatt u. Betrieb*, 1936, **69**, (7/8), (Special Suppt. No. 21)).—A table gives normal cutting speeds for copper, 4 brasses, aluminium, and 3 light alloys, and a number of ferrous and non-metallic materials.—P. M. C. R.

Powder Metallurgy. Charles Hardy (*Metal Progress*, 1936, **29**, (4), 63–67).—The production, selection, compression, and heat-treatment of metallic powders are described, with special reference to molybdenum and tungsten. The importance of compressed powder products in the automobile, electrical, and dental industries is emphasized, and the possibilities of alloy production are discussed.—P. M. C. R.

XIX.—CLEANING AND FINISHING

(Continued from p. 176.)

Coloring of Metals. II.—Copper and Brass. Herbert R. Simonds and C. B. Young (*Iron Age*, 1936, **137**, (6), 25–30).—The results of recent research work, including the new colour-by-electrolysis process, are described in some detail, and the colour of the whole range of bronze and brass alloys is tabulated. [*Note:* Part I deals with iron and steel.]—J. H. W.

Metal Colour Finishes. Simple Solution Processes. —— (*Machinery Market*, **1936**, (1853), 26).—A brief note of chemical solutions available for colouring metals.—L. A. O.

XX.—JOINING

(Continued from pp. 177–178.

Riveting Aluminium. A. J. T. Eyles (*Aluminium and Non-Ferrous Rev.*, 1936, **1**, (7), 329).—Workshop notes.—J. C. C.

Gold Solders. K. Bihlmaier (*Mitt. Forschungsinst. Edelmetalle*, 1935–1936, **9**, (8/9), 85–90; (10), 99–104).—The composition, preparation, and properties of various types of gold solders are described in some detail and methods of using the solders are briefly outlined. A useful table showing the melting range of 8-, 12-, and 18-carat solders containing zinc, cadmium, copper, and silver is included.—A. R. P.

The Joining of Light Alloy Sheet with Heavy Metal Sheet. —— (*Illust. Zeit. Blechindustrie*, 1936, **65**, (12), 360–361).—Directions are given for joining aluminium sheet with iron, copper, brass, nickel, Monel metal, lead, and zinc sheet: the approximate strength of the joint is indicated in each case, and a final note summarizes the method and results of corrosion tests.—P. M. C. R.

Welding and Soldering Materials for Aluminium. L. Rostosky (*Autogene Metallbearbeitung*, 1935, **28**, (24), 377–378).—Filler rods should be of almost exactly the same composition as the material to be welded, although an alloy with 4–5% silicon is sometimes used for pure aluminium. This is really a "hard solder," like Alpax. "Soft solders" are lower-melting-point alloys, which produce joints with poor resistance to corrosion.—H. W. G. H.

Gas-Welding Aluminium and Its Alloys. G. O. Hoglund (*36th Ann. Convention Internat. Acetylene Assoc.* (*Cleveland*), **1935**, 11 pp.; also *Met. Ind.* (*Lond.*), 1936, **48**, (1), 5–7; and (summary), *Light Metals Rev.*, 1936, **2**, 220–221; *C. Abs.*, 1936, **30**, 2159).—The effects of welding on characteristics of aluminium alloys are described, especially with regard to architectural, brewery, dairy transportation, and chemical applications. "3 S" aluminium (1·25% manganese) welded with "2 S" (commercially-pure aluminium) rod has been used for constructing acetic acid tanks; "2 S" aluminium drums are used for shipment of 80% or over nitric acid; 99·6% aluminium drums are used for hydrogen peroxide. The resistance of the welds is equal to that of the parent material. "51 S" and "53 S" are the only heat-treatable aluminium alloys adaptable to practical fusion-welding methods.—S. G.

Welding Sheet Aluminium. A. J. T. Eyles (*Aluminium and Non-Ferrous Rev.*, 1936, **1**, (7), 340–342).—Practical notes are given on the oxy-acetylene welding of aluminium and aluminium alloy sheet.—J. C. C.

Sound Welds in Brass. —— Leemann (*Autogene Metallbearbeitung*, 1936, **29**, (3), 37–39; and *Met. Ind.* (*Lond.*), 1936, **48**, (18), 511–512).—Brasses melt at about 850°–900° C. and zinc vaporizes at 918° C., so that blow-holes are usually produced when brass is welded. They may be avoided by using a large excess of oxygen in the blowpipe flame, thus producing a tenacious film of zinc oxide on the surface of the molten weld metal, and preventing vaporization of the zinc. Adequate preheating with a neutral flame is necessary. Similar technique is suitable for bronze and gun-metal.—H. W. G. H.

The Welding of Inconel. A. Boutté (*Rev. Soudure Autogène*, 1936, **28**, (263), 8–9).—Inconel (nickel 80, chromium 14, iron 6%) can be welded by oxy-acetylene, metallic arc, or electric resistance processes. It has extremely low ductility at about 740° C. and care has, therefore, to be taken to avoid contraction stresses. For blowpipe welding, a special flux is necessary to dissolve chromium oxide, and filler rods should have the same composition as the parent metal. For arc welding, heavily-coated electrodes are used on d.c. with reversed polarity. Welds have equal corrosion-resistance to the sheet, the recrystallized zones, caused by the heat of welding, having no detrimental effect.—H. W. G. H.

Welding Nickel and Its Non-Ferrous Alloys. A. Boutté (*Métaux*, 1935, **10**, (124), 341–346).—The weldability of nickel depends to some extent on its sulphur and magnesium content; the presence of 0·15–0·20 silicon is also useful. The electric arc, spot, press, carbon arc, and autogenous welding of nickel, Monel metal, Inconel, and nickel–brass are described.—J. H. W.

Welding Hard-Facings on Drilling Tools. J. Cuthill (*J. Inst. Petrol. Tech.*, 1936, **22**, (150), 205–210).—Hardtool materials are described and classified, and 5 methods of attaching them to drilling tools by oxy-acetylene or arc welding are described.—P. M. C. R.

Welding. E. Jimeno, A. Modolell, and F. R. Morral (*Anales soc. espan. fís. quím.*, 1935, **33**, 696–708; *C. Abs.*, 1936, **30**, 68).—A general survey of welding, giving the outstanding physical and chemical problems, and a macro- and micrographic study of 3 samples of welds shows the structure and hardness in the various regions. X-ray photographs show the defects.—S. G.

Some Recent Developments in Oxy-Acetylene Welding. E. J. Raymond (*Modern Eng.*, 1935, **9**, (12), 540–541; 1936, **10**, (1), 23–27).—The effect of flame adjustment and filler-rod composition on the physical properties of weld metal is discussed primarily with regard to mild steel. The importance of an oxidizing flame for welding brasses, is, however, made evident in a description of " bronze welding."—H. W. G. H.

New Schedule of Oxy-Acetylene Welding. Institut de Soudure Autogène (*Rev. Soudure Autogène*, 1936, **28**, (264), 2–9).—The various methods of blowpipe manipulation are described, with detailed particulars of the technique recommended by the Institut de Soudure Autogène and the speed of welding obtainable. The methods are: " Soudure à gauche " (ordinary leftward welding); " à gauche demi-montante " (leftward welding up a slope); " demi-montante en deux passes " (leftward up a slope in two runs); " à droite " (rightward); " montante à double cordon, ' A ' " (vertical welding from one side); " montante à double cordon, ' B ' " (vertical welding simultaneously from both sides); and also angle and fillet welding, horizontal welding of vertical sheets, and overhead welding. The applications to mild steel are treated fully, but brief particulars are also given for copper, brass, aluminium, nickel, Monel metal, German silver, stainless steel, and lead.—H. W. G. H.

The Use of Bottled Butane Gas in Rural Areas. Theodore Rich (*Engineering*, 1936, **141**, (3669), 496–498).—Mainly concerned with domestic applications, but suggests possible use as a heating medium for brazing and welding jobs in remote districts. Properties and relative costs of heating by this system and gas and electricity are considered.—R. Gr.

***Some Characteristics of Welding Fluxes Affecting the Welding Arc.** Haruhiko Shibata (*Trans. Soc. Mech. Eng. Japan*, 1935, **1**, (3), 247–254).—[In Japanese, with brief English abstract in suppt., p. 72.] An investigation of the effects of welding fluxes on the characteristics of the electric arc, when using ordinary compounds, shows that when one metallic compound is used as a flux, the arc-voltage decreases and the melting time increases as the atomic weight of the metal increases. The melting time of the welding rod is dependent on the arc-voltage so long as the arc-current and other conditions are constant, but when the arc-voltage is low, an instantaneous short-circuit frequently occurs, and on this account the value of the melting-time is apparently far greater than the theoretical value. The arc-voltage usually varies with the polarity of the electrodes, but many fluxes give smaller values when they are of normal polarity than when they are of reversed polarity. Boron oxide, aluminium oxide, and silicon oxide, however, give a much higher arc-voltage when their polarity is normal than when it is reverse. Bare welding rods different in composition and physical properties give different arc-voltages and melting-times when the arc-current is the same, but when coated with the same kind of flux give an arc-voltage and a melting time peculiar to the flux and independent of the kind of core.—J. W. D.

Arc-Welding in Argon Gas. Gilbert E. Doan and William C. Schulte (*J. Amer. Weld. Soc.*, 1936, **15**, (1), 23–27).—An apparatus is described for arc-welding in controlled gas atmospheres. Using extremely pure argon, it was found that a stable arc could not be maintained when the electrode was clean unless the open-circuit voltage was greater than 62 v. and the short-circuit current greater than 110 amp. No crater was formed under the iron arc, so that there was no penetration. The globules at the end of the electrode were detached apparently by gravity only. The melting rates per kw. hr. in argon and in air were approximately equal.—H. W. G. H.

Atomic Hydrogen Welding. A. L. Guest (*Metal Treatment*, 1936, **2**, (5), 17–23).—The equipment used in the atomic hydrogen arc-welding process is described and an account given of the method of its operation. Its principal application is for light sheet steel, in which it rapidly produces strong, neat welds. It is also used for making joints in vacuum apparatus, where slag inclusions must be entirely avoided, and for joining special metals such as stainless steels, Nichrome, nickel, aluminium, and Monel metal. Monel metal can be welded without a flux. Automatic machines have been developed for welding automobile radiators. Cleanliness, speed, and high quality of finish are special characteristics of the process.—J. C. C.

The Various Governing Factors of the Electric Spot-Welding Process and Their Use in Automatic Control of the Welding Conditions. G. Müller (*Elektroschweissung*, 1935, **6**, (12), 221–226).—Mainly electrical.—H. W. G. H.

Spot-Welding Problems. J. H. Zimmermann (*Welding Ind.*, 1936, **4**, (1), 13–18).—See *Met. Abs.*, this vol., p. 178.—H. W. G. H.

Residual Stresses, Distortion, and Welding Procedure. H. W. Townshend and J. L. Adam (*Welding Ind.*, 1936, **3**, (2), 436–441; discussion, **4**, (1), 39–42).—A review of papers read at the Iron and Steel Institute Welding Symposium, with a *bibliography* of 20 references.—H. W. G. H.

Fatigue Tests on Welded and Brazed Joints. L. Doussin (*Bull. Soc. Ing. Soud.*, 1935, **6**, (37), 1939–1959).—Rotating beam tests, with both single- and two-point loading, were carried out on tubes of mild steel, chrome-molybdenum steel, copper and brass, jointed by oxy-acetylene welding, " bronze " welding, silver and soft soldering, and ordinary brazing. For each joint, the effects of varied technique, of stress concentration due to the type of joint, of the length of the overlap, and of the length of the joint were determined. The original must be consulted for the detailed results which indicate, *inter alia*, that increasing the length of overlap above a certain value seriously reduces the fatigue-strength.—H. W. G. H.

Gas Protection for Autogenous Metal Workers G. Stampe (*Draeger-Hefte*, 1935, **(181)**, 3025–3026; *C. Abs.*, 1936, **30**, 2280).—When autogenous welding is carried out in enclosed spaces the poisonous materials are acetylene and its impurities, nitrogen oxides (produced in the electric arc), and vaporized metals such as lead, tin, zinc, antimony, and arsenic, which are present in the form of finely-divided smoke. A snout-type gas mask for protection against these poisonous constituents of the air is described. One modification of the mask contains dark glasses for protection of the eyes.—S. G.

XXI.—INDUSTRIAL USES AND APPLICATIONS

(Continued from pp. 178–182.)

Aluminium as a Domestic and as an Exchange Material; Recent Developments in Its Use. Hans Schmidt (*Aluminium*, 1936, **18**, (1), 21–28).—The properties of aluminium alloys as constructional materials are compared with those of steel and brass, and new uses for the alloys are indicated.—A. R. P.

Application of the Heat Conductivity of Aluminium in Heating Floors, by the Dériaz System. —— (*Aluminium*, 1936, **18**, (1), 19–21).—A system of room-warming using aluminium steam or hot-water heaters laid in the floor is described; it is claimed that this method of heating allows of a better distribution of heat and a better control than does the radiator system.—A. R. P.

Aluminium in the Chemical and Food Industries. —— (*Internat. Aluminium Bureau*, **1936**, 121 pp.).—The object of this publication is to present a correlation of the large amount of research carried out by various investigators into the behaviour of aluminium under the varied conditions of industrial use, together with experiences derived from practical application of the metal. The subjects covered are: methods of testing the corrosion-resistance of aluminium and its alloys; jointing of light metals; surface treatment; erection and maintenance; action of inorganic and organic substances on aluminium; behaviour of aluminium in contact with miscellaneous substances in common use; industrial plant. An index is provided.—S. G.

***Beer Scale and Aluminium.** H. Schnegg and K. Grunert (*Z. ges. Brauw.*, 1935, **58**, 89–91; *C. Abs.*, 1936, **30**, 2694).—Cf. *Met. Abs.*, 1934, **1**, 270, 399. The efficiency of 3 new preparations for removing beer scale was tested. All were in paste form and could readily be applied on vertical surfaces. With "T.S.T.," a new preparation under an old name, when applied for 1½ hrs., the scale could be removed easily by means of a wooden spatula. Strips of aluminium lost 0·40, 1·55, and 7·35 grm./m.^{2} on treatment by the paste for 1, 4, and 24 hrs., respectively. These values correspond to those obtained by treatment with 10% nitric acid. With the second preparation, "B.S.I.," the scale could be removed without a spatula in 40 minutes; aluminium strips lost 0·5, 2·5, and 9·45 grm./m.^{2} after treatment for 1, 4, and 24 hrs., respectively, corresponding to the action of 20% nitric acid. The most efficient preparation was "Mammut–Oxalith"; the scale could be washed off with water 1½ hrs. after application, and aluminium strips lost, after treatment for 1, 4, and 24 hrs., 0·15, 0·55, and 2·5 grm./m.^{2}, respectively. No noxious fumes were evolved with any of these preparations.—S. G.

The Transport of Compressed or Liquefied Gas in Light Alloy Containers. E. J. Drouilly (*Métaux*, 1935, **10**, (124), 467–470).—Describes and illustrates the use of Alumag for the transport and distribution of various compressed or liquefied gases.—J. H. W.

The Packing of Cast-Iron Soil Pipes with Aluminium. M. Mengeringhausen (*Illust. Zeit. Blechindustrie*, 1936, **65**, (16), 487–490).—An illustrated description is given of the use and testing of aluminium wool and aluminium foil as a packing for joints in cast-iron drainage pipes. The revised German Standard Specification for such joints (DIN 1986 U) is summarized.—P. M. C. R.

Building It with Aluminium. R. S. Merritt (*Eng. and Min. J.*, 1936, **137**, 195–198).—Discusses the application of aluminium and its alloys with particular reference to the mining industry. The use of aluminium skips in a mine made it possible to increase the operating depth from 2000 to 3000 ft., and the time required to get men out of a mine was reduced by half. The history and development of aluminium and its alloys are also briefly reviewed. Illustrated.—R. Gr.

Half-Hard Aluminium Alloy Sheets and Strips. —— ((*British*) *Air Min. Specification* No. **D.T.D. 296**, 1936, 4 pp.).—Covers the alloys generally known as NA 57 S. Sp. gr. is not greater than 2·85.—S. G.

Federal Specification for Aluminium Alloy; Forgings, Heat-Treated. —— ((*U.S.*) *Federal Specification* **QQ–A–367**, 1935, 7 pp.).—S. G.

Federal Specification for Aluminium Alloy (Aluminium–Manganese); Bars, Rods, Shapes, and Wire. Amendment 1. —— ((*U.S.*) *Federal Specification* **QQ–A–356**, 1935, 2 pp.).—S. G.

Aluminium Dry Points. H. Pasdermadjian (*Aluminium Ltd., Geneva, Abstract Bull.*, **1936**, Jan. 15; *Light Metals Rev.*, 1936, **2**, (19), 336).—Aluminium plate is now successfully replacing copper for dry points. The light colour enables the sketch to be made directly on the plate with a lithographic pencil. 99% purity soft sheet is used, finished by the Alumilite process. This gives a soft sheet with an extremely hard surface, many impressions being possible from one plate. The dry-point tool easily breaks through the hard coating which is very thin.—L. A. O.

†**Selection of Light Alloys for Aero Engines.** J. R. Handforth (*Metal Treatment*, 1936, **2**, (5), 3–13).—The demands made on constructional materials as a result of recent progress in engine design are discussed. Examples of unusual requirements include, for valve guides, good anti-friction properties at 450°–550° C.; for cylinder heads and pistons low specific heat and good thermal conductivity; and for pistons, specified values of coefficient of thermal expansion. Magnesium alloys are considered to be still in their early stages of development. Their use as forgings is negligible and their heat-treatment costly. In 6 lengthy tables, all the principal American, British, and German wrought and cast aluminium alloys are correlated and classified, details being given of their compositions and properties. In a further table, the alloys

chosen by 10 leading manufacturers for the main non-ferrous components of their aero engines are given. It is suggested that, with the greater reserves of power now becoming available, there will be less need to conserve weight, and light alloys will not in the future be used so extensively unless improvements in their characteristics are forthcoming.—J. C. C.

Duralumin Sheet Structures in Aviation. J. Bally (*Rev. Aluminium*, 1936, **13**, (79), 105–108).—Describes the use of sheet Duralumin in the construction of aeroplanes.—J. H. W.

The Use of Vedal for Hydroplanes. J. Bally (*Rev. Aluminium*, 1936, **13**, (78), 55–60).—Vedal is Duralumin covered on both sides with aluminium, and is very resistant to marine atmospheric corrosion. Its application in the construction of hydroplanes is described.—J. H. W.

On the Importance of the Light-Metal Cylinder Head in Motor Engines. Oskar Summa (*Aluminium*, 1936, **18**, (2), 51–53).—The advantages of light-alloy cylinder heads for internal combustion engines are discussed, examples of complicated heads are illustrated, and methods of casting them are briefly outlined.—A. R. P.

Relative Importance of the Thermal Properties of Surface and Mass in the Cylinder Heads of Explosion Engines. M. Serruys (*Mécanique*, 1936, **20**, (265), 68–69).—Engines having cylinder heads of plain, aluminium-coated, chromium-plated, or copper-plated cast iron with different surface finishes, and of Alpax (rough, polished, or grooved) were submitted to power, efficiency, and knock-resistance tests under stated conditions. The tabulated results demonstrate the importance of the mass rather than the surface properties of the metal. The use of Alpax noticeably improves power and knock-resistance.—P. M. C. R.

Aluminium Pistons. P. B. Jackson (*Diesel Power*, 1936, **14**, (3), 170–173). —The use of aluminium (light alloy) pistons in Diesel engines necessitates certain modifications of design, which are reviewed in detail, with illustrations. —P. M. C. R.

Aluminium Car Radiators. —— (*Aluminium*, 1936, **18**, (2), 58).—The high thermal radiation power of aluminium makes it particularly suitable for car radiators; a suitable construction of high radiating power is illustrated. —A. R. P.

Metal Bus Bodies. William Swallow (*Automobile Eng.*, 1936, **26**, (345), 216–217).—A summary of materials available and the best method for their application includes the light alloys Duralumin and Elektron. These alloys are prominent because of their low weight, resistance to corrosion, and easy working qualities, and can show a strength–weight ratio slightly more than double that of mild steel, and equal to that of high tensile steel strip. In fabricating such alloys for highly stressed structures bolts or rivets for jointing purposes are preferred to welding. Extruded aluminium alloy sections are also suitable and allow of uniform stress distribution.—J. W. D.

Aluminium Bumpers for Motor-Cars. W. Schnorrenberg (*Aluminium*, 1936, **18**, (2), 59–60).—The high elasticity of aluminium bumpers renders them more suitable as shock absorbers than ordinary steel bumpers; an example is given of their behaviour in a collision in which serious personal injury was avoided by the car being fitted with aluminium bumpers.—A. R. P.

Uses of Aluminium Foil in the Home. A. Singer (*Aluminium*, 1936, **18**, (1), 29–30).—Aluminium foil wrappings are useful for keeping meat, bread, and pastry fresh; the foil can also be used for various decorative purposes, examples of which are given.—A. R. P.

Metallization of Optical Mirrors with Aluminium. J. B. (*Rev. Aluminium*, 1936, **13**, (79), 118–119).—Describes the application of aluminium for the metallization of mirrors for large astronomical telescopes.—J. H. W.

Federal Specification for Aluminium Powder; (for) Paints (Aluminium–Bronze Powder). Amendment 2. —— (*(U.S.) Federal Specification* **TT–A–476**, 1935, 1 p.).—S. G.

Principal Applications of Aluminium–Bronze in Cases of Corrosion. R. Loiseau (*Métaux*, 1935, **10**, (124), 369–370).—Briefly describes the applications of aluminium–bronze, containing 8–12% aluminium under conditions in which it is subjected to the action of oxidation, sea-water, and saline solutions, sulphuric and organic acids, and superheated steam.—J. H. W.

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Non-Ferrous Alloys Available for the Use of Industry. High Tensile Bronzes and Brasses. —— (*Aluminium and Non-Ferrous Rev.*, 1936, **1**, (7), 300).—Cf. *Met. Abs.*, this vol., p. 181. Properties and uses are listed of the following proprietary alloys: Immadium II, III, IV, V, and VI, Crotorite IV and V, aluminium–bronzes Nos. 135 and 160.—J. C. C.

Bronze Moulds Developed in U.S.A. Herbert Chase (*Modern Engineer*, 1936, **10**, (2), 91–92).—From *British Plastics*. The advantages of cast bronze moulds for the plastics industry are lower cost than steel moulds and reduction of the amount of machining required. They are particularly suitable for ornamental and similar work for which it would be extremely difficult to machine a steel mould. Beryllium–bronze has been used with considerable success.—H. W. G. H.

Brass Wire Products. Properties and Applications. —— (*Wire Industry*, 1936, **3**, (27), 119, 121, 123, 125).—A review, with extensive extracts, of *Copper Develop. Assoc. Publ.* No. **16**, 1935. See *Met. Abs.*, this vol., p. 61.—W. E. A.

Aluminium–Nickel–Silicon Brass Sheets. (Annealed) (For Sheets not over 24 Inches Wide). —— (*(British) Air Min. Specification* No. **D.T.D. 283**, 1936, 3 pp.).—Covers the alloy generally known as Tungum.—S. G.

Lead Poisoning from Fruit Juices. Julius Duy (*Wien. Klin. Wochschr.*, 1935, **48**, 1413–1415; *C. Abs.*, 1936, **30**, 3108).—Lead-containing enamel and lead pipes leading from the fruit presses accounted for 3 cases of poisoning. —S. G.

Lead Sleeve Cases for Loading Coils. J. E. Ranges (*Bell Lab. Record*, 1936, **14**, (8), 260–264).—Protective cases constructed from lead–antimony alloy sleeves have been introduced to replace the cast-iron or sheet steel cases hitherto used to house loading coils installed either underground or on poles in telephone cable circuits. The new cases are cheap, easy to make and instal, light in weight, and resistant to corrosion.—J. C. C.

Federal Specification for Cable (Armoured and Lead-Covered Armoured) and Cord (Armoured); (600 volt Service and Under). —— (*(U.S. Federal Specification* **J–C–71**, 1935, 15 pp.).—S. G.

Federal Specification for Cable and Wire; Rubber-Insulated, Building-Type, Superageing-Grade (0 to 5000 volt Service). Amendment 1. —— (*(U.S.) Federal Specification* **J–C–106**, 1935, 1 p.).—S. G.

Magnesium Alloy Castings (Heat-Treated). (Suitable for Pressure Work.) —— (*(British) Air Min. Specification* No. **D.T.D. 281**, 1936, 3 pp.).—Covers the materials generally known as Elektron AZ 91 and Magnuminium alloy.—S. G.

Magnesium Alloy Castings (Fully Heat-Treated). —— (*(British) Air Min. Specification* No. **D.T.D. 285**, 1936, 3 pp.).—Covers the materials generally known as Elektron AZ 91 and Magnuminium alloy.—S. G.

Magnesium Alloy Castings (Heat-Treated). —— (*(British) Air Min. Specification* No. **D.T.D. 289**, 1936, 3 pp.).—Covers the materials generally known as Elektron A 8 and Magnuminium alloy.—S. G.

***Durable Nickel Matrices.** Masu Shoda (*Insatsu Zasshi* (*J. Printing*), 1935, **18**, (6), 44–55; *Japan Nickel Rev.*, 1936, **4**, (2), 377).—[In Japanese.] Automatic type-casting machines are widely used, but the single use of type exposes the matrices of the machines to frequent use and thus to great wear and tear. To overcome abrasion S. has used nickel and produced a matrix called Nl.B. that casts type with a highly-polished mirror-like surface. The technique of electrotyping of nickel is difficult, and it is usual to take 2 or 3 weeks to galvanoplastize type of sufficient thickness for practical use. To overcome these difficulties S. invented a speedier process by means of which Garamond matrices in 9-point and 5-go (Japanese type-size classification) can be electrotyped in 3 days. Matrices in 18-point and 2-go sizes can be completed in 5–6 days. The nickel matrices are made by the speedier galvano-plastic process at almost the same cost as that of copper matrices made by the ordinary method.—S. G.

Rhodium Surfaces for Metal Reflectors. Blasius Bart (*Product. Eng.*, 1935, **6**, 308–309; *C. Abs.*, 1936, **30**, 1715).—By electrically depositing metallic rhodium on a master mould, high optical accuracy (of the order of millionths of an inch) can be obtained in metal reflectors. Rhodium has a high specular reflection over a wider colour range than any other reflector material. It is harder than silver, non-oxidizing, resistant to heat, unaffected by industrial and chemical fumes, easy to deposit, requires no polishing and is not colour sensitive.—S. G.

Federal Specification for Tubing; Electrical, Metallic. —— ((*U.S.*) *Federal Specification* **WW–T–806a**, 1935, 5 pp.).—Supersedes No. WW–T–806 (1932).—S. G.

Native (German) Materials for Sanitary Fittings. G. Ehlers (*Illust. Zeit. Blechindustrie*, 1936, **65**, (12), 357–360).—A discussion of possible effective substitutes for copper, lead, and brass in sanitary installations is followed by a tabulated summary of materials at present in use and of possible substitutes, accompanied by brief notes on the efficacy of each.—P. M. C. R.

A Study of the Capping of Cables for Suspension Bridges. —— Magnien and —— Coquand (*Ann. Ponts Chaussées*, 1936, **106**, (2), 145–171).—An investigation of the fracture of cables within the capping included comparative tests on four capping materials—pure (electrolytic) zinc, a 90–5–5 lead–tin–antimony alloy, a 90–10 lead–antimony alloy, and the cadmium–zinc eutectic alloy (83–17). The last-named caused the least deterioration in the mechanical properties of immersed cable strands, and proved the most satisfactory in other respects. Its high cost may, however, render its use impossible, and either pure zinc or the ternary alloy were found to give satisfactory results, given care in construction and proper control of the pouring temperature. See also *Met. Abs.*, 1935, **2**, (13), 735 (Bachet).—P. M. C. R.

Costly Butter Defects and Their Prevention. O. F. Hunziker (*Proc. 8th Ann. State Coll. Wash. Inst. Dairying*, **1935**, 51–59; *C. Abs.*, 1936, **30**, 2652).—Contact of cream or butter with such metals as iron, copper, or copper alloys, and the presence of the salts of these metals in the cream or butter may cause and will intensify chemical deterioration. Other metals or their salts such as tin, nickel, stainless steel, and Inconel are harmless in this respect. The use of rusty milk utensils and cream cans on the farm is the most common cause of metallic flavour in butter. Tallowy flavour is caused by iron and copper salts. The presence of iron or copper and their salts hastens and intensifies fishy flavour in butter.—S. G.

Influence of Metal Salts on Lactic Acid Fermentation. As. Zlatarov and D. Kalcheva (*Biochem. Z.*, 1936, **284**, 12–23; *C. Abs.*, 1936, **30**, 2691).—The inhibiting effect of different metals on lactic acid fermentation increases in the order: manganese, iron, nickel, cobalt.—S. G.

Metal Spraying on Wood. —— (*Engineering*, 1936, **141**, (3664), 381).—Outlines the results of experiments conducted at the Forest Research Institute, India. It was found that metals of low melting point, such as tin, lead, and zinc, when sprayed on wood, reduced its susceptibility to changes in moisture content and dimensions due to variations in the humidity of the atmosphere by from about one-half to one-third. Metals melting at higher temperatures, like brass and copper, do not protect wood appreciably against changes in the atmospheric humidity. Sprayed metal coatings do not protect the wood against absorption of water during soaking, and the amount may be increased in most cases.—R. Gr.

XXII.—MISCELLANEOUS

(Continued from p. 182.)

The Development of the Non-Ferrous Metal Industries in Birmingham. Maurice Cook (*Met. Ind.* (*Lond.*), 1936, **48**, (17), 485–490).—Chairman's Address to the Birmingham Local Section of the Institute of Metals. Historical survey of the origin and growth of the metallurgical industries of Birmingham and district.—J. E. N.

The Aluminium Industry in Soviet Russia. —— (*Aluminium and Non-Ferrous Rev.*, 1936, **1**, (7), 286–287).—J. C. C.

From the History of Aluminium. The Methods of Making Aluminium and Aluminium–Bronze in Hemelingen. W. Kirchner (*Aluminium*, 1936, **18**, (1), 33–36).—Aluminium was first made at Hemelingen in 1886 by heating a mixture of alumina, salt, and tar in a current of chlorine and reducing the resulting sodium aluminium chloride with magnesium in a reverberatory furnace; the process was abandoned on economical grounds in the next year. The metal produced contained aluminium 92–94, silicon 5–7·4, iron 1·2–1·9, and magnesium 0·2–0·3%; the cost of production was 30–35 m./kg.—A. R. P.

The Technical Uses of Copper–Arsenic Alloys in the Pre-Christian Era. Wilhelm Witter (*Metall u. Erz*, 1936, **33**, (5), 118–120).—Examples of tools, weapons, and agricultural implements made of arsenical copper have been found in Egypt, Germany, and South America dating from about 2000 B.C. Generally the alloy contained 93–95% copper and 3–4% arsenic, sometimes with small amounts of nickel, iron, and tin.—A. R. P.

University Training in Metallurgy. —— (*Engineer*, 1936, **161**, (4193), 546).—The university training of personnel for the metallurgical industries is criticized.—R. Gr.

Ionic Acidity (P_H Value); Its Measurements, and Its Applications in Mechanical Industry. M. Déribéré (*Pratique Indust. mécaniques*, 1936, [1], **19**, (1), 9–17).—A discussion of the principle of ionic concentration and of methods of estimating the latter includes a list of 38 indicators, with their critical p_H values. The applications of this conception in electroplating, and the influence of the p_H value of corrosive media on copper, steel, and 6 light alloys, are discussed. A *bibliography* is appended.—P. M. C. R.

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[See *Met. Abs.*, this vol., p. 122.]

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[Reprinted from *Metal Progress*, 1936, **29**, (2), 64–70, 86.]

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***United States Federal Specifications.** *Federal Specification for Aluminium Alloy (Aluminium–Manganese); Bars, Rods, Shapes, and Wire.* Amendment—1. (No. QQ–A–356.) Post 8vo. Pp. 2. 1935. Washington, D.C.: Superintendent of Documents.

***United States Federal Specifications.** *Federal Specification for Aluminium-Powder; (for) Paints (Aluminium–Bronze Powder).* Amendment—2. [No. TT–A–476.] Post 8vo. 1 p. 1935. Washington, D.C.: Superintendent of Documents.

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***United States Federal Specifications.** *Federal Specification for Cable (Armoured and Lead-Covered Armoured) and Cord (Armoured); (600-Volt Service and Under).* [No. J–C–71.] Post 8vo. Pp. 15. 1935. Washington, D.C.: Superintendent of Documents. (5 cents.)

***United States Federal Specifications.** *Federal Specification for Cable and Wire; Rubber-Insulated, Building-Type, Superageing Grade (0 to 5000-Volt Service).* Amendment—1. [No. J–C–106.] Post 8vo. 1 p. 1935. Washington, D.C.: Superintendent of Documents.

***United States Federal Specifications.** *Federal Specification for Tubing; Electrical, Metallic.* [No. WW–T–806*a*.] Post 8vo. Pp. 5. 1935. Washington, D.C.: Government Printing Office. (5 cents.)

[Supersedes Federal Specification WW–T–806.]

Universities Bureau of the British Empire. *The Year-Book of the Universities of the Empire, 1936.* Pp. xxxi + 1080 + 26 + vi. 1936. London: G. Bell and Sons, Ltd. (15*s*. net.)

***Weidlein, Edward R.**, and **William A. Hamor.** *Glances at Industrial Research During Walks and Talks in Mellon Institute.* Cr. 8vo. Pp. x + 238, with 26 illustrations. 1936. New York: Reinhold Publishing Corpn. ($2.75); London: Chapman and Hall, Ltd. (13*s*. net).

Willard, Hobart H., and **N. Howell Furman.** *Elementary Quantitative Analysis: Theory and Practice.* Second Edition, second printing. Demy 8vo. Pp. x + 436. 1936. London: Macmillan and Co., Ltd. (14*s*. net.)

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Industria y química. Published bimonthly by the Asociacíon química argentina, Cerrito 1250, Buenos Aires, Argentina. Volume I, No. 1 (Aug. 1935). $3.00 *m/n* per annum in countries in the Hispano-Pan-American Postal Union, $5,00 *m/n* in other countries.

Revista brasileira de chimica. (Scientia & industria.) Published monthly at Rua 3 de Dezembro São Paulo, Brazil. Volume I, No. 1 (Jan. 1936). $25.00 per annum.

The Science Reports of the National University of Peking. (Continuation of the "Science Quarterly of the National University of Peking.") Published by the University Press, National University of Peking, Peiping, China. Irregular. Volume 1, No. 1 (Jan. 1936). Mexican $2 per year, domestic.

XXIV.—BOOK REVIEWS

(Continued from pp. 187–192.)

Werkstoffhandbuch—Nichteisenmetalle. Abschnitte G-K: **Leichtmetalle.** Herausgegeben von der Deutschen Gesellschaft für Metallkunde im Verein deutscher Ingenieure. Schriftleitung: G. Masing, W. Wunder, H. Groeck. Pp. 174, illustrated. [1936.] Berlin; V.D.I.-Verlag. (Loose-leaf file, R.M. 13.50; ring binder extra, R.M. 5.50.)

In preparing a new edition of this Handbuch, in which the loose-leaf arrangement has been retained, the subject-matter has been amplified, brought up to date, and in many cases entirely re-written. Each data sheet has been prepared by a specialist in his own field and of international repute. The information given is necessarily compressed, but will be found valuable for reference purposes and as giving a general survey of the industrial light metals, particularly those used in Germany. Each data sheet concludes with a brief bibliography, the references being mostly to German sources. The compilers have, in fact, produced a miniature encyclopædia on aluminium and magnesium and the light alloys of which these metals form the basis.

Section G deals with the extraction, physical and mechanical properties, and working of aluminium, and includes notes on anodic oxidation and on the uses of the metal in the chemical, food, and electrical industries. Section H deals with wrought aluminium alloys. Information on the theory and practice of age-hardening is given in 2 data sheets, and the remainder of the Section deals with the commercially important alloys, grouped according to their major alloying constituents. In Section J an account is given of the important casting alloys, grouped in a similar manner, and 3 data sheets are included specifying the most suitable alloys and giving practical details for sand-, chill-, and die-casting, respectively. Section K deals briefly with the extraction and properties of pure magnesium (1 sheet) and at greater length with the properties and technology of Elektron.—H. W. L. Phillips.

Corrosion: Causes and Prevention. An Engineering Problem. By Frank N. Speller. Second Edition. Med. 8vo. Pp. xiii + 694, with 141 illustrations. 1935. New York: McGraw-Hill Book Co., Inc. ($7.00); London: McGraw-Hill Publishing Co., Ltd. (42*s*. net).

In preparing this revised edition of his 1926 work Dr. Speller has succeeded in the difficult task of reviewing all the more important articles on corrosion written since that time and of presenting to the reader a clear picture of the present state of knowledge. While the work is intended to apply more particularly to iron and steel, Dr. Speller's treatment of the subject is so comprehensive that the book is really indispensable even to those whose interest in corrosion is mainly non-ferrous.

Part I (284 pages) deals with the mechanism and theories of corrosion, the influence of internal and external factors, the principles and methods of corrosion testing, and the relative corrosion of ferrous metals. Part II (327 pages) deals with preventive measures and their application in atmospheric and under-water corrosion, the methods of de-activation and de-aeration in closed systems, the prevention of corrosion in steam power plant and in heating systems, in chemical industries, in metals buried underground, and concludes with a chapter on stray current electrolysis. The appendix contains notes on methods of calculating corrosion damage, certain chemical analyses, the retardation of corrosion in refrigerating plants, and on resistant materials suitable for specified chemical purposes.

There is a selected bibliography of about 330 references in addition to those given in the text which number about 500. The indexing of the work is excellent.—R. May.

Wire-Drawing and the Cold-Working of Steel. By Alastair Thomas Adam. Second Edition. Cr. 4to. Pp. 160, with 67 illustrations. 1936. London: H. F. and G. Witherby, Ltd., 326 High Holborn, W.C.1. (35*s*. net.)

In a second edition of this book, published 11 years after its first appearance, the subject-matter is presented, as originally, in such a way as to interest the user rather than the manufacturer of wire; the book deals almost exclusively with steel wire. Successive chapters treat of the raw material and its preparation; wire-drawing; heat-treatment and its effects on structure and properties; the effect of cold-work on physical properties—hardness and tensile strength, elongation, torsion, bending, elastic properties, fatigue, density, electrical and magnetic characters, and corrosion-resistance; and the effect of heat-treatment after cold-work. The chapters dealing with cold-rolled strip and with theories of plastic flow have been omitted, while a new chapter is devoted to typical applications of wire—chiefly spring and rope making (this revision has the effect of making inapposite the references to chapter numbers in the reprinted preface to the first edition). Reference is made to modern wire-drawing and -testing machinery. A short section of the chapter on wire-drawing deals with the nature of the flow in drawing: brief reference is made to some of the work of Atkins and of Thompson and his co-workers, but none to that of Körber, of Taylor and Quinney, and of several other workers in this field.—W. E. Alkins.

Finishing Metal Products. By Herbert R. Simonds. Med. 8vo. Pp. x + 337, with 147 illustrations. 1935. New York: McGraw-Hill Book Co., Inc. ($3.65); London: McGraw Hill Publishing Co., Ltd. (21*s.* net).

Under modern conditions the complexity and competitive nature of industrial life are such that no matter how useful an article may be for its intended purpose it cannot be sold successfully unless it conforms to the purchaser's idea of surface appearance; it must not only *be* good it must also *look* good. The idea of this book is to instruct the small manufacturer in the art of making his metal wares look attractive to the purchaser by applying a modern type of finish. The various chapters are to a large extent a reprint of a series of articles on metal finishing from a sales point of view which were published recently in *Iron Age*. The author commences by discussing the commercial aspect of finish and appearance, then goes on to describe the preparation of the metal to receive the finish, and finally describes various types of finish under the headings: polishing and buffing, plating and spray coating, painting, and special finishes.

The book is printed in a large clear type and is profusely provided with illustrations and diagrams of apparatus used in the finishing processes and of typical commercial products provided with artistic finishes. The subject-matter is well written in a manner which is easy to read and understand even by the non-technical personnel of the works, and it is really to these that the book is intended to appeal. From a technical point of view it is doubtful whether there is enough detail to justify the price; the subjects are dealt with in rather a general manner and the majority of the technical men concerned in metal finishing are probably fully conversant with most of the points discussed. From the point of view of the purchasing agent and the salesman there is much of value, and to such the book can be thoroughly recommended.

—A. R. Powell.

Fortschritte des Chemischen Apparatewesens—Elektrische Öfen. Herausgegeben von Adolf Brauer und Josef Reitstötter. Dargestellt an Hand der Patentschriften des Deutschen Reiches unter Mitwirkung Zahlreichen Fachgenossen mit Unterstutzung der Dechema, Deutsche Gesellschaft für chemisches Apparatewesen, E.V. Imp. 8vo., Lief. 2: Pp. 65–176 + Patentregister; Lief. 3/4: Pp. 89–448; Lief. 5: Pp. 177–192 + Patentregister; Lief 6: Pp. 193–236 + Patentregister. 1935–1936. Leipzig: Akademische Verlagsgesellschaft m.b.H. (Br., R.M. 28; subscription price, R.M. 20; members of Dechema, R.M. 20 each part; complete volumes, Br., R.M. 168; Lw., R.M. 172.)

These are the five succeeding volumes of the series of which the first was reviewed in *Met. Abs.*, 1934, **1**, 541. As will be remembered, the subject of these volumes is the story of the technical development and application of the electric furnace in its many forms, as told by German patent literature.

Each of these volumes may be divided into two parts, the first of which contains descriptive matter relating to the various features of electric furnace practice and phases of their application. The second part, in each case, is a chronological series of abstracts some of which include a schematic diagram of the invention.

Volume 2 deals in its descriptive section (which is a continuation of the same part of Vol. 1) with coreless induction furnaces, their development, electrical equipment, inductor coils, movement of metal, lining, and other details. It also treats other types of induction furnaces, namely those with a partially closed iron circuit and with means of auxiliary heating. This concludes the survey of the types of furnaces begun in the first volume, and a review is commenced of the characteristic mechanical and constructional features of furnaces, including preheating mechanisms, discharging, stirring, and safety devices. All this descriptive matter throughout is carefully sub-divided under numerous headings, each of which has its pertinent list of German patent specifications.

The second part of Volume 2 gives the abstracts of German patent specifications from about 1910 to 1921.

In volume 3 the first part is a continuation of the review of mechanical and operating features dealing with such diverse subjects as sealing devices, furnace linings and walls, current regulation, electrical equipment, cooling mechanisms and crucibles. The second part deals with German patent abstracts from 1921 to 1924. At the end of this volume there is a useful numerical list of British Patent specifications under Class 39 (" Heating by Electricity ") dating from 1911 to 1930. These are, moreover, sub-divided under suitable headings referring to types of furnaces, furnace parts and appliances, and methods of operation and application.

The descriptive matter in volume 4 is particularly interesting and is concerned with metallurgical features such as the direct production of iron, the production of pig iron, the refining of steel, the melting and treatment of non-ferrous metals, graphite, carbides, and chemical applications. The abstracts in this volume date from about 1924 to 1929.

The fifth volume does not contain much descriptive matter of interest to the metallurgist. It is short and deals with applications of furnaces in the ceramic and refractory industries and then goes on to deal with laboratory furnaces and those used in industrial chemistry. The abstracts from specifications date from about 1929 to 1931.

The last volume continues the subject of the chemical applications of the electric furnace dealing with the production of such compounds as carbon disulphide, phosphorus, silica, nitrogen fixation, ammonia, &c. It also describes annealing, hardening, and drying processes. The abstracted patents in this *Journal* also cover the period 1929 to 1931. This volume contains a short supplementary list of British patent specifications and a complete names index to all the abstracted German specifications.

The volumes are characterized by their thoroughness and completeness. The important or " key " patent specifications are illustrated and are given very fully. The work as a whole should be particularly useful to those interested in the history, development, or design, of electric furnace parts, since the fund of information contained in it could not otherwise be obtained without much un-remitting labour. The binding and paper are possibly not commensurate with the price of the book, but for those interested, the subject-matter will be found of good value.—A. G. Robiette.

A Systematic Handbook of Volumetric Analysis. By Francis Sutton. Twelfth Edition. Revised throughout, with numerous Additions, by A. D. Mitchell. Demy 8vo. Pp. xvi + 631, with 128 illustrations. 1935. London: J. and A. Churchill, Ltd. (35*s.*)

Sutton's Volumetric Analysis is the " Grand Old Man " of text-books on chemical analysis, but, in spite of the fact that it was born in 1863, every succeeding edition sees a complete rejuvenation to keep it fully abreast of modern technique and methods. Our scientific grandfathers used it at college and as a work of reference in their consulting and commercial practice with every confidence; their grandsons can equally well follow their example with the new edition with the sure knowledge that it will not fail them in any respect. Dr. Mitchell has performed the difficult task of bringing the veteran up-to-date with commendable thoroughness and discrimination, a task in which he has been ably seconded by Dr. Glasstone, who has written a concise account of modern potentiometric methods, and by Dr. Thomas, who has completely revised the section on gas analysis. Volumetric methods are included for the first time for molybdenum, tungsten, thallium, and tellurium, and among the new reagents discussed, the use of which in volumetric analysis has effected considerable improvements in technique and accuracy, are hydroxyquinoline and ceric sulphate. To make room for these improvements various little-used methods have been deleted so that the size of the book remains practically the same as in the eleventh edition, published 11 years ago. Throughout the book the unit of volume is the ml. instead of the c.c.; in a preliminary chapter the reasons for this change are explained.

To sum up, the book in its revised form lives up to the high standard set by the original author and is worthy of an honourable place on the bookshelves of all chemists who use volumetric methods, whether for the analysis of organic or inorganic materials. As a reference book it is invaluable to experienced analysts, and as a text-book it can be thoroughly recommended to all students as the best in the English language.—A. R. Powell.

Technical Data on Fuel. Edited by H. M. Spiers. Fourth Edition, Revised and much Enlarged. Cr. 8vo. Pp. xvi + 358, with 66 illustrations. 1935. London: The British National Committee, World Power Conference, 36 Kingsway. (12*s.* 6*d.*)

One of the abiding, and as I think, the most valuable product of the world conferences, has been the publication of " Technical Data on Fuel," now in its fourth edition. It is unnecessary to give a list of the contents of the volume. The book is well known to all fuel technologists in whatever branch of industry they may be engaged. Metallurgists are thoroughly familiar with the value of the publication. Let me say that the book is really indispensable to anyone concerned in any industry where heat is employed. Metallurgists will be interested principally in the sections devoted to gaseous, liquid, and solid fuels, heat transfer, pyrometry, and metals and alloys. Here they will find all the data they are ever likely to require in the practice of their profession. The tables of constants have been nicely arranged, and an index extending over 14 pages makes reference to any special subject a very easy matter. The book is very well printed on good paper and is nicely bound. It is assured of a hearty welcome and a ready sale.—J. S. G. Thomas.