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Journal of the Institute of Metals,
1935, Vol. LVII.

Vol. 2. Part 8

The Monthly Journal of the
INSTITUTE OF METALS

BIBLIOTEKA POLITECHNIKI KRAKOWEJ

and

METALLURGICAL ABSTRACTS

AUGUST, 1935

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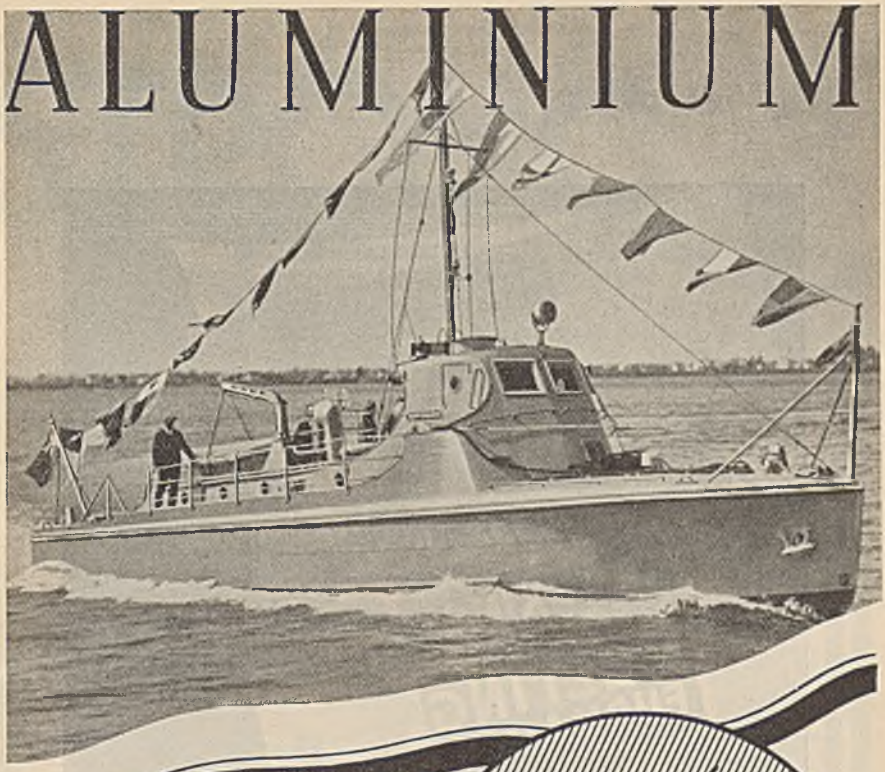

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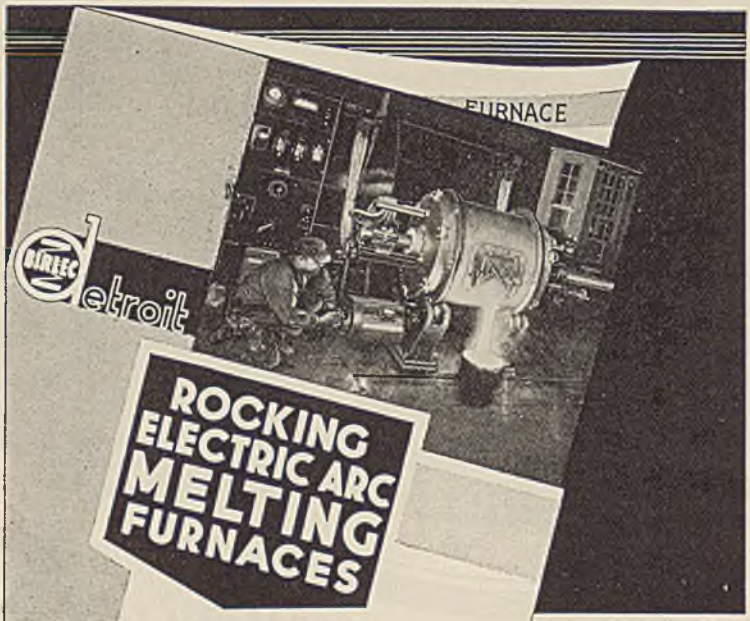

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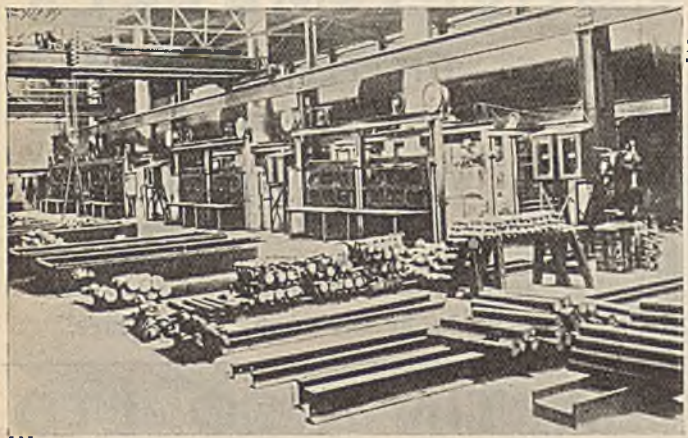

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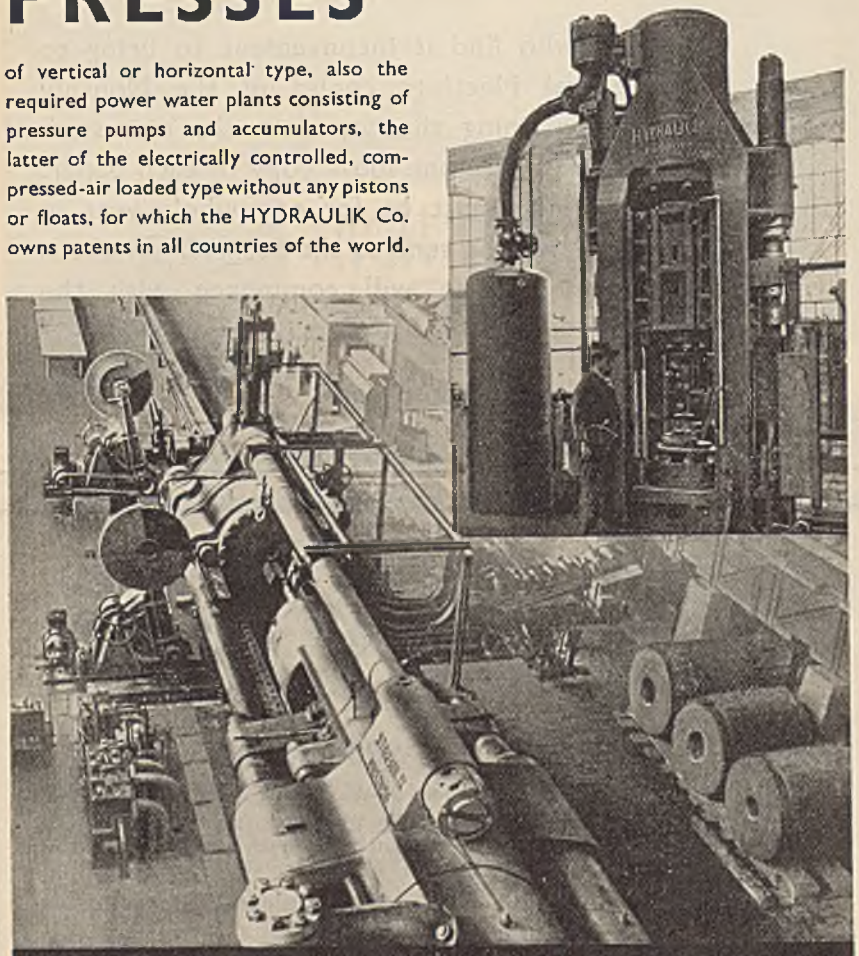

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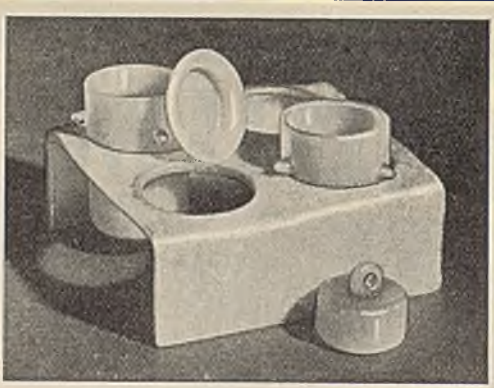

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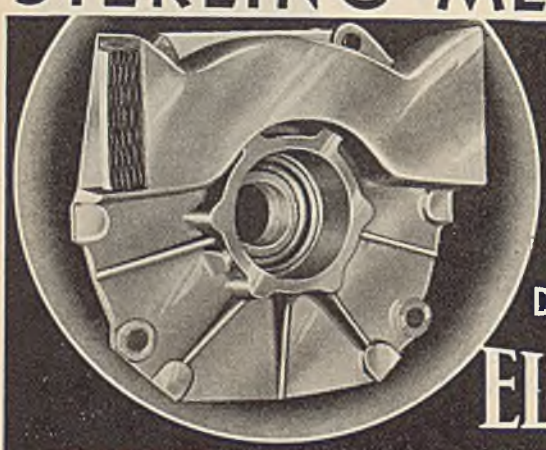

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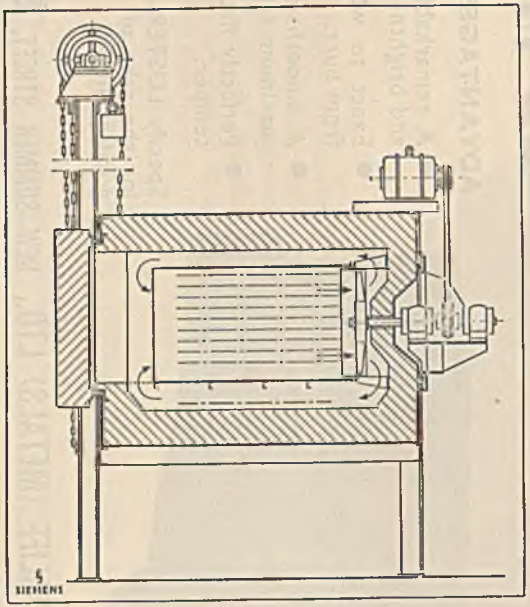

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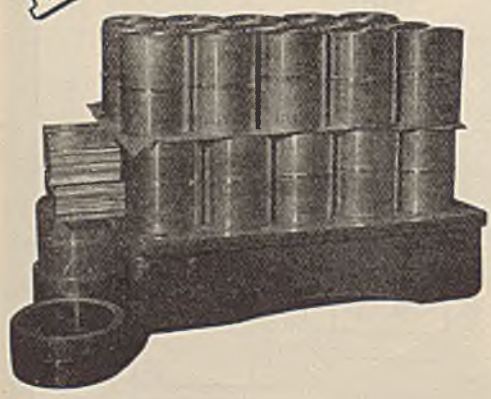

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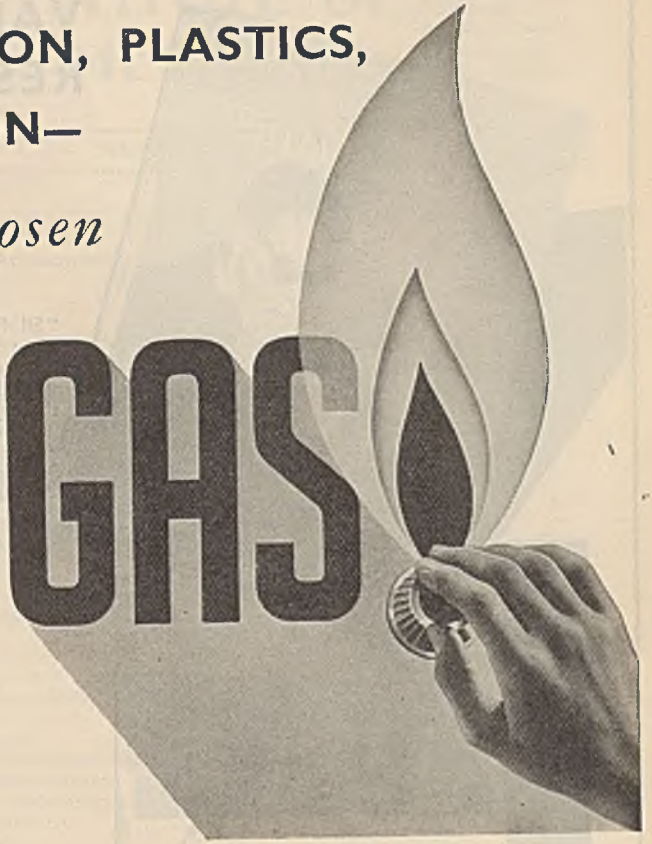

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Volume 2 AUGUST, 1935 Part 8

POLITECHNIKA ŚLĄSKA BIBLIOTEKA GŁÓWNA Gliwice

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INSTITUTE NEWS AND ANNOUNCEMENTS

Annual Autumn Meeting, Newcastle-upon-Tyne, September 9–12, 1935.

ALL members should have received a copy of the programme of this meeting, at which it is hoped there will be a large attendance. The meeting is the first to be held by the Institute in Newcastle since 1911. **Members who expect to be present should return immediately the reply form which accompanied the programme.** Duplicates of these documents, which were posted on July 12, can be obtained on application to the Secretary by members who may have mislaid, or may not have received, them.

Particular attention is directed to the General Discussion following the Autumn Lecture, which constitutes the opening function of the meeting in the evening of Monday, September 9. After Dr. Brownsdon has delivered the Lecture on "Metal Melting: its Effect on Quality," in concise form, a few members will speak briefly on different aspects and an open discussion of the subject will follow. Members who desire their contributions to the discussion to be published in the *Journal* are requested to submit a brief *résumé* of their contributions before October 1; no reporter will be present. After the discussion there will be an informal gathering of members and their ladies in the neighbouring University Union, where light refreshments will be available.

Members who have not yet booked accommodation at Newcastle should communicate without delay with the hotels listed in the programme, or with Mr. C. E. Pearson, M.Met., Armstrong College, Newcastle-upon-Tyne, who is reserving accommodation in the University Hostel, which has been kindly placed at the disposal of members attending the meeting. By staying at the hostel members will find that opportunity for social intercourse which is so valuable a feature of the Autumn Meetings. Members are, therefore, strongly urged to make use of the hostel facilities.

Members are reminded that they can proceed from London (and certain other centres) to Newcastle not only by rail but also by steamer and motor coach. A sea service is run from London by the Tyne–Tees Steam Shipping Company. Steamers leave the Free Trade Wharf, London Bridge, on Wednesday and Saturday, returning from Newcastle on Wednesday and Saturday. The cost of a first-class passage is 20*s.* single, or 35*s.* return. A road service between London and Newcastle is run by United Automobile Services, Limited. The first coach of the day leaves the Victoria Coach Station, London, at 7.30 a.m., and arrives at Newcastle at 7.54 p.m. The single fare is 20*s.* and the return fare 32*s.* 6*d.*

Candidates for membership whose applications are in the Secretary's hands by noon on August 29 will be entitled to take part in all the functions connected with the Newcastle meeting.

International Congress of Mining, Metallurgy, and Applied Geology.

Members are invited to take part in the International Congress of Mining, Metallurgy, and Applied Geology, to be held in Paris in October next. The metallurgy section of the Congress has Professor Albert Portevin as its President, whilst Professor P. A. J. Chevenard is one of the Vice-Presidents. Both of these gentlemen are well-known members of the Institute of Metals. Full particulars of the Congress can be obtained on application to the Commissariat Général du Congrès, 1 Rue Montgolfier, Paris (3e).

Shipping, Engineering, and Machinery Exhibition.

Members are invited by Messrs. F. W. Bridges & Sons, Limited, the organizers of the Thirteenth Olympia Shipping, Engineering, and Machinery Exhibition (incorporating the Foundry Trades' Exhibition), to visit the Exhibition and take tea together on Thursday, September 19. Invitations to members resident in

the British Isles will be despatched towards the end of the present month. Overseas members should already have received similar invitations, but duplicates may be obtained by such members, on their arrival in London, from the Secretary of the Institute of Metals, 36 Victoria Street, S.W.1.

The Exhibition will be open at Olympia from September 12 to 28, but the free tickets that are being issued to members are available only on "Institute of Metals Day," September 19.

Supper-Dance.

The Council has agreed to co-operate with the London Local Section in arranging on Friday, December 6, a Supper-Dance similar to that which was held so successfully last year at Thames House, Millbank. Particulars of the arrangements will be forwarded in due course to all members of the London Local Section; members of other Local Sections are cordially invited to take part.

Next Year's Meetings.

The Twenty-Eighth Annual General Meeting of the Institute will be held in London on March 11 and 12, 1936, the meeting again taking place, thanks to the courtesy of the Institution of Mechanical Engineers, in the Hall of that Institution. The Annual Dinner will be held in the evening of March 11, at the Trocadero Restaurant, Piccadilly Circus. Visits to works and other places of interest to members are being arranged for the afternoon of March 12.

The Twenty-Sixth Annual May Lecture will be given, also in the Hall of the Institution of Mechanical Engineers, on May 6, 1936. The name of the Lecturer and the subject of the Lecture will be announced in due course.

Papers for the Journal.

The Council will be glad to receive papers, or offers of papers, for publication in the Institute's *Journal*. Members who expect to submit papers shortly, should advise the Secretary of the subject and approximate length of their communications, which should be forwarded in duplicate. Intending authors, before preparing their manuscripts, should refer to the notes to authors to be found on p. 4 of the *Monthly Journal*, January, 1935.

Annual Subscriptions.

All members, except those who pay their subscriptions by means of Bankers' Orders, should have received notifications from the Secretary to the effect that their subscriptions are now due for the current financial year, which began on July 1, 1935. The amount payable is £3 3*s*., or £1 1*s*. in the case of Student Members. *The Finance Committee earnestly requests members to be good enough to remit their subscriptions without requiring the despatch of further "reminders."* In this way there will be saved to the Institute a considerable sum representing the cost to the Institute—in postage, stationery, and clerical labour—of sending out subscription "reminders." By paying their subscriptions promptly members not only obviate this unnecessary expenditure, but they also ensure the undelayed receipt of their *Journals*.

Lecturers for Canada.

Professor Alfred Stansfield, D.Sc., A.R.S.M., of McGill University, Montreal, Canada, visited London last month. He informed the Secretary that he was interested in the work of the Montreal Chapter of the American Society for Metals, which has a membership of more than 180, and holds monthly meetings. These meetings are often addressed by representatives of American firms which consider that in this way they are advertising their own products. At a recent meeting of the Executive the wish was expressed that the Chapter might have some speakers from England, and it was suggested that some English firms whose representatives were visiting Canada on business might be able to arrange for them to give addresses at some of the meetings of the Montreal Chapter. It was also thought that there might be some representa-

tives of British Universities who would be willing to speak at a meeting if they were giving other lectures in Canada.

Professor Stansfield will be glad to be put into touch with some English metallurgical firms or individual lecturers who would be willing to arrange to give lectures to the Society in Montreal during the coming session. Correspondence should be addressed to the present Chairman, Mr. F. O. Farey, Messrs. Donald-Hunt, Limited, Montreal, Canada.

PERSONAL NOTES

Herr Dr. A. Burkhardt, until now a research worker in the Metallurgical Laboratory of the Metallgesellschaft, Frankfurt-am-Main, has assumed, since August 1, the direction of the newly-erected research laboratory and alloys department of the Bergwerksgesellschaft Georg von Giesche's Erben, Magdeburg-Rothensee.

Mr. J. E. Chard has recently obtained his A.R.S.M. and B.Sc. (First Class Honours), being awarded also the Bessemer Medal and Glorney Prize of the Royal School of Mines. Mr. Chard has been appointed to the Brown-Firth Research Laboratories, Sheffield, where he took up his new duties on August 12.

Professor Pierre A. J. Chevenard will shortly vacate the Chair of Metallurgy in the École des Mines, St. Etienne, and will assume the duties of Scientific Director of the works of the Société Anonyme de Commentry-Fourchambault et Decazeville.

Mr. Thomas C. Gilchrist, Metallurgical Works Assistant at the St. Rollox Works of the London, Midland & Scottish Railway Company, has recently been transferred to Crewe Works.

Mr. H. H. A. Greer has proposed that the Institute should set up a Suggestions Book. If this were done he would wish to include in it the following: To Copper, Brass, Nickel, Aluminium, &c., Manufacturers: How better can you stimulate trade than by arranging for your agents or local managers to become members of the Institute of Metals, thus meeting in happy conditions those like-minded, having a "non-ferrous mentality"? Unity is Strength: Disintegration is weakness. Pull together!

Mrs. Harold Heywood (Frances D. Weaver) has been awarded the degree of Ph.D. (internal) by the University of London for a thesis on "Antimony–Tin–Lead Alloys."

Dr. H. Moore, C.B.E., President, represented the Institute at the Jubilee Celebrations of the North-East Coast Institution of Engineers and Shipbuilders, held in Newcastle-upon-Tyne last month.

Met. Eng. Sergius A. Pogodin, Senior Scientific Specialist of the Section of Metallic Equilibria (Institute for General and Inorganic Chemistry, Academy of Sciences of U.S.S.R.) was awarded the degree of Doctor of Chemistry, for his research work on metallography and corrosion of metals, by the Academy of Sciences of U.S.S.R.

Professor Albert M. Portevin has been nominated Ingénieur *honoris causa* of the University of Liége.

Dr. C. J. Smithells, M.C., has been appointed by the Council as Chairman of the Publication Committee in the place of Dr. R. Seligman, who asked to be relieved of the chairmanship owing to the pressure of other duties.

Deaths.

Dr. Arthur Bramley, A.R.C.S., died on July 19. He was Head of the Department of Pure and Applied Science, Loughborough College, and had been a member of the Institute since 1921.

Mr. G. C. Klug died suddenly, at Chester, on July 16. An Australian, Mr. Klug had been a member of the Institute since 1918.

GENERAL INDEX

TO

THE JOURNAL

AND

METALLURGICAL ABSTRACTS

Vols. 26 (1921) to 55 (1934)

Members are requested to order their copies of the above at an early date, as the publication of this Index can only be proceeded with if a sufficient number of orders are secured in advance.

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AN INVESTIGATION OF THE NATURE OF CREEP UNDER STRESSES PRODUCED BY PURE FLEXURE.*

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SYNOPSIS.

The paper deals with the results obtained in a study of the stresses and strains arising when a material is subjected to bending moments in conditions which produce creep. For experimental reasons, it was necessary to use a material which would creep at air temperature, and for this reason lead of commercial purity was chosen. Apparatus was constructed by which a beam of lead was subjected to uniform bending moment, and measurements of the creep of the beam were recorded. The whole equipment was housed in a chamber maintained at constant temperature. Tensile creep tests on the material of the beam were also carried out at constant temperature in order to provide stress–strain data for the calculation of the stresses in the beam.

The investigation led to the following conclusions: (1) in the case of a lead beam creeping under stresses produced by pure flexure, plane sections continue to remain plane; (2) the redistribution of stress arising from creep is complete within one-fifth of an hour after application of a bending moment, and the stresses continue unaltered with time; (3) the behaviour of the beam under flexure may be fairly computed solely from the relations between tensile stress and rate of strain corresponding to any period of tensile creep testing on the material of the beam.

INTRODUCTION.

MANY structural components are subject to complex systems of stress which, at high temperatures, give rise to creep. Among the more simple cases of complex stress is that which arises in a part subject to flexural stresses. Considerable experimental difficulties are associated with an investigation of the creep of a metal at high temperatures under flexural stresses, but advantage may be taken of the fact that a soft metal, such as lead, at air temperature simulates the behaviour of steel at high temperature. In the work here to be described, a pure lead beam was subjected to flexural stresses at a temperature of 21·5° C.

The objects of the investigation were:

(1) To determine the nature of the distribution of strain in a lead

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beam of rectangular section creeping under stresses produced by a uniform bending moment.

Theoretical considerations suggest that the law of proportional distribution of strain, which holds in the case of a beam bending under elastic conditions, should also hold when the strain is of a plastic nature. McCullough,[1] also experimenting with a lead beam (99·88 per cent. lead), obtained results which showed a 6 per cent. deviation from proportionality in the outside fibres of the beam. This was due, he suggested, to end effect produced by the beam-end clamping devices. The results of McCullough's work were received after the initiation of the present investigation, but it was considered desirable to proceed with the investigation since better experimental evidence was considered necessary before the proportional strain distribution law could be assumed valid.

(2) To determine the nature of stress distribution in the beam during the progress of creep.

It was considered that ordinary tensile creep tests on beam material would provide stress–rate of strain relations which would be of direct application in the calculation of fibre stresses in the beam from the rates of creep in beam fibres. McCullough made the assumption that all fibres of the beam settle down to their minimum rates of strain, and that the corresponding stresses are those which give the same minimum rates of strain in ordinary tensile creep tests. The authors considered it was unnecessary to make such an assumption, and believed it would be found possible to determine the stress distribution in the beam at any period of creeping from a consideration of the tensile stress–rate of strain curves at that period.

(3) To make an analytical study of the experimental results with a view to establishing simple relations between creep in bending and in tension (or compression).

Particulars of the Lead Sample Used.

The lead was supplied in the form of a block 4 ft. in length, and of section 8 in. by 2¼ in., and was stated by the suppliers to be well-rolled and homogeneous. The composition of the lead was:

	Per Cent.
Bismuth	0·0063
Iron	0·0008
Copper	0·0008
Tin	trace
Lead (by difference)	99·9921

From each end of the block a length of $4\frac{1}{2}$ in. was cut; these lengths being used for tensile creep test-pieces. The remainder of the block was used for a beam test-piece; its central portion, which was to be subjected to uniform bending moment, was machined all over to the dimensions 15 in. long by 7 in. deep by 2 in. wide.

Prior to the bending tests, tensile creep tests were carried out on specimens machined from the $4\frac{1}{2}$-in. portions of material taken from both ends of the block. These tests showed that there were considerable differences in the creep properties of the material from the two ends of the lead block, but the photographs (Fig. 13, Plate I), illustrating the structures of the end sections (*A* and *B*) are very similar, and do not offer an explanation of the differences in creep properties.

It was, of course, impossible to investigate the tensile creep properties of the material of the actual beam before the bending tests, but at the conclusion of the latter, creep tests were carried out on specimens taken in a longitudinal direction from top, centre, and bottom portions of the gauge-length, and a photograph (Fig. 14, Plate II), was taken showing the structure of a section through the beam. Both the creep tests and photograph indicated reasonably good uniformity in the material across the section of the beam. The creep curve forms of the material from the beam and from end *A* of the block were similar, but differed from that of material from end *B* (see Appendix II).

Although the condition of the beam after the bending tests was not necessarily a true indication of its original condition, it appeared unlikely that considerable modification had taken place during the bending tests. The maximum creep in outside fibres of the beam after the two bending tests described later was only 1 per cent. It appeared reasonable, therefore, to conclude that the portion of the beam under the bending test was initially reasonably homogeneous; support for this conclusion was given by the fact that the beam bent with central neutral axis.

Description of Apparatus.

The arrangement of beam and testing equipment is shown in Fig. 1. The ends of the beam, each being 12 in. long and 8 in. by $2\frac{1}{4}$ in. in section, were clamped between machined and fitted channel sections. The supporting knife-edges passed through the beam in steel guides situated on the neutral axis, and could be reversed to permit reversed bending of the beam. At one end the overhanging knife-edges rested on a pair of rigid, level plates, and at the other end on a similar pair of plates supported on roller bearings. A bending moment to the beam was applied by adding equal weights to the scale pans on the loading bar, which was supported by links from the rigid arms 50in., in length,

fixed to the ends of the lead beam. The beam was supported on a rigid table composed of steel sections.

The strain at various fibres of the beam was measured by four microscopes, two on either side of the beam. Measurements were made on a series of small stainless-steel pegs screwed into the beam faces, 8 in. apart horizontally, and at vertical intervals of $\frac{1}{2}$ in., giving measurements at thirteen horizontal sections of each beam face. The faces of the pegs were highly polished and carried two or three very fine vertical scratches crossed by one horizontal scratch. Strain measurements were corrected for temperature and other variations by reference to readings taken on a lead reference bar resting immediately under the beam and carrying four stainless-steel pegs. It is considered that extensions on an 8 in. gauge-length in the beam could be measured to an accuracy of about $\pm$ 0·004 mm.

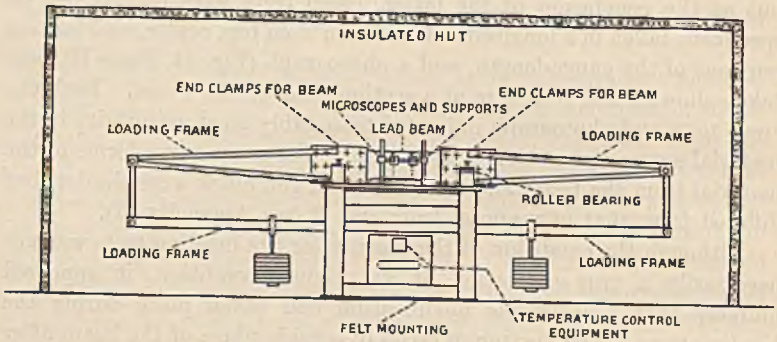

Fig. 1.—Creep in Bending Testing Machine.

A simple mirror extensometer resting on the top of the beam registered the strain in the top fibre. Three Ames' dials placed on the top of the beam were used to provide a rough indication of the curvature of the top surface during creep.

For the tensile creep tests a loading frame giving accommodation for four concurrent tests was constructed. The whole of the above testing equipment was housed in an insulated hut, maintained at a temperature of 21·5° $\pm$ 0·2° C. by means of a heating unit and thermostat.

Determination of the Distribution of Strain During Creep.

Tests have been carried out at bending moments of 13,340 and 17,152 in. lb. corresponding with maximum equivalent elastic fibre stresses of 817 and 1050 lb./in.^{2}, respectively.

Measurements of strain under the bending moment 13,340 in. lb.

were made at all fibres on six occasions during the first day of test, and thereafter twice daily for 7 days. After unloading, an extensometer determination of creep recovery in the top fibre was made. When creep recovery was complete the beam was reloaded to a bending moment of 17,152 in. lb. and periodic measurements of strain in the thirteen fibres were made during a 30 hours' test. The beam was then unloaded, and, when creep recovery was complete, the beam was reversed and the larger bending moment applied until the beam was straightened.

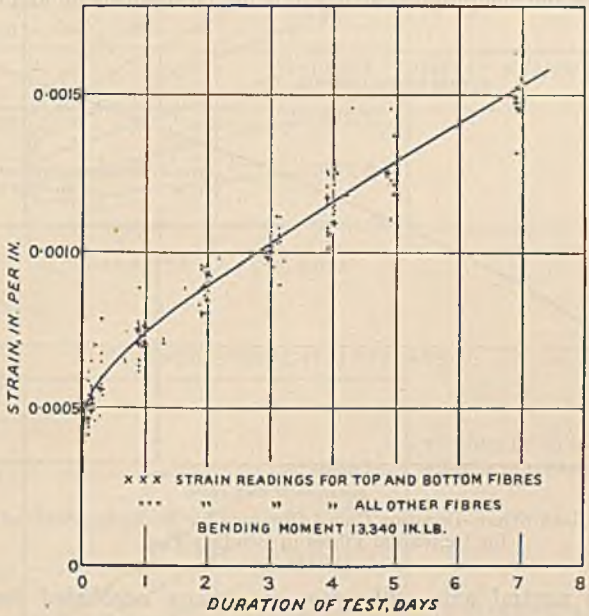

Fig. 2.—Mean Strain–Duration Curve Obtained by Modifying Scale of Curves for Individual Fibres.

If plane sections are to remain plane the creep curves in all fibres must be similar in form, and the strain in any fibre must be proportional to the distance of the fibre from the neutral axis.

The following analytical procedure with regard to the strain measurements was therefore adopted. The strain readings of the outside fibres were first plotted against time, then those of inside fibres were plotted to an increased scale in the inverse ratio of the relative distance of the fibre from the neutral axis; thus, readings for a fibre half-way between the top fibre and neutral axis were increased in the ratio 2 : 1. The mean curve through the points so obtained was then drawn.

Figs. 2 and 3 show the mean curves obtained for the test at bending moments of 13,340 and 17,152 in. lb. It should be noted that individual errors in readings for inner fibres are magnified, up to 6 times, in these diagrams. Curves similar to Figs. 2 and 3, reduced in scale according to the fibre in question, have been superimposed on the plotted strain–duration readings for each fibre in Figs. 4, 5, and 6. Within the limits of accuracy of the measuring equipment the superimposed curves are good mean curves for the readings obtained in each fibre, and leave no doubt regarding the similarity of creep curve forms in all fibres and the proportionality existing between strain and distance

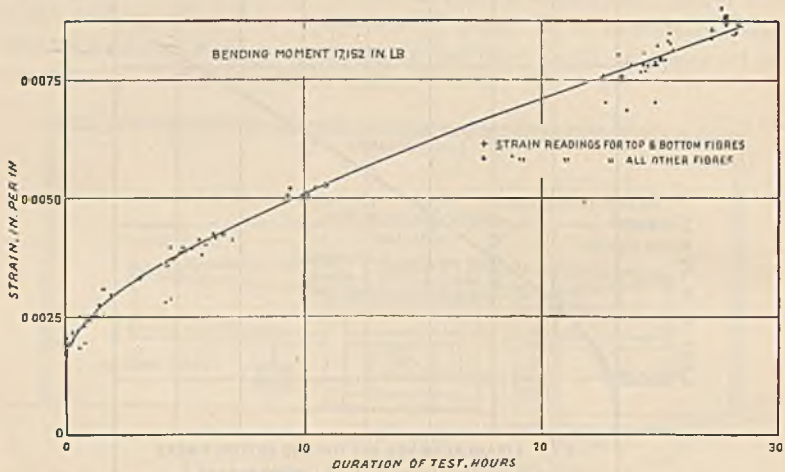

FIG. 3.—Mean Strain–Duration Curve Obtained by Modifying Scale of Curves for Individual Fibres in Bending Test.

from the neutral axis. *Therefore, it appears established that plane sections remain plane throughout the whole period of creep in the beam under uniform bending moment.*

DETERMINATION OF THE DISTRIBUTION OF STRESS IN THE BEAM.

For computation of the re-distributed stresses in the beam use was made of the results of tensile creep tests from material taken from the end *A* of the lead block. As already explained, the results of creep tests from the two ends, *A* and *B*, were different; even specimens taken from the same end (*A* or *B*) showed appreciable differences in creep rate for the same stress. The least uniform portions of lead were those near the outside surfaces of the block which were machined away for the bend test-specimen.

Creep under Stresses Produced by Pure Flexure

To determine the stress distribution in the case of the bend test at 13,340 in. lb., tensile creep tests at stresses from 300 to 700 lb./in.^{2} were

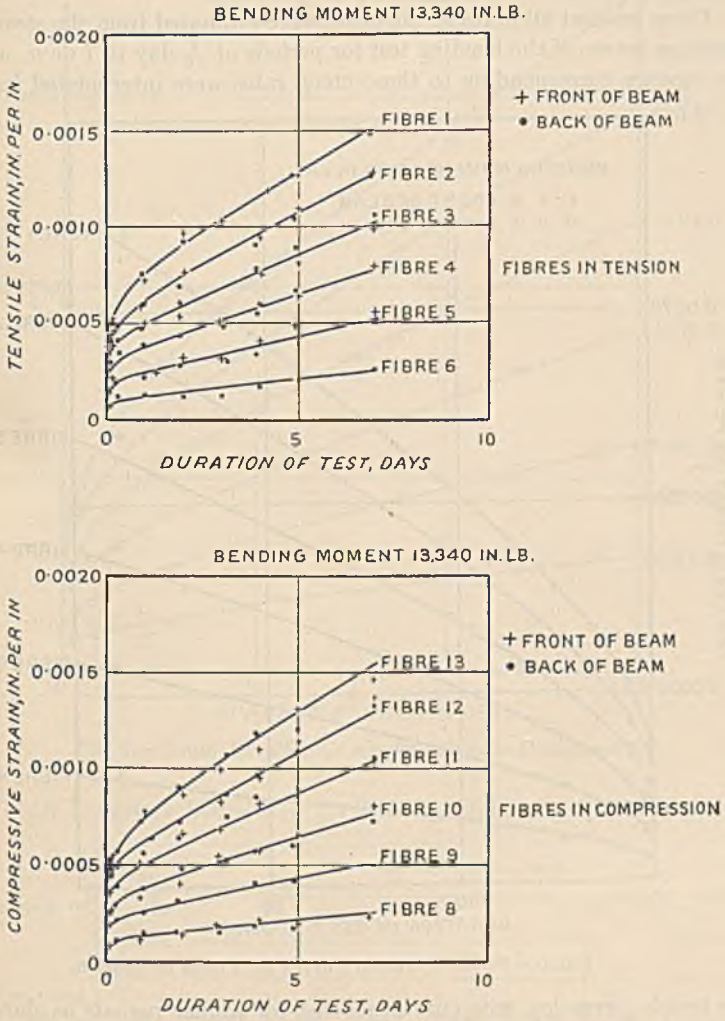

Fig. 4.—Strain–Duration Curves for Various Fibres.

carried out on specimens chosen from as uniform a portion of the lead block as possible.

It was observed that the strain duration (creep) curves *under constant stress* in the tensile creep tests were of similar form for different stresses,

and this form was also the same as the strain–duration curve of each fibre in the beam. Thus, evidence was obtained that *the stress in any fibre of the beam remained constant during bending.*

Creep rates at all fibres in the beam were estimated from the strain–duration curves of the bending test for periods of $\frac{1}{20}$ day to 7 days, and the stresses corresponding to these creep rates were interpolated from

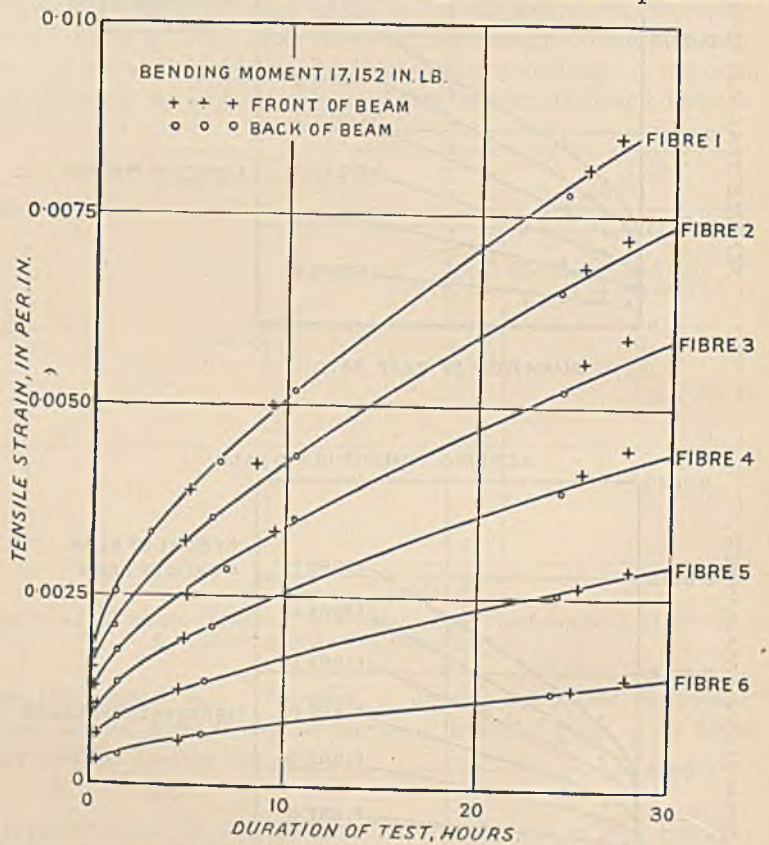

Fig. 5.—Strain–Duration Curves for Fibres in Tension.

the tensile stress–log. rate curves, plotted for similar periods as shown in Fig. 7. The creep rates plotted in Fig. 7 were measured at various time intervals during the tensile creep tests on " as received " material. It was possible to determine the creep rates for the early periods of these tests since a large number of accurate extension readings could be taken during these periods. The results of the interpolation are shown in Fig. 9, and recorded in Table I, from which it will be seen that the

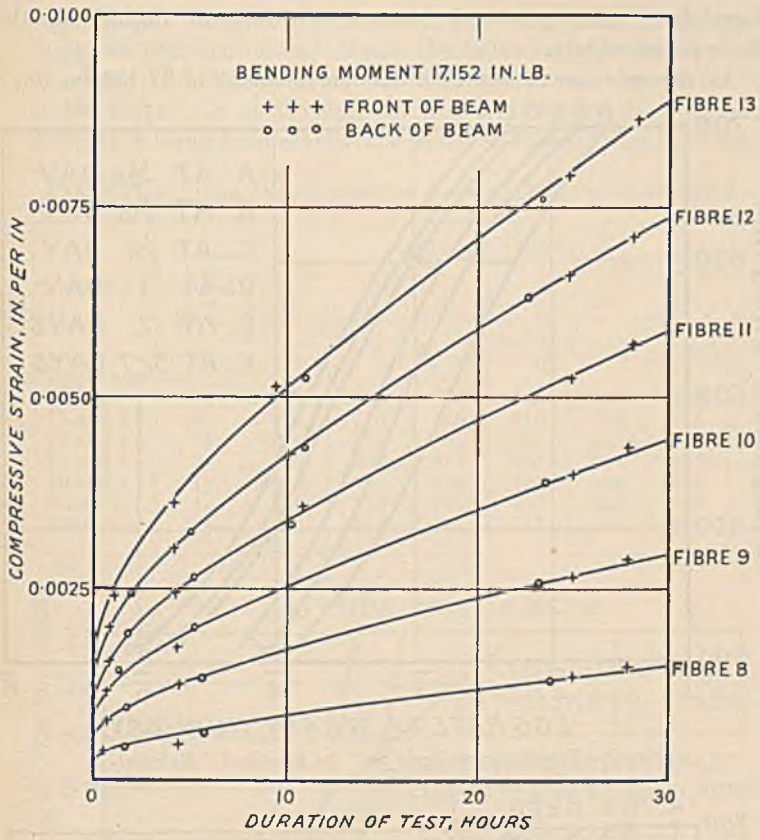

Fig. 6.—Strain–Duration Curves for Fibres in Compression.

Table I.—*Stress Distribution for Bending Moment of* 13,340 *In. Lb.*

Fibre No.	Distance from Neutral Axis, Inches.	Time after Loading, Days.						
		$\frac{1}{10}$.	$\frac{1}{10}$.	$\frac{1}{2}$.	1.	2.	5.	7.
		Stress, Lb./in.².						
Upper and lower .	$3\frac{1}{2}$	485	485	483	480	478	486	482
13 and 1 .	3	471	468	467	467	463	473	470
12 and 2 .	$2\frac{1}{2}$	455	454	449	451	446	455	455
11 and 3 .	2	440	431	426	429	425	438	437
10 and 4 .	$1\frac{1}{2}$	413	405	399	404	400	414	416
9 and 5 .	1	379	368	362	370	369	375	385
8 and 6 .	$\frac{1}{2}$	338	318	318	330	330	336	340

stress distribution remained constant within ± 10 lb./in.² for the whole period of test.

In the subsequent test at a bending moment of 17,152 in. lb., a

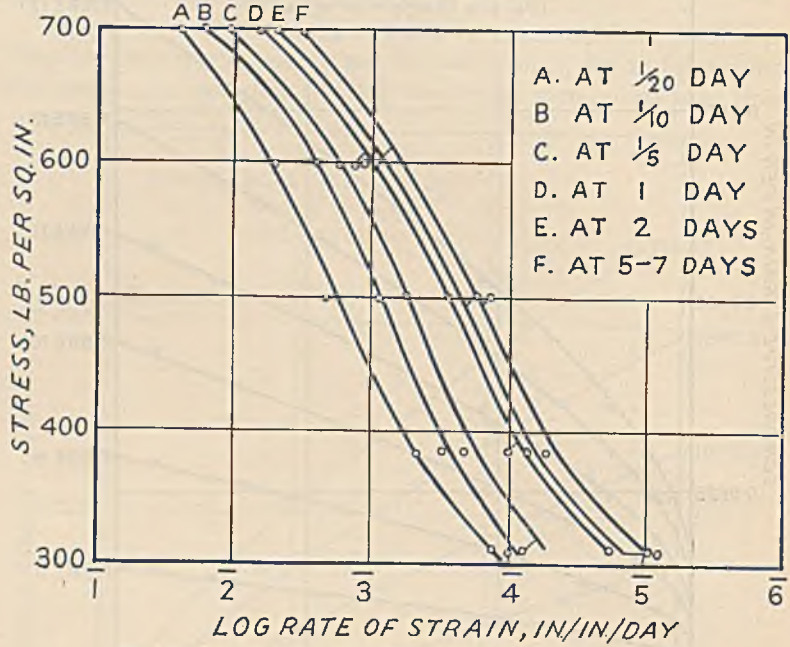

FIG. 7.—Tensile Creep Tests on "As Received" Material.

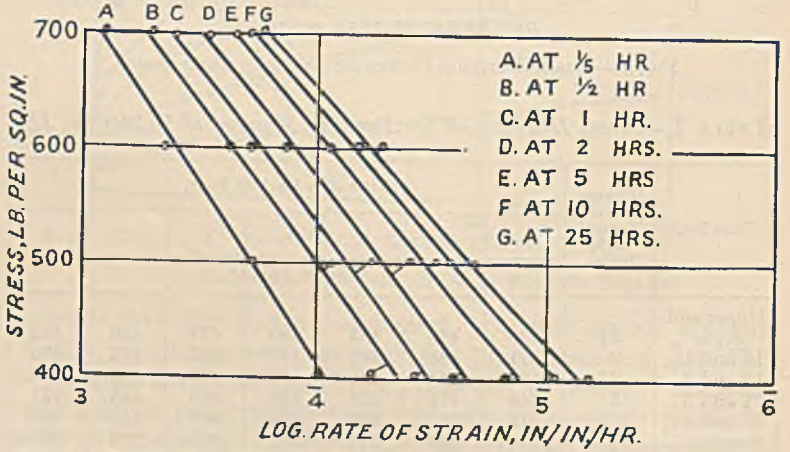

FIG. 8.—Tensile Creep Tests on Material Brought to the Condition of Fibre 1 of the Beam at the End of Test at 13,340 In. Lb.

beam already strained to some extent was being used. In interpreting the stress distribution in this case the following procedure was, therefore, adopted. A number of tensile test-pieces was strained for 7 days at 468 lb./in.^{2}, *i.e.* at the stress in fibre 1 in the first bending test (see Table I), it being assumed that the test-pieces should then be in the same

TABLE II.—*Stress Distribution for Bending Moment of* 17,152 *In. Lb.*

Fibre No.	Distance from Neutral Axis, Inches.	Time after Loading, Hrs.						
		¼.	½.	1.	2.	5.	10.	25.
		Stress, Lb./in.^{2}.						
Upper and lower .	3½	735	735	735	735	735	735	735
13 and 1 .	3	711	710	715	715	709	715	710
12 and 2 .	2½	679	682	681	682	682	682	683
11 and 3 .	2	652	652	652	654	655	655	655
10 and 4 .	1½	625	628	630	629	630	631	629
9 and 5 .	1	588	589	589	592	593	593	593
8 and 6 .	½	513	517	518	517	524	524	524

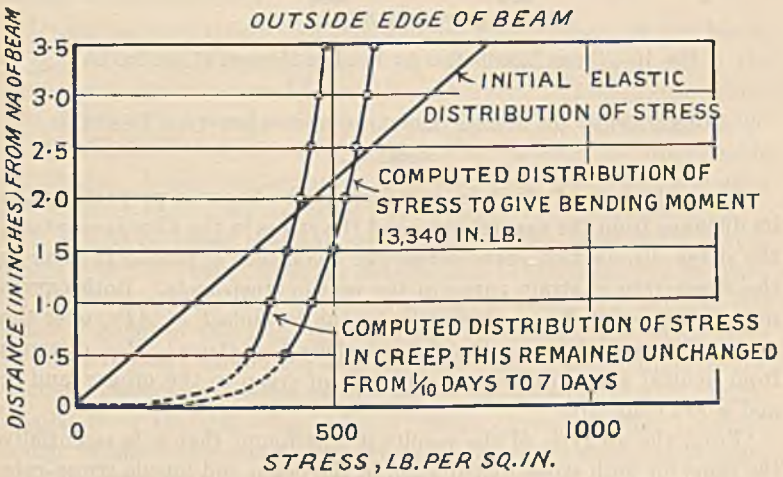

FIG. 9.—Stress Distribution for Bending Moment 13,340 In. Lb.

condition as fibre 1. Creep curves were then determined; these curves, compared with the curves for the "as received" material, showed some modification due to stiffening by the initial straining. Evidence was obtained that it was fair to assume that the modification of the creep curve in any fibre was proportional to the extent of the strain of that fibre at the conclusion of the bend test at 13,340 in. lb. A new

series of stress–log. rate of strain curves was then obtained for the new conditions for each fibre. Fig. 8 shows the series for fibre 1, the curve forms for other fibres being intermediate between the forms of Fig. 7 and Fig. 8. The stresses in the beam were interpolated as in the first bend test.

The results obtained are recorded in Table II, and illustrated by Fig. 10. It is again evident that the stress distribution remains constant during the bending test.

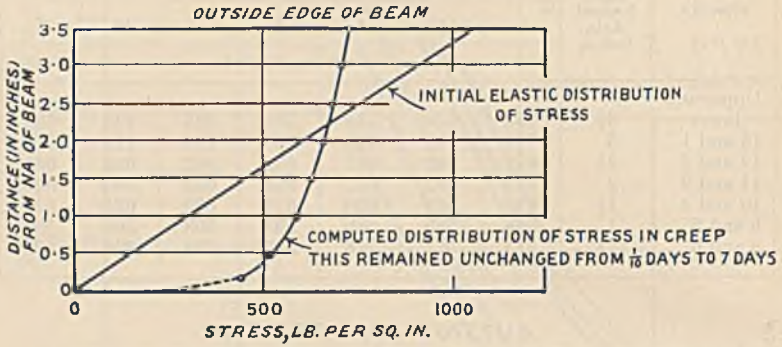

Fig. 10.—Stress Distribution for Bending Moment 17,152 In. Lb.

Correlation of Stress Distribution with the Bending Moment.

Since the rate of strain in any fibre of the beam is proportional to its distance from the neutral axis, and the stress in the fibre is constant, the stress–distribution curve across the beam face is similar in form to the stress–rate of strain curve in the tensile creep tests. Both curves may be represented approximately by the formula $S = AP^n$, over the range of stress arising in the tests; where S = stress; P = distance from neutral axis, in one case, and rate of creep in the other; and A and n are constants.

From the analysis of the results it was found that n is essentially the same for both stress distribution in the beam and tensile stress–rate of strain curves. Any dissimilarity of the material used in the tensile and beam tests, owing to lack of homogeneity in the lead, results only in a modification of the constant A.

Considering first the beam test at 13,340 in. lb., it was found that the calculated stress distribution was equivalent to a bending moment 18 per cent. less than that applied. This result is mainly due to the fact that the lead block was not completely homogeneous; the material

of the beam over the gauge-length appeared to be somewhat stiffer than were the tensile creep specimens taken from the end of the block. A computed stress distribution conforming to the full applied bending moment, 13,340 in. lb., is shown in Fig. 9, being obtained simply by modification of the constant A in the above formula.

In the case of the test at 17,152 in. lb. the previous straining of the beam and of the tensile specimens appeared to have rendered these more nearly alike in creep characteristics, with the result that the computed stress distribution conforms within 4 per cent. with the applied bending moment.

In Appendix I it is shown mathematically that the redistributed stress in the outer fibre of the beam is $\frac{n+2}{3}$ (initial elastic stress in the fibre). Taking an experimentally determined value of 0·173 for n, the outer fibre stresses are computed to be 591 lb./in.^{2} and 763 lb./in.^{2} for bending moments of 13,340 and 17,152 in. lb., respectively, and the corresponding stress distributions agree with these bending moments to within 1 per cent. The accuracy of the mathematical treatment appears to be established.

Owing to the existence of longitudinal fibre stresses in the beam, elastic transverse stresses were set up of magnitude $1/m$ times the longitudinal stress, where $1/m$ is Poisson's ratio. These elastic transverse stresses were small, and after redistribution by slight creep would not be expected subsequently to give rise to creep of appreciable magnitude. A micrometer survey of the beam section before and after each bending test failed to reveal any evidence of transverse creep.

It should be noted that the computed distribution of stress curves in Figs. 9 and 10 extend from the outside edge of the beam to a distance $\frac{1}{2}$ in. from the neutral axis, and cover a range of stress of about 300–700 lb./in.^{2}. Between the $\frac{1}{2}$ in. distance and the neutral axis the curves are shown dotted; should the lead possess a definite elastic limit (below which no creep occurs) the curves would be modified in this region. Judging from the stress–log. rate of strain curves of Fig. 7, creep, though of small dimensions, would be expected to occur at stresses well below 300 lb./in.^{2}. Moore and Alleman [2] found continuous creep to occur for commercially pure lead at 200 lb./in.^{2}. Recently, Bruce Chalmers [3] stated that a lead sample examined by him had an elastic limit of 120–130 lb./in.^{2} in the unstrained condition. From the point of view of this investigation, however, it is immaterial whether or not the stress curve is modified in close proximity to the neutral axis.

In Appendix II an account is given of the unusual character of the creep curves displayed by material from end B of the lead block.

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General Conclusions.

The investigation has led to the following conclusions:

(*a*) In the case of a lead beam creeping under stresses produced by pure flexure plane sections continue to remain plane.

(*b*) The redistribution of stress is complete within $\frac{1}{6}$ hr. after application of a bending moment, and the stresses continue unaltered with time.

(*c*) The behaviour of the beam under flexure may be fairly computed solely from the relations between tensile stress and rate of strain corresponding to any period of tensile creep testing on the material of the beam.

APPENDIX I.

Mathematical analysis showing that the redistributed system of stresses in a beam creeping under uniform bending moment remains unchanged if plane sections remain plane, and that the distribution may be determined from a knowledge of the initial "elastic" stress distribution in the beam.

Let *OB*, Fig. 11, represent the initial "elastic" stress distribution

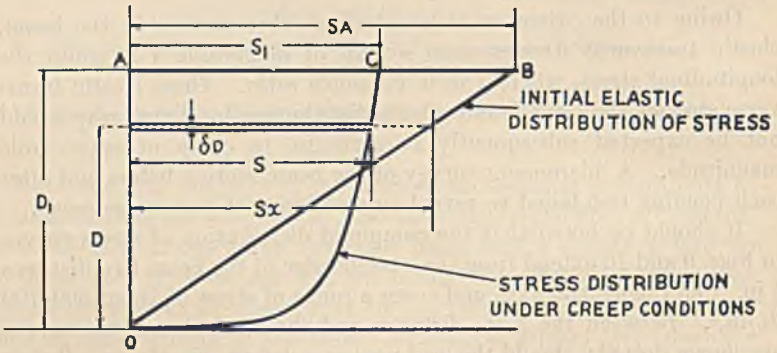

Fig. 11.—Redistribution of Stress in Beam when Creep Occurs.

in a beam subject to uniform bending moment M, and let OC represent a distribution curve of stress in the beam when creep is in progress.

Let S_A = initial elastic stress in outer fibre;
S_1 = redistributed stress in this fibre;
D_1 = distance of this fibre from neutral axis;
S_x = initial elastic stress in a fibre of thickness δD;
S = redistributed stress in this fibre;
D = distance of this fibre from neutral axis;

In the elastic state $S_A = KD_1$ and $S_x = KD$, where K is a constant.

When creep takes place we have the relation $S = AR^n$ where R is

the creep rate, and A and n are constants. Reference to Fig. 12 will show that this relation holds fairly closely for the material under experiment for the range of stress under consideration * and over the test period, n having a constant value of about 0·173.

Now, since plane sections remain plane, $R \propto D$ and the relation $S = bD^n$, and $S_1 = bD_1^n$ will hold for materials having the same creep characteristics as the lead beam.

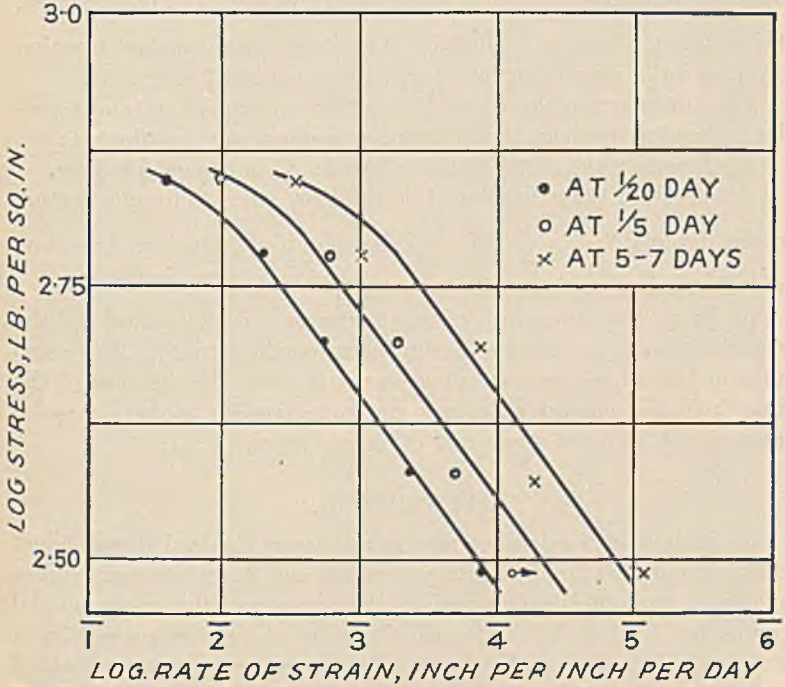

FIG. 12.—Log. Stress–Log. Rate of Strain Curves for " As Received " Material.

Further, the bending moments under elastic, and creep conditions must each be equal to the applied bending moment M, *i.e.* the moment of area OAC = moment of area OAB about the neutral axis;

i.e. $$\int_0^{D_1} S \,.\, \delta D \,.\, D = \frac{S_A \,.\, D_1}{2} \times \tfrac{2}{3} D_1$$

i.e. $$\int_0^{D_1} bD^{n+1}\, \delta D = \tfrac{1}{3} S_A D_1^2$$

thus $$\frac{b}{n+2} D_1^{n+2} = \tfrac{1}{3} S_A D_1^2$$

* Over the greater part of the beam section the stress ranges from about 300 to 700 lb./in.^{2}.

But $$\frac{S_1}{b} = D_1^n$$

therefore $$\frac{1}{n+2} S_1 D_1^2 = \tfrac{1}{3} S_A D_1^2$$

or $$S_1 = \frac{n+2}{3} S_A$$

Thus $\frac{S_1}{S_A}$ varies only as n may vary with time, and, as Fig. 12 shows, this variation, if any, is negligible. Therefore S_1 is a constant function of S_A, and the stress distribution remains unchanged with time.

Thus to ascertain the stress distribution corresponding to any particular bending moment the following procedure may be adopted:

(*a*) Ascertain the initial "elastic" stress S_A in the outside fibre.

(*b*) Obtained the redistributed outside fibre stress S_1 by substitution in the formula $S_1 = \frac{n+2}{3} S_A$, n being obtained from log. stress–log. rate of strain curves in tensile creep tests.

(*c*) From the stress–rate of strain curves for *any* period for the material, determine the creep rate corresponding to S_1. The creep rates in the other fibres are then proportional to the distance of the fibre from the neutral axis, and the corresponding stresses may be interpolated from the stress–rate of strain curves.

APPENDIX II.

In examining the tensile creep properties of the lead it was found that one end B of the block was softer than end A, and its creep curves exhibited unusual characteristics. The curves followed a normal course for 1 or 2 days after which the creep rate increased for a time and then decreased again.* This phenomenon occurred at all stresses, and it would appear that some recrystallization of the lead was taking place leading to an increasing creep rate, followed by cessation of recrystallization or by grain-growth sufficient to produce a further decrease in creep rate. An annealing treatment at 100° C. for 2 hrs. followed by slow cooling enabled creep curves of normal characteristics to be obtained, but in this condition the lead was too soft to be of value in the investigation.

Acknowledgments.

The investigation described forms part of the current research carried out on behalf of the Committee on the Behaviour of Materials at High Temperatures of the Department of Scientific and Industrial

* Similar curves for lead have recently been reported by Neill Greenwood.[4]

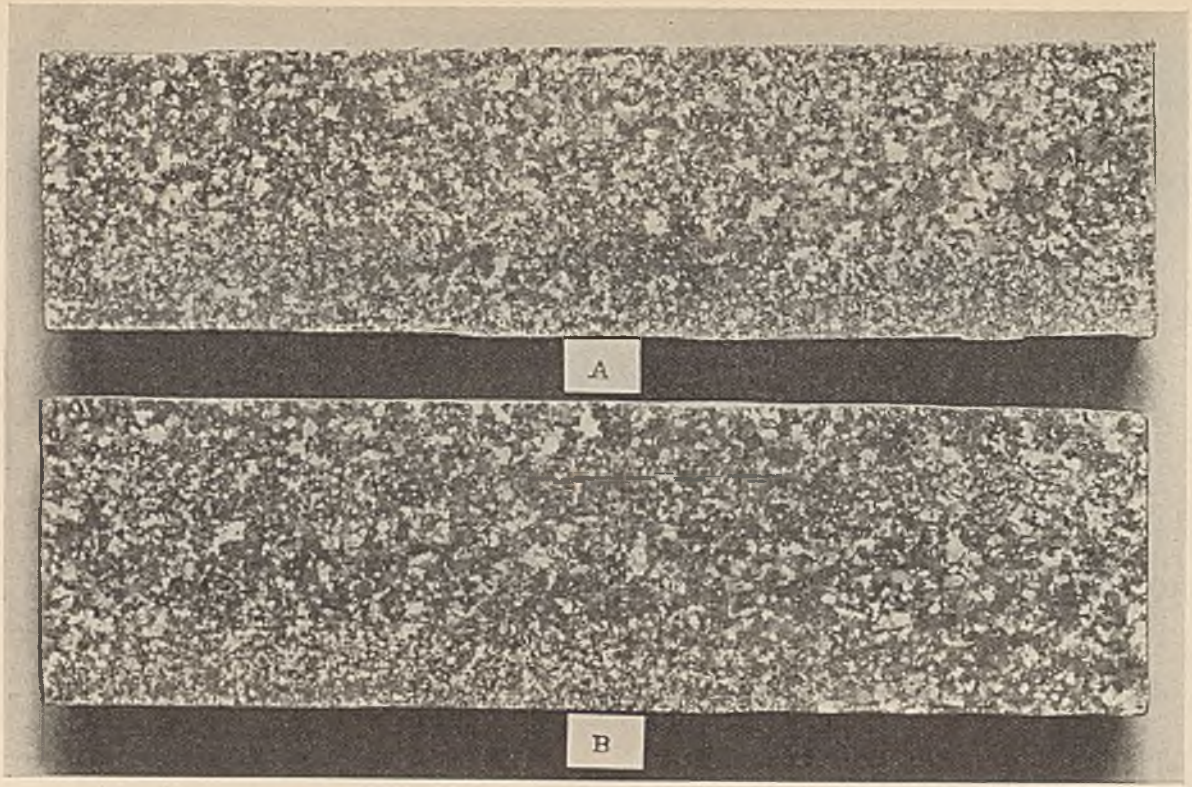

FIG. 13.—Opposite Ends of the Lead Block. Etched in Ammonium Molybdate.

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FIG. 14.—Section of Lead Beam Gauge-Length. Etched in Ammonium Molybdate.

Research, under the supervision of the Executive Committee of the National Physical Laboratory. The authors are indebted to these authorities for the facilities afforded for the work, and for permission to publish the results. The thanks of the authors are due to Dr. H. J. Gough, M.B.E., Superintendent, Engineering Department, National Physical Laboratory, for his interest and encouragement in the work, and to Dr. M. L. Becker, National Physical Laboratory, for the preparation of the photomicrographs.

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TEDDINGTON,
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NOTE ON THE TARNISHING OF LIQUID METALS AS STUDIED BY X-RAYS.*

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SYNOPSIS.

An apparatus has been constructed for the X-ray study of liquid metals up to 700° C. by surface reflection. Spectrograms taken with Cu X-radiation in an atmosphere of hydrogen just above the melting point of lead, tin, and SnSb showed the structure of surface tarnish films. Preferred orientation effects were observed. On heating to higher temperatures the tarnish was reduced in thickness, and the Debye ring of the liquid metal replaced the X-ray spectrum of the tarnish.

THE primary intention of the investigation described in this paper was to study the Debye rings of liquid intermetallic compounds at increasing temperatures, but unexpected and interesting difficulties were encountered in connection with tarnishing. Electron diffraction is the most sensitive method for examining tarnish films, but the positive results obtained with soft X-rays—such as are available in many metallurgical laboratories—seemed worthy of record. Circumstances have prevented the continuation and completion of the research, but it was thought desirable to publish such information as has been obtained.

DESCRIPTION OF APPARATUS.

Fig. 1 gives an indication of the general form of the high-temperature X-ray camera used, the metal to be examined being contained in a porcelain crucible placed within a Nichrome-wound furnace tube. This was preferred to a tubular glass specimen container as the intention was to work eventually at high temperatures and to study such effects as the suggested existence of "liquid crystals" in copper–aluminium alloys. The back part of a quarter-plate Kodak camera was incorporated, so that it was possible to advance a roll of film in the usual way and to obtain five exposures without unsealing the camera. The authors had hoped, after gaining experience with the present experimental camera,

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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. LVII, 1935. Reference should accordingly be as follows: *J. Inst. Metals*, 1935, 57 (Advance copy).

to construct a smaller one on the same general principal, and to arrange to expose films suitable for kinematograph projection; in this way, the solidification of metals and alloys might be studied with advantage.

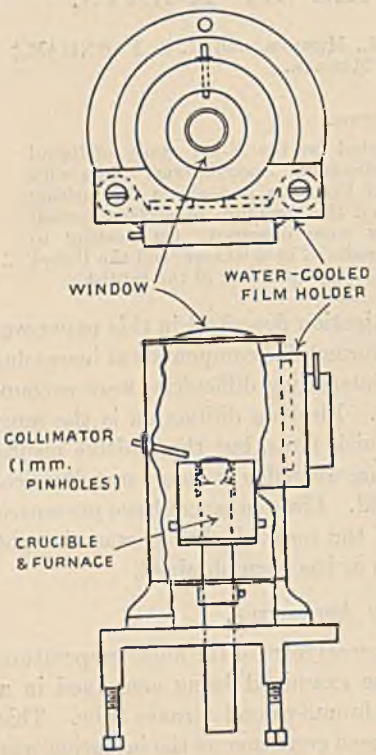


Fig. 1.—High-Temperature X-Ray Camera. Diameter of Camera, 4·75 in.

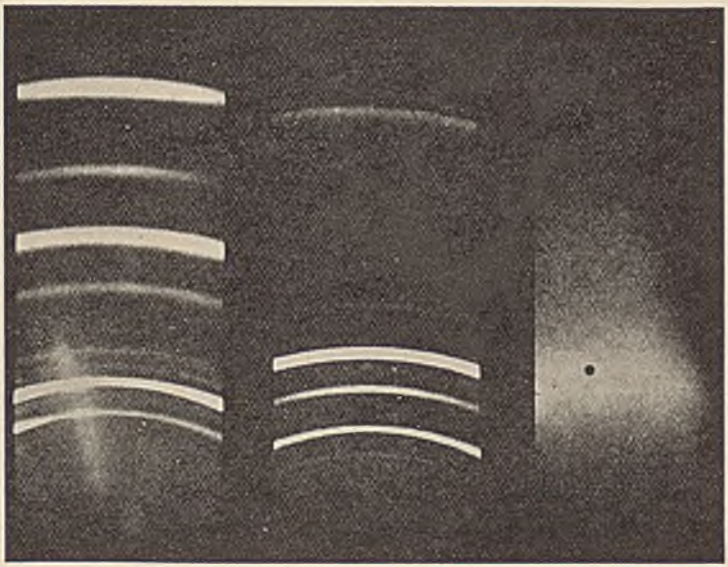
Experiments on Lead.

The crucible was filled to overflowing with pure molten lead, and a thermocouple sheath was allowed to freeze in the metal. The top surface of the lead was filed flat and all tarnish removed before fixing the crucible in the camera, which was finally sealed, an X-ray spectrogram of the solid lead then being taken for calibration purposes. The air in the camera was next displaced by nitrogen, after which cylinder hydrogen was circulated continously. This hydrogen contained about 0·2 per cent. oxygen, but was passed through pyrogallol and the usual drying train. This degree of contamination, however, together with any oxygen or oxide initially present in the metal, was sufficient to cause a tarnish film on molten lead maintained at 400° C., and, instead of a Debye ring of the liquid, the spectrogram of the tarnish was obtained. In an attempt to identify this surface film, the angular positions of the rings were determined and hence the values of d; these are given in Table I, with the spacings obtained by Darbyshire [1] for yellow PbO, and kindly given to us by him.

The values obtained by Darbyshire for the other lead oxides gave no agreement whatever with results of the present authors, who conclude that in this case the tarnish was yellow PbO.

Experiments on Tin.

Precautions were always taken to bake the furnace free from water vapour before exposures were made, but this did not cure the tarnishing.



(*a*) at 18° C. (*b*) at 450° C. in Cylinder Hydrogen. (*c*) at 500° C. in Purified Hydrogen.

FIG. 2.—Tests on SnSb (Melting Point 418° C.).
Each Exposure at 26 m.a. for 2/2·5 Hrs.

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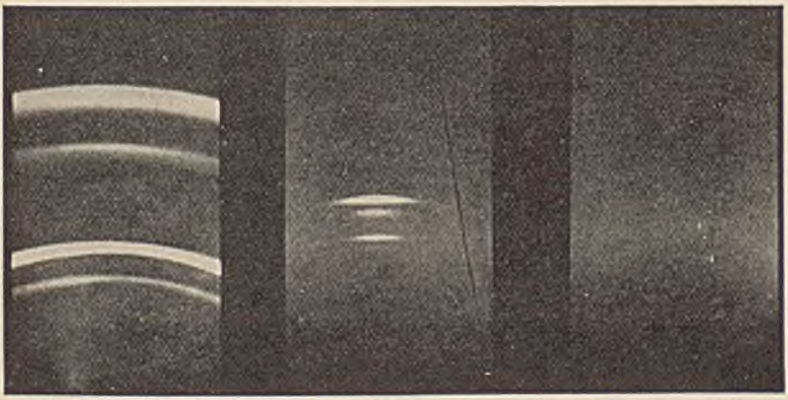

(*a*) at 18° C. (*b*) at 455° C. (*c*) at 550° C.

FIG. 3.—SnSb in Purified Hydrogen.
Each Exposure at 26 m.a. for 2/2·5 Hrs.

TABLE I.—*Tarnish on Molten Lead at 400° C.*

Spacings Obtained.	Darbyshire's Values for Yellow PbO.
3·14 A.	3·06 A.
2·84	2·93
2·73	2·72
2·67	2·61
2·57	2·48
2·33	2·36
2·15	2·26
1·98	2·00
1·94	1·95
&c.	&c.

It was next arranged to purify the hydrogen by passing it over platinum black catalyst at 700° C., and through the usual drying train—liquid air not being available at the time. Even with this precaution, however, tarnishing was produced on liquid tin at temperatures up to 400° C., approximately.

Incidentally, it may be remarked that Rosenberg and Jordan[2] performed wear tests on steels in hydrogen which gave no indication of oxygen content when analyzed in apparatus sensitive to 0·03 per cent. oxygen, but X-ray examination of the abraded steel particles showed that relatively large amounts of Fe_2O_3 and Fe_3O_4 had been formed.

It was next observed that as the temperature of the liquid tin was increased, so the tarnish spectrum changed and eventually disappeared. Treatment for 1 hr. at 450° C. was sufficient to give the Debye liquid spectrum free from tarnish rings. Further, it appears that the Debye ring for liquid tin at 450° C. occurs at approximately the same angle as the first intense ring for solid tin (about 16·5°). The tarnish spectrum at 250° C., differs from that in the 400° C. region, the latter showing intensity maxima similar to " preferred orientation " effects.

Additional experiments indicated that the tarnish formation was a reversible reaction, and when the metal had been cleared by heating to a temperature approaching 500° C., the tarnish returned during subsequent cooling, 350°– 400° C. apparently being the temperature at which films thick enough to be photographed had formed in the conditions of the authors' experiments.

Steinheil[3] found by electron diffraction that the layer formed on hot, solid tin is partly stannous and partly stannic oxide, both having tetragonal structures. Incidentally, the present authors have since noticed Cowan's[4] report that " pure " hydrogen tarnishes commercial brass at 430° C., owing to gas evolution from the brass, but heating to 680° C. removes the oxide film.

Experiments on SnSb.

Tests were next carried out on the compound SnSb, which has a rock-salt structure and melts at 418° C. Fig. 2 (*a*) (Plate I) shows the spectrum from the solid alloy. When this alloy was melted at 450° C. in cylinder hydrogen passed through pyrogallol, the tarnish structure shown by Fig. 2 (*b*) (Plate I) was obtained. Changing to hydrogen purified over platinum black, and a temperature of 500° C., gave the Debye liquid ring visible in Fig. 2 (*c*) (Plate I). At this temperature, the ring occurs at about the same angular value as the first line of the solid alloy spectrum for which the *K* radiation is responsible, *i.e.* about 15°. The Debye liquid ring obtained for tin was very diffuse, but appeared to occur at a somewhat greater angle than this. Provided that the temperatures can be considered nearly equivalent, there is the possibility that the spectrum in this case is due to molecules of compound as distinct from tin. Fig. 3 (*b*) (Plate I) shows the slight tarnish spectrum existing at 455° C. and having a preferred orientation effect such as was found by other investigators [5, 6] in electron diffraction experiments on oxides with hexagonal or rhombohedral structures.

Acknowledgments.

This investigation was carried out in the Metallurgical Department of the University of Manchester, with the encouragement of Professor F. C. Thompson, D.Met. One of the authors (G. S. F.) is indebted to the Royal Commission for the Exhibition of 1851 for an Overseas Research Scholarship.

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METALLURGICAL ABSTRACTS

(GENERAL AND NON-FERROUS)

Volume 2 AUGUST 1935 Part 8

I.—PROPERTIES OF METALS

(Continued from pp. 333–336.)

Refined Aluminium. R. Gadeau (*Rev. Aluminium*, 1935, 12, 2831–2837).—A commercial method has recently been devised for the production of aluminium of a purity of 99·99% or more, by direct electrolysis, using particularly pure alumina and very pure oil-coke as anodes. The physical and mechanical properties, and the uses of this product are given.—J. H. W.

Beryllium. W. Hessenbruch (*Metall u. Erz*, 1935, 32, 234–237).—A short review of manufacture, uses, and properties.—A. R. P.

***The Size and Arrangement of Bismuth Micro-Crystals Formed from Vapour.** C. T. Lane (*Phys. Rev.*, 1935, [ii], 47, 644).—Abstract of a paper read before the American Physical Society, Feb. 1935. The magneto-resistance of bismuth films, deposited on glass and mica, has been measured at room and liquid-air temperatures and for various angles between the film normal and the magnetic field ($H = 16{,}000$). The ratio $\Delta R_{-180}/\Delta R_{+20}$ increases steeply for thicknesses between 0·1 μ and 0·4 μ and then much more gradually to a thickness of 4 μ. The thermal coeff. of resistance shows no corresponding anomaly. X-ray analysis shows all the films to be composed principally of small crystals with (111) parallel to the backing. ΔR varies with the direction of H, the current remaining always in one direction in the film, approximately as predicted from experiments on monocrystals for such an assembly. It is suggested that at a thickness of 0·4 μ the microcrystals first attain a normal distribution of sizes.—S. G.

***Change in the Resistance of Bismuth Single Crystals at the Melting Point.** J. Henry Schroeder (*Proc. Iowa Acad. Sci.*, 1934, 41, 254; *C. Abs.*, 1935, 29, 3570).—The resistances of 7 single crystals of bismuth of various orientations were measured as the temperature gradually increased to a few degrees above the melting point. The change from solid to liquid did not occur suddenly when the melting point was reached, but began at a temperature about 2° below, and continued to a temperature about 1·5° C. above, the melting point. As an explanation, it is supposed that bismuth undergoes a change in crystal structure near the melting point, and that this crystal structure persists in the liquid bismuth.—S. G.

***Mean Free Path of Electrons in Bismuth.** A. Eucken and F. Förster (*Göttingen Nachrichten*, 1934, 1, (3), Fachgruppe 2, 43–54; *Sci. Abs.*, 1934, [A], 37, 1016).—The mean free path of electrons in bismuth is deduced from measurements of the specific resistances of a series of single crystal wires of bismuth ranging down to 1·9 μ diameter. The measurements were made over the range 93° to 473° K., the value of the mean path being found to decrease with increase in temperature. The observed change with temperature is in agreement with the classical electronic theory rather than the Fermi–Sommerfeld theory. The number of free electrons per cm.^{3} is derived, the classical theory again appearing the more appropriate to employ.—S. G.

***The Reduction by Hydrogen of Stannic Oxide Contained in H.-C. Copper.** W. E. Alkins and A. P. C. Hallowes (*J. Inst. Metals*, 1935, 56, 125–129; discussion, 129–132).—Samples of H.-C. copper wire, No. 16 s.w.g., containing 0·021% stannic oxide, SnO_2, were heated in a constant current of hydrogen

* Denotes a paper describing the results of original research.
† Denotes a first-class critical review.

for 15, 30, 60, and 120 minutes at temperatures increasing from 550° to 850° C., and the tin oxide content determined after each treatment. Reduction of the stannic oxide commences at about 550° C., and is complete after 30 minutes at 850° C. and after 60 minutes at 800° C. Thus, in the case of coppers containing amounts of tin oxide such as are usually encountered, conditions of temperature and time which are satisfactory for determination of "loss in hydrogen" will effect complete reduction of any stannic oxide which may be present.—W. E. A.

***On the Existence of an Oxide Film on Gold.** W. J. Müller and E. Löw (*Ber. deut. chem. Ges.*, 1935, [2], **68**, 989–991).—The observation of a gold electrode by polarized light resulted in the association of passivation phenomena with the formation of a crystalline salt, later replaced by a film of oxide. The film was removed by treatment with acid, and the electrode, after rinsing and drying, was exposed to atmospheric action at room temperature. Observations were continued at minimum intervals of 2 hrs. The gradual formation of an oxide film similar to that produced by electrolysis was observed, and it was further established that the period required for passivation to set in when the electrode was again put into use decreased with increasing periods of atmospheric exposure.—P. M. C. R.

***A Study of the Vapour Pressures of Magnesium, Thallium, and Zinc, and the Determination of Their Chemical Constants.** F. F. Coleman and A. Egerton (*Phil. Trans. Roy. Soc.*, 1935, [A], **234**, 177–204).—The vapour pressures of solid magnesium and zinc, and of liquid thallium were determined by the effusion method, and the results used to calculate the chemical constants. The theory of the method, and the probable errors are discussed in detail, and improvements of the apparatus are described. The vapour pressures and chemical constants may be represented as follows between the temperatures indicated:

$$\mathrm{Mg}\ {}^{740^\circ\ \mathrm{K.}}_{700^\circ\ \mathrm{K.}}\left[\log p^{\mathrm{Mg}}_{\mathrm{mm.}} = \frac{-7527\cdot_0}{T} + 8\cdot589_9\right];\ C_{\cdot(\mathrm{obs.})} = 0\cdot47 \pm 0\cdot21.\quad C_{\cdot(\mathrm{theoretical})} = 0\cdot49.$$

$$\mathrm{Zn}\ {}^{630^\circ\ \mathrm{K.}}_{575^\circ\ \mathrm{K.}}\left[\log p^{\mathrm{Zn}}_{\mathrm{mm.}} = \frac{-6787\cdot_8}{T} + 8\cdot972_8\right];\ C_{\cdot(\mathrm{obs.})} = 1\cdot21 \pm 0\cdot15.\quad C_{\cdot(\mathrm{theoretical})} = 1\cdot14.$$

$$\mathrm{Tl}\ {}^{905^\circ\ \mathrm{K.}}_{845^\circ\ \mathrm{K.}}\left[\log p^{\mathrm{Tl}}_{\mathrm{mm.}} = \frac{-8927}{T} + 7\cdot993\right];\ C_{\cdot(\mathrm{obs.})} = 2\cdot37 \pm 0\cdot28.\quad C_{\cdot(\mathrm{theoretical})} = 2\cdot18.$$

The results of other investigators are discussed, and equations given for calculating the vapour pressures over wider ranges of temperature.—W. H.-R.

***Length Variation of Nickel on Quenching.** H. Goulbourne Jones (*Metallurgia*, 1935, **12**, 86).—The length changes of a nickel bar quenched from 525° C. in cold water were measured with an optical lever comparing the nickel with a glass prism. The nickel decreases in length for 10 minutes; then follows a period of little change, and finally a gradual decrease in length. The hardness variations after quenching (Herbert) are also quoted, and show little evidence for correlation between length and hardness variations.—J. D.

***The Diffusion of Hydrogen Through Highly Degassed Palladium.** J. D. Sauter and W. R. Ham (*Phys. Rev.*, 1935, [ii], **47**, 645).—Abstract of a paper read before the American Physical Society, Feb. 1935. A 30 mil sheet of palladium was heated for over 1 month until readings of rates of diffusion at pressures from 1 cm. to 74 cm. could be reproduced between temperatures of 180° and 800° C. The isothermals are exceedingly straight if log rate is plotted against log p except for the lowest values of p for high temperatures, and except for increasingly high values of p for low temperatures. The slope

varies from 0·535 to 0·5, but goes through a maximum of about 0·585 at 248° C. This residual and variable excess above 0·5 is probably due to the presence of a small amount of unremoved nitrogen in solution in the palladium. The deviations of the isotherms from a straight line at low temperatures and pressures seem predicted in the general formula as derived by one of the authors. The authors have yet to find a case in measurable diffusion in which the variation of adsorption on the ingoing surface is sufficient to affect the rate of diffusion.—S. G.

***Large and Sudden Change of the Permeability of Palladium to Hydrogen a Little Below 200° C.** Victor Lombard and Charles Eichner (*Compt. rend.*, 1935, **200**, 1846–1848).—A continuation of previous investigations (see *Met. Abs.*, 1934, **1**, 163, 164). The permeability of sheet palladium, 0·074 and 0·259 mm. thick, was determined at temperatures below 250° C. The thicker specimen was of particularly pure metal, and the results confirmed that the effect of purity on permeability observed at higher temperatures extends to below 250° C. The 0·074 mm. sheet lost 0·9995 of its diffusivity on cooling from 225° to 125° C., but slowly recovered it on heating. Large variations in the diffusivity occur at about 180° C. on cooling and 190° C. on heating. The 0·259 mm. sheet behaved similarly, except that the large variations of the diffusivity began some degrees lower in temperature. These results are shown graphically. It is considered that just below 200° C., there is not a change of state of the palladium, but a change in the behaviour of hydrogen to the metal.—J. H. W.

***Thermionic Emission of Platinum in Bromine and Chlorine Vapours.** S. Kalandyk (*Acta Phys. Polonica*, 1934, **3**, 165–178; *C. Abs.*, 1935, **29**, 3591).—[In German.] A method is described for investigating the thermionic emission of platinum in highly rarified bromine and chlorine vapours. At high temperatures a thermionic emission of platinum bromide, or of platinum saturated with bromine, takes place, while at low temperatures the emission is a result of a chemical reaction between platinum and bromine. The activity of bromine is more effective the greater the pressure and the higher the incandescent temperatures. At 785° C. the magnification of the emission equals 1 : 100; at 1290° C. it is 1 : 27. The work-function for platinum glowed in bromine is 1·4 v. The lowest temperature at which an influence of chlorine on the emission is perceptible is much higher, *viz.* 380° C., than of bromine (200° C.). In the interval 760°–1010° C., the emission in both gases is almost identical; at 1100°–1200° C. the action of chlorine is considerably stronger than that of bromine.—S. G.

***Coefficient of Expansion of Silver by X-Ray Method.** H. Saïni (*Helv. Phys. Acta*, 1933, **6**, 597–607; *Sci. Abs.*, 1934, [A], **37**, 171).—[In French.] The coeff. of expansion of silver was measured between 20° and 300° C., a modified form of a Seeman–Böhlin camera being used. The lattice const. at 18° C. was found to be $4{\cdot}0774_0$ A. The coeff. of expansion is $(19{\cdot}1 \pm 0{\cdot}2) \times 10^{-6}$ per degree.—S. G.

***Mean Path of Electrons in Silver.** A. Eucken and F. Förster (*Göttingen Nachrichten*, 1934, **1**, (10), Fachgruppe 2, 129–137; *Sci. Abs.*, 1935, [A], **38**, 545).—See also *Met. Abs.*, this vol., p. 143. The mean free path of electrons in silver is deduced from measurements of the specific resistance of very thin wires of this element. Wires of the order of 1 μ diameter are used, prepared by drawing out a glass capillary containing the molten metal. It is found necessary to anneal the wires at about 500° C. before consistent results can be obtained. The value finally given for the mean free path at 0° C. is $57{\cdot}7 \pm 0{\cdot}88 \times 10^{-7}$ cm., which agrees very well with the value predicted by the Fermi–Sommerfeld theory. Earlier work on bismuth (*Met. Abs.*, this vol., p. 365) had given, on the other hand, a result in closer agreement with the classical theory. Other metals are to be examined.—S. G.

***The Surface Chemistry of Tin.** Artur Kutzelnigg (*Z. Elektrochem.*, 1935, **41**, 450–453).—Tin containing up to 1% antimony is darkened by ferric chloride solution; when dissolved in concentrated hydrochloric acid, a black, flaky residue remains. 0·1% antimony cannot readily be detected in this way. While the solution of tin in more strongly concentrated acid was considerably accelerated by the presence of 0·01% antimony, it was retarded by the presence of bismuth. The slow action of iodine vapour on tin and the non-appearance of a colour film depends on the existence of a thick film of oxide. Etched tin, out of contact with air, tarnishes readily in iodine vapour. The possibility of isolating the oxide film was investigated. Tin is slightly soluble in an alcoholic solution of iodine.—J. H. W.

***The Contact Difference of Potential Between Tungsten and Barium. The External Work-Function of Barium.** Paul A. Anderson (*Phys. Rev.*, 1935, [ii], **47**, 958–964).—Full experimental details are given for determining the contact potential difference between a tungsten reference surface and another metal by the electron beam method, in which the displacement of the electron current–potential curves along the potential axis by surfaces of different work-function is determined. The details refer to extreme precautions in outgassing and prevention of contamination. The contact difference of potential between tungsten and barium is 2·13 $\pm$ 0·05 v., whilst the external work-function of barium is 2·39 $\pm$ 0·05 equivalent volts.—W. H.-R.

***Resistance and Radiation of Tungsten as a Function of Temperature.** W. E. Forsythe and E. M. Watson (*J. Opt. Soc. Amer.*, 1934, **24**, 114–118; *Sci. Abs.*, 1934, [B], **37**, 308).—This investigation checks results previously described. The relation between log resistance and log temperature was found to be linear with a slope of 1·195, agreeing fairly well with the value of 1·20 previously obtained. Confirmation was also obtained for Langmuir's calculated values for elimination of end losses. The slope of 1·195 was over the range 1200°–2800° K., with only a slight change between 1200° K. and room temperature. The straight line drawn through the log temperature–log resistance points for 1200° and 293° K., as experimentally determined, has a slope of 1·209. Whilst the slope of the curves is in agreement with previous results, the actual value of the resistance for a definite temperature is not in agreement, being about 6% lower and confirming more nearly within 0·2% those of Jones and of Geiss. No adequate explanation is offered for this discrepancy. By using the data from which the specific resistance–temperature relationship is determined, the total emissivity of tungsten for the range 2800° K.–room temperature is recorded, and the values agree within 0·5% with those previously published. A full table is given over the range of temperature examined for the specific resistance, total emissivity, brightness, &c., for tungsten. The brightness is related to that of a black body by the relation

$$\log B_w = \log B_{bb} + \frac{C_2 \log e}{\lambda}\left(\frac{1}{T_c} - \frac{1}{S}\right),$$

where B_w is the brightness of tungsten at a colour temperature T_c, corresponding to a brightness temperature S for wave-length λ; the brightness of a black body at a temperature T_c being B_{bb}.—S. G.

***Effect of Additions of Cadmium on Growth of Zinc Crystals.** E. P. T. Tyndall (*Proc. Iowa Acad. Sci.*, 1934, **41**, 252; *C. Abs.*, 1935, **29**, 3568).—Using the Czochralski–Gomperz method and various specimens of zinc containing less than 1% cadmium, Schilling (*Met. Abs.*, 1934, **1**, 177) encountered mosaic crystals and failed to find the region of successful growth of Hoyem and Tyndall (*J. Inst. Metals*, 1929, **41**, 414). By using zinc containing several tenths of 1% cadmium, the mosaics are prevented to a large degree, and a region of growth similar to the previous one reappears.—S. G.

†**Plasticity of Crystalline Materials, Especially of Metals.** W. G. Burgers (*Nederlandsch Tijds. Natuurkunde*, 1935, **2**, 113–130).—[In Dutch.] A survey of the phenomena occurring during the plastic deformation of crystals: the experiments of Joffé, Polanyi, and in particular of Smekal and collaborators on the strength of undeformed and of plastically deformed NaCl crystals, and the mechanism of gliding and hardening of metal crystals, are discussed.—L. O.

***The Influence of Time of Heating on the Recrystallization and Recovery of Cold-Worked Metals.** J. A. M. van Liempt (*Rec. trav. chim.*, 1934, **53**, 941–948).—The relation between the recrystallization temperature and time of heating for a definite degree of deformation is given by the formula $T_R = C/ln4\nu t$ (where T_R = absolute temperature of recrystallization, C is a constant of the order of 5 to 7 times the absolute melting point, ln = Naperian log., ν is the characteristic monochromatic atomic frequency per second of the metal, and t = time of heating in seconds). It is also valid for each definite degree of recovery, so that it can be used for corresponding states of recovery. The formula is tested on results obtained by various authors for copper, platinum, and silver, and also by some measurements on cold-worked tungsten wire. It gives results in very good agreement with experiment. Some conclusions are also reached regarding the recrystallization of metals at room temperature.—C. E. H.

***On Cold-Shortness in Metals and Alloys.** Yoshiro Fujii (*Kinzoku no Kenkyu*, 1935, **12**, (4), 189–209).—[In Japanese.] The resistance to shock of about 37 pure metals and some alloys of practical use was measured in the temperature range −190° to 500° C. From the results it is established that cold-shortness depends mainly on the type of crystal lattice; metals with a face-centred cubic lattice are free from cold-shortness, while in metals with other types of lattice the brittleness increases at a certain low temperature.—S. G.

***Equations for Diffusion of Gases Through Metals.** W. R. Ham (*Phys. Rev.*, 1935, [ii], **47**, 645).—Abstract of a paper read before the American Physical Society, Feb. 1935. In determining the general equations for diffusion of gases through metals, the fundamental flow equation from the kinetic theory of gases, *viz.*

$$dm/dt = p(m/2\pi KT)^{\frac{1}{2}}e^{-b/T}$$

may be applied in succession to ingoing surface, to the body of the metal, and to the outgoing surface. Since in a steady state the rates at all points are equal, this gives a general equation for diffusion provided that there is expressed the relation between concentrations (or pressures) on the outside and inside and also the variation of concentration (or pressure) with distance on the inside. The latter is difficult to obtain from theoretical considerations. An empirical relation that fits existing experimental data is $p_x = p_1(1 - e^{-a/x})$, where p_x is the pressure at depth x and p_1 the pressure just inside the incoming side. A solution of the three simultaneous equations gives

$$dm/dt = \{A_1 p_0^{\nu}(1 - e^{-a/x}) - A_0 p_3^{\nu} - dm/dt(1 - e^{-a/x})(m/2\pi KT)^{\frac{1}{2}}e^{-b/T}\}(m/2\pi KT)e^{-b/T}.$$

Since the third term in the bracket is exceedingly small compared with the other two, and since the second is usually made small or corrected for in diffusion experiments, there is obtained

$$dm/dt = Ap_0^{\nu}(1 - e^{-a/x})(m/2\pi KT)^{\frac{1}{2}}e^{-b/T},$$

which may be written to a first approximation

$$dm/dt = (Bp_0^{\nu}/x)T^{-\frac{1}{2}}e^{(-b + \Delta w)/T}$$

and this, except for $T^{-\frac{1}{2}}$, is the Richardson equation. Several similar methods, leading to the same result, are discussed.—S. G.

***On the True Specific Heat of Some Metals and Alloys.** Kotarô Honda and Masakatu Tokunaga (*Sci. Rep. Tôhoku Imp. Univ.*, 1935, [i], **23**, 816–834 (in English); and *Kinzoku no Kenkyu*, 1935, **12**, 267–279 (in Japanese)).—The Nernst–Lindemann method for determining the true specific heat has been improved, the advantages of the new method being (1) the temperature increase in the specimens is reduced to a very small amount of 1° or 2°, hence the exact value of true specific heat can be obtained; (2) the increase in temperature is uniform throughout the specimen; (3) the loss of heat by radiation and conduction can be corrected accurately. The true specific heat of copper, nickel, iron, magnesium, copper–nickel alloys, magnesium–zinc alloy (4% Zn), magnesium–aluminium alloy (4% Al), aluminium–copper alloys (6·5 and 12·1% Cu), Duralumin, bronzes and brasses have been determined at room temperature.—S. G.

***Temperature Coefficient of the Work-Function for Composite Surfaces.** Albert Rose (*Phys. Rev.*, 1935, [ii], **47**, 889–890).—A note. The slopes of Richardson plots for electron emission from thoriated tungsten vary with the applied field, this variation being related to the temperature coeff. of the work-function. By assuming that the adsorbed atoms are distributed in patches, and that the patch distribution is a function of the temperature, a satisfactory theory can be developed. The temperature coeff. of the work-function may be resolved into 4 parts due to (*a*) the base metal; (*b*) the uniform layer of the adsorbed atoms; (*c*) the variation of the distribution of adsorbed atoms; and (*d*) the variation of local fields.—W. H.-R.

Electron Theory of Metals. G. Wataghin (*Elettrotecnica*, 1933, **20**, 777–779; *Sci. Abs.*, 1934, [B], **37**, 84).—It is pointed out that the classical electron theory is insufficient to explain conductivity in metals, but that by the application of quantum and statistical mechanics a theoretical explanation is obtained of the different behaviour of conductors and insulators. The theory is illustrated by the application of a photoelectric cell to rectification. —S. G.

Mott Theory of Liquid Metals and Transition Points of Metals and Other Solids. R. H. Fowler (*Helv. Phys. Acta*, 1934, **7**, Suppt. II, 72–80; *Sci. Abs.*, 1935, [A], **38**, 436).—[In French.] A description is given of the work of Mott on the variation of electrical resistance of a metal during fusion, and its importance in the electronic theory of conductors is emphasized. Parling's work on transition points is mentioned, and theoretical considerations are applied to a study of the variation with temperature of the dielectric const. of dipolar bodies.—S. G.

Transformation Temperatures. R. Peierls (*Helv. Phys. Acta*, 1934, **7**, Suppt. II, 81–83; *Sci. Abs.*, 1935, [A], **38**, 436).—[In German.] The change from a solid to a liquid phase is discussed on an atomic basis, and the existence of a definite transition point is indicated.—S. G.

II.—PROPERTIES OF ALLOYS

(Continued from pp. 336–342.)

***The Variation of the Thermal and Electrical Resistance in Precipitation-Hardening of Aluminium–Copper Alloys.** A. Eucken and Hildegard Warrentrup (*Z. Elektrochem.*, 1935, **41**, 331–337).—Experiments were carried out on sheets of pure aluminium and of aluminium containing 0·5% magnesium and 4, 5, and 7% copper, and on sheets and castings of aluminium containing 4 and 8% copper. The alterations of thermal and electrical resistance of the sheet specimens after heat-treatment at 0° C. and ageing at 100° and 215° C. were investigated at 0° and — 192·2° C.; they follow closely parallel curves, the Lorenz number remaining constant within narrow limits. The time : decrease of resistance relation by age-hardening can be represented

by a hyperbolic function. The steady values for the thermal (W) and electrical (ρ) resistances reached after ageing at 215° C. agree very well with E. Grüneisen's straight-line representation in the $W-\rho$ diagram (*J. Inst. Metals*, 1927, **38**, 390). The lower Lorenz number found by W. Mannchen (*Met. Abs.* (*J. Inst. Metals*), 1932, **40**, 10) was confirmed in the case of cast specimens, but not in the case of rolled sheet; this is attributed to the presence of oxide films on the polished specimens.—J. H. W.

***"Y"-Series Aluminium Alloys.** Eiichiro Itami (*Suiyôkwai-Shi*, 1934, **8**, 343–366, 519–532, 585–615; *C. Abs.*, 1935, **29**, 3639).—[In Japanese.] I. studied the influence of chemical composition on the mechanical properties of sand-cast aluminium alloys containing copper, nickel, and magnesium, *i.e.* the so-called "Y" alloys, and also the effect of heat-treatment on the age-hardening of these alloys. The mechanical properties of forged alloys containing copper 1–8, nickel 1–3, and magnesium 0·5–2% were systematically examined. The alloys containing copper 3–5, nickel 1–2, and magnesium 1–1·5% showed the best tensile properties, and the alloy with copper 3, nickel 1–2, and magnesium 1–1·5% is recommended for forged materials. The effect of heat-treatment on these alloys is discussed in detail.—S. G.

***Solid Solubility of Magnesium in Aluminium.** Sakichi Kishino (*Nippon Kwagaku Kwai Shi* (*J. Chem. Soc. Japan*), 1935, **56**, 322–324.—[In Japanese.] —S. G.

***Study of the Alloying of the Aldrey-Type Light Alloys.** Sakichi Kishino (*Kôgyô Kwagaku Zasshi* (*J. Soc. Chem. Ind. Japan*), 1935, **38**, (3); *C. Abs.*, 1935, **29**, 3963).—[In Japanese, with English summary in supplemental binding, pp. 116–117.] Wires 2 mm. in diameter were prepared from A.S.M. and A.C.S.M. process castings (addition of Mg_2Si). The test wires were placed in a molten nitre bath at 520° C. and made homogeneous by annealing for 50 hrs., then quenching at 20° intervals while gradually cooling them. A quenching temperature–electrical resistance curve was used to determine the breaking point. The wires were also annealed at 160° C. for 5 hrs. The tensile strength and electrical resistivity were greater and the elongation smaller for the samples from the A.C.S.M. process melts.—S. G.

***Study of the Ageing of Aldrey-Type Light Alloys Made by Two Different Melting Processes.** Sakichi Kishino (*Kôgyô Kwagaku Zasshi* (*J. Soc. Chem. Ind. Japan*), 1935, **38**, (3); *C. Abs.*, 1935, **29**, 3963).—[In Japanese, with English summary in supplemental binding, pp. 117–118.] A study of the relation between the quenching temperature and the natural ageing of the same alloys as previously described (preceding abstract) prepared by the A.S.M. and A.C.S.M. processes showed that (1) the rate of increase of electrical resistance due to natural ageing becomes greater for A.S.M. and A.C.S.M. materials, the greater the Mg_2Si content, and is independent of the quenching temperature; (2) if the Mg_2Si content is the same, the degree of natural ageing of the alloys is greater in the A.C.S.M. than in the A.S.M. materials at any quenching temperature; (3) the degree of natural ageing of A.S.M. material has never tended to approach that of A.C.S.M. material, even when the quenching temperature is greatly increased.—S. G.

***On the Modification of Silicon–Aluminium Alloys.** Jn. A. Kliachko (*Kolloid-Z.*, 1934, **69**, 215–218; *Chem. Zentr.*, 1935, **106**, I, 3844).—The combined silicon in a 13% silicon-aluminium alloy before and after modification has been determined by the gas-evolution method; the results were: normal alloy 0·41%, well-modified alloy 0·20%, over-modified alloy 0·57%, under-modified alloy 0·34%. These figures are considered to confirm Edwards and Archer's theory of the modification of Silumin. The protection of the ultramicrons of pure silicon by sodium must lead to impoverishment of the mother liquor in silicon so that the crystallizing temperature of the solvent is

increased; in hypereutectic alloys the temperature at which primary silicon is deposited is reduced by the modification treatment.—A. R. P.

***Light Alloys of Aluminium, Zinc, and Cadmium.** J. Ibarz (*Anales soc. españ. fis. quim.*, 1935, **33**, 140–165; *C. Abs.*, 1935, **29**, 3964).—To improve the properties of aluminium–zinc alloys by addition of cadmium, alloys containing up to 20% zinc and up to 2% cadmium were prepared, examined microscopically, and tested for elasticity, notch toughness, hardness at various temperatures, and corrosion-resistance. The properties of the alloys are altered very slightly by the addition of cadmium, and the alloys containing it will be little used in industry. Theoretically, cadmium has a certain stabilizing effect on the intermetallic compound Al_2Zn_3, variable at low temperatures and with non-uniformity of the alloy; this is explained by observed fracture and elasticity. Hardness produced on long heating and its great increase on cooling can be explained by the Tiedemann theory. The true nature of the action of cadmium in binary aluminium–zinc alloys is not yet known.

—S. G.

New Investigations in Aluminium Casting Alloys. H. Obermüller (*Giesserei-Praxis*, 1935, **56**, 284–285).—A brief summary of recently described investigations.—J. H. W.

Characteristics of Modern Light Alloys for Mechanical Casting. V. S. Prever (*Industria meccanica*, 1935, **17**, 91–97; *C. Abs.*, 1935, **29**, 3963).—An exhaustive survey of light alloys, especially of ternary and quaternary alloys on a 4, 8, and 12% copper basis; curves of properties, tables giving composition, change of properties with heat-treatment, equilibrium diagrams, and photomicrographs are given. A *bibliography* of 12 references is appended.

—S. G.

***The ε, γ, and β-Phases of the System Cadmium–Silver.** P. J. Durrant (*J. Inst. Metals*, 1935, **56**, 155–164).—The constitution of the alloys of cadmium and silver from 30 to 60% by weight of silver was reinvestigated by thermal and micrographic analysis. The liquidus consists of 4 smooth curves intersected by peritectic horizontals at 592°, 640°, and 736° C. The boundaries of the phases ε, γ, and β were mapped. No changes occur below the solidus in phases ε and γ, but the β phase undergoes 2 transformations. The upper transformation $\beta \rightleftharpoons \beta'$ occurs at 470° C. when γ is present, at 440° C. when α is present, and at some intermediate temperature dependent on the composition when β alone is present; the lower transformation $\beta' \rightleftharpoons \beta''$ occurs at 230° C., 240° C., or at some intermediate temperature in the same respective conditions. Both of these transformations are associated with marked changes in the range of solid solubility, and with the existence of eutectoid points at which the solid solution decomposes into a characteristic duplex structure of the Widmanstätten type.—P. J. D.

***Hardening Phenomena in Aluminium–"Bronzes."** E. Söhnchen (*Giesserei*, 1935, **22**, 289–294).—The structural changes which occur on quenching and tempering aluminium–"bronzes" were investigated by thermal, X-ray, dilatometric, and micrographic methods, using 5 alloys containing 10·45–13·8% aluminium and a maximum of 0·05% of impurity. The eutectoid alloy when quenched from 750° C. has a typical Widmanstätten structure, with different orientation of the lines in the various grains. Even very rapid quenching of small specimens in 10% sodium hydroxide solutions fails to retain a homogeneous β-phase structure. Very slow cooling in the furnace produces a well-defined and characteristic eutectoidal structure. Heating and cooling curves show two heat effects below the eutectoid transformation point; the temperature at which these effects occur varies considerably with the rate of cooling, being 65°–45° C. lower with very rapid cooling (148° C./second) than with slow cooling (5·6° C./minute). From a survey of the results, S. concludes that the following transformations occur: $\beta \longrightarrow \beta_1 \longrightarrow \alpha'$ or γ'.—A. R. P.

Tinless Bronze. M. Rezkov (*Vestnik Standardizatzii*, **1935**, (1), 21–26; *C. Abs.*, 1935, **29**, 3967).—[In Russian.] Examples of tinless "bronzes" are classified as: (1) aluminium–"bronzes" having (*a*) aluminium 5 or 10% (the rest being copper), (*b*) aluminium 9 and manganese 2%, (*c*) aluminium 9 and iron 4%, (*d*) aluminium 10, iron 3, and manganese 1·5%, (*e*) aluminium 5–10 and nickel 1–8%, (*f*) aluminium 7 and silicon 1%; (2) silicon–"bronzes" with (*a*) silicon 3%, (*b*) silicon 4 or 3 and zinc 4 or 9%, (*c*) silicon 3 and lead 6%; (3) manganese–"bronze" (manganese 5%). The most important advantage of manganese–"bronze" is its heat-resistance: at 400° C. its tensile strength decreases from 36 kg./mm.^{2} only to 26 kg./mm.^{2}.—S. G.

***Type Metal Alloys.** Frances D. Weaver (*J. Inst. Metals*, 1935, **56**, 209–233; discussion, 233–240).—The microstructure and properties of lead-base antimony–tin–lead "type metal" alloys have been investigated by means of thermal analysis and microexamination. The liquidus surface for alloys containing up to 24% antimony and 14% tin has been constructed. The general lines of the constitutional diagram put forward by Iwasé and Aoki (*Met. Abs.* (*J. Inst. Metals*), 1931, **47**, 378) have been confirmed. The existence of a true ternary eutectic in the lead-base corner is confirmed, but with the composition antimony 12, tin 4, and lead 84%, solidifying at 239° C. The ternary peritectic invariant point of Loebe and contemporary workers is shown to be the eutectic point of a pseudo-binary system of lead and the compound SbSn. A method of etching has been devised which distinguishes between the α and β antimony–tin phases, whether present as primary crystals or as eutectic constituents. The microstructures obtained with different rates of cooling through the solidification temperatures, including those of industrially cast types, have been examined and compared. Hardness tests have been carried out on the alloys.—F. D. W.

***Alloys of Magnesium. II.—The Mechanical Properties of Some Wrought Magnesium Alloys.** W. E. Prytherch (*J. Inst. Metals*, 1935, **56**, 133–150; discussion, 150–154).—An investigation into the mechanical and rolling properties of some binary magnesium alloys with zinc, cadmium, and aluminium, ternary alloys with zinc and cadmium, and cadmium–aluminium, and also zinc–cadmium–aluminium–magnesium alloys is described. The alloy systems studied were selected with reference to their constitution, with a view to the production of alloys of good mechanical properties amenable to heat-treatment. Although no alloys have been made which respond satisfactorily to heat-treatment in the manner characteristic of certain well-known aluminium alloys, some alloys having interesting properties have been studied. —W. E. P.

***Researches on the Complex Alloys of Magnesium, Based on the Magnesium–Cadmium System.** Ichiji Obinata and Masami Hagiya (*Tetsu to Hagane* (*J. Iron Steel Inst. Japan*), 1935, **21**, (2), 85–90).—[In Japanese.] Additions of 0·5–6% of copper, silver, zinc, mercury, aluminium, titanium, tin, lead, antimony, tellurium, chromium, manganese, and nickel were made alone or in pairs to the binary magnesium–cadmium alloys containing 1–10% cadmium. Measurements were made of the Rockwell hardness of the alloys in the cast, annealed, quenched, and aged state, as well as of their corrosion in distilled, ordinary, and salt water. The third constituents which harden the binary alloys most noticeably are copper, nickel, silver, and aluminium. Tin, manganese, zinc, antimony, and mercury harden the alloys to a certain extent, whilst the hardening effect of lead and tellurium is very small. The alloys in the cast state give, in general, the greatest hardness values; annealing and quenching make them softer. A remarkable ageing effect is found in the alloys containing aluminium or zinc. The addition of nickel, copper, and silver has a markedly injurious effect on the corrosion-resistance of the magnesium–cadmium alloys. Aluminium, lead, tellurium, and antimony also increase the corrosion. Although tin, zinc, manganese,

mercury, and titanium do not improve the corrosion-resistance of the binary alloys to any marked extent, the presence of these metals is not very harmful. —S. G.

***Magnesium–Cobalt Alloys.** J. P. Wetherill (*Metals and Alloys*, 1935, **6**, 153–155).—Cobalt–magnesium alloys containing up to 5% cobalt were prepared by adding strips of electrolytic cobalt to magnesium melted below a flux of potassium and magnesium chlorides and sodium fluoride. The microstructure of all the alloys showed the presence of a eutectic which appears to lie at 635° C. and about 5% cobalt. The density, melting point, and Rockwell "B" hardness of a number of the alloys are tabulated, and some characteristic microstructures are shown.—A. R. P.

***The Constitution of the Magnesium–Zinc–Silicon Alloys Rich in Magnesium.** Émile Elchardus and Paul Laffitte (*Compt. rend.*, 1935, **200**, 1938–1940).—Completes the investigation of the constitution of the magnesium-rich magnesium–zinc–silicon alloys (cf. *Met. Abs.*, 1934, **1**, 9). The existence has been established of a labile system due to unstable Mg_2Si and melting at 932° C. This compound forms in the binary magnesium–silicon system a eutectic containing 2·7% silicon and melting at 575° C. There results for the ternary system the possibility of 2 systems, one stable and one labile, and the phase boundaries of these 2 systems were determined by thermal and micrographic analysis. In the stable system, the equilibrium diagram of the $Mg–MgZn_2–Mg_2Si$ region contains a ternary eutectic, T_1. The labile system corresponding to the region $Mg–MgZn_2–Mg_2Si$ is similar and contains a ternary eutectic, T_2, melting at 314° C., and having the composition magnesium 51·85, zinc 47·7, silicon 0·45%. The existence of the labile system explains certain anomalies observed in the study of the physical and mechanical properties of the alloys.—J. H. W.

***Free Energy of Formation of Lead Amalgams.** C. S. Hoyt (*Univ. Pittsburgh Bull.*, 1933, (**30**), 159–165; *Sci. Abs.*, 1934, [A], **37**, 309).—Potentials of lead/lead amalgam concentration cells were measured. Free energy of formation of amalgams has been determined and the heat of solution of lead in dilute amalgam calculated from the temperature coeff. of the solution e.m.f.—S. G.

***Vapour Pressure Abnormalities for Amalgams.** H. H. von Halban, Jr. (*Helv. Phys. Acta*, 1935, **8**, 65–81; *Sci. Abs.*, 1935, **38**, 427).—[In German.] The vapour pressures of potassium, sodium and zinc amalgams are determined by v. H.'s method, which depends on the intensity of absorption of resonance radiation by the vapour. By comparison with the vapour pressure of very pure mercury, it is found that the amalgams show enormous decreases of vapour pressure even when the concentration of potassium, sodium or zinc is very low. This must be due to surface adsorption of the metals, the surface concentration being much higher than that in the interior of the liquid, for when the liquids are agitated during the measurements, the vapour pressure is observed to increase almost to that of pure mercury. The same effect is shown by mercury unless it is carefully purified. The high surface adsorption is adduced as an explanation of the observed fact that the photoelectric sensitivity of liquid alkali metal amalgams is practically independent of the concentration.—S. G.

Chromium–Nickel Alloys as Materials for Heating Resistances. Erich Becker (*Elektrotech. Anz.*, 1935, **52**, 289–290).—The characteristics of these alloys, with and without small additions of iron or molybdenum, are described, and a table of thermal and electrical properties is given. The usual alloys contain 15–20% chromium, since the resistance to oxidation is too low when the chromium content is below 15%, and the alloys become unworkable when it exceeds 20%. The effect of furnace atmosphere on the life of heating elements is discussed: this varies between 1 and 5 years at 1000°–1100° C. —C. E. H.

***Experience with Kanthal-A Used in an Electric Furnace.** Josef Zimmerman (*Elektrotech. Anz.*, 1935, 52, 392–395).—An account is given of the precautions necessary in drawing and welding the alloy and fitting the resistance elements into the furnace. Experiments on the performance and efficiency of these elements are described, showing the material to be very satisfactory.—C. E. H.

The Properties of Monel Metal. —— (*Brewers' J.*, 1935, 71, 288).—Corrosion-resistance and heat conductivity of Monel metal are discussed from the point of view of applications in the bottling and brewing industries.—H. W. G. H.

***Effect of Tension on the Magnetic Hysteresis of Permalloy.** T. Aizawa and G. Wachi (*Res. Electrotech. Lab. Tokyo*, 1933, (351), 1–20; *Sci. Abs.*, 1934, [A], 37, 208).—[In Japanese.] The results are given of experiments on the effect of tension on the magnetic hysteresis properties of nickel–iron alloys containing 40·04 to 79·6% nickel. With the exception of the alloy containing 40·05% nickel, all the alloys showed the minimum hysteresis loss at a certain value of the applied tension. The magnetic induction of the Permalloys under tension is lower than that under no tension when they are placed in a weak magnetic field, and this condition continues up to a certain field intensity at which the magnetic induction increases abruptly to its saturation value, producing a hysteresis loop of rectangular shape. This change disappears on stopping the tension, and the decreased initial permeability is recovered somewhat, but the magnetic property as a whole is degraded because of the mechanical deformation produced by the application of tension. The results are in good agreement with those of Buckley and McKechan (*J. Inst. Metals*, 1926, 35, 557) and also of Preisach (*Met. Abs.* (*J. Inst. Metals*), 1933, 53, 74).—S. G.

***Magnetostrictive Alloys with Low Temperature Coefficients of Frequency.** J. M. Ide (*Proc. Inst. Radio Eng.*, 1934, 22, 177–190; *Sci. Abs.*, 1934, [B], 37, 263).—34 magnetic alloys of iron, nickel, chromium, and cobalt were prepared and studied in order to find compositions of alloys which have substantially zero temperature coeff. of frequency of longitudinal vibration. Rods of these alloys were made to be used as secondary frequency standards, to stabilize the frequency of magnetostriction oscillators. The same alloys would be valuable as tuning forks. It was found that the temperature coeff. of frequency is a function of composition, heat-treatment, temperature, and magnetization. The compositions were found of 7 alloys which gave temperature coeff. of the order of 1 cycle in a million per ° C., when properly heat-treated and magnetized; 5 of these showed large dynamic magnetostriction, and gave good frequency stabilization when used with a magnetostriction oscillator.—S. G.

On Electrical Resistance Metals. Alfred Schulze (*Giesserei*, 1935, 22, 312–314).—Curves are given for the resistance between 0 and 1000° C. of wires of chromium–nickel and of various iron–chromium–nickel alloys. All the alloys containing iron have a resistance at 1000° C. of 1·1–1·4 ohms per metre (wire of 1 mm. cross-section). The composition, specific resistance, temperature coeff. of resistance, linear coeff. of thermal expansion, specific heat, density, melting point, and maximum temperature in use of Manganin, nickel silver alloys, Nickelin, Constantan, Isabellin, 80 : 20 nickel–chromium, various iron–nickel–chromium alloys, Megapyr, and Kanthal are shown in a table. On the basis of these constants, the value of these alloys for various electrical purposes is discussed.—A. R. P.

***Constitution and Structure of Alloys of Silver and Calcium.** (Degard.) See p. 378.

***Some Properties of Tin Containing Small Amounts of Aluminium, Manganese, or Bismuth.** D. Hanson and E. J. Sandford (*J. Inst. Metals*, 1935, 56, 191–204; discussion, 205–207).—Aluminium has a large effect on the

strength of tin; 0·5% increases the strength of pure tin from about 1·0 to about 5 tons/in.², while the elongation decreases from about 80 to 30%. Further additions, up to 1·0%, produce no appreciable effect. The improved properties are not permanent when the alloys are stored in normal conditions, owing to a deterioration of the material which commences at the surface and spreads slowly inwards: a brittle "skin" is formed, which cracks when the alloy is bent or otherwise strained. The tensile strength is seriously affected in thin sections, and a mass of cracks forms on the surface of the specimens. The "core" remains ductile for long periods. Rolled alloys deteriorate more rapidly than similar alloys in the cast condition, but the latter are not immune. A method for alloying manganese with tin is described. The effect of manganese on the strength of tin is only slight, and is practically independent of heat-treatment. Manganese is probably soluble in solid tin to only a very small degree at all temperatures. The addition of about 0·10–0·15% manganese to tin greatly refines the crystal size at all temperatures up to the solidus; the effect of about 0·2% is much less. With manganese contents exceeding about 0·3% a fine grain is again produced. The slight variations in tensile strength have been correlated to corresponding variations in crystal size. Bismuth greatly increases the tensile strength of tin, from about 1·0 ton/in.² in the pure metal to about 4·5 tons/in.² with a bismuth content of 4 or 5%. Heat-treatment has little effect on the strength, but alloys heat-treated near the eutectic temperature have low elongations. An explanation of the mechanical properties is suggested, based on the assumption of certain approximate values for the solid solubility; the values deduced are approximately the same as those given by Cowan, Hiers, and Edwards (*Amer. Soc. Steel Treat. Handbook*, **1929**, 563). Bismuth has a profound refining effect on the grain-size of tin, producing much finer grain structures than any other alloying element yet investigated: it is particularly effective in restraining grain-growth at elevated temperatures.—D. H.

***The Constitution and Properties of Cadmium-Tin Alloys.** D. Hanson and W. T. Pell-Walpole (*J. Inst. Metals*, **1935**, **56**, 165–182; discussion, 183–189).—The constitution of cadmium–tin alloys was determined by means of cooling curves and microstructures. A eutectic is formed at 176° C. and 33% of cadmium, but while there is a solid solubility at either end of the system, the exact positions of the sloping solidus lines have not yet been determined. Above 131° C. tin holds between 5 and 6% cadmium in solution, but at 131° C. two conjugate solid solutions are formed, which at 127° C. contain 1·25 and 5% cadmium. At this temperature, the one richer in cadmium decomposes to form a eutectoid. This transition occurs in all compositions from 1·25 to 99·5% cadmium. In alloys containing 40–90% cadmium, a slight transition, connected with a change of solubility of tin in cadmium, occurs at 170° C. The tensile strength and hardness of alloys containing up to 10% cadmium were measured after various heat-treatments. A permanent value of 5 tons/in.² can be obtained after suitable heat-treatments with addition of 5% cadmium. Cadmium has a very marked refining effect on the grain-size of tin. After a reduction of 80% by rolling, the grain-size is reduced from 1600 grains/cm.² in the case of pure tin to 26,000 grains/cm.² when 1% cadmium is present; further additions have little effect. After annealing for 1 day at 160° C., tin containing 5% cadmium has a grain-size of 48,000 grains/cm.².—D. H.

A Treatise on Pewter. Elsie Englefield (*London: Englefields*, **1935**, 35 pp.; and (abstract) *Found. Trade J.*, 1935, **52**, 379–381, 388).—Read before the Worshipful Company of Pewterers. Discusses the early history and the definition of pewter-mould making, casting the alloy, soldering and pewterers' moulds.—J. H. W.

***Spectral Emissivities of Tungsten–Molybdenum Alloys.** P. N. Bossart (*Univ. Pittsburgh Bull.*, 1933, (30), 59–64; *Sci. Abs.*, 1934, [A], **37**, 280).—Tubular filaments of the alloys and of the pure metals were made by extruding a paste containing tungsten and molybdenum powders, mixed in the desired proportions, through a die. Small side holes were then pierced with a fine wire and, after sintering and polishing, the filaments were mounted in lamp bulbs which were subsequently evacuated. The filaments were heated to the test temperature by passage of a current, and the temperatures of the external surface and the internal surface seen through the side holes were determined, using a disappearing filament optical pyrometer. From these measurements the emissivity could be derived (Worthing's method). Data are given for the emissivity at $\lambda = 0{\cdot}66\ \mu$ for tungsten, molybdenum, and alloys containing respectively 25, 62·5, and 87·5 weight-% of tungsten, for a number of temperatures in the range 1300°–2800° K. The emissivity of the alloys exceeded by 10% at 2200° K. to 20% at 1300° K. the value calculated assuming the alloy to be merely a mechanical mixture of its components. Variations were observed in the emissivity of the alloys after ageing, which are attributed to enrichment of the surface in tungsten owing to the higher rate of evaporation of molybdenum.—S. G.

***A New Alloy Specially Suitable for Use in Radium Beam Therapy [Tungsten–Nickel–Copper Alloys]** J. C. McLennan and C. J. Smithells (*J. Sci. Instruments*, 1935, **12**, 159–160).—The high density (19·3 grm./c.c.) of tungsten would make it very satisfactory for protective screens in radium therapy, but there are difficulties in preparing large pieces. A tungsten–nickel–copper alloy containing nickel 5 and copper 5%, can be prepared by sintering the powdered metals at temperatures of the order 1250°–1350° C., and has a density of 16·5 and a mean absorption coeff. for hard γ rays of 0·83 cm.$^{-1}$ Details of preparation of this and other ternary alloys are given.—W. H.-R.

***Resistance Alloys for High Temperatures.** P. Silberbach (*Elektrotech. Anz.*, 1935, **52**, 336–338).—A series of curves is given, showing the variation of electrical resistance with temperature, and the thermal expansion on heating to various temperatures, for Megapyr (a chromium–aluminium–iron alloy), Kanthal (a similar alloy with an addition of cobalt), and a chromium–nickel alloy. Both Megapyr and Kanthal were found to have a higher specific resistance at all temperatures, and to reach a higher temperature for the same current than the chromium–nickel alloy.—C. E. H.

***Vapour Tensions and Activities of Completely and Partially Miscible Metals in Molten Binary and Ternary Alloys with One or Two Volatile Components.** Karl Jellinek and Hans-Andreas Wannow (*Z. Elektrochem.*, 1935, **41**, 346–362).—In a series of experiments on ternary alloys of tin with antimony, lead, zinc, and cadmium, and on binary alloys of these metals, the following determinations have been made: the heat of vaporization of molten antimony between 785° and 1100° C.; the vapour tension and activity of the completely miscible molten binary alloys, antimony–zinc at 785° C., tin–cadmium at 700° C., and tin–zinc at 700° and 785° C., and of the partially miscible alloys lead–zinc at 653° and 754° C., above and below the miscibility gap—from the measurement of the vapour tension, the extent of the miscibility gap can be determined or confirmed; the vapour tension and activity of molten zinc–cadmium alloys, having zinc as the volatile constituent, at 700° C., and the data of N. W. Taylor (*J. Amer. Chem. Soc.*, 1923, **45**, 2865) were corrected; the activity of the single volatile component, zinc, in the completely miscible ternary alloys, tin–antimony–zinc, at 700° C., and in the partially miscible ternary alloys, tin–lead–zinc, at 653° C., and the extent of the inhomogeneous region was checked; the activity of both volatile components, zinc and cadmium, in the completely miscible molten ternary alloys, tin–cadmium–zinc at 700° C.—J. H. W.

III.—STRUCTURE

(Metallography; Macrography; Crystal Structure.)

(Continued from pp. 342–344.)

***On the Crystal Structure and Crystalline Configuration of the Normal and Modified Si–Al Alloys.** Hajime Kotô (*Mem. Coll. Sci. Kyoto Imp. Univ.*, 1935, [A], **18**, 17–33).—[In English.] The cooling curves and microstructures of various sand-cast specimens of normal and modified aluminium–silicon alloys were preliminarily examined to ascertain the characteristic modifying effects of a series of substances analogous in some respects to sodium. To revise and complete the conclusions arrived at, an X-ray examination of the crystal structures and crystalline configurations of the same alloys was then carried out. The microstructures give little information regarding the actual crystalline configurations. The peculiarities of the substances efficacious for the modification of aluminium–silicon alloys were found not always to be in good agreement with those generally accepted by present theories of modification.—S. G.

***The Structure of Electrolytic Chromium.** L. Wright, H. Hirst, and J. Riley (*Faraday Soc. Advance Copy*, **1935**, Mar., 3 pp.).—Chromium is deposited in the body-centred cubic form from chromic acid solutions containing less than 18% of the total chromium in a reduced condition, irrespective of the current, acidity, or temperature conditions, but when more than 20% of the chromium is present in a reduced condition the whole of the deposit consists of the hexagonal modification with $c/a = 1{\cdot}626$ A. and the distance between neighbouring atomic centres 2·717 A. On heating the hexagonal allotrope at 800° C. *in vacuo* it is converted into the cubic modification with $a = 2{\cdot}8788$ A. —A. R. P.

***The Crystal Structure of Au_2Bi [Equilibrium Diagram of the System Gold–Bismuth].** T. Jurriaanse (*Z. Krist.*, 1935, **90**, 322–329).—[In English.] The system gold–bismuth contains an intermetallic compound of fixed composition Au_2Bi. The crystal structure is face-centred cubic with an atomic arrangement $8f$—16c and space group O_h^1, and $d = 7{\cdot}942 \pm 0{\cdot}002$ A. Debye–Scherrer photographs with powders quenched from different temperatures indicate that the compound is formed by a peritectic reaction at 373° C. The solid solubility of bismuth in gold is probably much less than the value of 4% given by Vogel (*Z. anorg. Chem.*, 1906, **50**, 147) since the lattice parameter of the gold phase in heterogeneous alloys is identical with that of pure gold, and an alloy containing 0·2% bismuth contained particles of Au_2Bi after annealing for 48 hrs. [temperature not stated]. The compound has the same type of structure as Cu_2Mg, W_2Zr, Bi_2K, and Au_2Pb.—W. H.-R.

Two-Dimensional Superstructures [in the Compound Ni_3As_2]. Fritz Laves (*Z. Krist.*, 1935, **90**, 279–282).—A note. Weissenberg photographs of single crystals of naturally occurring Maucherite (Ni_3As_2) show faint continuous lines as well as the usual spots. This indicates (see Laves and Nieuwenkamp, this vol., p. 380) the existence of a two-dimensional superstructure. The crystals are probably not of uniform composition, and contain a two-dimensional superstructure with doubled a axis.—W. H.-R.

***Constitution and Structure of Alloys of Silver and Calcium.** Ch. Degard (*Z. Krist.*, 1935, **90**, 399–407).—[In French.] Silver–calcium alloys of compositions corresponding to the compounds and eutectics in the diagram of Baar (*Z. anorg. Chem.*, 1911, **70**, 352) were prepared by melting the metals in sealed quartz tubes which were slowly cooled. X-ray crystal analysis confirmed the existence of the compounds AgCa and Ag_3Ca, but not of Ag_4Ca,

Ag_2Ca, or $AgCa_2$ which were claimed by Baar. Ag_3Ca has a tetragonal structure with $c/a = 0{\cdot}88$, whilst AgCa is face-centred cubic in contrast to structures such as CuZn which have a body-centred cubic structure in agreement with the Hume-Rothery rules.—W. H.-R.

***Structure of Silver Amalgam.** A. Weryha (*Acta Physica Polonica*, 1933, **2**, 161–179; *Sci. Abs.*, 1934, [A], **37**, 8).—The structure of Ag_3Hg_4 was investigated by the powder method. It is cubic, the unit cell containing 4 molecules, the length of the edge being 10·09 A. The space group is O_h^3. The silver atoms are in the 12 V_d positions, and the mercury atoms in the 16 C_{3v} positions, the parameter value of the latter being 23/120. The same structure is found for Ag_3Hg_4 prepared by dropping mercury in a solution of silver nitrate as for the amalgam formed when a silver wire is dipped in mercury. A tabular method of calculation for the case of Ag_3Hg_4 is given, which shortens the work by about 80–85%.—S. G.

***The Determination of the Axis of Bending of Deformed Crystals from Laue Photographs [Distortion of Zinc Crystals].** W. Boas and H. Ekstein (*Z. Krist.*, 1935, **90**, 408–414).—On the assumption that the asterism of the spots on Laue diagrams indicates a bending of all the crystal planes about one axis, a method for determining the direction of this axis relative to the incident X-ray beam is developed for transmission and back-reflection Laue photographs. The method does not require an identification of the indices of the spots. A zinc crystal extended in tension is examined and the axis of bending coincides with a digonal axis of the second order.—W. H.-R.

†Atomic Arrangement in Metals and Alloys. W. L. Bragg (*J. Inst. Metals*, 1935, **56**, 275–299).—May Lecture. An account is given of the theory of atomic arrangement in the crystalline structure of an alloy. The arrangement has two features, which may to a large extent be considered independently. The first is the pattern of sites characteristic of each phase, and the second is the mode of distribution of the constituent atoms amongst the phase-sites. In both respects, considerable progress has been made towards an explanation of the features revealed by X-ray analysis.—W. L. B.

The Crystalline Structure of Metals. —— (*Met. Ind.* (*Lond.*), 1935, **46**, 669–670).—An interesting and informative summary. Recent theories based on mosaic, secondary, and lineage structures, the modified crack-broadening theory, and Taylor's theory of plasticity of crystals are briefly but clearly reviewed.—J. H. W.

***An Analytical Method for Determining the Preferred Orientations of Crystals in Mechanically Worked Cubic Metals.** Carl B. Post (*Z. Krist.*, 1935, **90**, 330–340).—[In English.] The method of Davey, Nitchie, and Fuller (*J. Inst. Metals*, 1929, **42**, 523) is further developed. Measurements of 2 diffraction patterns made in different directions across the sheet of metal are sufficient to determine the preferred orientation. The data of Hollabaugh (*Met. Abs.* (*J. Inst. Metals*), 1931, **47**, 25) for sheets of rolled silver are re-examined. The orientation is such that the face diagonal of the basal plane of the unit cell makes an angle of 22° with the direction of rolling. The range of preferment is $\pm$ 15° about this mean position. The 2 symmetrical orientations about the direction of rolling which were assumed by Hollabaugh are not essential to explain the data, although 2 orientations of this kind might exist without the method being able to decide whether one or both were present.—W. H.-R.

***A Method for Detection and Evaluation of Residual Distortion in Crystals with Special Reference to Electric Steel.** George L. Clark and M. M. Beckwith (*Z. Krist.*, 1935, **90**, 392–398).—[In English.] A method is developed for estimating the residual distortion in crystals from measurements of the elongation of spots in a Laue X-ray photograph, and is applied to silicon–steel.—W. H.-R.

***A Direct Method for the Determination of the Components of Interatomic Distances in Crystals.** A. L. Patterson (*Z. Krist.*, 1935, **90**, 517–542).—[In English.] The method is based on the theory of Fourier series.—W. H.-R.

Determination of the Grain-Size in the Region 1 to 100 μ by the Debye–Scherrer Method. H. S. Schdanow [G. S. Zhdanow] (*Z. Krist.*, 1935, **90**, 82–91).—Methods are described for the estimation of the grain-size for crystals of the order 1 to 100 μ by a development of the Debye–Scherrer method of X-ray crystal analysis. An example is given of the change in grain-size on annealing hard-worked copper.—W. H.-R.

A Suggested Method for the Simple Reproduction and Study of Debye [–Scherrer] Photographs. Karl Meisel (*Z. Krist.*, 1935, **90**, 92–95).—A note. Describes a method by which Debye–Scherrer films can be copied photographically. By photographing through narrow wedge-shaped slits, the relative intensities of the lines can be brought out clearly.—W. H.-R.

***A Nomogram for Computing Structure Factors.** I. Fankuchen (*Z. Krist.*, 1935, **90**, 284–286).—[In English.]—W. H.-R.

***The Weissenberg Reciprocal Lattice Projection and the Technique of Interpreting Weissenberg Photographs.** M. J. Buerger (*Z. Krist.*, 1935, **90**, 563).—[In English.] Corrections to a previous paper. See *Met. Abs.*, this vol., p. 101.—W. H.-R.

The Interpretation of Weissenberg Photographs in Relation to Crystal Symmetry. D. Crowfoot (*Z. Krist.*, 1935, **90**, 215–236).—[In English.] —W. H.-R.

***Interference Phenomena in Two-Dimensional Crystals.** F. Laves and W. Nieuwenkamp (*Z. Krist.*, 1935, **90**, 273–278).—An examination of interference effects produced by two-dimensional crystals with monochromatic and polychromatic X-rays.—W. H.-R.

***A Note on the Diffraction of Cathode Rays by Single Crystals.** Ken'ichi Shinohara (*Phys. Rev.*, 1935, [ii], **47**, 730–735).—W. H.-R.

***On the Theory and Refractive Index of Crystals for Cathode Rays and the Breadth of Reflection Line.** Seishi Kikuchi (*Sci. Papers. Inst. Phys. Chem. Res. Tokyo*, 1935, **26**, (563), 225–241).—[In English.] A theoretical investigation, some results of which are compared with data from nickel crystals.—W. H.-R.

The Rôle of X-Ray Analysis in Works' Laboratories. B. A. Krasuk (*Zavodskaia Laboratoria* (*Works' Laboratory*), 1934, **3**, 732–737).—A review. —D. N. S.

Electron Diffraction as a New Method of Investigation of Matter. M. M. Umanski (*Zavodskaia Laboratoria* (*Works' Laboratory*), 1934, **3**, 810–818).—[In Russian.] The applications of the method are surveyed.—D. N. S.

***Quantum Theory of Metallic Reflection.** L. I. Schiff and L. H. Thomas (*Phys. Rev.*, 1935, [ii], **47**, 860–869).—The classical theory of metallic reflection is revised from the point of view of the new quantum theory. The Drude theory modified where necessary by Kronig's results (*Proc. Roy. Soc.*, 1929, [A], **124**, 409; 1931, [A], **133**, 255) gives the electromagnetic field correctly except within a transition layer extending a few electron wave-lengths from the surface. In this transition layer the continuously varying electric intensity perpendicular to the surface, which was assumed to be discontinuous in the Drude theory, does not have the values required by that theory, but fluctuates considerably. The fluctuations depend on the nature of the surface potential barrier in a complicated way, and their calculation is required in the theory of the surface photoelectric effect.—W. H.-R.

IV.—CORROSION

(Continued from pp. 345–348.)

***A New Method for Studying the Corrosion of Aluminium by Soda.** Yeu Ki-Heng and Yeou Ta (*Compt. rend.*, 1935, **200**, 2153–2155).—In a basic solution, there exists an alumino-tartrate of the formula $Na_3AlT'_3$, where $T = C_4H_4O_6$, which appears to be a double tartrate of aluminium and sodium. It has been studied by immersing a sheet of aluminium in a solution of sodium tartrate to which a certain amount of soda in excess is added. The aluminium is converted to aluminate, which combines with the tartrate. The power of rotation corresponds initially with that of sodium tartrate, and finally with that of $Na_3AlT'_3$. The power of rotation and the loss in weight of aluminium was measured from time to time, and the rotation and the weight of combined aluminium were calculated. The rate of attack varies considerably with the amount of soda added and with the purity of the metal. This method for studying the corrosion of aluminium has the advantage that it can be used with very weak solutions of soda, with an accuracy scarcely possible with the ordinary loss-in-weight method. It is stated that the mechanism of the reaction, and the effect of the temperature and of neutral salts, &c., are being studied, and a rapid and accurate method for determining the purity of aluminium is being investigated (the results are not given). Aluminium alloys are more easily attacked than the metal, and the purest metal is the least attacked.—J. H. W.

On the Influence of Various Concentrations of Sodium Chloride and Hydrogen Peroxide on the Results of Rapid Corrosion Tests [on Aluminium]. H. Röhrig and K. Schönherr (*Korrosion u. Metallschutz*, 1935, **11**, 136–137).—Variations in the concentration of sodium chloride between 3 and 20% have little effect on the rate of corrosion in the oxidizing salt test as measured by the change in breaking stress or elongation of aluminium wires. Additions of hydrogen peroxide have a pronounced effect on the rate of loss of elongation but practically no effect on the tensile strength; this effect is attributed to local pitting, the sharply defined pits reducing the capacity to flow of the alloy.—A. R. P.

***Investigation of the Structure Corrosion of Aluminium Alloys.** G. W. Akimov and A. S. Oleshko (*Korrosion u. Metallschutz*, 1935, **11**, 125–132).—See abstract from a Russian source, *Met. Abs.*, this vol., p. 58.—A. R. P.

***Corrosion-Fatigue Properties of Duralumin With and Without Protective Coatings.** I. J. Gerard and H. Sutton (*J. Inst. Metals*, 1935, **56**, 29–45; discussion, 45–53).—Rotating cantilever endurance tests on Duralumin 3LI (copper 4·1–4·4, manganese 0·64, magnesium 0·62–0·67, iron 0·84–0·81, silicon 0·22%) were made in air and in a salt-spray, after protecting the surface in various ways. In air the untreated material gave a fatigue limit of stress of $\pm$ 9·1 tons/in.^{2} at 10^7 cycles and the anodized material $\pm$ 11·1 tons/in.^{2}. In a salt-spray lanolin-coating and cadmium-plating afforded little protection, but zinc plating gave a substantial improvement in the corrosion-fatigue range. Spraying with aluminium was not so good as zinc-plating at long endurance. Coatings of organic resins and enamels afforded a very high degree of protection, especially when the metal had previously been anodized; the best results were obtained with a coating of synthetic resin varnish and stoving for 2 hrs. at 100° C., metal so treated giving a corrosion-fatigue endurance stress of $\pm$ 12·2 tons/in.^{2} at 10^7 cycles.—H. S.

Age-Hardening and Corrosion [of Copper–Aluminium Alloys]. E. Söhnchen (*Giesserei*, 1935, **22**, 294–296).—Copper–aluminium alloys undergo strong intercrystalline corrosion in the age-hardened condition, the rate of corrosion depending on the time of ageing and being greatest when the alloy is in the hardest state. After exposure to an oxidizing salt test, the breaking stress

(σ_B), is related to the time of exposure (t) by the expression: $\log \sigma_B = kt + b$, where k and b are constants. The slope of the graphs for Lautal becomes steeper with increasing age-hardness.—A. R. P.

***Basic Copper Carbonate and Green Patina.** W. H. J. Vernon (*J. Chem. Soc.*, 1934, 1853–1859).—When copper is immersed in an aqueous solution of carbon dioxide, basic copper carbonate is formed, but in air containing carbon dioxide and water vapour another reactant, such as a trace of carboxylic acid vapour, and less effectively chlorides and sulphur dioxide, is necessary for the formation of the substance. When these additional reactants are present the probable mechanism is the formation of the normal salt followed by hydrolysis in the presence of carbon dioxide resulting in the formation of the basic carbonate. Thus basic copper carbonate, a minor constituent of the open-air patina on copper, is a maximum (up to 24·2%) in towns owing to the presence of carboxylic acid vapours in the atmosphere and sometimes at the sea-board owing to the presence of chlorides. Similarly the presence of sulphur dioxide can indirectly result in the formation of basic copper carbonate inland, but the quantity can only be appreciable in urban districts. The incorrect statement that the green out-door patina on copper is basic copper carbonate has been traced to Fourcroy (1786).—S. V. W.

Influence of External Factors on the Corrosion of Lead in Sulphuric Acid Production. V. Pershke and V. Ignat'eva (*Khimstroi*, 1935, **7**, 38–40; *C. Abs.*, 1935, **29**, 3786).—[In Russian.] Cf. *Met. Abs.*, 1934, **1**, 499. In the uniformly even and the local disintegrations of lead lining of sulphuric acid chambers and towers, the latter form of corrosion may be ascribed to a formation of a galvanic element: (+) PbH_2SO_4 or nitroso acid | H_2SO_3 (or nitroso acid) + HNO_3 | Pb (−). The mechanical imperfections of lining (folds, seams, &c.) cause local differences in temperature and condensation of the reacting mixture. This contains traces of free nitric acid, as a result of varying conditions of production, which attacks lead. The lead nitrate formed is immediately converted, in the presence of sulphuric acid, into lead sulphate, with liberation of nitric acid, and the cycle is indefinitely repeated. These spongy and brittle corrosion products, deposited on the anode, easily fall off, exposing a new surface to the destructive process. Detection of lead nitrate in the corrosion products substantiates the proposed explanation of the corrosion process. The corrosion can be counteracted by a preliminary exposure of lead lining to the action of sulphur dioxide.—S. G.

Electrolytic Corrosion of Cable-Sheaths. I. Panara (*Elettrotecnica*, 1934, **21**, 209–219; *Sci. Abs.*, 1934, [B], **37**, 330).—The return current in a d.c. tramway system with a single trolley wire passes along the rails, which are never insulated from the earth. There are consequently, in all but completely dry soils, stray currents which will enter and pass along any metallic structures in their path. A lead-covered cable when installed near a tramway system is consequently in danger from damage to the sheath by electrolytic corrosion. The corrosion, which nearly always takes place in the zone where the stray currents pass out of the sheath to return to the rails, takes the form of pitting, which may eventually penetrate right through to beneath the lead. The products of electrolytic corrosion always contain large quantities of lead chloride, and the presence of this salt enables the corrosion to be identified as electrolytic rather than as purely chemical. There are many kilometres of unarmoured cable in the dustwork of the city of Milan, and a system of protection against electrolytic corrosion has been developed after much experimental work. The principles of this system are: (1) the potential of the cable-sheath is caused to be lower than that of the surrounding earth; (2) the current flowing in the sheath is drained off at appropriate points by means of metallic connections to the rails; (3) the potential difference between the sheath and earth is kept as low as possible. It is necessary to instal

insulating joints to separate the cable-sheath into electrolytically-insulated sections, and these have to be constructed with great care. The potential difference between the sheath and earth at the drainage points can be read at a central control station, and the resistance of the drainage connection adjusted when necessary by a variable resistance. When the cable has to be installed without ductwork, an alternative method of protection is to enclose it in troughing filled with bitumen, thus preventing any direct contact with the earth. This article is particularly clearly written and illustrated.

—S. G.

***The Effect of Five Years' Atmospheric Exposure on the Breaking Load and the Electrical Resistance of Non-Ferrous Wires.** J. C. Hudson (*J. Inst. Metals*, 1935, **56**, 91–101; discussion, 101–102).—Gives the results of atmospheric corrosion tests in which various non-ferrous wires (H.-C. coppers, silicon–copper, cadmium–copper, arsenical copper, copper–nickel alloys, 70 : 30 brass, Post Office bronzes, nickel, zinc, and galvanized iron) were exposed to an urban atmosphere for 5 years; the extent of corrosion was measured both by determinations of the extent to which the breaking load of the wires had been decreased by exposure and by measurements of the increase in the electrical resistance of the wire. The results of the 2 series of tests are in reasonable agreement with each other and with those of earlier tests. In general, the rate of corrosion observed was small, that of copper being, for instance, of the order of 0·0002 in. per annum; the rate was definitely higher for nickel, nickel–copper alloys with high nickel contents, zinc, and brass, the breaking load of the last material being appreciably impaired by the effects of "copper redeposition." The most corroded material was a galvanized iron wire, which failed rapidly when the zinc coating had corroded. Comparison of the present results with those of similar tests over shorter periods points to the conclusion that in many cases, such as those of copper and high-copper bearing alloys, the rate of corrosion decreases with time of exposure.—J. C. H.

***Some Further Experiments on Atmospheric Action in Fatigue.** H. J. Gough and D. G. Sopwith (*J. Inst. Metals*, 1935, **56**, 55–80; discussion, 80–89).—Describes experiments carried out to investigate further the effect of atmospheric environment on the fatigue-resistance of metals. Previous experiments (*J. Inst. Metals*, 1932, **49**, 93–112), had shown that the substitution of a partial vacuum for the atmosphere led in some metals to a considerable improvement in the values of the fatigue limit determined using cycles of reversed direct stress. Three suggestions have been made as to the cause of this improvement: (1) that oxygen is the primary factor, the presence of water—as a catalytic agent—also being necessary; (2) that atmospheric impurities, acid and alkaline, are responsible, and (3) that impurities, mainly gaseous, dissolved in the metal under test, react with the metal during fatigue. To examine possibilities (1) and (2), fatigue tests were carried out using copper and brass in 4 environments, *viz.* air, partial vacuum, and purified air (freed from acid and alkaline impurities) in the dry and damp conditions. To examine possibility (3) fatigue tests in air and in a partial vacuum were made on a copper containing cuprous oxide, on oxygen-free copper, and also on copper deoxidized with phosphorus. As a matter of general interest fatigue tests conducted both in the atmosphere and in a partial vacuum were carried out on pure lead, and on Armco iron tested in 2 forms of heat-treatment. The results of the tests on copper and brass suggest strongly that the acid and alkaline impurities present in the atmosphere can have little, if any, influence on atmospheric corrosion-fatigue, but that oxygen in the presence of water is probably primarily responsible. The results of the tests on the oxide-bearing and deoxidized coppers show that the comparative behaviour of these materials when tested in air and in a partial vacuum is unaffected by the different compositions of the dissolved gases present in the two materials.—H. J. G.

POLITECHNIK

***Corrosive Action of Brines on Metals Used in Dairies.** A. Burr and M. Miethke (*10th World Dairy Congress, Milan, Sect. II*, **1934**, 281–286; and (summary) *Food*, 1934, **4**, 7; *C. Abs.*, 1935, **29**, 4091).—[In English.] A study of the corrosive action of commercial brines of corresponding density on single metals kept in movement and half immersed. "Chrome–Reinhartin" (I) (a 1 : 3 mixture of $CaCl_2 \cdot 6H_2O$ and $MgCl_2 \cdot 6H_2O$, with Na_2CrO_4) and "Dairy brine" (II) were the best solutions. I attacks zinc most, lead and iron are encrusted and all other metals tested are unaffected; II attacks lead (severely), copper and copper alloys, but other metals are unaffected. "Frigisol" (a 1 : 3·7 mixture of $CaCl_2 \cdot 6H_2O$ and $MgCl_2 \cdot 6H_2O$, together with some $NaClO_3$) attacks solder and tinned sheets severely, and corrodes lead, zinc, and iron. "Reinhartin" (similar to I, but containing protective colloids and buffers, but no Na_2CrO_4) does not attack solder and tinned sheets, and corrodes lead, zinc, and iron.—S. G.

***Corrosion Caused by Brines on Refrigerating Machinery.** O. Stueber (*10th World Dairy Congress. Milan, Sect. II*, **1934**, 439–447; and (summary) *Food*, 1934, **4**, 9; *C. Abs.*, 1935, **29**, 3969).—[In English.] S. studied the corrosive action of brines on iron, brass, bronze, copper, zinc, and aluminium. Brines are classified as (1) having a constant corrosive action, (2) having a decreasing corrosive action, and (3) forming crusts on the metal.—S. G.

***Action of Metals and Their Alloys on Whole Milk, and of Milk on Metals and Alloys.** W. Mohr, R. Kramer, A. Burr, and H. Osterburg (*10th World Dairy Congress, Milan, Sect. II*, **1934**, 199–205; and (summary) *Food*, 1934, **4**, 10; *C. Abs.*, 1935, **29**, 4090).—[In English.] A study of the corrosive effect of whole milk on single metals, and of the taste produced in milk at different temperatures. Metals kept in movement and half immersed were corroded more rapidly than when still and fully immersed; corrosion varies with the temperature. V2A steel, welded V2A steel, aluminium, aluminium alloys, and tinned sheets were unaffected; nickel, nickel alloys, copper, brass and zinc were affected at all temperatures. Nickel alloys, Duralumin, copper, brass, and zinc affected the taste of the milk. Iron in combination with aluminium is attacked at room temperature; other metals when connected to a more electropositive one appear to be stable. At 65° C. only V2A steel, electrolytic chromium, chrome–copper, tin, tinned copper, and tinned iron remained unattacked when so joined.—S. G.

The Corrosion of Metals in the Course of Manufacture of Condensed Milk. G. Genin (*Lait*, 1935, **15**, 159–167; *C. Abs.*, 1935, **29**, 4468).—Practically all metals are superior to copper for the construction of evaporators for milk products. Corrosion is retarded in most metals by the formation of a protective milk film. This protective film is less effective on copper.—S. G.

Eleventh Annual Report (1934) of the Association Suisse des Électriciens and Three Associated Societies. J. Landry (*Bull. Assoc. Suisse Élect.*, 1935, **26**, 399–401).—The work of the Corrosion Committee included the investigation of isolated instances of corrosion of electric supply and telephone cables, and water and gas piping. Regular testing was carried out on certain railways and tramways. Tests have proceeded on the comparative rates of corrosion of iron, lead, aluminium, and light alloy electrodes; an automatically operated apparatus records experimental conditions and effects reversals of current. The Committee concludes that the use of return wires may cause electrolytic corrosion if the insulation of negative cables is defective, and that the earthing of cable-sheaths in each section increases the risk of such corrosion through the possible setting up of additional stray currents.—P. M. C. R.

V.—PROTECTION
(Other than Electrodeposition.)

(Continued from pp. 348–349.)

Electrically Oxidized Aluminium as a New Material for Electrotechnical Purposes. —— Blume (*Elektrotech. Anz.*, 1934, **51**, 452).—By the use of anodically treated aluminium for conducting parts of electrical plant, a saving of insulating material is effected, since the hard oxide film is a good insulator. Methods for treating the aluminium to give a film of this kind are briefly described.—C. E. H.

Protection of Oxidizable Metals by Pitch and Aluminium Powder. A. Vila (*J. usines gaz*, 1934, **58**, 655–657; *C. Abs.*, 1935, **29**, 3635).—Good results were obtained with mixtures of 57–62·5% tar, 25–30% special "gas plant diluent," and 11·5–12·5% aluminium powder used as paint for outside steel work in a rapid corrosion-test apparatus. The coverage is about 11–15 m.^{2} per kg. of paint.—S. G.

Lead Coating with the Oxy-Acetylene Flame. Leo Knez (*Autogen Schweisser*, 1934, **7**, (Apr.), 54–56).—S. G.

The Condition of the Material and the Composition of the Zinc Bath as Causes of Defects in Zinc Coatings. E. Schreiber (*Illust. Zeit. Blechindustrie*, 1935, **64**, 502–504).—The formation of a uniform zinc coating may be prevented by (*a*) residues from the pickling bath; these contain a high proportion of metallic oxides, notably ferrous oxide; (*b*) segregates in the basis metal; (*c*) surface defects, which prevent the formation of a uniform "hard" layer and thus may cause exfoliation. An excess of the "hard" iron–zinc compound, which is considered to be present in the bath as a result of action on the plate rather than on the material of the vat, may be due to local overheating; the addition to the bath of enough lead to cover the heated area retards the formation of "hard zinc," but allowance must be made for an increase in volume of the lead, as the latter dissolves 7% of zinc at 440° C. Additions of aluminium or copper to the bath improve the mechanical properties and corrosion-resistance of the coating.—P. M. C. R.

***Submersion Time Versus Quality of Hot-Dip Zinc Coatings.** Wallace G. Imhoff (*Iron Age*, 1935, **135**, (23), 16–17, 124, 126, 128).—The effect of the time of submersion in hot-dipping on the following characteristics of the zinc has been experimentally investigated: spangle or crystallization effect, finish of non-spangled coatings, and thickness, iron content, weight, bending qualities, smoothness and lustre of the coating, and its adherence to the base metal. Specific recommendations are given as to the time of submergence in the case of each of these characteristics.—J. H. W.

The Thickness of Zinc in Galvanized Wires and Sheets and Its Determination. H. Meyer auf der Heyde (*Oberflächentechnik*, 1935, **12**, 58–59).—Methods for stripping the zinc layer are described and tables are given for calculating the zinc deposit from the loss in weight or diminution in thickness or diameter after stripping.—A. R. P.

The Drossing Temperature Should be the Same as the Operating Temperature in Hot-Dip Galvanizing. Wallace G. Imhoff (*Amer. Metal Market*, 1935, **42**, (115), 3, 5).—Reasons are given for maintaining an equable temperature at all stages of the galvanizing operation in order to avoid difficulties due to the irregular formation of iron–zinc alloy drosses.—A. R. P.

***Metallic Cementation. III.—Metallic Cementation by Means of Tin Powder.** Tsutomu Kase (*Kinzoku no Kenkyu*, 1935, **12**, (4), 210–219).—[In Japanese.] The cementation of iron, copper, and nickel by commercial tin powder was studied at various temperatures between 300° and 1100° C. Measurements of depth of penetration, microscopic and chemical analyses, and corrosion

tests in some acids and water were carried out. Diffusion of tin into iron, copper, and nickel occurs at a temperature above 230° C., or near the melting point of tin, and the rate of diffusion increases with increase of temperature. The rate of diffusion into iron changes, however, almost abruptly at the A_3 point (906° C.). The relation between the increase of weight of the specimen (ΔW) or the depth of penetration (P) and the absolute temperature of cementation (T) is given by an exponential function, ΔW (or P) $= ae^{-b/T}$. The relation between ΔW or P and the length of time for cementation (0) is given by a similar function, ΔW (or P) $= ae^{b\theta}$, where a and b are different constants in each case.—S. G.

Cold-Spraying of Aluminium. O. Kühner (*Maschinenbau*, 1935, **14**, 151–152).—The method is described and its economics and use are discussed.
—K. S.

Sprayed Metal and Its Uses. E. J. Tangerman (*Machinist* (*Eur. Edn.*), 1935, **79**, 360–363).—A description is given of metal-spraying pistols and their operation, selection of the metal to be used as the spray, wire-feed rate, thickness of deposit for various purposes, bond strengths, and the Alumetizing process. The latter consists in spraying, with aluminium, parts to be subjected to high temperatures and gas impingement. They are then given 3 coats of potassium silicate, heated to 760° C. for 5 minutes, and then to 1040° C.
—J. H. W.

***Improvement of the Quality of Metallic Coatings by the Use of Non-Metallic Intermediaries and Supports.** H. Reininger (*Faraday Soc. Advance Copy*, 1935, Mar., 8 pp.).—Ordinary sprayed metal coatings adhere only by adhesion, are porous, and crack readily on bending, but by impregnating them with soft copal or Bakelite varnishes they are considerably strengthened, their adhesion is improved, and they may be bent considerably without flaking. The varnish coats the individual particles, fills up the interstices, and protects both coating metal and base metal from corrosion. Varnished coatings can be ground down almost to the base metal without the resultant stresses producing flaking. Examples of varnished nickel coatings on hard brass are illustrated and discussed.—A. R. P.

The Study of Anticorrosive Varnishes and Paints. R. Servant (*Métaux*, 1935, **10**, 50–64).—The use of various oils, gums, tars, paints, and such materials as red lead, iron oxides, and powdered aluminium as anti-corrosives is discussed.
—J. H. W.

The Greasing of [Aluminium] Free Transmission Lines. Paul Behrens (*Aluminium*, 1935, **17**, 305–306).—Outdoor exposure tests and accelerated laboratory tests have shown that a coating of vaseline on all the strands of aluminium free transmission lines will preserve them from any signs of corrosion, even in marine atmospheres, for periods of at least 5 years.—A. R. P.

Lubrication and Corrosion. P. F. Thompson (*Australian Chem. Inst. J. and Proc.*, 1935, **2**, 50–54; *C. Abs.*, 1935, **29**, 3817).—In order to prevent water coming in contact with metal surfaces, especially in refrigerating machines, where it can cause corrosion of bearings, a perfect bond between the metal surfaces and the lubricating oil must be effected. To do this, some substance should be added which produces a lowering of the surface tension of the mineral oil by the presence of polar groupings. Lanolin, which may contain unsaturated groups but which most certainly possesses an alkaline nature, contains certain polar groupings which give it the power to exclude water and thus to promote a better bond between the oil and the metal. Although fatty acids would reduce the surface tension of the mineral oil, they are not applicable because of reactivity with gases used in the refrigeration process.—S. G.

VI.—ELECTRODEPOSITION

(Continued from pp. 349–351.)

***Electroplating Bismuth on Metals.** G. S. Vozdvizhenskii, M. I. Kamaletdinov, and N. Ya. Khusainov (*Trans. Butlerov Inst. Chem. Tech. Kazan*, 1934, (1), 102–107; *C. Abs.*, 1935, 29, 3918).—Experiments on the electrodeposition of bismuth on brass were carried out at room temperature from a bath containing bismuth trinitrate and nitric acid. In one series of experiments, the concentration of bismuth trinitrate and current density were varied, to study the effect of these on the thickness of the deposit. Each experiment lasted 30 minutes. For concentrations of bismuth trinitrate of 29·3, 38·0, and 93·3 grm./litre, the thicknesses were 0·0047, 0·0049, and 0·0050 mm., respectively, at 5 milliamp./cm.^{2} and 0·0068, 0·0070, and 0·0069 mm., respectively, at 8 milliamp./cm.^{2}. The bismuth coating was smooth, and adhered firmly to iron, steel, copper, and brass. When polished, the coating resembles nickel in appearance. The bismuth coating resists the corrosive action of concentrated sulphuric acid, concentrated hydrochloric acid, 15% nitric acid, water, moist air, sea-water, 0·1*N* sodium hydroxide, and *N* potassium hydroxide solutions.—S. G.

The Structure of Electrolytic Chromium. (Wright, Hirst, and Riley.) See p. 378.

Estimating Ammonia in Brass Plating Baths. (Pan.) See p. 389.

Multiple Nickel Plating on Zinc. E. A. Anderson (*Monthly Rev. Amer. Electroplaters' Soc.*, 1935, 22, (6), 24–32).—Heavy nickel coatings (*e.g.* thicker than 0·0005 in.) cannot be applied to zinc from the ordinary cold plating bath since they are so hard that they have a high tendency to crack. Satisfactory thick coatings (up to 0·001 in.) can be obtained, however, by applying a thin coat in a cold bath and continuing the plating in a warm bath. The solutions recommended are: (*a*) cold bath—nickel sulphate 15, sodium sulphate 15–18, ammonium chloride 2–3, boric acid 2 oz./gall., temperature 25°–30° C., p_H 4·9–5·4, current density 24–30 amp./ft.^{2}; (*b*) warm bath—nickel sulphate 20, ammonium chloride 4, boric acid 2 oz./gall., temperature 40°–45°, p_H 5·0–5·3, current density 40–80 amp./ft.^{2}. The function of the ammonium chloride is to prevent deposition of basic compounds and thus to keep the deposit ductile. Thorough rinsing between the 2 plating operations is essential to prevent the introduction of sodium salts into the warm bath which rapidly causes "burning" at the edges of the deposit; any tendency to pitting may be overcome by the addition of hydrogen peroxide. Two methods for removing any zinc contamination from the bath are described.—A. R. P.

Nickel and Chromium Plating of Sheet Zinc and Zinc-Base Die-Castings. B. Trautmann (*Tech.-Ind. Schweiz. Chem.-Zeit.*, 1935, 18, 25–27).—See *Met. Abs.*, this volume, p. 301.—S. G.

[Nickel] Deposits with a Low Content of Hydrogen. W. Eckhardt (*Oberflächentechnik*, 1935, 12, 43).—Good nickel plates with a very low content of adsorbed hydrogen can be obtained from a bath containing nickel sulphate 80, nickel fluoride 8, sodium chloride 1, sodium sulphate 0·5, sodium nitrate 0·02, sodium citrate 2, sodium phenolsulphonate 0·12, boric acid 6, and ammonium fluozirconate 0·2 grm./litre.—A. R. P.

The Present Position of Nickel-Plating. Marcel Ballay (*Métaux et Machines*, 1935, 19, 201–204, 217).—A review. The industry is stated to have derived considerable benefit from the issue of authoritative specifications (quoted in summary) by the French railways.—P. M. C. R.

Early Silver Plating in America. William J. Snow (*Monthly Rev. Amer. Electroplaters' Soc.*, 1935, 22, (6), 34–42).—An historical survey.—A. R. P.

***The Anodic Behaviour of Tin in the Electrolysis of Sodium Stannate Solutions.** Günther Hänsel (*Z. Elektrochem.*, 1935, **41**, 314–321).—It is shown that, in the electrolysis of a stannate solution, the tin on the anode can be completely brought into solution in the tetravalent form. A study of the composition of the electrolyte, the current density and the temperature indicated that with anodes of a suitable shape, a yellowish layer of tin oxide must be formed, although it may be extremely thin. This is an example of mechanical passivity. The process described, which has been patented, should be of special value in electrolytic tinning.—J. H. W.

Electroplating on Aluminium. Joh. Fischer (*Tech. Ind. Schweiz. Chem.-Zeit.*, 1935, **18**, 50–51).—The aluminium is treated anodically for a short time in an acid bath until it is covered with a blue film; this is then removed by cathodic treatment in a brass-plating bath and the brass-coated metal is then plated with nickel in any suitable bath.—A. R. P.

Calculations for Electroplating Cells. B. N. Kabanov (*Khimstroĭ*, 1935, **7**, 41–45; *C. Abs.*, 1935, **29**, 3607).—[In Russian.] Cf. Kabanov and Frumkin (*Z. physikal. Chem.*, 1933, [A], **165**, 433–452) and Stepanov, Kabanov, and Kudriavtzev (*Met. Abs.* (*J. Inst. Metals*), 1931, **47**, 385). Procedures for wire plating with zinc, lead, and antimony are described. Mathematical formulæ for the interrelation of various factors in the electroplating process are proposed.—S. G.

Improved Finishes for Die-Castings. Joseph Fox (*Steel*, 1935, **96**, (22), 34–38).—An account of the application of nickel and chromium plating and various non-metallic finishes to zinc-base and aluminium-base alloy castings, and of anodic treatment to aluminium alloys. The technique of the plating or other finishing process is briefly dealt with in each case.—C. E. H.

Making Moulds for Plastic Materials by the Electroplating Process. Herbert Chase (*Machinery* (*N.Y.*), 1935, **41**, 590–591).—Complex moulds for soft rubber and synthetic plastics can be made by depositing bronze on a metal pattern and backing the plated shell with cast aluminium. Typical moulds are illustrated.—J. C. C.

VII.—ELECTROMETALLURGY AND ELECTROCHEMISTRY

(Other than Electrodeposition.)

(Continued from pp. 351–352.)

The Importance of Physical Chemistry in Applied Electrochemistry. G. Grube (*Z. Elektrochem.*, 1935, **41**, 403–412).—Read before the Deutsche Bunsen-Gesellschaft für angewandte physikalische Chemie.—J. H. W.

VIII.—REFINING

(Continued from p. 241.)

Refining of Aluminium. Erik Hallström (*Gjuteriet*, 1933, **23**, 127; *C. Abs.*, 1935, **29**, 3633).—Oxygen and other impurities in molten aluminium are removed by the aid of a fusing agent consisting of equal parts of aluminium and sodium chlorides.—S. G.

IX.—ANALYSIS

(Continued from pp. 352–351.)

***The Spectrographic Analysis of Aluminium.** D. M. Smith (*J. Inst. Metals*, 1935, **56**, 257–268; discussion, 268–272).—Ordinary photographic records of

arc and spark spectra of graded series of standard alloys of Al with Cu, Fe, Mn, Si, and Ti were investigated from the point of view of the establishment of a satisfactory routine method of analysis. The spark gives a steadier and more reproducible source of light and, since adequate sensitivity of detection of the impurities usually occurring in Al is obtained, analytical tables have been compiled for use with the spark method. For routine testing of samples an auxiliary alloy of Al with 1% Ni is used for the auxiliary spectrum method, but further accuracy of determination would be obtained by direct comparison with suitably selected standard samples. The arc method is more sensitive for the detection of traces of such impurities as Pb and Ga.—D. M. S.

Quantitative Spectroscopic Analysis.—III. R. Breckpot and A. Mevis (*Ann. Soc. sci. Bruxelles*, 1935, [B], **55**, 16–30; *C. Abs.*, 1935, **29**, 3623).—Data are given for the determination of Li, Na, K, Sr, B, Si, P, Te, and Tl. —S. G.

Illumination of the Spectrograph in Quantitative Spectroscopic Analysis. R. Breckpot and L. Lialine (*Ann. Soc. sci. Bruxelles*, 1935, [B], **55**, 30–42; *C. Abs.*, 1935, **29**, 3623).—The importance of the illumination is emphasized. —S. G.

Estimating Ammonia in Brass Plating Baths. L. C. Pan (*Monthly Rev. Amer. Electroplaters' Soc.*, 1935, **22**, (6), 20–23).—The solution is boiled with twice its volume of 6*N*-NaOH and the NH_3 evolved is collected in 0·1*N*-H_2SO_4 the excess of which is titrated with 0·1*N*-NH_4OH using methyl red as indicator. The optimum ammonia content of the standard brass plating bath is 0·1–0·3 grm./litre.—A. R. P.

Detection of Cadmium as Cyanide. P. Krumholz and O. Kruh (*Mikrochemie*, 1935, **17**, 210–214).—Cd may be detected in the presence of a large excess of Cu, Ni, Co, or Zn by adding NH_4OH and sufficient KCN to decolorize the solution, then adding a 1% solution of Na_2Se containing 0·5% of KCN. In the presence of Zn a large excess of KCN must be added. The Cd is precipitated as brown CdSe which collects at the interface, when the solution is shaken with $(C_2H_5)_2O$.—A. R. P.

***Para*-Aminophenol Hydrochloride as a Reactant for Copper and Ferrous Iron.** Selim Augusti (*Mikrochemie*, 1935, **17**, 118–126).—[In Italian.] A 2% alcoholic solution of the reagent gives a bluish violet precipitate in slightly acid solutions containing Cu; the sensitivity is improved by addition of $CH_3{\cdot}CO_2H$. Other metals do not interfere except $Fe^{\cdots}$ which should previously be oxidized or removed.—A. R. P.

***A Method of Quantitatively Separating Nickel and Cobalt.** Elie Raymond (*Compt. rend.*, 1935, **200**, 1850–1852).—The addition of an excess of triethylolamine, $N(CH_2{\cdot}OH{\cdot}CH_2)$ (cf. *Met. Abs.*, 1934, **1**, 356) to solutions of salts of Co and Ni results in the formation of complex solutions, those of Co being perfectly stable and those of Ni breaking down into $Ni(OH)_2$ on heating. In the presence of an excess of soda, the Ni complex is completely decomposed, and the separation is quantitative. The Ni can be easily filtered, but requires purifying owing to absorption of the alkali. The Co is precipitated as sulphide by H_2S, after destroying the complex amine by the addition of a slight excess of $C_2H_4O_2$, and the sulphide converted to sulphate. Triethylolamine tends to prevent the deposition of Co electrolytically. This, however, can be effected in the presence of a large excess of $(NH_4)_2SO_4$, but the process is slow and requires careful attention. By the addition of urea to the neutralized solution, a very adherent deposit of Co can be obtained in about 4 hrs.—J. H. W.

Separation of Selenium from Cadmium, Lead, Bismuth, Antimony, Molybdenum, Tungsten, and Vanadium. V. Hovorka (*Coll. trav. chim. Tchécoslov.*, 1935, **7**, 182–197).—Treatment of the boiling HCl solution with $N_2H_4{,}H_2O$ effects a separation of Se from Cd, Bi, Sb, and V; separation of Se from Mo, W, Sb, and V can also be effected by precipitating the Se with $N_2H_4{,}H_2O$

in tartaric acid solutions containing Rochelle salt. Although there is a slight co-precipitation of other metals, in some cases the figures for Se are not more than 0·6 mg. high. Sn and Cu interfere in the process.—A. R. P.

Utilization of Electrical Resistance Measurements for Controlling the Composition of Alloys, with Special Reference to the Determination of Antimony in Lead. Earle E. Schumacher and Lawrence Ferguson (*Metals and Alloys*, 1935, **6**, 150–152).—For the rapid determination of 0·2–2% of Sb in Pb cable-sheathing the metal is cast into a slug 3 in. long and 0·5 in. diameter, which is swaged and drawn to wire of 0·08 in. diameter, the wire is mounted in the spiral grooves of a lavite jig, and the whole assembly is heated in an oil-bath at 247° C. for 15 minutes to cause the Sb to go completely into solid solution; it is then quenched in cold H_2O, rinsed in CCl_4 to remove grease and immersed in a mixture of ice and water. After 5–10 minutes the resistance of the wire is measured and the Sb content read off from a previously constructed graph. A 1% change in resistance is produced by a change of 0·1% in the Sb content. The process can be shortened by preparing the wire from the slug in a miniature extrusion press operating at just below the eutectic temperature, so that the extruded wire is immediately in the solid solution state. As impurities affect the resistivity measurements appreciably, the standard graph should be constructed from alloys of known Sb and Pb contents made from metals from the same stock as the cable-sheathing.—A. R. P.

Determination of Cobalt in the Form of a New Complex Compound. Alfred Taurinš (*Z. anal. Chem.*, 1935, **101**, 357–359).—The Co solution is rendered 2–3*N* with NH_4OH in a CO_2 atmosphere and an excess of K_2HgI_4 added; the Co is precipitated as $[Co(NH_3)]_6(HgI_3)_2$ which is collected in a porous crucible, washed with 2–3*N*-NH_4OH containing 1% of KI, then with C_2H_5OH and finally with $(C_2H_5)_2O$, dried and weighed.—A. R. P.

Argentometric Determination of Copper. Rosario Biazzo and Barbara Tanteri (*Ann. chim. applicata*, 1935, **25**, 44–45).—The nitrate solution of the metal is made ammoniacal and boiled with NH_2OH,HCl in a flask fitted with a Bunsen valve until the blue colour disappears and all the air is expelled. After cooling, 5 c.c. of acetone are added (to convert the excess of NH_2OH into acetonoxime) followed by an excess of $AgNO_3$ solution to re-oxidize the $Cu^{\cdot}$ to $Cu^{\cdot\cdot}$ with the precipitation of metallic Ag, the solution is boiled and the Ag collected, dissolved in HNO_3, and titrated with NH_4CNS in the usual way.
—A. R. P.

On the Quantitative Microdetermination of Copper. Friedrich Hecht and Richard Reissner (*Mikrochemie*, 1935, **17**, 127–134).—The application of the salicylaldoxime, benzoinoxime, and 5 : 7-dibromo-8-hydroxyquinoline methods to the microdetermination of Cu is described. Salicylaldoxime is preferred since the precipitate formed has the lowest Cu content, but all give excellent results.—A. R. P.

Microchemical Determination of Gold and Silver in Alloys. Julius Donau (*Mikrochemie*, 1935, **17**, 174–185).—The alloy is inquarted with the eutectic zinc–cadmium alloy by melting the two together in a glass tube through which H_2 is passed. The bead is parted first in 1 : 1 then in concentrated HNO_3 in the same tube, and the washed residue of Au is dried, heated to 500° C., cooled and weighed. Ag can be determined by the usual methods in the solution. Pd does not interfere but Pt does. Sn is converted into SnO_2, which may be removed from the Au by heating with NH_4Cl at a low temperature.—A. R. P.

On the Quantitative Determination of Some Metals with Anthranilic Acid. IV.—Determination of Lead and Mercury. H. Funk and F. Romer (*Z. anal. Chem.*, 1935, **101**, 85–88).—The neutral nitrate solution containing 0·1 grm. /100 c.c. of Pb or 0·1 grm. /200 c.c. of Hg is treated with a hot 3% solution of anthranilic acid. The Hg precipitate can be filtered immediately but the Pb solution

should be allowed to cool for 1 hr. prior to filtration. Both precipitates are washed with a cold 0·5% solution of the precipitant, then with C_2H_5OH, dried at 105°–110° C., and weighed. The Pb salt contains 43·23% Pb and the Hg salt 42·44% Hg.—A. R. P.

The Determination of Magnesium as Magnesium Ammonium Phosphate Hexahydrate. J. P. Mehlig (*J. Chem. Education*, 1935, **12**, 288–290).—The precipitated $MgNH_4PO_4 \cdot 6H_2O$ is filtered on a Gooch crucible, washed free from chlorides with NH_4OH, then with 95% CH_3COOH, and finally with $C_4H_{10}O$. The crucible is wiped and placed in a dessicator for 20 minutes, and the precipitate weighed as $MgNH_4PO_4 \cdot 6H_2O$. This method is recommended for the determination of both Mg and P, and compares favourably with the pyrophosphate method.—J. H. W.

Volumetric Determination of Tin with Ceric Sulphate. A. Rudnev (*Trans. Butlerov Inst. Chem. Tech. Kazan*, 1934, (2), 51–62; *C. Abs.*, 1935, **29**, 3625).—The titration of Sn^{++} with $Ce(SO_4)_2$, with Ph_2NH as indicator, is described.
—S. G.

The Quantitative Determination of Zirconium with 8-Hydroxyquinoline. Gr. Banescu (*Z. anal. Chem.*, 1935, **101**, 101–108).—The NH_4OH precipitate is dissolved in HNO_3, the solution evaporated twice with 10 c.c. of HNO_3 to a low volume, diluted to 50 c.c., treated with 5–10 c.c. of a 3% alcoholic solution of the reagent, poured into 50–70 c.c. of 2*N*-$CH_3 \cdot CO_2NH_4$, and boiled, and the precipitate is collected in a porous crucible, washed with hot water and dried at 130°–140° C.; it may be weighed as $Zr(C_9H_6ON)_4$ or dissolved in HCl and titrated with $KBrO_3$.—A. R. P.

X.—LABORATORY APPARATUS, INSTRUMENTS, &c.

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

(Continued from p. 354.)

***Small High-Temperature Hydrogen Furnace.** J. A. V. Fairbrother (*J. Sci. Instruments*, 1935, **12**, 200–201).—Describes the construction of a small tubular resistance furnace with a tungsten or molybdenum winding, suitable for heating materials in hydrogen. With quartz tubes a temperature of 1300° C. can be maintained for many hrs.; much higher temperatures can be reached with a tube of alumina.—W. H.-R.

An Application of the Thermionic Valve to the Measurement of Physical Quantities [Extensometer for Wires]. F. de la C. Chard (*J. Sci. Instruments*, 1935, **12**, 191–194).—When small changes in length or other quantities can be made to cause changes in capacitance, they can be measured or instantaneously recorded by means of a single valve tuned-grid, tuned-anode circuit. An apparatus of this type for the measurement of change in length of wire specimens is described.—W. H.-R.

A Corrosion-Proof Reagent Feeder. —— (*Eng. and Min. J.*, 1935, **136**, 241).—Describes a simple device for maintaining a regular supply of a liquid from about 30 c.c./minute upwards.—R. Gr.

***A Device for the Centering of [Specimen] Tubes in Debye-Scherrer Cameras.** K. Bennewitz (*Z. Krist.*, 1935, **90**, 559–560).—An apparatus is described which permits rapid and accurate centering of the glass capillary tubes (containing the powder) in an X-ray camera of the Debye-Scherrer type.—W. H.-R.

***Thermostats for Thermo-Optical Investigations with the Reflecting Goniometer.** H. Rose and A. Ehringhaus (*Fortschr. Min. Krist. u. Petr.*, 1934, **18**, 69–110).—After a historical survey of the development of thermostats for

thermo-optical investigations with the reflection goniometer at low and high temperatures, several new types of instrument for use at 125°–1400° C. are described.—B. Bl.

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

(Continued from pp. 354–357.)

***Photographically Recording Micro-Machines for the Mechanical Testing of Metals.** Pierre Chevenard (*Bull. Soc. Encour. Ind. nat.*, 1935, **134**, 59–73; discussion, 73–77; also *Métaux*, 1935, **10**, 37–48; discussion, 48–49).—In mechanical testing, very small test-pieces offer possibilities in a field of their own, supplementing rather than replacing larger test-pieces. They may be indispensable in studying heterogeneous or anisotropic material, in determining the variations in properties in the neighbourhood of welds, and have applications in studying series of alloys, investigating the laws of deformation, and testing samples cut from finished products. A testing machine is described for tensile, shear, and bending tests on specimens 1·5 mm. in diameter and 7 mm. long, using optical recording methods, and applying the load through a graduated Elinvar spring which is specially heat-treated to give stability and a high elastic limit (above 50 kg./mm.^{2}). Test results are recorded, including results of shearing tests made in different crystal directions on a zinc single crystal.
—J. C. C.

A Method for Static Testing of Welded Joints. H. Blomberg (*Elektroschweissung*, 1935, **6**, 61–67).—It is pointed out that the properties of the complete joint, rather than those of the jointing material alone, require to be determined. The usual forms of tensile test, transverse and longitudinal to the seam, and of bend test, are described and criticized. A method of testing is proposed in which, for fillet welds, the usual cross test-piece, and, for butt-welds, a symmetrical double-bevel joint with incomplete penetration, are used. In both, fracture takes place in the weld metal owing to the reduced cross-sectional area. A simple form of extensometer is used to obtain load–extension diagrams, from which the deformability of the joint is deduced. Examples are given for welds in different steels with various types of electrodes.—H. W. G. H.

***Photo-Elastic Study of Stresses Due to Impact.** Zirô Tuzi and Masatako Nisida (*Sci. Papers Inst. Phys. Chem. Res. Tokyo*, 1935, **26**, (566), 277–309).—[In English.] The stresses in phenolite test-pieces during impact have been investigated by photo-elastic methods with a high-speed cinematograph camera, and the results are analyzed.—W. H.-R.

The Measurement of Creep of Metals. Evan A. Davis (*Instruments*, 1935, **8**, 128–129, 132).—The usual methods for conducting creep tests at elevated temperatures and for plotting the results are briefly reviewed. Tests have also been made at constant rates of strain by a modified slow-running tensile testing machine. Greater attention to tests of this type seems indicated for the future. A short *bibliography* is given.—J. C. C.

New [Hardness] Testing Machines. R. Guillery (*Bull. Soc. Encour. Ind. nat.*, 1935, **134**, 218–232).—Descriptions are given of a 2750 kg. tensile machine, a diamond or ball hardness machine for Rockwell or Brinell tests, a semi-automatic Brinell machine in which pressure is applied by a motor-driven pump in stages under the operator's control, and a fully-automatic Brinell machine. In the Brinell machines, the difference in penetration of the ball under $\frac{1}{7}$ of full load and under full load is recorded.—J. C. C.

XII.—TEMPERATURE MEASUREMENT AND CONTROL

(Continued from p. 357.)

Cause of Breakdown of Constantan–Iron Thermocouples when Used in a Zinc-Coated Iron Tube. D. Shigorin (*Sintet. Kauchuk*, 1935, **4**, (1); *C. Abs.*, 1935, **29**, 3880).—[In Russian.] The couple deteriorated because of evaporation of zinc and its deposition on the Constantan side. Volatile metals should not be used as protective media for thermocouple iron pockets.—S. G.

Pivoting Systems in Pyrometers. C. E. Foster (*J. Inst. Fuel*, 1934, **7**, 171–174).—Deals with the design details of pivoting from the user's point of view.—S. G.

Theoretical Foundations of the Automatic Regulation of Temperature. A. Ivanoff (*J. Inst. Fuel*, 1934, **7**, 117–130; discussion, 130–138).—Proposes a general theory for the elucidation of the contradictions of the expected behaviour of a plant for automatic temperature regulation in place of the purely empirical methods previously employed.—S. G.

Induction Annealing Furnace with Automatic Temperature Control. J. Hak (*Elektrotech. Zeit.*, 1934, **55**, 367–369; *Sci. Abs.*, 1934, [B], **37**, 346).—A portion of the magnetic circuit of the furnace transformer is made of an iron–cobalt alloy, and takes the temperature of the furnace. When it passes through the Curie point it loses its permanence and the magnetic leakage increases, reducing the power input. The control point may be varied between 780° and 1100° C. by increasing the cobalt content from 0 to 60%.—S. G.

XIII.—FOUNDRY PRACTICE AND APPLIANCES

(Continued from pp. 357–358.)

Blisters. A. Rodehüser (*Giesserei-Praxis*, 1935, **56**, 233–237).—Discusses the cause of, and remedies for, blister-formation in sand-castings.—J. H. W.

Some Advice for the Aluminium Caster. Faults Often Noticed in Practical Work. H. Nipper (*Giesserei*, 1935, **22**, 287–289).—When using oil-fired reverberatory furnaces for melting aluminium and its alloys, the furnace should be heated to 700° C. before charging the metal, so as to reduce loss by oxidation during melting and to obviate undue adsorption of gas. When the metal is tapped into the ladle and found to be too cold for casting, it should be returned to the furnace through a special inclined trough, arranged to prevent splashing, which causes oxide inclusions and "foaming" of the bath. The flame should be slightly oxidizing to obviate gas adsorption which is considerable when a reducing flame is used. In treating the metal with zinc chloride the spoon containing the salt should be rapidly but quietly immersed well below the surface and kept stationary for some time before stirring; a few minutes should then elapse before skimming to allow time for the impurities to rise to the surface. In crucible melting in a coke fire the crucible should be kept as full as possible and should be covered with a graphite lid, the coke should be dry, and the surface of the metal should be skimmed with an iron strip, not with wood. In all cases careful pyrometric control and the use of warm and dry moulds are essential for good work.—A. R. P.

***Unsoundness in Aluminium Sand-Castings. III.—Solidification in Sand Moulds under Pressure.** D. Hanson and I. G. Slater (*J. Inst. Metals*, 1935, **56**, 103–112; discussion, 112–123).—By allowing gassy aluminium alloy melts to solidify in sand moulds under an extraneous pressure of air or nitrogen, pinholes are reduced in size and ingots of high density may be obtained. With most aluminium alloys a pressure of 50 lb./in.^{2} is sufficient to remove all visual traces of pinholes from a 2 in. × 2 in. diameter sand-cast block. At higher

pressures ingots having densities approaching the optimum are obtained. The applied pressure appears to affect the gas cavities by compressing them to finer dimensions. The mechanical properties of the alloys are much improved by solidification under pressure, whilst shrinkage is confined to a single cavity. —D. H.

Adventures in Bronze [Casting]. A. V. Mackenzie (*Heat-Treat. and Forging*, 1935, **21**, 241–242).—Notes on the casting of bronze.—J. H. W.

An Unusual Defect in Thin-Walled Brass Castings. M. Schied (*Giesserei-Praxis*, 1935, **56**, 182–183).—Thin-walled brass castings sometimes crack parallel to the surface of the castings, giving a double-walled effect; this is chiefly due to excessive chilling by a too-cold mould, although there may be other causes. To obviate this defect, thin-walled brass castings should be cast into warm dry-sand moulds, or the metal should be cast at a higher temperature.—J. H. W.

Difficulties in the Production of Large Brass and Red Brass Covers. —— Rahn (*Giesserei-Praxis*, 1935, **56**, 224–226).—Details for moulding, melting, and casting a large brass cover, and the difficulties encountered and their elimination are described.—J. H. W.

Foundry Production of Nickel Silver. I.—Production of Nickel Silver Castings. T. E. Kihlgren (*Metals and Alloys*, 1935, **6**, 139–143).—Cf. *Met Abs.*, this vol., p. 151. Practical details are given of all the stages of melting and casting. Good castings are ensured by using pure metals, melting rapidly in slightly oxidizing conditions, deoxidizing by the successive addition of 0·1% of manganese, 0·05% of magnesium, and 0·02% of phosphorus (as 15% phosphor-copper), casting at about 1350° C., and filling the moulds rapidly with the minimum of turbulence and with sufficient and properly located gates and risers. The moulds should be made of fairly open sands, and the cores should be moderately soft and should collapse readily; moulds and cores must be thoroughly vented.—A. R. P.

Zinc and Lead, and Their Importance in the Foundry. Willi Claus (*Giesserei-Praxis*, 1935, **56**, 226–228).—A general survey of the use of zinc and lead for foundry purposes.—J. H. W.

Art Casting by the Cire Perdue Method. Carlo Panseri (*Rev. Aluminium*, 1935, **12**, 2811–2820).—The various methods for art casting in bronze from the Middle Ages onwards are briefly reviewed, and the making of such castings in aluminium alloys by the *cire perdue* method is described in detail.—J. H. W.

Vacuum Die-Casting Process for Aluminium-Bronze. C. O. Herb (*Machinery* (*Lond.*), 1935, **46**, 221–224).—See *Met. Abs.*, this vol., p. 252.—J. C. C.

Die-Casting Dies That Achieve the Impossible. Charles O. Herb (*Machinery* (*N.Y.*), 1935, **41**, 534–537; and *Machinery* (*Lond.*), 1935, **46**, 473–476).—The construction of a die set, for producing a zinc air-horn of an automobile carburettor, is described and illustrated.—J. C. C.

Adjustable Die-Casting Dies for Parts of Different Dimensions. Charles O. Herb (*Machinery* (*N.Y.*), 1935, **41**, 593–596).—Two dies, for typewriter top-plates in 3 different lengths and for elevator step-plates in 2 different lengths, respectively, are described and illustrated. Interchangeable inserts are incorporated in the dies.—J. C. C.

Sand Problems in a Brass Foundry. F. Howitt (*Found. Trade J.*, 1935, **53**, 9–13; and *Met. Ind.* (*Lond.*), 1935, **47**, 6–12, 37–39; discussion, 39–40).—Read before the Sheffield Branch of the Institute of British Foundrymen. Discusses the effect of the moisture content on Bunter sand, moisture control, variation in grain-size, basic dual character of sands, core sands and difficulties, ramming load, selection of a binder, dextrin-oil binders, core surfaces, determination of metal pressure, and blowing control.—J. H. W.

The Control of Mould Drying Processes. V. Aronovitch (*Found. Trade J.*, 1935, **52**, 393–396).—A new method of control which may be used during the

actual drying process without any damage to the moulds or cores under control is described in detail, and the applications of the method are discussed.
—J. H. W.

***Examining Moulding Sands.** Dániel Diószeghy (*Banyász. Kohász. Lapok*, **1935, 68**, 78–83, 93–101, 109–113; *C. Abs.*, 1935, **29**, 3633).—Clay was removed by sedimentation. The time of precipitation was determined and graphically indicated according to the Stokes' formulæ. Rodwell's observation on the connection of colloidal clay content and hygroscopicity was confirmed. The clay content should be less than 30% in wet moulding. 16 samples examined had *d* 2·62–2·78, moisture 0·24–5·68%, clay content 0·96–32·70%, gas permeability 1·4–360·0 c.c./minute and c.c., compressive strength 0·10–1·35 kg./cm.^{2}, melting point 1200°–1400° C., CaO content 0·41–13·85%, iron content 0·49–3·36%. The iron content increases the hygroscopicity; only sands containing less than 5% iron are suitable.—S. G.

Moulding Sand. O. Hallström (*Gjuteriet.*, 1933, **23**, 119).—S. G.

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

(Continued from p. 252.)

The Remelting of Scrap Aluminium. Harold Silman (*Met. Ind.* (*Lond.*), 1935, **46**, 667–668).—The economical disposal of aluminium scrap is described as regards cleaning the scrap, melting practice, use of fluxes, and older and new refining methods.—J. H. W.

XV.—FURNACES AND FUELS

(Continued from pp. 358–359.)

Improved Electric Furnaces for Low-Temperature Heat-Treatment. —— (*Iron Coal Trades Rev.*, 1935, **130**, 939).—A diagram is given of the latest type of Birlec electric furnace, which incorporates an improved air path having a new type of centrifugal fan.—L. A. O.

Experiences with Kanthal-A Used in an Electric Furnace. (Zimmerman.) See p. 375.

XVI.—REFRACTORIES AND FURNACE MATERIALS

(Continued from pp. 359–360.)

Difficulties in the Manufacture of Firebrick. C. R. F. Threlfall (*Sands, Clays, and Minerals*, 1935, **2**, (3), 67–70).—Modern practice in making firebricks is reviewed, and difficulties encountered are discussed with a view to encouraging research on methods of overcoming them.—A. R. P.

Quartz Sand in Silica Brick Manufacture. P. Budnikoff (*Sands, Clays, and Minerals*, 1935, **2**, (3), 85–88).—The properties of silica bricks prepared with additions of up to 50% of various types of Russian silica sand by mixing in pan and pug mills are tabulated. The results indicate that the ratio of mechanical strength to crushing resistance falls with increasing sand percentage, while the water absorption and volume porosity increase; in no case do the bricks soften below 1700° C., however. Examination of the microstructure shows that a satisfactory structure can be obtained with up to 35% of sand in the mixture.—A. R. P.

XVII.—HEAT-TREATMENT

(Continued from p. 309.)

The Effects of Thermic Treatment upon the Physical Properties of Aluminium Alloys. J. Towns Robinson (*Metallurgia*, 1935, **12**, 51–56).—The physical properties after heat-treatment of the principal high-strength casting alloys, including "Y," Hiduminium, and Silumin alloys, are briefly discussed, and similar properties of the wrought alloys, including Duralumin, "Y," Hiduminium, and Super-Duralumin alloys, are also considered in greater detail. Results of repeated impact tests, whirling rig or rotation fatigue tests, compression tests on sand-cast and chill-cast test-pieces, and tensile and Brinell hardness tests at elevated temperatures on pieces taken from actual sand-castings are given for the casting alloys. Results of impact, fatigue, and compression tests of the wrought alloys are also given as well as those of tensile and Brinell tests from actual stampings. The effect of ageing on wrought alloy sheet, and the effects of cold-working in conjunction with various heat-treatments is considered in detail both as regards physical strength and crystal structure.—J. W. D.

XVIII.—WORKING

(Continued from p. 360.)

†**Principles of Cold-Deformation.** A. Pomp (*Maschinenbau*, 1935, **14**, 143–147).—The profound change in the properties of a material is the characteristic of the cold-deformation process. With increasing deformation the crystal grains become stretched. Methods for investigating the process and the distribution of stress and pressure are described with reference to an extensive *bibliography*.—K. S.

Metallic Propellers. M. Chartron (*Rev. Aluminium*, 1935, **12**, 2821–2830).—The manufacture of air propellers of the monobloc, assembled, and variable-pitch types is described in detail.—J. H. W.

Free-Cutting Aluminium Screw Machine Stock. L. W. Kempf and W. A. Dean (*Metal Progress*, 1935, **27**, (1), 21–27).—Materials for modern screw-cutting machines must permit high rates of speed, form small chips which rapidly become detached (thus causing the minimum of wear) and be capable of a good finish. A description is given of attempts to incorporate lead in light alloys in order to impart free-cutting properties. Tables show the cutting characteristics of some newly-developed light alloys as compared with those of certain brasses and steels, and a comparison of mechanical properties. Tool wear is slightly greater than with lead-brasses, but the corrosion-resistance is high.—P. M. C. R.

Abrasive Cutting-Off Turns Minutes into Seconds. H. G. Robinson (*Canad. Mach.*, 1935, **46**, (5), 13–14, 35; (6), 9–10, 38).—The abrasive method of cutting is applicable to brass, bronze, and Monel metal. Alundum wheels are most suited to the cutting of metals. The special applications of the dry, wet, and submerged modifications of abrasive cutting are described. Resinous-bonded wheels tend to be replaced by rubber-bonded cutters, which are unsuitable, however, for dry work. The finish obtained with submerged abrasive cutters is much superior to that produced by dry cutting, and the life of the wheel is 3 or 4 times as great. The arrangement of the "coolant box" is described, and modifications suited to various types of work are illustrated.—P. M. C. R.

XIX.—CLEANING AND FINISHING

(Continued from pp. 360–362.)

The Detergent Properties of Alkalis, Particularly Plating Cleaners. N. Promisel (*Monthly Rev. Amer. Electroplaters' Soc.*, 1935, **22**, (6), 4–19).—A study has been made of the value of caustic soda, sodium carbonate, sodium metasilicate, trisodium phosphate, and soap in cleaning solutions for removing grease from metals prior to plating. The results show that the grease is removed chiefly by emulsification, and for this purpose soap is by far the best reagent, although the newer types of detergent made from sulphonated higher alcohols are also very satisfactory. Caustic soda should be used when the grease is saponifiable, but borax is satisfactory when a lower p_H is required. Sodium metasilicate has a high deflocculating power and a good buffering action but relatively little saponifying power. Contrary to popular belief, trisodium phosphate is of little use in a cleaner, since it improves only the saponification and deflocculation and these only to a limited extent.—A. R. P.

Solution for Cleaning Metallic Parts Before Painting. N. Neznamov (*Novosti Tekhniki, Seriya Gornorudnaya Prom.*, **1935**, (7), 11; *C. Abs.*, 1935, **29**, 4100).—[In Russian.] The solution is prepared from 1 litre 28% NH_4OH, 26 litres denatured alcohol, and 25 litres water. The solution must be carefully removed from the metal after use.—S. G.

Copper and Abrasives. Harold L. Wynn (*Machinist* (*Eur. Edn.*), 1935, **79**, 403).—It is stated that the only abrasive for copper used in the electrical industry which will not cause permanent scouring is powdered glass; this should be as fine as possible, and mixed with ordinary lubricating oil.—J. H. W.

Boron Carbide Abrasive and Mouldings. —— (*J. Sci. Instruments*, 1935, **12**, 204).—A note. Boron carbide is now prepared free from graphite under the name of "Norbide." In powder form it is a very hard abrasive, and in moulded form it can be used for pressure blast nozzles, thread guides, and extrusion dies.—W. H.-R.

XX.—JOINING

(Continued from pp. 362–364.)

Thermal Methods of Joining, Soldering, and Welding Light Metals. L. Rostosky (*Aluminium*, 1935, **17**, 316–319).—An historical review, with details of modern procedures and fluxes, is followed by a discussion of the present position of electric welding.—A. R. P.

Contribution to the Construction of Soldered Aluminium Parts. E. Lüder (*Aluminium*, 1935, **17**, 315).—A practical example is given of the method of joining 2 parts of aluminium alloy by means of a hard solder.—A. R. P.

Soldering Aluminium Castings. A. Eyles (*Machinist* (*Eur. Edn.*), 1935, **79**, 375E).—Details are given for repairing fractured and defective aluminium castings by soldering, when the relatively high temperature required by oxy-acetylene welding may cause distortion.—J. H. W.

Welding and Soldering in Electrotechnics. Erich Becker (*Elektrotech. Anz.*, 1934, **51**, 1047–1050).—A practical account of the welding, hard soldering, and soft soldering of aluminium, copper, nickel, and their respective alloys, and of the welding of chromium–nickel alloys. Oxy-acetylene and electric welding are described, and suitable fluxes for the various soldering and welding operations are given. Soft soldering is dealt with in less detail than the other processes.—C. E. H.

***The Penetration of Steel by Soft Solder and Other Molten Metals at Temperatures up to 400° C.** L. J. G. van Ewijk (*J. Inst. Metals*, 1935, **56**, 241–248; discussion, 248–256).—Investigation of the failure of a nickel–chromium

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

On the Hard-Soldering of Ferrous and Non-Ferrous Metal Parts of Castings and Its Importance in Foundry Practice. Erich Becker (*Giesserei*, 1935, **22**, 195–198).—For joining cast-iron parts a 60 : 40 brazing brass with small additions of tin, manganese, iron, and silicon gives the best results; the presence of lead in the brass results in porous joints. Tin up to 1% improves the strength and reduces the oxidation of zinc and iron up to 1·5% and manganese up to 1% improve the resistance to wear, iron hardening the alloy and manganese toughening it. Nickel silver solders give joints which are stronger than at high temperatures, and more closely resemble the colour of the iron. In all cases the surface graphite should be removed before soldering by heating with the blowpipe, preferably in the presence of an oxidizing flux. A final anneal strengthens the joint. Brief notes on the soldering of aluminium, cast steel, copper, and nickel alloys are also given.
—A. R. P.

Continuous Electric Brazing in Controlled Atmospheres. A. G. Robiette (*Machinery* (*Lond.*), 1935, **46**, 193–196).—In electric furnace brazing, brass, copper, or silver solder is applied as wire or as powder in a cellulose bond, and the parts passed through a furnace having a controlled atmosphere. Typical products are illustrated, savings and advantages discussed, and recent trends in furnace design described. The replacement of hydrogen by cracked and burnt ammonia enabled large batch furnaces with sealed doors to be built, and the later use of the still cheaper partially burnt butane or coal-gas has been accompanied by the development of continuous furnaces of the pusher or conveyor type.—J. C. C.

Lead Jointing of Metals. H. Goulbourne Jones, G. E. Rowland, and A. Williams (*J. Sci. Instruments*, 1935, **12**, 201).—A note. Fairly large pieces of metals may be joined by placing the edges together, and surrounding them by a cardboard mould into which lead is poured; after solidification the mould is cut away. With aluminium the lead will only seize the metal if a large block of metal is held under the joint to ensure rapid cooling.—W. H.-R.

"Lumisold" and "Aiagin" Welding Pastes [for Aluminium and Its Alloys]. M. Bosshard (*Aluminium*, 1935, **17**, 319–321).—"Lumisold" is a mixture of potassium, lithium, and zinc chlorides with aluminium fluoride (proportions not given); it melts at 350° C. and has a good solvent action on alumina. "Aiagin" paste is a mixture of potassium, lithium, ammonium, zinc, and tin chlorides melting at 175° C. and reacting with aluminium at about 200° C. to yield the eutectic tin–zinc alloy (8–9% zinc) and a very fusible slag having a good solvent action for the oxides. To prevent deterioration by exposure to air the mixture is made into a paste with carbon tetrachloride or paraffin oil. The use of these fluxes in soldering aluminium is described and the melting points of some halide mixtures are tabulated.—A. R. P.

Current Practices for Welding Aluminium. —— (*Oxy-Acetylene Tips*, 1935, **14**, 101–108).—Describes American oxy-acetylene practice, gives some advice of doubtful value, and contains some statements of doubtful accuracy.
—H. W. G. H.

Supernickel: Its Properties and Uses, and Methods of Fabrication. Ira T. Hook (*Welding Eng.*, 1935, **20**, (4), 24).—Supernickel is the name given, for unknown reasons, to 70 : 30 copper–nickel alloy. Its properties and its use for condenser tubing are discussed. Metallic-arc welding is said to require heavy-coated rods which are used with reversed polarity (*i.e.* in American usage, electrode positive). A special welding rod is also necessary for oxy-acetylene welding: this is said to contain elements which combine with the copper to form a protective slag. Copper backing plates are recommended for arc, but not for gas welding. Warning is given that the material has a hot-short range, so that care must be taken to avoid strain during welding.—H. W. G. H.

The Welding of Nickel and Its Alloys. A. Boutté (*Rev. Soudure Autogène*, 1935, **27**, (254), 6–7).—The welding difficulties caused by the smallest amounts of sulphur in nickel are described. The improvement produced by additions of magnesium is pointed out, and the optimum content is given by the equation $\frac{Mg - 0{\cdot}02}{S} = 4$ to 5. Silicon is also necessary in amounts of 0·15–0·2%. The use of a flux is essential to avoid loss of magnesium by oxidation. Rightward welding is recommended for all thicknesses of nickel. Inconel is easily welded by the oxy-acetylene process, but has a very low ductility at temperatures about 700° C. Similar flux to that used for welding stainless steel is recommended.—H. W. G. H.

The Welding of Monel Metal and Nickel. —— (*Henry Wiggin and Co., Ltd.*, 1935, (MA 2), 8 pp.).—Oxy-acetylene, metallic-arc, and electrical resistance welding are discussed. For the first, the use of a slightly reducing flame and boric acid as flux are recommended. Metallic-arc welding is impracticable for thicknesses below 18 G. The electrode diameter should be a little greater than the thickness of the sheet, and should be connected to the positive pole. Satisfactory coated electrodes are on the market. For spot- and seam-welding oxidation should be prevented or minimized by a stream of water flowing over the electrodes. The corrosion-resistance of welds in nickel and Monel metal is practically as good as that of the metal itself, and it is emphasized that there is no possibility of "weld decay."
—H. W. G. H.

Arc Welding Monel Metal and Nickel. F. G. Flocke and J. G. Schoener (*Welding Eng.*, 1935, **20**, (5), 28–29).—The development of a heavy-coated electrode of the shielded-arc type has improved the welding characteristics of nickel and Monel metal. The electrode should be connected to the positive pole. The carbon arc process also presents no difficulty if the carbon is negative and a suitable coated filler-rod is used.—H. W. G. H.

Gas Welding and Silver Soldering Monel Metal and Nickel. F. G. Flocke and J. G. Schoener (*Welding Eng.*, 1935, **20**, (4), 17–20).—Details of technique are described; the need for careful clamping and jigging is emphasized.—H. H.

Overstressing in Welded Joints. H. Buchholz (*Autogene Metallbearbeitung*, 1935, **28**, 82–89; criticism and reply, 122–123).—Recent German research on stresses in weld-seams is critically reviewed, with particular reference to the work of Bollenrath (*Met. Abs.*, 1934, **1**, 633), and the following conclusions are reached: (1) the height of the stress in a seam is governed by the highest elastic limit of the parts joined; (2) the resistance to deformation, caused by the multi-dimensional stress conditions and by the sharp reversal of stress, leads to stresses which may considerably exceed the normal elastic limit; (3) the stresses in the seam, with freely movable or rigidly gripped parts, are greater than in the neighbouring material; (4) the stresses in the direction of the seam are always (for not too short seams) greater than those perpendicular to it; (5) with increasing thickness of material, the influence of the third principal stress becomes noticeable; (6) broadening the heating zone reduces

the stress in the seam; (7) the seams are always "under flow conditions"; (8) the first occurrence of extra stress produces plastic-flow and consequent stress dissipation; although the seam stresses can be much reduced by hammering, annealing, &c., the seams still remain "under flow conditions." Recommendations for practice are based on these conclusions. The latter are criticized by Bierett, who points out that the last two are contradictory, and protests that the results of Bollenrath have been applied too freely by Buchholz. Buchholz replies, and an editorial note closes the discussion pending further investigation to clarify several points.—H. W. G. H.

A Method for Static Testing of Welded Joints. (Blomberg.) See p. 392.

How to Bronze-Weld. —— (*Oxy-Acetylene Tips*, 1935, **14**, 125–131).—A summary of practical information on the process. Gives some hints on its application to copper, brass, bronze, nickel, Monel metal.—H. W. G. H.

New Metals for "Bronze-Welding." J. Bruneteau (*Soudeur-coupeur*, 1935, **14**, (5), 1–3).—In welding brass, the use of an oxidizing flame reduces the evolution of zinc from the welding rod. Such is not possible in most cases of "bronze-welding" because of the deleterious effect on the parent metal. Additions of special elements, such as silicon, are, therefore, made to the filler-rod. Where a "weld" of colour similar to iron or steel is desired, a special copper–zinc–metal alloy rod is suggested.—H. W. G. H.

Automatic Arc Welding. R. Sandelowsky (*A.S.E.A. Journal* (*Allmänna Svenska Elektriska A.B.*), 1934, **11**, 2–9; *Sci. Abs.*, 1934, [B], **37**, 274).—Describes in detail and illustrates a modern automatic welder, and discusses its applications.—S. G.

***Welding Arcs in Argon.** C. G. Suits (*Phys. Rev.*, 1935, [ii], **47**, 975).—A note. The relatively poor heat transfer when arc-welding in argon is probably due to the gas being monatomic. This prevents heat transfer by a process of dissociation–diffusion–recombination, which is known to occur in welding in air or hydrogen where diatomic O_2, N_2, or H_2 molecules can dissociate and then recombine.—W. H.-R.

Where is Special Care Required in Spot-Welding? H. E. Neese (*Illust. Zeit. Blechindustrie*, 1935, **64**, 688–689).—An illustrated analysis is given of the causes of burning (imperfectly cleaned material), and adhesion of electrodes (insufficient cooling, due principally to the form of the electrode). The appropriate size of the latter is discussed with relation to the thickness of the material.—P. M. C. R.

The Capacity of Spot-Welders. J. E. Languepin (*Bull. Soc. Ing. Soudeurs*, 1935, **6**, 1724–1729).—The designation of spot-welding machines by their power in k.v.a. or the maximum thickness of material which they can weld, is shown to be misleading, and the information necessary for adequate description of a machine is discussed.—H. W. G. H.

Contribution to the Study of Oxy-Acetylene Blowpipes. P. Modro (*Rev. Soudure Autogène*, 1935, **27**, (255), 2–3).—The principles underlying the design of low-pressure blowpipes are outlined and simple laws are evolved relating the capacity with nozzle diameter and oxygen pressure. The gas consumption is found to vary with the fourth power of the nozzle diameter, and, for a given nozzle, with the square-root of the absolute pressure.—H. W. G. H.

The Calculation of Flame Temperatures. G. Ribaud and Rochan Zaer (*Rev. Soudure Autogène*, 1935, **27**, (255), 11).—Abstract of a paper read before the Academie des Sciences. Describes a graphical method for determining the temperatures of flames, taking into account preheating of the gases, composition and dissociation of the constituents of the flame.—H. W. G. H.

Contribution to the Study of Regulators for Compressed, Liquefied, or Dissolved Gases. A. Baillon and R. Jurion (*Bull. Soc. Ing. Soudeurs*, 1935, **6**, 1645–1673).—Regulators are classified according as the valve is in the high-pressure or low-pressure chamber, and as the diaphragm is directly connected

to the valve or by means of levers. A mathematical expression is evolved relating the various factors, such as diameter of diaphragm, stiffness of springs, &c., which influence the quality of a regulator from the point of view of constant pressure control, sensitivity, &c. The various factors are analyzed, improved designs are deduced, and representative instruments on the market are illustrated.—H. W. G. H.

Gas Absorption in Acetylene Cylinders in Relation to the Acetone Content. W. Rimarski and H. Friedrich (*Autogene Metallbearbeitung*, 1935, **28**, 65–68). —H. W. G. H.

Measures for Safety and Hygiene in Welding and Oxygen Cutting. R. Granjon (*Rev. Soudure Autogène*, 1935, **27**, (255), 8–10).—No risks to health are to be feared if the following are borne in mind: (1) the effect of radiation on the welders' eyes is nil in the case of gas-welding but must be guarded against in arc-welding; (2) rays emitted by the electric arc have serious physiological effects on some subjects, who should, therefore, be kept under observation; (3) the products of combustion in oxy-acetylene welding are innocuous except in confined spaces; (4) the fumes from coated electrodes may be extremely harmful; in such cases the electrodes should be specially labelled; (5) welding or cutting of material which has been painted or coated should only be carried out with special precautions against noxious fumes.—H. W. G. H.

XXI.—INDUSTRIAL USES AND APPLICATIONS

(Continued from pp. 314–317.)

The Economic Development and Importance of Aluminium. H. Gerh. Steck (*Aluminium*, 1935, **17**, 297–304).—Statistics are given of the production, consumption, and uses of aluminium in various countries.—A. R. P.

Recent Developments in the Use of Aluminium. A. J. Field (*Amer. Metal Market*, 1935, **41**, (92), 5, 6).—A brief account of the extending uses of aluminium, especially in the automobile, shipbuilding, aircraft, chemical, and canning industries and in the furnishing, painting, and decorative trades. —A. R. P.

The Metallury and Applications of Aluminium. G. Reyes (*Bol. minero soc. nac. mineria (Chile)*, 1934, **46**, 567–582; *C. Abs.*, 1935, **29**, 3265).—A review of processes for obtaining pure alumina and of its electrolysis, and of properties and applications of aluminium and its alloys.—S. G.

Aluminium in the Gas Industry. F. Delarozière (*J. usines gaz*, 1934, **58**, 602–608).—A review.—S. G.

The New Sliding Surface for Light Metal Pistons. Investigations of the Elnüral Process. O. Summa (*Motor-Kritik*, 1935, **15**, (3), 69–73; *Aluminium*, 1935, **17**, 351).—The pistons are cast and finished in the usual way, then cleaned with trichlorethylene and anodically oxidized in 10–20% sulphuric acid containing some formic or oxalic acid. After washing and drying, the film is impregnated with vaseline which renders it impervious to atmospheric oxygen and moisture but readily absorbent for oil, so that in use the piston is almost frictionless. Carbonization in the cylinder and wear of the cylinder walls are reduced to a minimum with this type of piston.—A. R. P.

Light Alloys in Machine Tool Construction. M. von Schwarz (*Werkstatt u. Betrieb*, 1935, **68**, 176–182).—Light alloys, especially as die-castings, find increasing application in machine tool construction, particularly where reduction in weight is important. Elektron is used for tool-holders, casings, and dust-proof lids, and the self-hardening alloys Neonal, Quarzal, and Zirkonal are employed for more heavily stressed parts. It is claimed that the strength and hardness of the two latter approximate to those of good cast iron, and that the use of the alloys obviates the employment of steel insets.—P. M. C. R.

Span Calculation for Steel-Reinforced Aluminium Cables. Takashi Ohtsuki and Katsutaro Jōno (*Denki-Hyōron*, 1933, **21**, (1), 9–15).—[In Japanese.] —S. G.

A New Clamp for Aluminium Conductors in High-Tension Cables. —— Schiller (*Aluminium*, 1935, **17**, 307–309).—To overcome the difficulties caused by the presence of the oxide film the ends of the 2 cables to be joined are inserted in a metal tube with an internal thread, and the joint is then consolidated by a special drawing process which ruptures the oxide film, and gives a good electrical contact. Full working details are given.—A. R. P.

Experiences in the Use of Aluminium in Electrical Apparatus. T. Müller (*Aluminium*, 1935, **17**, 310–315).—A record of 15 years' experience in the use of aluminium for electric cables and for the construction of electrical apparatus.—A. R. P.

The Medical Applications of Electricity. Aluminium in the Apparatus. J. Bally (*Rev. Aluminium*, 1935, **12**, 2769–2788).—Describes the applications of aluminium in the construction of apparatus used in radiography, electrotherapy, high-frequency current treatment, and actinotherapy.—J. H. W.

Aluminium in Building.—II. E. Herrmann (*Aluminium*, 1935, **17**, 322–341).—See *Met. Abs.*, this vol., p. 123. Numerous examples of the use of aluminium and its alloys in architectural work are illustrated and discussed. —A. R. P.

Aluminium in Decorative Metalwork. G. O. Taylor (*Met. Ind. (Lond.)*, 1935, **46**, 593–596; and *Light Metals Rev.*, 1935, **1**, 443–450).—Describes the types of aluminium alloys suitable for decoration, the types of plain and anodic finishes used, and the internal and external applications of these alloys and finishes.—J. H. W.

Alfol Heat-Insulation in the Electrical Industry. A. von Zeerleder (*Bull. Assoc. Suisse Élect.*, 1935, **26**, 354).—Alfol may be used advantageously in electrically maintained apparatus, both for heating and refrigeration. Comparative curves demonstrate its efficiency as compared with glass-wool and Kieselguhr. In the case of apparatus which must be heated daily, Alfol effects a special economy on account of its extreme lightness and consequent low absorption of heat.—P. M. C. R.

Pipe-Covering Materials for High Temperatures [Aluminium]. Ralph R. Gurley and W. P. Sinclair (*J. Amer. Soc. Naval Eng.*, 1935, **47**, 247–256).—The materials approved by the American Navy for pipe coverings for temperatures over 260° C. include aluminium foil which has a limited approval. The method of using the foil is considered, and the advantage which it has over other types of pipe coverings such as mineral wool, insulating cements, and moulded covers as regards weight is discussed, and it is shown that this advantage is reduced considerably in the case of small pipes due to the increased percentage of the total weight of the installation represented by sheet metal. Heat insulating and thermal conductivity tests are given for the various materials.—J. W. D.

Special Priming Paints for Wood. F. L. Browne (*Indust. and Eng. Chem.*, 1935, **27**, 292–298).—One of the results of subjecting priming paints to practical exposure tests showed that a reasonably effective primer is made by adding aluminium powder in substantial amount to conventional white-lead priming paint.—F. J.

On the Loosening of Locomotive Firebox Stays on Cooling. Hermann Blomberg (*Organ Fortschr. Eisenbahnwesens*, 1935, **90**, (9), 157–162).—The effect of alternate heating and cooling on the dimensions and fit of firebox stays was investigated by experiments on a series of assemblies consisting of a central bolt, fitting closely through an inner ring, which was surrounded by an outer ring of cast iron. The materials of the first two members were selected from copper of the quality usual in firebox plates, 6% manganese

copper, Armco iron, and "Cuprodur." Oxidation effects were eliminated by nickel-plating all specimens prior to heating. Observations were taken after 8 hrs.' heating at 100°, 200°, 300°, and 400° C. The degree of permanent deformation, which was already appreciable at 100° C., appeared to depend on the relative coeff. of expansion and on the thermal conductivities of the materials, and was least when the material of the stay possessed a higher thermal conductivity and a lower coeff. of expansion than that of the fire-box. In practice the choice of materials appears limited to materials whose coeff. of expansion and thermal conductivities are similar.—P. M. C. R.

Ants Shun Copper Sheet [Use of Copper in Tropics]. —— (*Bull. Copper Brass Res. Assoc.*, 1935, (82), 15).—The use of copper-bound support pillars in the construction of bungalows erected in the tropical climate of the Panama Canal zone has done away with the ant scourge, as it has been observed that ants avoid copper.—J. S. G. T.

Commercial Production of Metallic Beryllium. Edgar R. Larsen (*Mining Congress J.*, 1935, **21**, 26, 35).—A discussion of future uses for beryllium and its alloys.—S. G.

Lead [in the Paper Timber Industry]. E. Wigzell (*Finnish Paper Timber J.*, **1934**, 940–941; *C. Abs.*, 1935, **29**, 3268).—A brief account of the history of lead and its uses. Lead of 99·99% purity has been developed for use in the paper industry. Most of the Finnish cellulose industries, however, use antimonial lead (up to 2% antimony). Tellurium–lead has many desirable properties.—S. G.

Use of Magnesium Alloys in Aircraft Construction. E. Player (*Metallurgia*, 1935, **12**, 61–65).—The composition of the various Elektron alloys and their mechanical properties both in the form of castings and after heat-treatment, and also the mechanical properties of the various wrought forms, as extruded rods, bars and sections, sheets and strips, and forgings are given and considered in detail. Consideration is also given to the application of the cast alloys for engine parts, air frames, and general engine castings, and of wrought alloys for such parts as undercarriages, sections, tubes, propeller blades, forgings, and pressings, and the most suitable compositions to use for each application.—J. W. D.

Aluminium and Magnesium in Aircraft Motors. J. Bally (*Rev. Aluminium*, 1935, **12**, 2851–2866).—The applications of light alloys, particularly those containing magnesium, to aircraft motor construction are described.—J. H. W.

Research Has Put Molybdenum on the Economic Map. C. M. Loeb, Jr. (*Tech. Eng. News*, 1935, **16**, 68–70).—The economics and some of the properties and applications of molybdenum are given.—J. H. W.

Low Cost [Dental] Alloys and Their Application in Practice. R. C. Willett (*Brit. J. Dental Sci.*, 1935, **80**, 100–104).—Reprinted from *Internat. J. Orthodontia*. An alloy suitable for cheap inlays and one-piece castings consists of silver 79·29, copper 19·29, zinc 0·71, tin 0·71%. A casting alloy comparing favourably with the usual hard gold alloys consists of palladium 5, gold 10, sterling silver 85%.—J. C. C.

The Oligodynamic Action of Metals and Its Use in Water Purification. O. Casagrandi and A. Seppilli (*Ref. riv. biol.*, 1934, **16**, 14–16; *C. Abs.*, 1935, **29**, 3434).—Catadyn (silver) sterilization was effective against cholera, typhoid, and dysentry organisms. It was less effective against *B. faecalis alcaligenes*. The catadyn method is considered practical.—S. G.

Catadyn and Electrocatadyn [Oligodynamic Action of Silver]. F. Linke (*Z. Krkhauswes.*, 1934, **8**, 170; *C. Abs.*, 1935, **29**, 3434).—The catadyn process, the preparation of catadyn silver, &c., are discussed.—S. G.

Utilization of Tinplate. Ching-Chuan Wei (*Science (China)*, 1935, **19**, 181–193).—S. G.

Characteristic Equations of an Ideal Tungsten Filament. Ziro Yamauti and Zinta Nishikawa (*J. Illuminating Eng. Soc. Japan*, 1932, **16**, (5), 85–93; *Jap. J. Eng. Abs.*, 1935, **12**, 22).—S. G.

Zirconium and Its Uses. L. Sanderson (*Sands, Clays, and Minerals*, 1935, **2**, (3), 47–50).—A brief review of the occurrence, extraction, and uses of zirconium.—A. R. P.

Low Melting-Point Alloys. A. Eyles (*Machinery* (*Lond.*), 1935, **46**, 323–324).—The composition and uses of a number of fusible alloys are described, with particular reference to the alloys "Cerro-matrix," "Cerrobase," "Cerro-bend," and "Cerroseal."—J. C. C.

Metals in the Dairy. Richard Seligman (*Milk Ind.*, 1935, **15**, (11), 85–87).—A review of 25 years' progress, contrasting the former use of metals which had to be covered with a protective coating, with the modern applications of aluminium and alloys which form their own protective coating.—H. H.

Influence of the Material of the Containers on the Duration of Coagulation of Milk with Rennet. F. Springer (*10th World Dairy Congress, Milan, Sect. II*, 1934, 307–315; and (summary) *Food*, 1934, **4**, 8; *C. Abs.*, 1935, **29**, 4090).—[In English.] The rapidity of coagulation depends to a large extent on the material from which the vessels are made.—S. G.

Constructional Materials for Food Processing. —— (*Food*, 1934, **4**, 88–92).—A useful summary of the special characteristics, corrosion-resistance, methods of fabrication, and applications of the following metals, with special reference to the food industries: aluminium, copper, Monel metal, nickel, silver, stainless steel, tin, and glass-lined steel. The effects of the different materials on the taste and colour of certain foods are also noted. A table lists both satisfactory and unsatisfactory materials for processing a number of special food products.—C. E. H.

Iron Alloys for Electrical Purposes. M. Colonna (*Bull. Soc. Franç. Élect.*, 1935, [v], **5**, 593–604).—The applications to the electrical industry of iron alloys containing varying proportions of chromium and nickel, with or without small additions of other metals, are classified and described. These alloys, containing in some cases over 80% nickel and/or chromium, combine with an exceptional range of electrical and thermal properties, a high resistance to corrosion, and considerable strength at elevated temperatures.—P. M. C. R.

Reducing Abrasion by Compound Contact Pieces. S. Saito and N. Yamamoto (*Metal Progress*, 1935, **27**, (6), 52–55).—In order to obtain results applicable to such problems as the wear of brake-shoes and that of trolley-wires, the mutual wear of systems consisting of 3 members was measured periodically. In the case of copper trolley wires, a considerable degree of wear was obtained from copper working on copper, whilst wear was reduced to a negligible amount when one of the copper members was replaced by hard rubber or a synthetic resin. The following characteristics are deduced for the anti-friction member of the assembly: (*a*) brittleness, with formation of very fine particles in wear; (*b*) comparative softness of the reduced particles; (*c*) anti-oxidant action of reduced material.—P. M. C. R.

Metal for Decoration and Statuary. Erich Becker (*Giesserei-Praxis*, 1935, **56**, 139–141).—The properties required of alloys for decorative purposes and for statues are described. A typical large statue in Germany consisted of an alloy containing approximately copper 80–88·5, tin 6–17·3, lead traces to 0·1, iron 0·3–1·2, cobalt traces to 0·54, arsenic none to a trace, sulphur up to 0·22%, according to where the sample was taken. Modern alloys for decoration mostly consist of copper 80–90, tin 1–10, and lead 1–3%. Tables are given showing: the composition of a number of ancient statues and large modern statues; the effect of composition on the shrinkage; the colour of the alloy and the formation of a patina; the compositions of a number of proprietary alloys containing 60–95% of copper, of medal alloys (92–97% of copper), and of proprietary tin, zinc, and lead alloys.—J. H. W.

[**Metals Used in**] **Refining the Salt of the Earth.** James A. Lee (*Chem. and Met. Eng.*, 1935, **42**, 124–128).—In the handling and processing of salt obtained from salt-brine in the Silver Springs plant of the Worcester Salt Co., U.S.A., Monel metal is largely used, *e.g.* for facing the mechanical rakes for collecting the salt crystals obtained by evaporation in the long shallow pans known as grainers, and for the lips of the grainers themselves. It is also used for the conveyors which separate brine and salt in the washers, for screens in the Oliver filters, and for lining the revolving cylindrical dryers. The results of tests made by the development and research organization of the International Nickel Co. are quoted to show the extremely slow rates of corrosion of Monel metal, and nickel under various conditions as to temperature, steam, air, and brine. The huge cylindrical quadruple-effect evaporators used in the plant at the present time are fitted with copper tubes.—F. J.

Piping Transportation. Wm. H. Dopp (*Valve World*, 1935, **32**, 81–84).—In a history of the transportation of materials by means of pipes and tubes, reference is made to the use of thin sheets of beaten copper for the oldest metallic pipe, and later of lead pipe for conveying water.—J. W. D.

XXII.—MISCELLANEOUS

(Continued from pp. 317–318.)

†**Recent Trends and Future Developments in Metallurgical Research.** Harold Moore (*Monthly J. Inst. Metals*, **1935**, Mar., 139–156).—An address to the London Local Section of the Institute of Metals.—S. G.

Contribution of Science to the Non-Ferrous Metal Industry During Recent Years. J. O. Elton (*Proc. 5th Pacific Sci. Congress*, 1934, **1**, 633–635).—A general discussion.—S. G.

The Importance of Physical Chemistry in the Metal Industry. Werner Köster (*Z. Elektrochem.*, 1935, **41**, 386–393).—Read before the Deutsche Bunsen-Gesellschaft für angewandte physikalische Chemie.—J. H. W.

Metallurgy in the Service of Man. G. Masing (*R.T.A. Nachr.*, 1934, **14**, (1), 5).—B. Bl.

Man and Metal. (Sir) William J. Larke (*Found. Trade J.*, 1935, **53**, 26–29).—An address to the Institute of British Foundrymen. A brief historical survey is given of the relation of man to metals from the earliest times to the present day.—J. H. W.

Metals and Some National Problems. A. A. Robertson (*Modern Eng.*, 1935, **9**, 172–175).—The present position of metal resources in Australia is reviewed, their conservation for the future is advocated and a warning is given against industrial unpreparedness in case of war.—H. W. G. H.

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Co. for commercial use, the process has been improved by the use of oil condensation pumps of multiple type and a heater system not requiring wire coils. Films of copper, chromium, tin, silver, and lead are also producible. The film of metal may be deposited on paper, fabric, Bakelite, and porcelain.
—R. G.

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XXIV.—BOOK REVIEWS

(Continued from pp. 323–332.)

Was muss der Ingenieur vom Messing Wissen? Herausgegeben vom Deutschen Kupfer-Institut E.V. 8vo. Pp. 134, with 13 illustrations. 1935. Berlin: V.D.I.-Verlag G.m.b.H. (Br., R.M. 2.50.)

This is a concise, yet comprehensive, compilation of essential data with regard to brass considered in the broad theoretical sense and also from the manufacturing point of view. It is divided into two main sections. The first deals with general properties of the copper–zinc alloys: colour, influence of the addition of a third metal, mechanical and physical characteristics including thermal and electrical conductivity, influence of temperature changes, fatigue-strength, chemical behaviour, corrodibility, heat-treatment, soldering and welding. The second part embraces technological considerations, especially castings, sand, chill, and die; cleaning and blanching; rolling and forging; sheets; drawing and pressing; annealing; stampings; tube drawing; industrial application. Finally some 40 pages are devoted to various standard specifications for different types of brasses.

The book is a worthy successor to its forerunner on copper published by the Deutsche Gesellschaft für Metallkunde. It is well produced and fully informative. In one respect it is perhaps less perfect than it might be. Like all publications of a similar nature, the work which has been established in other countries is grudgingly mentioned, if at all.—W. A. C. Newman.

Resistance of Materials. By F. B. Seely. Second Edition. Med. 8vo. Pp. xii + 436, with 383 illustrations. 1935. New York: John Wiley & Sons, Inc. ($3.75); London: Chapman & Hall, Ltd. (18*s.* 6*d.* net).

This is the second edition of a book first published 10 years ago. Any text-book on the strength of materials inevitably challenges comparison with Morley's classic work on the subject. In the present book prominence is given rather to the application in actual practice of the results obtained, than to mathematical analysis; thus, whilst there is a tendency to use approximate methods without any attempt at justification, such subjects as the strength of welded and riveted joints and the applications of the various column formulæ are treated rather more fully than is usual.

Chapters are devoted to fatigue and to impact and energy loading. The emphasis placed on the use of the fatigue limit with an appropriate stress concentration factor and factor of safety (or as the author would prefer it, "reduction factor") as a basis of design is refreshing, but caution is needed in the application of the values given. Two statements made in connection with fatigue must be challenged—that the lower fatigue limit in direct stress than in bending is due to eccentricity of loading, and that no experimental data as to corrosion-fatigue are available. The importance of energy and impact loading is well brought out, but the assumption that the stress–strain diagram for a material is the same under impact as under static conditions is not justified. The torsion of non-circular shafts is briefly treated, as is the strength of reinforced concrete beams, whilst appendices deal with the properties of areas—moment of inertia, centroid, &c.—properties of rolled sections, and strengths and working stresses for a large range of materials.

Noteworthy omissions are the strength of rings, chain links, &c., and the effect of vibration. Much use is made of problems, including a considerable number of worked illustrative problems. The student is left to discover from the problems the useful properties of hollow sections in torsion and bending, and what are usually regarded as standard cases of bending of beams are also relegated to problems. The solution given to the hook problem on p. 343 makes two dubious assumptions.

The book is well got up and illustrated, and there are very few misprints.—D. G. Sopwith.

Zerspanung und Werkstoff. Ein Handbuch für den Betrieb. Von Ernst Brödner. Demy 8vo. Pp. x + 173, with 154 illustrations. 1934. Berlin: V.D.I.-Verlag G.m.b.H. (Geb., R.M. 5; V.D.I.-Mitgl., R.M. 4.50.)

A large amount of research work on the mechanics of workshop processes and the machining qualities of metals has been carried out in Germany during the last 10 years. This book collects together and critically examines the chief results of these investigations and indicates how they may be applied.

The first part of the book deals with machining processes. After a preliminary survey of the objects and methods of research work on machining and an outline of the principal conclusions, a section is devoted to the use and choice of lubricants and cooling liquids. The following machining processes are then examined: turning and planing, drilling, reaming and countersinking, tapping, milling and sawing, broaching, and grinding. The best shapes for the tool, cutting speeds and feeds, and the forces on the machine, and the various factors which affect these quantities are dealt with briefly; a number of useful tables and charts are given. Copious references to the original research papers are provided.

The second section of the book is devoted to a description of DIN Standards for materials. The importance of using standard metals for investigatory work on machining processes is stressed. The choice of materials for tools is then discussed; carbon, alloy, and high-speed tool steels are described and compared with the more recent hard alloys such as the sintered tungsten carbide alloys and diamond-tipped tools.

A very full classified bibliography, mainly of German work, is appended.

This book should certainly be consulted by any young engineer or metallurgist who contemplates starting a research on machining.—G. A. Hankins.

L'Aluminium dans les Industries Chimiques et Alimentaires et Industries connexes. Demy 8vo. Pp. 139, illustrated. 1935. Paris: Bureau international des applications de l'Aluminium, 23 bis Rue Balzac.

Four preliminary chapters deal with the properties of aluminium, methods of corrosion testing, fabrication, and surface treatment. The main part of the book gives concise information on the action of a large number of inorganic and organic substances on aluminium. The concluding chapter describes some applications based on the corrosion-resistance of the metal. The information given appears to be accurate, and the book will be found extremely useful for reference purposes. It would have been much more valuable if references to original literature had been given. The printing and illustrations are excellent.—H. W. G. Hignett.

Bibliography of Literature on Spectrum Analysis. Compiled by D. M. Smith. Med. 8vo. Pp. 20. 1935. London: British Non-Ferrous Metals Research Association, Regnart Bldgs., Euston St., N.W.1. (1s. 6d. post free.)

The author's "Metallurgical Analysis by the Spectrograph" (*Met. Abs.*, 1934, **1**, 110), published in 1934, embodied the results of work carried out by him for the British Non-Ferrous Metals Research Association over a period of some 8 years, and included a bibliography of the literature of the subject.

Even in the short time which has elapsed since publication of the book, many papers bearing on the subject have appeared. References to these papers have now been incorporated in the bibliography (up to March, 1935) and the revised bibliography is issued as a Supplement to the book.

Procédées électrochimiques de Protection des Métaux contre la Corrosion. Par P. Jacquet. (Actualités scientifiques et industrielles, 163. Exposés d'électrochimie appliquée, publiés sous la direction de Ch. Marie.) Roy. 8vo. Pp. 42, with 14 illustrations. 1934. Paris: Hermann et Cie. (12 francs.)

The author gives a brief exposition of present-day views on the mechanism of corrosion, maintaining that the phenomena are too complex to be explained completely by any single theory. The protective effect of electrodeposited metallic coatings is discussed, and brief reference is made to methods for testing adhesion, porosity, and corrosion-resistance, and for metallographic examination. Data are given concerning the protective properties of electrodeposits of nickel, copper, zinc, cadmium, and chromium, and brief mention is made of coatings of tin, cobalt, lead, silver, and gold. The anodic oxidation of aluminium and its alloys, and of iron and steel, is described. The publication is illustrated by 10 diagrams and 4 photographs, and contains a bibliography of 69 references to the original literature.

—E. S. Hedges.

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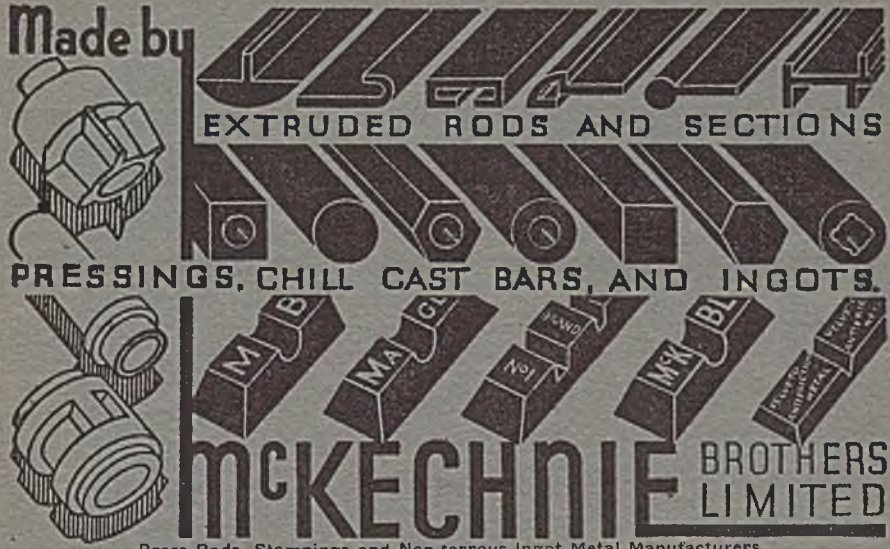

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