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1935, Vol. LVI.

Vol. 1. Part 10.

The Monthly Journal of the
INSTITUTE OF METALS

and

METALLURGICAL ABSTRACTS

OCTOBER, 1934

Printed in Great Britain by Richard Clay and Sons, Ltd., Bungay, Suffolk.

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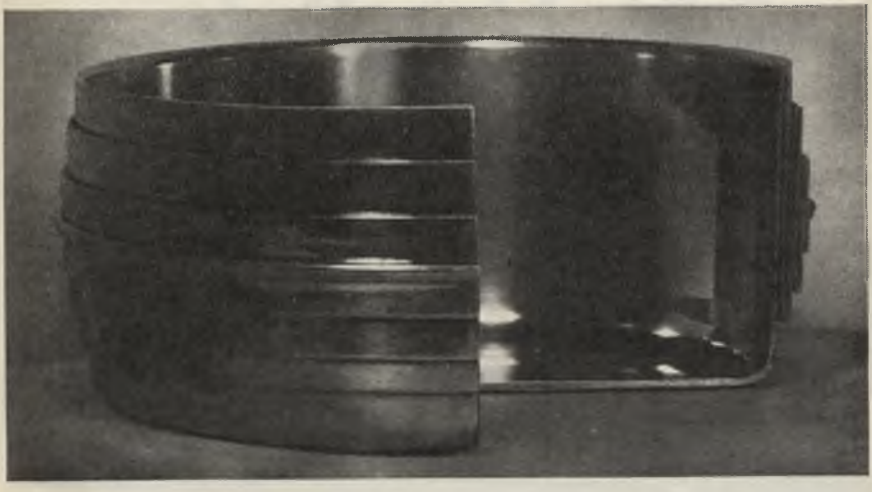

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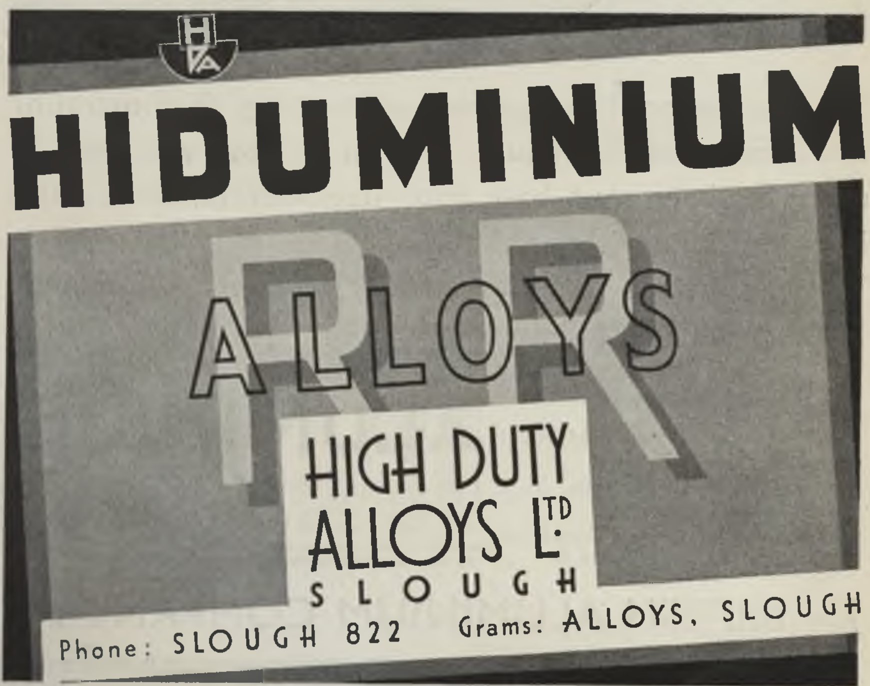

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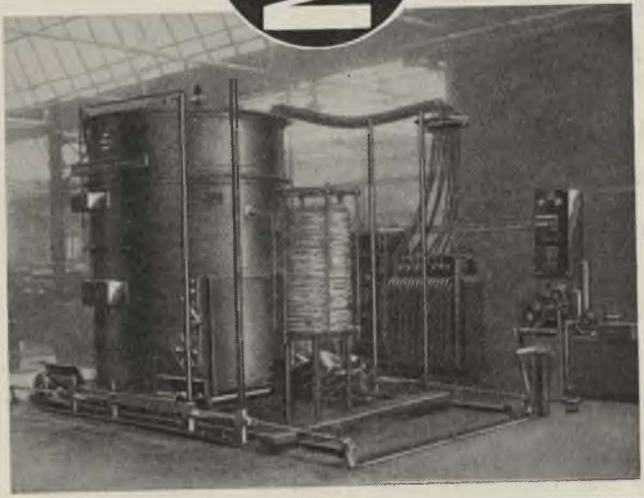

THE INSTITUTE'S LIBRARY

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

Encyclopædia Britannica (latest issue).

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

"Brass World." Volumes 1–6.

Electrochemical and Metallurgical Industry. Volumes 1–3.

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

Mineral Industry. Issues since 1932 (incl.)

Foundry Trade Journal. Volumes 1–25.

Journal of the Electroplaters' and Depositors' Technical Society. Volumes 1–3 incl.

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

Metal Industry (London). Volumes 1–4.

Metallwirtschaft. Volumes 1–5.

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

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

Revue de Metallurgie. Volume 1.

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

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

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

INDEX TO ADVERTISERS

OCTOBER, 1934

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Volume 1 **OCTOBER, 1934** **Part 10**

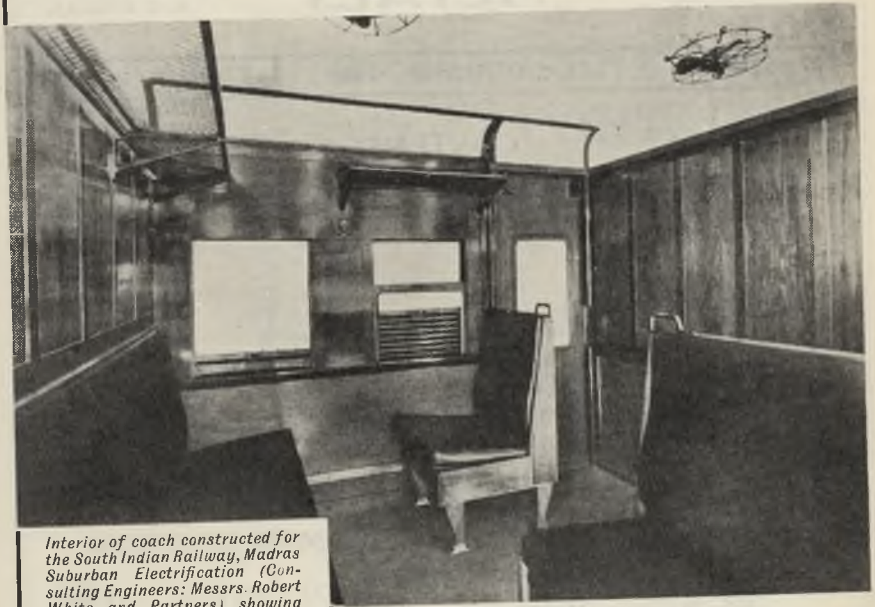
CONTENTS

Papers to be Read at the March Meeting :

METALLURGICAL ABSTRACTS

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

ALUMINIUM ALLOYS IN ELECTRIC TRAIN CONSTRUCTION



Interior of coach constructed for the South Indian Railway, Madras Suburban Electrification (Consulting Engineers: Messrs. Robert White and Partners) showing "Alpax" doors, louvres and window frames (patented construction), net rod brackets, etc., made by Messrs. Lightalloys Ltd., London, N.W.10.

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INSTITUTE NEWS AND ANNOUNCEMENTS

Papers for Spring Meeting.

THE present issue of the *Monthly Journal* contains the first of the papers to be accepted by the Council for presentation at the Annual General Meeting, to be held in London on March 6–7, 1935. Other papers will appear monthly, those due for publication in November being :

" Some Further Experiments on Atmospheric Action in Fatigue," by H. J. Gough, M.B.E., D.Sc., Ph.D., F.R.S., and D. G. Sopwith, B.Sc.Tech.

" Corrosion-Fatigue Properties of Duralumin With and Without Protective Coatings," by I. J. Gerard, M.Sc., and H. Sutton, M.Sc.

Authors who desire their papers to be presented next March, and who wish to secure early advance publication in the *Monthly Journal* (with all that this means in the way of stimulating discussion), should submit their MSS. without delay, so that they may be refereed, and, if approved by the Council, printed in the *Monthly Journal.*

Manuscripts should be submitted in duplicate. Drawings for reproduction must be submitted in india ink on Bristol board, tracing or good drawing paper, and should be approximately twice the size that they will be when reproduced. *All lettering must be in pencil* to enable the Institute's draughtsman to add this to conform to the style adopted throughout the *Journal.* Guide lines in graphs should be drawn in *faintly* and curves boldly.

Photomicrographs must be trimmed to one of the following sizes, preferably the first-mentioned : 2 in. × 2¼ in. ; 3 in. × 2¼ in. ; 3 in. × 4 in. Magnifications should be given in all cases.

A brief synopsis should be given at the head of each paper submitted, which should be accompanied by a declaration of originality, the form for which may be obtained from the Editor, who should be advised as soon as possible by intending authors of papers when their MSS. may be expected, and also the subjects of their papers.

Issue of Journals and Programmes.

Members should by now have received their copies of Volumes LIII and LIV of the *Journal.* The Editor should at once be notified of any cases of non-receipt of these volumes, in order that the matter may be taken up with the carriers.

To all British members there have been sent copies of the programmes of the Local Sections for the session 1934–1935. The Council trusts that members resident in areas where Local Sections exist will make a point of attending the meetings and of taking part in the discussion of any papers in which they are interested.

May Lecture.

The Council is glad to announce that the Twenty-Fifth May Lecture will be given on May 8, 1935, by Professor W. L. Bragg, F.R.S., whose father, Sir William Bragg, delivered the Sixth May Lecture in 1916.

Supper-Dance in November.

In co-operation with the London Local Section the Council is arranging for a Supper-Dance to take place on Friday, November 30, at Thames House, Millbank, S.W.1. The dance will begin at 7 p.m. and will conclude at midnight. Tickets, price 6*s.* each, are now obtainable from the Honorary Secretary of any Local Section or from the Secretary of the Institute.

Overdue Subscriptions.

This issue of the *Journal* comes into the hands only of those members whose subscriptions for the current year, which became due on July 1 last, have been paid. Those members whose subscriptions are still unpaid have received a letter from the Secretary reminding them of this fact and indicating that, pending the receipt of their subscriptions, their *Journals* are being withheld. The amount payable by members is £3 3*s.*, and by student members £1 1*s.*

Membership Additions.

The following were elected on August 30, 1934 :—

As Members.

Bastien, Paul Gaston, Dr.es.Sci., Paris, France.
Bell, Donald Helliar, B.Met., Port Kembla, N.S.W., Australia.
Bentham, Cecil, Cheadle Heath, Stockport.
Brucklacher, Hermann, Hettstedt/Südharz, Germany.
Carder, Charles Henry, Birmingham.
Charles, Lieut.-General Sir J. Ronald E., K.C.B., C.M.G., D.S.O., London.
Chatwin, Sidney Shilvock, Birmingham.
Clements, Waldo John, Prescot.
Dechaume, G. E. Henri, St. Nazaire, Loire Inférieure, France.
del Fresno, Professor Carlos, D.Sc., Oviedo, Spain.
Harris, Edward Percival, B.Sc., A.R.S.M., London.
Headlam-Morley, Kenneth, B.A., London.
Hoare, William Edward, B.Sc., London.
Kusaka, Kazuji, Darien, South Manchuria.
Poulton, Miss Winifred E., Ilford.
Raub, Ernst, Dr.-Phil., Schwab, Gmünd, Germany.
Read, Henry Colin Seabrook, B.Sc., A.R.C.S., London.
Reuter, Hans, Bockum, Rhein, Germany.
Roche, John Fenwick Adair, B.A., Bedminster, Bristol.
Scheller, Ernest, B.Sc., Louisville, Ky., U.S.A.
Sohon, Julian A., Bridgeport, Conn., U.S.A.
Warren, Miss Althea, Los Angeles, California, U.S.A.
Williams, Charles Garrett, M.Sc., London.

As Student Members.

Foden, Robert Frederick, Birmingham.
Proctor, William Leonard, Burnley.
Rawlins, Kenneth Sidney, Banbury.

PERSONAL NOTES

Sir Harold Carpenter, F.R.S., Past-President of the Institute of Metals and President of the Institution of Mining and Metallurgy, has been nominated as President-Elect of the Iron and Steel Institute. When Sir Harold takes up his new office in May next he will enjoy the unique distinction of having been President of the three great metallurgical Institutes.

Dr.-Ing. E. W. Fell, M.Sc., has been appointed Lecturer in Iron and Steel in the University of Manchester under Professor F. C. Thompson.

Professor J. N. Greenwood, D.Sc., Honorary Corresponding Member to the Council for Australia, is engaged in extending the School of Metallurgy in the University of Melbourne. The additions to be made include a special laboratory for lead research.

Mr. E. A. Jenkinson has obtained the degree of B.Sc. (Engineering) in Metallurgy of London University.

Mr. J. C. Kidd, B.Met.E., of Burma Corporation Limited, Namtu, Northern Shan States, is on six months' leave; correspondence until April 1, 1935, may be sent to him addressed c/o David Kidd, Esq., 38 Peel Street, Windsor, S.I., Victoria, Australia.

Mr. L. C. Percival, B.Sc., has developed an oxy-acetylene welding rod which, it is stated, more than satisfies the requirements of Lloyd's Register of Shipping in connection with the application of welding to ship construction.

Mr. A. B. Winterbottom, M.Sc., Tech., relinquished his appointment as Senior Assistant in the Research Department of Tube Investments, Ltd., at the end of September in order to undertake investigations on corrosion of metals and alloys by hot gases, using Dr. Tronstad's optical technique in the latter's laboratory at the Norges Tekniske Hoiskole, Trondhjem, Norway.

OBITUARY.

Mr. William Bamford died on August 29 of heart failure. Mr. Bamford was Works Manager of Messrs. Dewrance & Company, London, and had been a member of the Institute since 1923.

Mr. William Hastings Bassett, S.B., died at his home in Cheshire, Conn., U.S.A., on July 21, with unexpected suddenness. He was the newly-elected President of the American Society for Testing Materials, and had been a member of the Institute of Metals since 1910.

Mr. John Karl Gwilym James, B.Eng., an engineer on the staff of The British Aluminium Company Limited at Kinlochleven, died at Glasgow on July 14 last. He was elected a member in 1925.

Mr. L. Vogelstein, Chairman of The American Metal Company, died suddenly in New York on September 23. He had been a member of the Institute since 1925.

Beilby Memorial Awards

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

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

The administrators of the Fund are the Presidents, the Honorary Treasurers, and the Secretaries of the three participating Institutions, who will meet towards the end of this month, and will be glad to have their attention directed, not later than Saturday, the 27th October, to outstanding work of the nature indicated.

Correspondence should be addressed to the Convener, Sir George Beilby Memorial Fund, Institute of Chemistry, 30, Russell Square, London, W.C.1.

LOCAL SECTIONS NEWS

SYNOPSES OF PAPERS TO BE READ IN NOVEMBER.*

London Section.

Recent Trends and Future Developments in Metallurgical Research. By Harold Moore, C.B.E., D.Sc., Ph.D., President. (*November* 8, *at the Royal School of Mines*, 8 *p.m.*)

A broad review of recent progress, particularly in research bearing on the manufacture and applications of non-ferrous metals and alloys, and an account of directions in which further developments may be expected. Examples will be selected from the following subjects : some properties of liquid metals (*e.g.* their reactions with, and solvent power for, gases); study and control of stages between the liquid metal or alloy and the final product, cast or worked; heat-treatment; "precipitation"-hardening; metals and alloys of extreme purity; light alloys—the growing use of magnesium; applications of rare or unusual metals; properties of metals and alloys in form in which they are used; search for general principles controlling properties, *e.g.* relating properties to composition; mechanical properties—creep, fatigue; internal stress; surface properties; corrosion and oxidation; corrosion-fatigue; mechanical wear; effect of temperature on useful properties; structure (macro-, micro-, and atomic), its study and its practical significance; special properties of the soft metals and alloys; use of non-ferrous metals for protection of steel; electrodeposition; powder metallurgy.

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

Local Sections News

Scottish Section.

The Influence of Manufacture of Wrought and Cast Aluminium Alloys on Design. By W. C. Devereux. (*Nov.* 12.)

The author endeavours to show certain aspects of the use of aluminium and magnesium alloys which escape the knowledge of the casual observer, and points out the need for different methods of casting to suit the various compositions of the aluminium alloy group. The effect of correct feeding on the physical properties of the casting is described in the case of heat-treatable alloys, as well as the influence of internal stress on delicate and large castings and the necessity of designing to allow cooling from high temperatures to be effected without strain.

Certain work which has been done on the spectrographic detection of stress is described, and an indication given of the amount of stress in heat-treatable parts. There follows a description of a test rig used for testing levers of various alloys under shock load where the blow does not exceed the elastic limit of the material. An attempt is also made to show the effect of the fluxing material on the grain size and the need for moderation in the use of fluxes. In dealing with wrought alloys, the author shows the effect of hot-pressing when using incorrect temperatures. A chart will be exhibited—a development of the familiar " Southwell " curve—showing the advantages obtained by securing a higher yield point on extruded and drawn tube.

The effect of the shape of the test-piece in fatigue tests is considered, and some work done in the author's laboratory on the effect of cold-work on various aluminium alloys is shown to illustrate how variations in heat-treatment and cold-work can be used to advantage when the question arises of a design necessitating heavy deformations. He concludes by showing the need for care in the heat-treatment and cold-working of the material to preserve the ductility.

Sheffield Section.

The Flow of Metals in the Extrusion Process. By C. E. Pearson, M.Met. (*Nov.* 9.)

A brief survey of the chief methods which have been used in studying the course of flow in material undergoing extrusion. These involve the use of (*a*) composite wax or plasticine billets, (*b*) composite metal billets, (*c*) etched sections of extruded billets. An adaptation of Siebel and Hühne's method, in which metal billets are sectioned longitudinally and inscribed with a grid pattern prior to extrusion, will be described and its application to the comparison of flow in the direct and inverted processes illustrated. This method has also been used in tracing the origin of extrusion defects and in investigating the flow of metal through dies of varying profile.

The Chairman's Address, announced to be given by Mr. Kenneth Gray on October 12, had to be postponed and will be delivered on October 19. Mr. Gray's subject will be " Some Manufacturing Faults and Other Defects in Extruded Lead Products."

Swansea Section.

Copper in Architecture : Some Chemical and Other Aspects. By W. H. J. Vernon, D.Sc., Ph.D. (*Nov.* 13.)

An historical review of the use of copper by man, especially for purposes associated with architecture. Noteworthy examples of copper roofing, ancient and modern, are described and factors to be considered in the selection of a roofing material—resistance to corrosion, creep, attack by boring insects, patina, &c.—are discussed, together with the advantages of the use of copper. The green patina on copper, its composition, properties, and artificial reproduction, are considered in the light of recent investigations.

PAPER No. 685. This paper is not to be reprinted, wholly or in part, until presented (and then only with due acknowledgment) at a meeting to be held on March 6–7, 1935, in the Hall of the Institution of Mechanical Engineers, Storey's Gate, Westminster, London, S.W.1. The Institute as a body is not responsible for the statements or opinions expressed in this paper, on which written discussion may be sent to the Secretary not later than April 1, 1935.

685

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

THE ϵ, γ, AND β PHASES OF THE SYSTEM CADMIUM–SILVER.*

By P. J. DURRANT,† M.A., Ph.D., MEMBER.

SYNOPSIS.

The constitution of the alloys of cadmium and silver from 30 to 60 per cent. by weight of silver has been reinvestigated by the methods of thermal and micrographic analysis.‡ The liquidus has been found to consist of four smooth curves intersected by peritectic horizontals at 592°, 640°, and 736° C. The boundaries of the phases ϵ, γ, and β have been mapped. No changes occur below the solidus in phases ϵ and γ, but the β undergoes two 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 under 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.

All compositions, except when otherwise stated, are expressed in percentages of silver by weight, and all temperatures in degrees Centigrade. An individual alloy is described by its composition : " the alloy 50·3 " *means " the alloy containing* 50·3 *per cent. by weight of silver." The accepted nomenclature for solid solutions has been adopted in this paper. The phases II and III of the previous paper are here denoted as* ϵ *and* γ *respectively.*

MATERIALS EMPLOYED.

THE metals used were chemically pure; some of the cadmium was purified as previously described, and some was obtained by the kindness of Professor R. S. Hutton, M.A., D.Sc., from the National Smelting Company, Ltd.

THERMAL ANALYSIS.

Thermal analysis experiments were made on 24 alloys in the composition range 32–60 per cent. of silver. The alloy was contained in an apparatus similar to that previously described.§

* Manuscript received June 6, 1934.

† Fellow of Selwyn College, Cambridge.

‡ The results of similar experiments on the cadmium-rich alloys of the system have been described in a previous paper: Durrant, *J. Inst. Metals*, 1931, **45**, 99.

§ Durrant, *loc. cit.*

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

The rate of cooling, normally 1·5° per minute, was controlled by admitting a steady stream of oxygen to the hot bulb of the Haughton–Hanson thermostat. The oxygen was generated by the electrolysis of a saturated solution of copper sulphate in a cell in which the anode was a coil of platinum wire and the cathode a co-axial copper cylinder. A soda–lime tube served to dry the oxygen and to free it from traces of acid spray.[*] The degree of polarization of this electrolytic cell became constant when a current had passed for about 15 minutes, after which a steady stream of oxygen could be maintained for 2 or 3 days. The galvanometers in the thermocouple circuit were uninfluenced by the operation of the thermostat relays, provided that the tube containing the alloy was separated from the furnace windings by means of an earthed nickel sheet. For this insulating device the author is indebted to Mr. W. E. L. Brown.

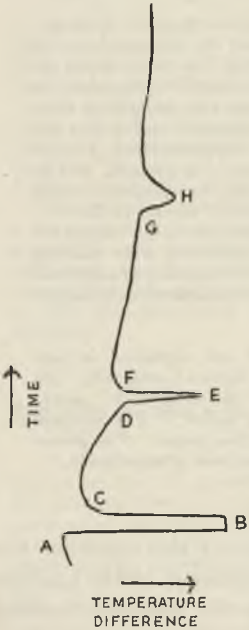

Fig. 1.—Difference Curve of Alloy 50·5.

Two series of curves were taken : (1) difference curves on a double-drum thread-recorder, (2) direct temperature–time curves on a water-dropper having a screen sensitivity of 1·4 cm. per 1°. An ingot of silver, placed in an apparatus similar to that containing the alloy and heated in the same furnace, served as the standard body for the difference curves. The difference curves obtained agreed exactly in form with those obtained by Fraenckel and Wolf [†] for alloys of corresponding compositions. These authors, however, regarded the temperature range at the base of a peak on the difference curve, for example the range *D–F* in Fig. 1, as the nearest indication of the temperature of transformation. The point *D* nevertheless indicates the temperature at which the transformation is initiated, and so must correspond with the earliest temperature of departure from regularity on the direct cooling curve, and the author has taken the temperatures corresponding with the points *A*, *D*, and *G* to indicate the temperatures of the cooling arrests associated with the peaks *B*, *E*, and *H*. Ideally, for isothermal changes, the temperatures corresponding with the points *A*, *D*, and *G*

[*] The use of calcium chloride proved disastrous, as free chlorine was liberated from it.

[†] Fraenckel and Wolf, *Z. anorg. Chem.*, 1930, 145, 189.

should be identical with those corresponding respectively with the points *B*, *E*, and *H*, but in practice this result is not attained. For non-isothermal changes the identity of temperatures does not hold even theoretically. Because of the above difference in interpretation, the arrest temperatures recorded in this paper are somewhat higher than those given by Fraenckel and Wolf.

When the final curve of each experiment had been taken, the inner crucible was removed from the outer tube, and the inner crucible and the couple-sheath were broken away from the alloy. Four samples of 1–2 grm. each were sawn from the ingot (usually two from the top and two from the bottom) and analyzed for their silver content. Some indication was thus obtained of the uniformity of composition of the ingot during the taking of the cooling curves. In all cases there had been a considerable loss of cadmium, and usually the top of the ingot was richer in silver than the bottom. The differences of composition between the tops and bottoms of the ingots 12, 14, 15, 19, 21, 22, were greater than 1 per cent. of silver. The detailed results of the analyses are not published, but some results given below show the degree of consistency attained.

TABLE I.

Number of Ingot.	Synthetic Composition.	Analytic Composition.			
		Top.	Middle.	Bottom.	Mean value.
4	35·0	37·16; 37·13	...	37·37; 37·37	37·26
13	45·5	44·73; 44·71	...	45·11; 45·08	44·91
21	50·5	51·94; 52·11	51·48; 51·53	50·51; 50·55	51·34
23	55·0	55·46; 55·42	...	55·33; 55·33	55·39

The arrest points obtained on the two series of thermal analysis experiments are given in Tables II and III; thermal analysis points are not plotted on the equilibrium diagram in Fig. 2.

The forms of the boundaries *HM* and *IN*, which are based on evidence from the micrographic experiments, suggest that an isothermal change might be expected to occur in the $\varepsilon + \gamma$ region at about 470° C. No points were observed in the $\varepsilon + \gamma$ region at or near this temperature, but the difference curves of ingots 2–7 showed faint irregularities between the solidus and 350° C. which were absent from the curves of other alloys. These irregularities probably arose on account of the change of direction of the boundaries *HM* and *IN*, and do not afford adequate evidence for the insertion of a new phase boundary. Moreover, no arrests were observed in the $\gamma + \beta$ region except those due to the well-known horizontals *QRSTUU′* and *VWZXYY′*, which undoubtedly refer to

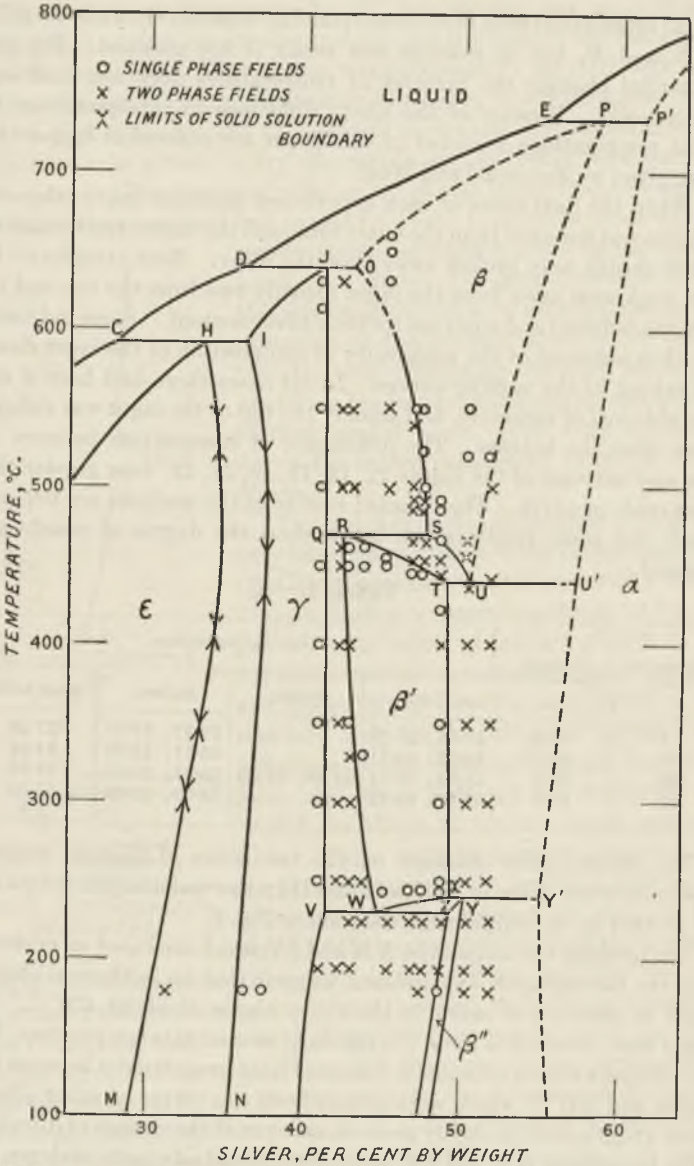

Fig. 2.—The Re-Investigated Area of the Equilibrium Diagram of the System Cadmium–Silver. The dotted boundaries represent those on which few or no experiments have been made. The points plotted are selected from the results of micrographic analysis. Points recorded in Tables II, III, and IV are not plotted.

Table II.—*Temperatures of Arrests on Difference Cooling Curves.*

Number of Ingot.	Analytic Composition Per Cent. by Weight Silver.	Range of Cooling, ° C.	Temperatures of Arrests, ° C.					
1	32·5	730–170	628		592			
2	35·2	730–30	636		586			
3	36·0	725–50	643	640	586			
4	37·3	740–160	651	640				
5	38·4	740–135	655	638				
6	38·3	740–175	655	640				
7	39·5	720–20	661	640				
8	41·0	800–20	671	...*				
9	42·2	690–20	678	640		459		215
10	43·8	780–20	683	623 590		460		212
11	43·9	730–20	686	608		460		212
12	45·5	720–160	689	635 595		459		207
13	44·9	760–20	693	588		460	439	198
14	47·1	720–20	695			459	436	204
15	47·3	740–20	700			462	435	210
16	50·5	800–20	720				436	212

* Galvanometer boom against stop.

changes in the β phase, and those on the curves of the ingots 10–13 in the neighbourhood of 600° C. (Table II) which refer to the boundary *OS*. The temperature of the peritectic horizontal *EP′* on both heating and cooling curves was 736° C.; the temperature of the peritectoid horizontal *QRS* on cooling curves was 460° C., but micrographic experiments showed that it should be placed 10° C. higher; the temperature of the eutectoid horizontal *TUU′* was 436° C. on cooling curves and 442° C. on heating curves. These results entirely confirm the observations of Fraenckel and Wolf that the changes *QRS* and *TUU′* take place at different temperatures. The change shown on the equilibrium diagram (Fig. 2) by the horizontals *VWZ* and *XYY′* was marked on cooling curves by a pronounced but vaguely defined arrest (*GH*, Fig. 1), initiated at about 210° C., except in the case of the alloy 54·1, when the change occurred at 225° C. The corresponding arrest on the heating curve of this alloy took place at 256° C. There is, therefore, evidence that *XY′* should be placed at a higher temperature than *VZ*. On the evidence of annealing experiments the line *VZ* is drawn at 230° C.

Micrographic Analysis.

Alloys of desired composition were prepared by melting together portions of a stock alloy with the calculated quantities of either cadmium

TABLE III.—*Temperatures of Arrests on Water Dropper Curves.*
(Heating Curve Points are given in Italics.)

Number of Ingot.	Analytic Composition Per Cent. by Weight Silver.	Range of Curve, ° C.	Temperatures of Arrests, ° C.			
17	36·8	675–563	643	637		
		571–400	No	point		
18	40·1	700–553	667	638		
19	43·7	722–560	679	629		
		587–647		*643*		
20	43·4	730–580	684	607		
21	51·3	770–700	720			
		460–430			437	
		225–200				210
22	54·1	750–702	728			
		700–730		*719*		
		465–433			435	
		435–450			*442*	
		274–180				225
		180–276				*256*
		610–525		No	point	
23	55·4	770–577	735			
		640–740		*724*		
		470–428			433	
		425–450			*442*	
		250–170	No	point		
		170–265	*No*	*point*		
24	59·8	800–730	766	736		
		730–770		*736*		
		455–407		No point	at 433	

or silver in a silica or Pyrex tube under hydrogen, and casting the melt in an iron mould dressed with graphite. During the fusion and casting the proportion of silver in the alloy increased by about 0·5 per cent. The silver content of each alloy was determined by dissolving samples in nitric acid and titrating the solutions against standard potassium bromide solution using tartrazine as an adsorption indicator.*

Anneal temperatures were controlled by thermostats, including one of the thermoelectric type designed by D. Stockdale,† which gave efficient service and required very little attention.

Two etching agents were employed: (*a*) a solution containing 5 grm. of chromic oxide and 0·5 grm. of sodium sulphate in 1 litre of water; (*b*) a solution prepared by mixing one volume of a 10 per cent. aqueous solution of potassium cyanide with an equal volume of a 10 per cent. aqueous solution of ammonium persulphate.

The micrographic experiments were made in the following manner.

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* Berry and Durrant, *Analyst*, 1930, **55**, 613.

† Stockdale, *J. Sci. Instruments*, 1925, **2**, 392.

Anneals of about 10 days' duration were carried out at 250°, 300°, 350°, 400°, 450°, 500°, and 550° C., on batches of 21 chill-cast specimens of compositions ranging from 30·4 to 51·8 per cent. silver. Individual specimens were then given a series of heat-treatments to ascertain with more accuracy the limits of solid solutions. Where possible, a specimen was first annealed until homogeneous, and then annealed at a succession of temperatures until a second phase appeared. Further anneals were made at different temperatures until homogeneity was regained. The phase boundary must pass between the single and duplex fields thus observed.

The Boundaries HM *and* IN *of the* $\varepsilon + \gamma$ *Field.*

The determination of the positions of the triple points *H* and *I* was described in the previous paper. Table IV sets out the results of annealing specimens in this region of the equilibrium diagram at temperatures between 250° and 550° C.

TABLE IV.—*Number of Phases Present in Chill-Cast Specimens of the above Compositions after an Anneal of* 10 *days at the Stated Temperatures.*

Temperature, ° C.	Alloy.							
	31·4.	32·5.	33·3.	34·2.	35·4.	36·2.	37·3.	38·4.
550	1	1	1	2	2	2	1	1
500	1	1	1	1	2	2	2	1
450	1	1	1	1	2	2	2	1
400	1.	1	1	2	2	2	1	1
350	1	1	2	2	2	2	1	1
300	1	2	2	2	2	2	1	1
250	1	2	2	2	2	2	1	1

Tables V and VI summarize the results of experiments conducted on individual specimens to ascertain the temperatures at which they undergo constitutional changes.

TABLE V.—*Position of Boundary* HM.

Composition.	Temperature, ° C.
34·2	535
34·2	408
33·3	347
32·5	305

TABLE VI.—*Position of Boundary* IN.

Composition.	Temperature, ° C.
37·4	510
37·4	450

Below 250° C. the γ took a considerable time to separate from homogeneous ε. This change should occur at 240° C. in an alloy containing 31·4 per cent. of silver. A uniform specimen of this composition was maintained at 208° C. for 24 hrs., and at 150° C. for a further 48 hrs., without undergoing any change. After an anneal of 12 days at 180° C. γ had separated in considerable quantity. Specimens of alloys 36·2 and 37·4 were uniform after similar treatment.

The disposition of the $\varepsilon + \gamma$ field as shown in Fig. 2 removes the discrepancy between the determination of the field at low temperatures by Åstrand and Westgren and the determination at high temperatures by the author.*

THE β-PHASE.

Previous workers have reported that it is not possible to retain the β-phase undecomposed if quenched from above 450° C. In the course of the experiments described in this paper many specimens of compositions ranging from 46·8 to 51·8 were quenched from temperatures up to 550° C. without any sign of decomposition on quenching, to yield structures which provided consistent evidence for the working out of the equilibrium diagram. On the other hand, specimens which at the moment of quenching would be expected to consist of pure β, often displayed a two-phase structure on examination. In some cases, no doubt, this two-phase structure originated from the decomposition of β during quenching (it was found, for example, that specimens of the 50·3 alloy quenched in iced brine from temperatures between that of the eutectoid point *U* and 470° C. invariably contained β′), but in other cases two different explanations may be advanced for the presence of small quantities of a second phase.

(i) The initial annealing may have been too short for the attainment of equilibrium. At least 5 days' annealing at 500° C. was found necessary to render uniform alloy specimens containing about 49 per cent. of silver.

(ii) Distillation of the volatile cadmium from the surface of the specimen and from cracks and crystal boundaries will lead to silver enrichment, which may remain localized, if solid diffusion throughout the bulk of the specimen is slow. This seems the most probable explanation for the existence of the crystals of α shown in Fig. 8, Plate II.

The results of thermal analysis and dilatometry show that the changes $\beta \rightleftharpoons \beta'$ and $\beta' \rightleftharpoons \beta''$ occur rapidly in either direction. It is probable, therefore, that the uniform structure observed on quenching, say, the 51·8 alloy from 550° C., is not the original β present at the moment of

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* Discussion by A. J. Murphy on previous paper, *J. Inst. Metals*, 1931, **45**, 113.

FIG. 3.—Alloy 43·8 Annealed until Uniform β' and Slowly Cooled to 224° C. Large primary crystals of γ (white), and small crystals of secondary γ in grey (visually pink) β''. × 150.

FIG. 4.—Alloy 46·8 Annealed until Uniform β' and Slowly Cooled to 224° C. Small γ crystals in β''; primary γ is absent. × 150.

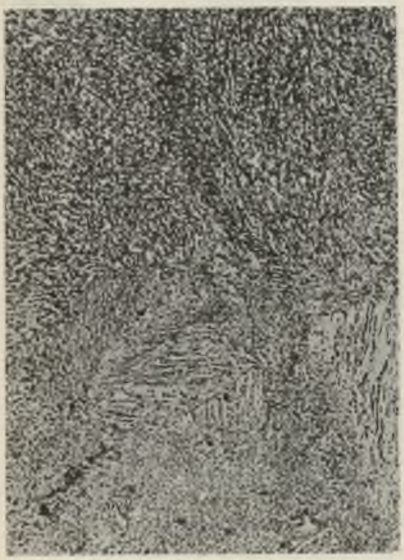

FIG. 5.—Alloy 45·3 Annealed until Uniform β' and Slowly Cooled to 224° C. Widmanstätten structure of γ in β''. × 150.

FIG. 6.—Alloy 45·3 Annealed until Uniform β' and Slowly Cooled to 224° C. Widmanstätten structure of γ in β''. × 500.

All specimens etched with a mixed solution of ammonium persulphate and potassium cyanide.

FIG. 7.—Alloy 42·3 Annealed for 5 Days at 462° C. White γ in grey (visually pink) β'. × 150.

FIG. 8.—Alloy 51·8. Annealed at 586° C. Intergranular α (white) in β. × 150.

FIG. 9.—Alloy 51·8. Chill-Cast and Annealed at 300° C. Widmanstätten structure of α (white) in β'. × 150.

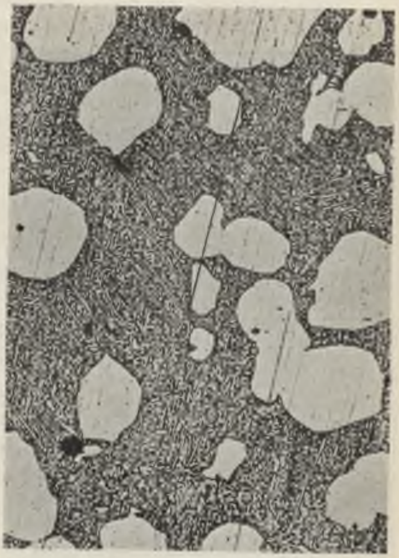

FIG. 10.—Alloy 51·8 Slowly Cooled and Quenched at 420° C. Primary α (white) and parallel crystals of secondary α in grey (visually pink) β'. × 150.

All specimens etched with a mixed solution of ammonium persulphate and potassium cyanide.

quenching, but a martensitic structure. If the quenching is not rapid, α is thrown out of solution at the eutectoid U, and the β changes definitely to β'. If the alloy is reheated to 550° C., the β' reverts to β almost immediately, but the reabsorption of the precipitated α takes place only in the course of several hours or days. The same phenomena, the rapid change $\beta' \rightleftharpoons \beta''$ and the slow absorption of α or γ, are probably associated also with the change at 230° C.

Between 600° C. and 250° C. all annealed specimens of alloy 41·0 consisted of pure γ. A specimen annealed for 28 days at 195° C. contained small quantities of β'', which indicates that the solubility of β'' in γ is less than that of β'. Specimens which were annealed at 613° C. and at 630° C. for 2 days consisted of pure γ, except that on the edges and crystal boundaries were small areas of $\gamma + \beta$ which probably arose through local silver enrichment by volatilization.

The triple point J must lie at about 41·5 per cent. of silver, and not at 39·0 per cent., as reported in the previous paper. All annealed specimens of the 42·3 alloy displayed two-phase structures. Neither the position of the triple point O (which is at 640° C. and at about 43 per cent. of silver) nor the course of the solidus OP was exactly determined.

The line QRS is drawn at 470° C. R is at the composition 42·5 and S at the composition 47·8 per cent. of silver. The course of SU could not be exactly determined, as specimens quenched from 470° C. which from thermal analysis evidence should have consisted of pure β, contained β', indicating that the annealed structure was not successfully retained by quenching. The line TUU' is drawn at 440° C., T is at the composition 49·0 and the eutectoid point U is between 50 and 51 per cent. of silver. If specimens containing β were slowly cooled from above 440° C. to a slightly lower temperature and there quenched, a characteristic Widmanstätten structure was developed, in which the separated α took the form of parallel needles or plates in the apparently unchanged β. β and β' when separately present were indistinguishable on etching, but if present together the β' etched yellow and the β pink. The two-phase field $\beta + \beta'$ ($RSUT$) was very easily identified.

At 440° C. the solid solution β' extends from 42·5 to 49 per cent. of silver; as the temperature falls the range of this solid solution slightly decreases. The mapping of the β' region at low temperatures was at first confused owing to the difficulty of bringing specimens into equilibrium. At or below 300° C. an anneal of 10 days was insufficient to render uniform chill-cast specimens which contained γ in fair proportion. Specimens of alloys 42·3, 42·9, 43·8, 45·3, 46·8, 47·5, 48·7 were annealed until in equilibrium at 440° C., and then for 2 days at each of a number of successively lower temperatures. It was found that the alloy 42·3 was duplex at all temperatures; the 42·9 alloy first showed definite primary γ at 331° C.; the alloy 43·8 first showed γ (but in considerable quantity) at 245° C.; no other specimen showed any second phase down to 230° C. At 228° C. alloy 45·3 showed traces of the Widmanstätten structure which would be expected at the point *W*, and after a further 2 days' anneal at 224° C. this structure was fully and beautifully developed (Fig. 6, Plate I). All the remaining specimens after annealing at 224° C. showed a fine two-phase structure, together with primary γ or β″ (Figs. 3 and 4, Plate I). On annealing for a further 28 days at 195° C. the duplex structure was maintained.

The range of the solid solution β″ must be very small. At 180° C. the alloy 48·7, which was a duplex at 224° and at 195° C., showed a single-phase field, but the alloy 50·3 was duplex at temperatures between 224° and 180° C., and contained fair quantities of α.

The Goldsmiths' Metallurgical Laboratory and Selwyn College,
Cambridge.

June 3, 1934.

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686

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THE CONSTITUTION AND PROPERTIES OF CADMIUM–TIN ALLOYS.*

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

SYNOPSIS.

The constitution of cadmium–tin alloys has been determined by means of cooling curves and microstructures. A eutectic is formed at 176° C. and 33 per cent. 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 per cent. and 6 per cent. of cadmium in solution, but at 131° C. two conjugate solid solutions are formed, which at 127° C. have the compositions 1·25 per cent. and 5 per cent. of cadmium. At this temperature, the one richer in cadmium decomposes to form a eutectoid. This transition occurs in all compositions from 1·25 per cent. to 99·5 per cent. of cadmium. In alloys containing 40 per cent. to 90 per cent. of 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 per cent. of cadmium, have been measured after various heat-treatments. A permanent value of 5 tons/in.^{2} can be obtained after suitable heat-treatments with addition of 5 per cent. of cadmium. Cadmium has a very marked refining effect on the grain-size of tin. After a reduction of 80 per cent. 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 per cent. of cadmium is present. Further additions have little effect. After annealing for 1 day at 160° C., tin containing 5 per cent. of cadmium has a grain-size of 48,000 grains/cm.^{2}.

INTRODUCTION.

THE research described in this paper is a further contribution to the study of the effects of added elements on tin, and has been undertaken with the aid of a grant from the International Tin Research and Development Council, to whom the authors are indebted for permission to publish the results. They are particularly grateful to Mr. D. J. Macnaughtan, Director of Research to the International Tin Research and Development Council, for assistance in various ways and for his keen interest in the work.

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

PREVIOUS WORK.

A considerable number of workers have investigated the constitution of tin–cadmium alloys but, while there is fair agreement in regard to the freezing range, there has been much dispute as to the conditions of equilibrium in the solid state.

The general form of the freezing range has been determined by Kapp[1] and checked by Stoffel,[2] Lorenz and Plumbridge,[3] and Schleicher.[4] There is general agreement that the liquidus consists of two branches intersecting at the eutectic point at 177° C., but the composition of the eutectic is given at figures varying from 28 per cent. to 33 per cent. of cadmium.

Solid solubilities have been investigated in connection with a transition which occurs at 125° C. The transition was first observed by Stoffel,[2] who reported a maximum thermal effect at 20 atomic per cent. of cadmium, and put forward the hypothesis that the transition was caused by a compound $CdSn_4$, formed during cooling, at 125° C., in all alloys containing 5–95 per cent. of cadmium. This hypothesis was supported by Le Blanc, Naumarin, and Tochaino,[5] who, by thermal, electrical, and microscopic methods, gave the temperature of formation of the compound as 130° C., and the solubility of cadmium in tin as 2·5 per cent. at 130° C., increasing to 7·5 per cent. at 175° C.

The second hypothesis is that the transition is a eutectoid transition due to an allotropic change in tin at 127° C., accompanied by a change of solubility for cadmium. This view was first advanced by Schleicher,[4] thus: γ tin $\xrightarrow{127^\circ \text{C.}}$ β tin. Schleicher reported that γ-tin dissolved 10 per cent., but the β form retained only traces of cadmium in solution.

Guertler[6] obtained microstructures resembling the troostite constituent of quenched steels, and attributed them to a lack of completion of the $\gamma \longrightarrow \beta$ transformation.

Mazzatto[7] observed a maximum thermal effect at 5·5 per cent. of cadmium, 128° C., and gave the solubility change as from 10 per cent. of cadmium in γ-tin to 1 per cent. in β-tin. Bucher[8] observed a discontinuity in electrical conductivity at 130° C., which did not occur in either of the pure metals or in alloys with less than 3 per cent. of cadmium. He recorded a mutual solubility of 3 per cent. at either end of the system, and, by photomicrographs, showed a decreasing solubility of tin in cadmium.

Fedorov[9] reported a solubility of 10 per cent. of cadmium in tin, but stated that tin is insoluble in cadmium.

The most recent work on the tin-rich tin–cadmium alloys was carried out by Matuyama,[10] whilst investigating the supposed allotropic change in tin at 127° C. Cooling curves, electrical conductivity measurements, and X-ray investigations failed to reveal any evidence of such a transformation, and the tin-rich end of the equilibrium diagram was revised as shown in Fig. 1.

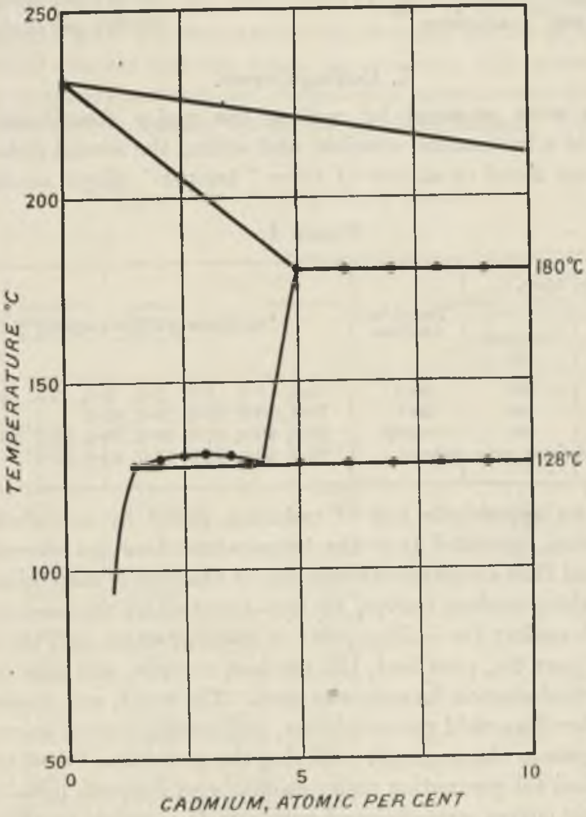

Fig. 1.—Tin-Rich End of System. (By Matuyama.)

Very little work has been done on the mechanical properties of these alloys, but di Capua [11] reported a hardness maximum at 6 per cent. of cadmium in cast alloys. After annealing for 330 hrs. at 150° C., he found the maximum hardness at 8 per cent. of cadmium, and suggested this figure as the limit of solid solubility of cadmium in tin, and 3 per cent. as the solubility of tin in cadmium.

Part I.—CONSTITUTION OF CADMIUM–TIN ALLOYS.

Experimental Work.

The materials used for this research were the purest obtainable :

"Chempur" tin	99·997 per cent. pure.
"Tadanac" cadmium	99·957 per cent. pure.

1. *Cooling Curves.*

Alloys were prepared by melting the major constituent under charcoal in a Salamander crucible, and adding the second metal either as the pure metal or as one of three "temper" alloys, as shown in Table I.

Table I.

Temper Alloy.		Tin, % by Analysis.	Cadmium in Alloys Prepared, %.
Tin, %.	Cadmium, %.		
90	10	90·3	0·5, 1·0, 1·5, 2·0, 3·0, 3·5, 4·0, 5·0
50	50	50·1	15·0, 20·0, 25·0, 70·0, 80·0
10	90	9·97	95·0, 96·0, 97·0, 98·0, 99·0, 99·5, 99·8
Prepared from pure metals.			25·0, 30·0, 33·0, 35·0, 40·0, 60·0

There is no appreciable loss of cadmium either by oxidation or by volatilization, provided that the temperature does not exceed about 400° C. and that a continuous covering of charcoal is maintained.

For taking cooling curves, an iron–Constantan thermocouple was calibrated against the boiling point of distilled water and the melting points of pure tin, pure lead, the tin–lead eutectic, and pure zinc. A small vertical electric furnace was used. The e.m.f. was measured on a Carpenter–Stansfield potentiometer, and cooling curves were plotted on a Rosenhain chronograph. Stirring the metal was found to be the best method for preventing under-cooling, and for each metal at least two cooling curves were obtained with arrests agreeing to within 1° C. The most suitable rate of cooling was found to be 1° C. per minute.

Alloys containing 30–35 per cent. of cadmium gave liquidus and eutectic arrests so close together that a slower rate of cooling was necessary in order that the readings might be taken at 0·2° C. intervals.

It was found impracticable to take a cooling curve on any alloy from the liquid state to room temperature, since a very slow rate of cooling developed below about 150° C.; hence the first series of curves was taken from about 50° C. above the liquidus arrest of each alloy to about 150° C. When satisfactory curves had been obtained on an alloy, it was re-melted and cast into a ½-in.-diameter cylindrical chill mould.

For cooling curves over the temperature range 150°–50° C., a length of 1·25 in. was cut from each of the chill-cast ingots, and drilled to take the bare junction of the thermocouple, thus avoiding the slight temperature lag caused by the silica sheath. The specimen was packed with asbestos wool in a Salamander crucible and heated to 165° C. in the vertical electric furnace, when the crucible with specimen and couple was quickly removed and packed with asbestos wool in a similar but smaller electric furnace which had not been heated. The cooling

TABLE II.—*Cooling Curve Results.*

Cadmium, %.	Liquidus Temperature, °C.	Eutectic Temperature, °C.	Arrests in Solid Alloys—Temperatures ° C.				
			Unannealed.		Annealed 7 days at 160° C.		
			1.	2.	1.	2.	
						Cooling.	Heating.
0	231·9	...	...	...	...	...	...
1	229·0	...	...	127·5	...	...	...
1·5	...	...	...	...	...	126·25	...
2	226·25	173·5	...	130·5	...	128·0*	...
3	224·5	174·5	...	130·5	...	128·5†	...
3·5	...	...	...	...	...	128·5*	...
4	223·0	174·75	...	130·5	...	127·0	...
5	219·25	175·25	...	128·0		127·0	135·5
10	209·5	176·25	...	127·5	...	...	135·0
15	200·0	176·0	170 ?	127·5	...	...	135·0
20	192·0	176·0	170 ?	127·8	...	127·0	135·5
25	185·5	176·0	170 ?	126·8	...	...	135·0
30	179·8	175·9	170 ?	125·9	...	...	135·2
33	...	175·25	170 ?	125·8	...	...	135·2
35	177·9	175·6	170 ?	124·7	...	...	135·5
40	189·1	176·25	170·0	124·5	...	127·0	135·0
50	204·4	175·5	169·5	123·7	...	...	135·2
60	222·7	176·1	170·0	123·1	...	124·0	136·5
70	238·1	176·25	169·5	123·5	...	...	135·2
80	259·1	176·1	170·0	121·9	...	122·5	139·0
90	283·5	175·5	171·0	120·3	...	...	140·7
95	299·5	175·57	171·0	118·0	172·0	114·5	140·5
96	304·5	172·0	171·0	115·5	171·5		...
97	307·75	172·5	170·5	115·5	171·0	...	...
98	312·5	...	170·5	113·5	169·0	...	...
99	317·75	...	168·0	113·5	167·0	...	...
99·5	...	...	165·0	110·6	164·0	...	...
99·8	...	...	...	...	...		...
100	321·25	...	...	...	...	...	...

* A change of gradient occurred at 130° C.

† A slight arrest occurred at 131° C.

curve was taken immediately. This method provided efficient protection from draughts, and gave a very satisfactory rate of cooling. Duplicate curves were obtained as before. Finally, heating and cooling curves over the same temperature range were taken on the specimen, annealed for 7 days at 160° C. in an electric furnace controlled by a Haughton-Hanson thermostat.

Collected results are shown in Table **II**.

2. *Investigation of Microstructures.*

The remaining portions of the chill-cast ingots obtained from the cooling curve alloys were cut up into specimens for microscopic examination.

Difficulties were encountered in the preparation of specimens owing to the tendency of the structures to be distorted by even a slight cold-working, the ease with which the surface was scratched by particles of grit, and the tendency for the surface to become coated with a layer of grease and dirt. Each specimen, therefore, was cut from the ingot with a very gentle sawing motion, using a sharp hacksaw well lubricated with paraffin, after which the surface was ground very lightly on an emery wheel to remove the saw-marks, then on a No. 1 emery cloth, and afterwards on a No. 00 emery paper, in a paraffin bath. This treatment was followed by light polishing with alumina, and later with magnesia, on a revolving cloth pad, much water being used as a lubricant. The final polish was obtained by gentle rubbing on Selvyt cloth dressed with a mixture of " Sylvo " metal polish and a dilute solution of caustic soda. The alkali removes grit from the surface and prevents the formation of a layer of grease. When scratch marks had been removed so far as possible, the specimen was etched in a dilute solution of potassium dichromate in nitric acid, until the grain structure appeared, indicating that the flowed surface layer had been removed. It was necessary to re-polish and etch again several times before satisfactory results were obtained. Structures were then photographed at suitable magnifications.

When structures resulting from heat-treatments were to be examined, the specimen was prepared previously so that it could be photographed, if necessary, almost immediately after the heat-treatment.

Alloys were examined in the following conditions :

A. As chill-cast.

B. Annealed for 3 days at 160° C. and quenched.

C. Annealed for 3 days at 160° C., slowly cooled through the temperature of the transition, and annealed at 120° C.

In addition to these, the 3 per cent. cadmium alloy was examined after quenching from 130° C.

Alloys containing 95–100 per cent. of cadmium were also examined in the following conditions:

A. Annealed for 3 days at 173° C. and quenched.

B. Annealed for 3 days at 173° C., quenched, and annealed for 1 hr. at 100° C.

Discussion of Results

The liquidus, plotted from cooling curve results (Table II and Fig. 2), agrees closely with that determined by Kapp,[1] but has been fixed more accurately at either end and in the region of the eutectic, which occurs at 176° C. and 33 per cent. of cadmium: this composition has been checked by analysis. The eutectic arrest was observed in alloys containing 2–97 per cent. of cadmium, but no indications of the positions of the sloping solidus at either end of the system were obtained.

The microstructures of chill-cast alloys show tin-rich primary plus eutectic in compositions from 5 to 30 per cent. of cadmium (Fig. 3, Plate I); the 33 per cent. alloy (Fig. 4) is completely eutectic, whilst alloys containing 35–95 per cent. of cadmium show primary cadmium plus eutectic (Figs. 5 and 6).

It is probable that the limits of solid solubility at the ends of the system extend further than is indicated by the limits of the eutectic arrest, since it is unlikely that complete equilibrium was attained during cooling over the freezing range. This is confirmed by microstructures of alloys annealed for 1 week at 160° C. and quenched in cold water. Only one phase is indicated in alloys of 1–5 per cent. of cadmium, although the structure is not a simple solid solution, but has peculiar markings within the grains (Fig. 7, Plate II) similar to the martensitic structure of quenched steels, suggesting that the transition occurring at 127° C. (to be discussed later) has not been entirely suppressed by quenching; an even more drastic quench, from 170° C. into a freezing mixture of ice and ammonium nitrate at —5° C., produced the same featureless structures. Alloys with 6–30 per cent. of cadmium show increasing amounts of eutectic (in which the cadmium has become spherodized) plus the tin-rich phase continuous with the primary constituent (Figs. 8 and 9, Plate II). Alloys of 40–90 per cent. of cadmium show increasing proportions of primary cadmium plus eutectic (Fig. 10). With more than 90 per cent. of cadmium, the cadmium rich constituent of the eutectic joins the primary constituent, but the tin-rich phase is present at 99·8 per cent. of cadmium (Figs. 11 and 12, Plate II).

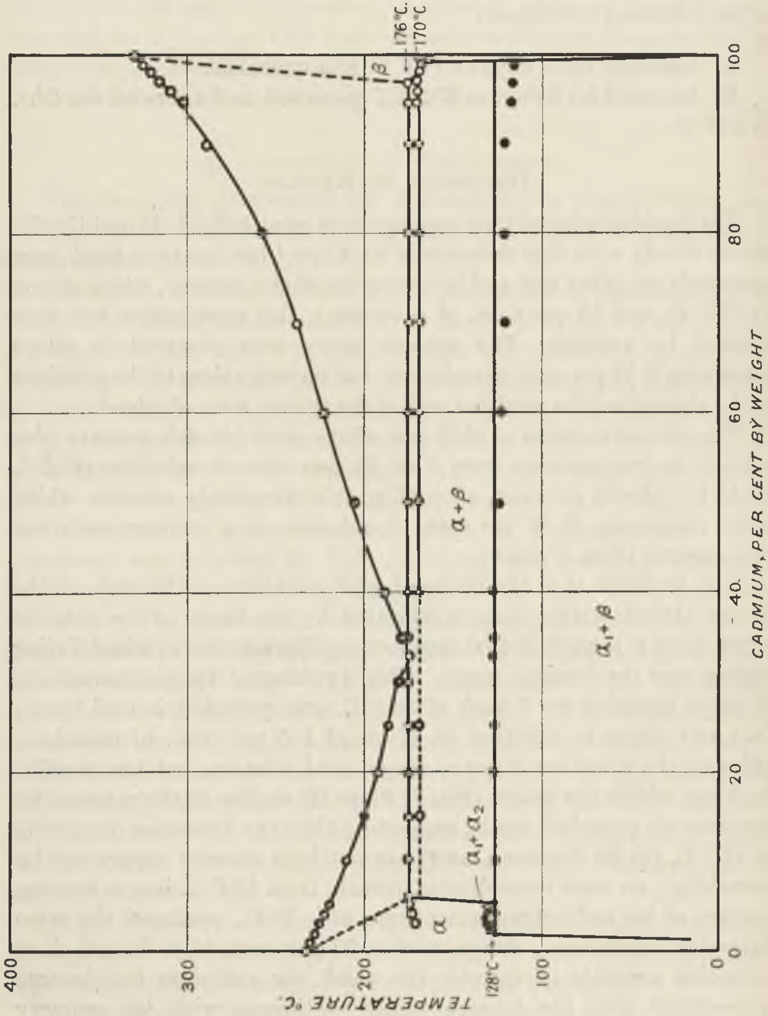

Fig. 2.—Cadmium-Tin Equilibrium Diagram. By Authors.

PLATE I.

CHILL-CAST. ETCHED IN DILUTE POTASSIUM DICHROMATE.

FIG. 3.—30% Cadmium. α + Eutectic.
× 500.

FIG. 4.—33% Cadmium. Eutectic only.
× 800.

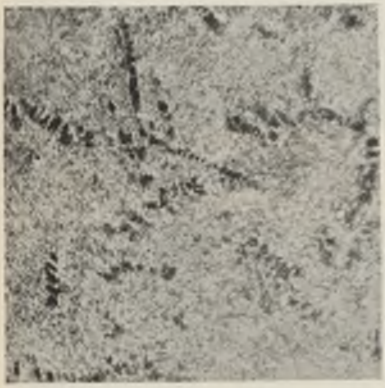

FIG. 5.—40% Cadmium. β + Eutectic.
× 500.

FIG 6.—70% Cadmium. β + Eutectic.
× 500.

ANNEALED AT 160° C. AND QUENCHED. ETCHED IN 2% NITRIC ACID IN ALCOHOL.

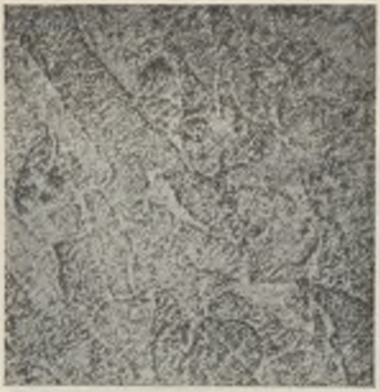

FIG. 7.—5% Cadmium. α only. Annealed 3 Days. × 500.

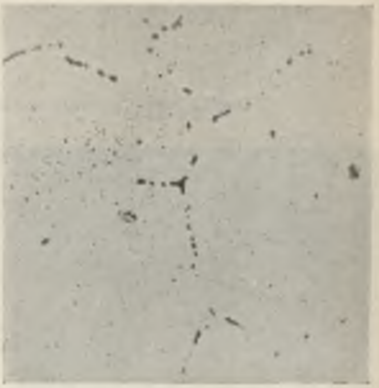

FIG. 8.—6% Cadmium. α + Eutectic. Annealed 3 Days. × 200.

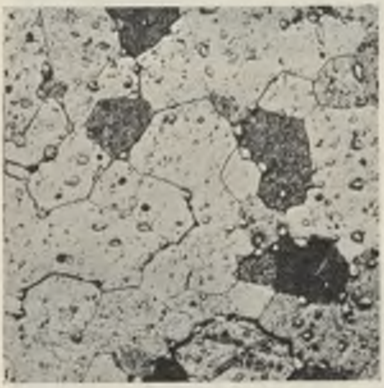

FIG. 9.—20% Cadmium. α + Spherodized Eutectic. Annealed 3 Days. × 200.

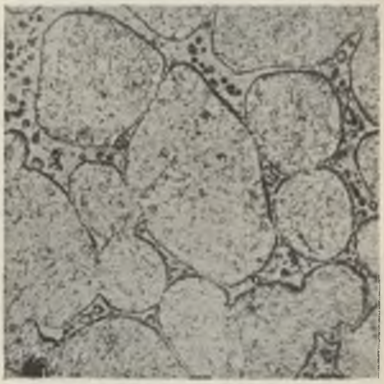

FIG. 10.—80% Cadmium. β + Spherodized Eutectic. Annealed 3 Days. × 250.

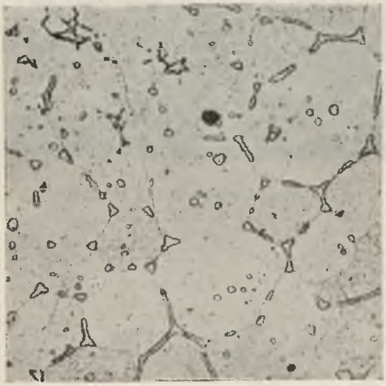

FIG. 11.—95% Cadmium. β + α. Annealed 7 Days. × 200.

FIG. 12.—99·5% Cadmium. β + α. Annealed 7 Days. × 500.

PLATE III.

ANNEALED AT 160° C., SLOWLY COOLED AND ANNEALED AT 120° C. ETCHED IN DILUTE ACIDIFIED POTASSIUM DICHROMATE.

FIG. 13.—5% Cadmium. Eutectoid of White α_1 and Dark β. × 500.

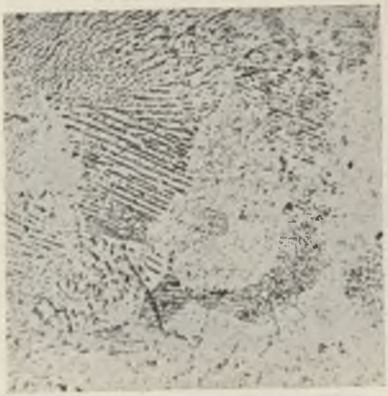

FIG. 14.—2% Cadmium. α_1 + Eutectoid. × 500.

FIG. 15.—1% Cadmium. α_1 only. × 500.

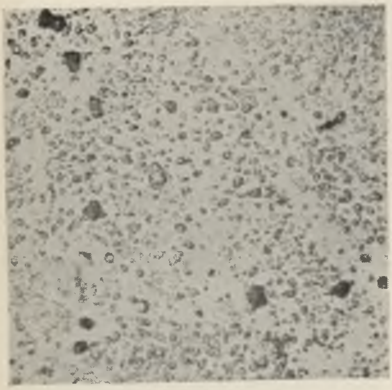

FIG. 16.—6% Cadmium. Eutectic + Eutectoid. Both Spherodized. × 500.

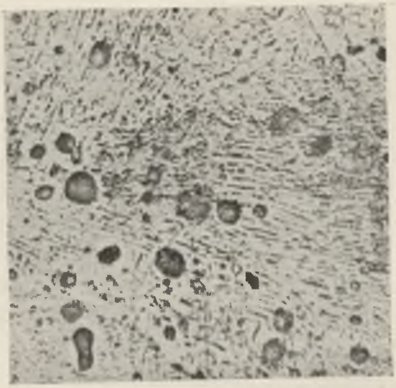

FIG. 17.—10% Cadmium. Spherodized Eutectic + Lamellar Eutectoid. × 500.

ETCHED IN 2% NITRIC ACID IN ALCOHOL.

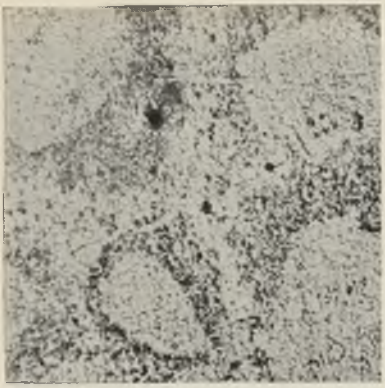

FIG. 19.—3% Cadmium. Quenched from 130° C., showing α_1 + Decomposing α_2. × 500.

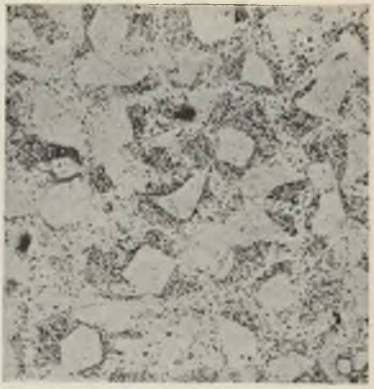

FIG. 20.—Specimen as Fig. 19. 2 Weeks after Quenching. α_1 + Decomposed α_2. × 500.

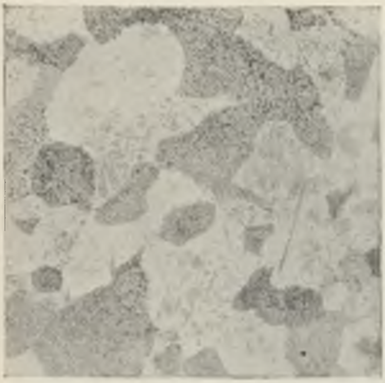

FIG. 21.—3% Cadmium. Annealed and Etched (in Potassium Dichromate) at 130° C., and Quenched. Probably $\alpha_1 + \alpha_2$. × 250.

FIG. 22.—95% Cadmium. Quenched from 173° C. Dark β + Light α. × 200.

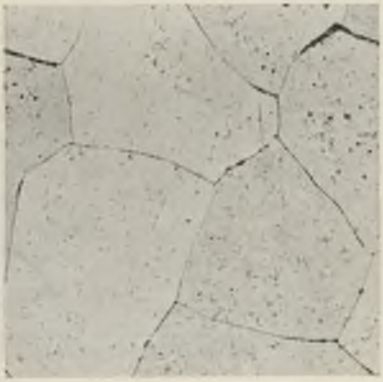

FIG. 23.—99·8% Cadmium. Quenched from 173° C. β only. × 200.

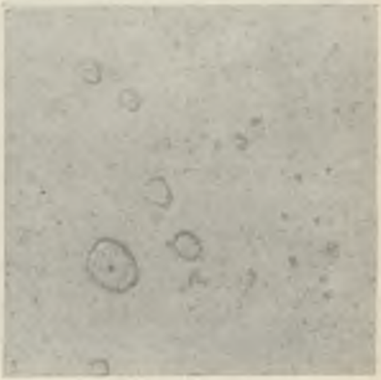

FIG. 24.—As Fig. 22. Re-Annealed at 100°C. One Large Grain of β with Precipitated α.

In agreement with the findings of Murphy[12] and of Jenkins,[13] no evidence was discovered of the allotropy of tin or cadmium at elevated temperatures.

Cooling curves on the solid alloys not previously annealed show arrests corresponding with the transformation in the solid state previously reported at 120°–130° C. between the compositions 1 and 99·5 per cent. of cadmium. Curves taken on alloys annealed for 7 days at 160° C. and slowly cooled, show arrests only between 1·5 and 95 per cent. of cadmium (Table II, columns 4 and 6). The maximum thermal effect is between 4 and 5 per cent. of cadmium; the temperature of the arrests is constant at 127° C. for compositions 1·5–40 per cent. of cadmium, but with alloys of higher cadmium content, this temperature is lowered to 115° C. at 95 per cent. of cadmium. This apparent decrease in temperature is accompanied by a decrease in intensity of the thermal effect, and is probably due to under-cooling, since heating curves show a corresponding increase of temperature of the arrest with increasing cadmium content. There seems little doubt, therefore, that these arrests indicate, for equilibrium conditions, a transition occurring at constant temperature over the range of compositions 1·5–99·5 per cent. of cadmium (Fig. 2).

The cooling curves of the 3 per cent. cadmium alloy show a slight arrest at 131·5° C., in addition to the prolonged arrest at 128·5° C. Similarly, curves of alloys containing 2, 3, and 3·5 per cent. of cadmium show an additional change of gradient a few degrees above the prolonged arrest at 128° C., but no definite additional arrest. The tin-rich end of the diagram plotted from these results (Fig. 18) resembles that obtained by Matuyama by electrical conductivity measurements (Fig. 1) and suggests a region of two conjugate solid solutions.

Since cooling curves on alloys annealed at 160° C. gave different results from those on unannealed alloys, specimens were annealed at 160° C. for 1 week, slowly cooled to 120° C., and annealed at 120° C. for 1 week, in order to investigate the structures produced on cooling through the transition.

The 5 per cent. cadmium alloy shows a eutectoid structure entirely similar to the pearlite of slowly-cooled steels (Fig. 13, Plate III). This composition agrees closely with that of the maximum thermal effect observed on cooling curves, and the etching properties indicate that the constituents are very similar to those of the eutectic. Alloys of 4, 3, and 2 per cent. of cadmium (Fig. 14) have a eutectoid structure plus an increasing excess of the white constituent, that is, the tin-rich phase, and the 1·5 per cent. alloy has only a small amount of eutectoid at the grain boundaries, whilst the alloy of 1 per cent. of cadmium shows no eutectoid whatever (Fig. 15). The 6 per cent. alloy (Fig. 16) consists of eutectoid plus a slight excess of the dark (cadmium-rich) constituent in the form of large globules along the grain boundaries, that is, as the cadmium-rich constituent of the eutectic. With increasing cadmium content, alloys of 10–30 per cent. show increasing proportions of eutectic, of which the tin-rich constituent has joined the primary tin-rich phase, and decomposed to give the eutectoid (Fig. 17). The alloys with more than 33 per cent. of cadmium contain primary cadmium, and the tin-rich phase is present only in the eutectic; no additional evidence is obtained as to the nature of the transition, but again there are no indications of a chemical compound at any composition.

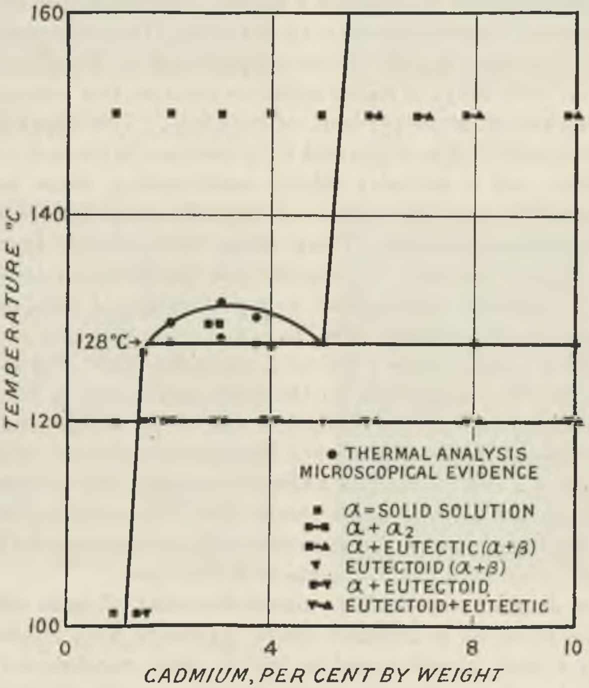

Fig. 18.—Tin-Rich End of Cadmium–Tin System. (By Authors.)

To investigate the nature of the small phase field contained between compositions 1·5–5 per cent. of cadmium, and temperatures 127°–131° C., as indicated by the slight additional disturbance observed on the cooling curves of these alloys, the 3 per cent. cadmium alloy was cooled very slowly from 170° to 130° C., held at 130° C. for 3 hrs., and quenched in a freezing mixture. The structure produced was photographed 10 minutes after quenching, and shows (Fig. 19, Plate IV) pools of a light constituent surrounded by areas which contain a small amount of the dark constituent, dispersed in such a manner as to suggest that it had been precipitated from solid solution. The same specimen was examined again a fortnight later (Fig. 20) and shows the pools of the light constituent more clearly defined and surrounded by a structure very similar to the eutectoid of slowly-cooled alloys. This indicates that during annealing at 130° C. the solid solution formed on solidification separated into two conjugate solid solutions, which have not been retained entirely as such on quenching, the one having precipitated the dark cadmium-rich constituent. The same specimen was again slowly cooled from 170° to 130° C., held at 130° C. for 3 hrs., and etched while still in the furnace by projecting a small amount of acidified potassium dichromate solution on to it. The specimen was then quenched and photographed immediately. The structure shows two phases which are probably conjugate solid solutions (Fig. 21).

Thus the microstructures confirm the cooling curve results, and the transition at 127° C. is shown to be in the nature of a eutectoid decomposition, but is not associated with an allotropic change in tin or with the formation of a chemical compound, as previous theories have indicated, but is due to the separation of the tin-rich α solid solution into two conjugate solutions, α_1 and α_2 (Fig. 18), which at 127° C. have the compositions 1·25 and 5 per cent. of cadmium, respectively. At 127° C. α_2 decomposes into a eutectoid consisting of α_1 plus the cadmium-rich phase, whilst α_1 cools unchanged. Thus, in effect, the transition is a sudden change of solubility of cadmium in tin from 5 to 1·5 per cent. at 127° C., and will therefore occur on cooling in all alloys which contain the α solid solution with more than 1·25 per cent. of cadmium.

Cooling curves on cadmium-rich alloys show a slight arrest at 170° C. corresponding with a transition which has not been previously reported. Alloys of 40–95 per cent. of cadmium show the arrest at 170° C. Curves of alloys with less than 40 per cent. of cadmium show, occasionally, slight disturbances at this temperature, but over this range of compositions no definite results were obtained. Alloys of 95–99·5 per cent. of cadmium show the arrest at temperatures falling to 164° C. at 99·5 per cent. of cadmium. The arrest does not occur in pure cadmium. The transition indicated is probably connected with a sudden change of solubility of cadmium for tin, and since the maximum thermal effect (which occurs in the 95 per cent. cadmium alloy) is relatively small, the effect in alloys with only small amounts of cadmium present would be very slight indeed. It is interesting to note that the transition as plotted from these results (Fig. 2) is similar to that which occurs in lead–tin alloys.

The microstructures of alloys with 95–99·5 per cent. of cadmium annealed at 160° C. (Figs. 11 and 12, Plate II) show, in addition to this second phase at the grain boundaries, a smaller amount of the same phase distributed as globules throughout the grains. This suggests that there has been a fine precipitate which has coalesced during the annealing. The same alloys quenched from 173° C. have the second phase at the grain boundaries, but only a trace of a very fine precipitate within the grains (Fig. 22, Plate IV), whilst the 99·8 per cent. alloy is entirely a solid solution (Fig. 23). After a further annealing for 1 hr. at 100° C., all compositions examined (95, 97, 98, 99·5, 99·8 per cent. cadmium) have a fine precipitate throughout the grains (Fig. 24). Thus the transition observed at 170° C. is due to a change of solubility of tin in cadmium.

The constitutional diagram, as far as it is determined from these results, is shown in Figs. 2 and 18.

PART II.—MECHANICAL PROPERTIES OF CADMIUM–TIN ALLOYS.

EXPERIMENTAL WORK.

1. *Preparation of Material for Tests.*

Alloys of compositions 0–10 per cent. of cadmium were prepared as previously described and chill-cast in ingots 10 in. × 2 in. × $\frac{1}{2}$ in. No mould dressing was used, but, in order to obtain a good surface, it was essential to have the mould quite dry and thoroughly warmed.

2. *Hardness Tests.*

The Vickers hardness testing machine was used with a 5-kg. load and a 2-mm. ball. (For alloys of large grain-size, the ball gives more consistent results than the diamond.)

For every test on each alloy, ten impressions were made, and two readings at right angles were taken for each impression. The median value of the ocular readings for each test was obtained, and the Brinell hardness number calculated. The mean deviation of the ocular readings from the median value was also calculated, and the figures obtained showed that the degree of accuracy of the results varied from 1 to 2 per cent.

3. *Tensile Tests.*

For tensile test-pieces, the rolled strip was sawn by hand to specimens 8 in. × 1 in., which were finished by milling to the following dimensions: gauge-length, 2 in.; cross-section, 0·5 in. × 0·1 in. Since the tensile strength of soft metals varies with the rate of loading this factor was kept constant for all tests, which were carried out at the maximum rate of loading possible—1·16 in. per minute on a 5-ton vertical testing machine.

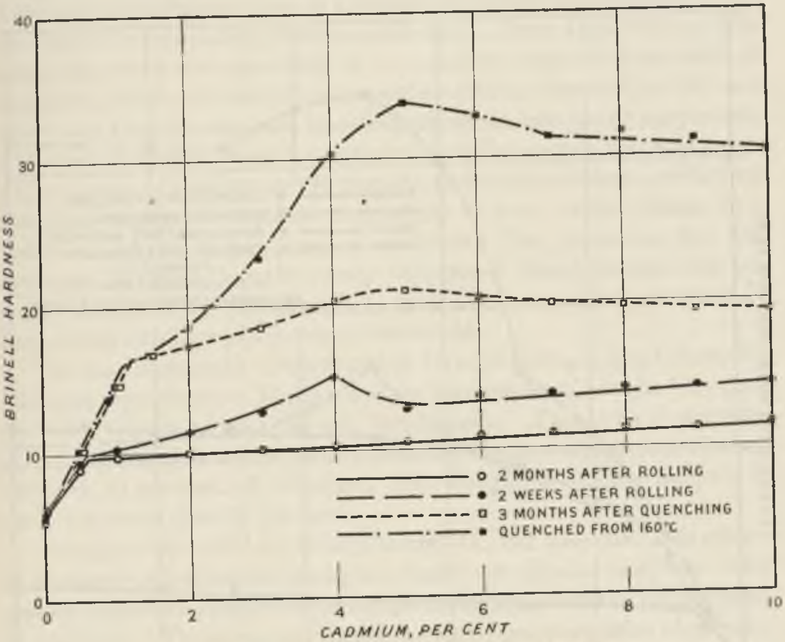

Fig. 25.—Hardness of Cadmium–Tin Alloys.

The following tensile and hardness tests were carried out on alloys containing 1 to 10 per cent. of cadmium:

1. Hardness tests 2 weeks after rolling.
2. Hardness and tensile tests 2 months after rolling.
3. Hardness and tensile tests on alloys annealed for 3 days at 160° C., slowly cooled to 120° C., annealed at that temperature for 1 day, and slowly cooled. This treatment should produce a fine eutectoid structure, and alloys should be stable at room temperatures.
4. Hardness and tensile tests on alloys quenched from 160° C. into cold water.
5. Hardness and tensile tests on alloys quenched from 170° C. into a freezing mixture of ice and ammonium nitrate.

6. Hardness tests carried out periodically on quenched alloys (4 and 5) to determine what changes (if any) take place at room temperatures.
7. Tensile tests on alloys quenched from 160° C., and annealed at room temperature for 3 months.

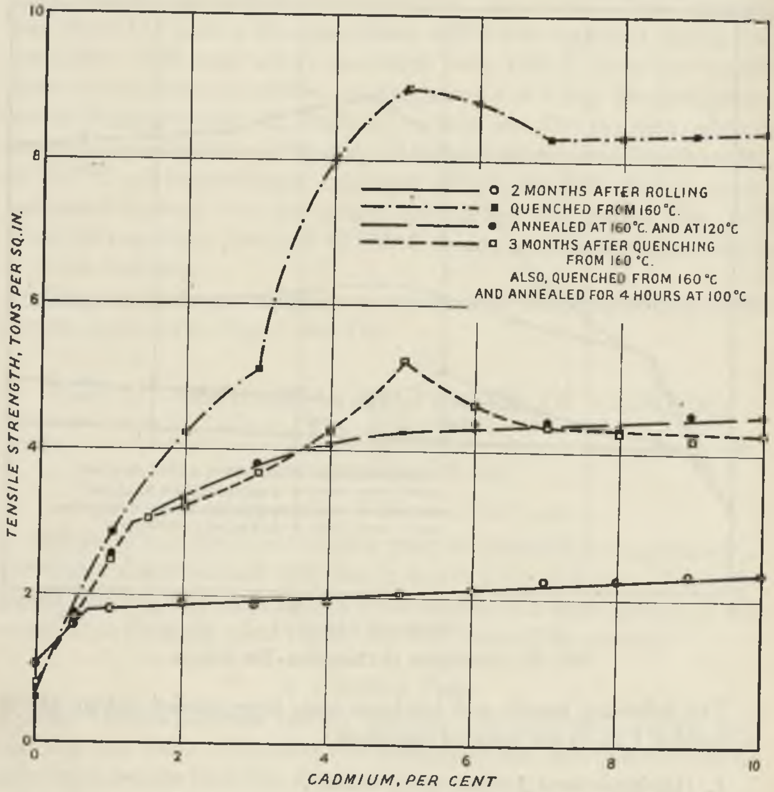

Fig. 26.—Tensile Strength of Cadmium–Tin Alloys.

8. After the results of the previous tests had been obtained, a series of hardness tests was carried out to determine a treatment which would produce optimum stable properties.
9. Hardness and tensile tests on alloys annealed for 2 hrs. at 170° C., quenched and subsequently annealed at 100° C. for 4 hrs. This is the stabilizing treatment determined from (8).

Results of hardness tests are shown graphically in Fig. 25, and of tensile tests in Fig. 26.

DISCUSSION OF RESULTS.

The hardness curve for alloys tested 2 weeks after rolling shows a rapid increase in Brinell hardness from the value of 6·8 for pure tin to 9·5 with 0·5 per cent. of cadmium. Between the compositions 0·5 and 1 per cent. of cadmium, there is a change in gradient corresponding with the limit of solid solution in alloys chill-cast. From 1 per cent. of cadmium the curve rises gradually to a maximum value at 4 per cent. of cadmium, which indicates the composition of the eutectoid in chill-cast alloys, and that the eutectoid transformation has been partly suppressed. The same specimens tested 2 months after rolling gave a hardness curve with a change of gradient at 0·75 per cent. cadmium as before, but beyond this composition the increase in hardness is very gradual, rising to a value of 11·5 at 10 per cent. of cadmium. The maximum has disappeared, showing that the partly suppressed transformation has become completed by self-annealing, with a corresponding decrease of hardness in all alloys which contain eutectoid.

The tensile strength of alloys tested 2 months after rolling follows the hardness very closely. There is a sharp increase from 1 ton/in.^{2} for pure tin to 1·8 tons/in.^{2} with 1 per cent. of cadmium. From 1 to 10 per cent. of cadmium there is a slow linear increase of tensile strength to 2·35 tons/in.^{2} with 10 per cent. of cadmium. The elongation of these alloys is in each case more than 70 per cent.

For alloys annealed for 3 days at 160° C., and quenched, the curves of hardness and of tensile strength are also very similar, and both show greatly improved properties for compositions of more than 0·5 per cent. of cadmium. The hardness, tensile strength, and elongation of pure tin are less than the values obtained before annealing, probably due to the very coarse grain-size produced by annealing, as shown by the appearance of the fractured specimen. The alloy containing 0·5 per cent. of cadmium shows slightly improved properties, and the 1 per cent. alloy is considerably stronger, due to the greater amount of cadmium taken into solution during annealing. Between compositions of 2 and 4 per cent. of cadmium, both curves show a slight flattening, followed by a very rapid rise to maximum values of 9 tons/in.^{2} and a Brinell number of 34, when 5 per cent. of cadmium is present. Beyond this composition the curves fall to values of 8·3 tons/in.^{2} and a Brinell number of 31 at 7 per cent. of cadmium; with more than this amount there is little change from these values.

Corresponding with the increased tensile strength, the elongation is less for quenched alloys than for alloys tested after rolling, but is generally greater than 30 per cent.

The shape of the hardness and tensile strength curves indicates that the transition has been suppressed, and that the sharp peak probably corresponds with a very rapid age-hardening which takes place during the brief interval of time between quenching and testing. The curves of hardness and tensile strength of alloys annealed at 120° C., and slowly cooled after a preliminary annealing at 160° C., show a rapid rise to values of 2·5 tons/in.^{2} and Brinell hardness of 14·5 with 1 per cent. of cadmium. Between compositions of 1 and 2 per cent. of cadmium there is a change of gradient corresponding with the true limit of solid solubility below the transition. Beyond this composition the curves rise more gradually to 4–5 tons/in.^{2} and a Brinell number of 22, with 5 and 6 per cent. of cadmium. Further additions of cadmium have no effect on the tensile strength, but the hardness decreases slightly. The elongations of these alloys are of the same order as for quenched alloys. These alloys, according to the heat-treatment, would contain eutectoid in a stable form, and since there is no marked change of properties on exceeding the eutectoid composition, further evidence is obtained that the cadmium-rich phase of the eutectoid is the same as that of the eutectic.

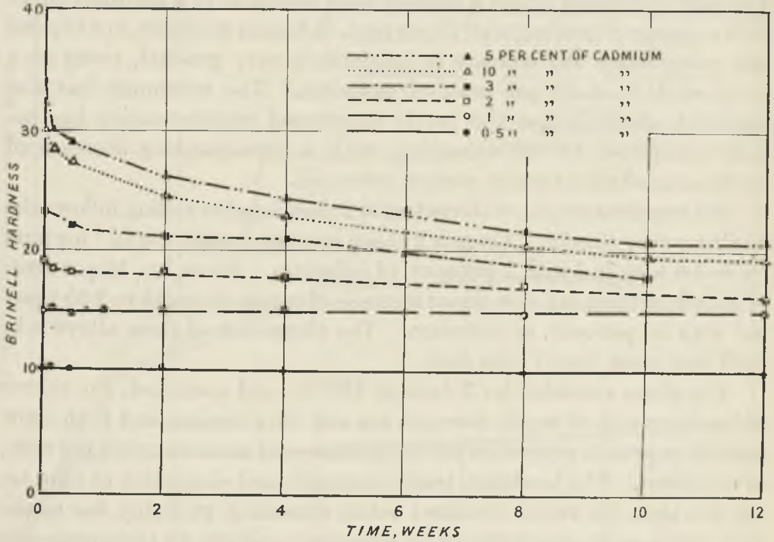

FIG. 27.—Hardness of Cadmium–Tin Alloys after Quenching.

Hardness tests carried out periodically on the quenched specimens show that the high values obtained on quenching are not permanent, but that softening takes place for about 10 weeks, when the alloys have reached a stable condition (Fig. 27).

The curves of hardness and tensile strength for alloys tested 3 months after quenching are very similar to those for alloys annealed at 120° C. after a preliminary annealing at 160° C., but the values are slightly higher and the maximum occurs at 5·3 tons/in.^{2} with 5 per cent. of cadmium. Alloys quenched from 170° C. in a freezing mixture have similar properties to those quenched from 160° C., but the curves show no marked peak at 5 per cent. of cadmium, but a sharp change of gradient. Periodical hardness tests show that these alloys self-anneal at room temperature similarly to those quenched from 160° C.

An investigation to produce optimum permanent properties was carried out by annealing the 5 per cent. alloy for successively longer periods of time, at 170° C. and measuring the hardness immediately after quenching, followed by hardness tests after similar annealings at temperatures below the transition. These tests showed that annealing for 2 hrs. at 170° C., followed by quenching in cold water, produces maximum hardness, and that permanent values are obtained by subsequently annealing for 4 hrs. at 100° C.

Tensile strength and hardness tests on alloys subjected to this stabilizing treatment give results very similar to those for tests carried out on alloys which had self-annealed for 3 months after quenching. The 5 per cent. cadmium alloy has a tensile strength of 5·3 tons/in.^{2} with 35 per cent. elongation.

GRAIN-SIZE DETERMINATIONS.

Grain-size determinations were made on alloys containing up to 6 per cent. of cadmium in various states of heat-treatment. The intercept method was used, and the grains were counted by means of a travelling microscope in the case of the coarse-grained alloys, whilst the microscope of a Vickers hardness machine was used for alloys with finer grains.

Details of the investigations carried out are shown together with the results in Table III.

In the rolled and self-annealed condition there is a marked refining of the grain-size with increasing cadmium content from 1600 grains/cm.^{2} for pure tin to 26,000 grains/cm.^{2} with 1 per cent. of cadmium. From 1 to 2 per cent. of cadmium there is a further refining effect to 28,900 grains/cm.^{2}, but with higher cadmium contents there is no further change.

Annealing at 160° C. for 24 hrs., followed by quenching, causes grain-growth in compositions up to 1 per cent. of cadmium, but with 2 per cent. of cadmium there is a further refining effect which increases slowly with increasing cadmium content to 48,000 grains/cm.^{2} with 6 per cent. of cadmium. The sudden change of grain-size from 2,000 to 10,000 grains/cm.^{2} between compositions of 1 and 1·5 per cent. of cadmium corresponds with the changes in mechanical properties observed at this composition, and indicates the limit of the eutectoid transition.

Further annealing at 100° C. causes grain-growth to a slight extent in compositions up to 1 per cent. of cadmium, but with 1·5–6 per cent. of cadmium there is little change from the grain-size of quenched alloys; thus the presence of free cadmium as eutectoid appears to prevent grain-growth on annealing.

Table III.—*Grain-Size of Cadmium–Tin Alloys.*

Cadmium, %.	Grains per cm.^{2}.		
	A.	B.	C.
0	1,600	1	1
0·5	12,100	675	650
1·0	26,000	2,500	2,000
1·5	...	10,000	12,500
2	28,900	38,000	32,400
3	28,800	36,000	40,000
4	28,900	40,000	44,000
5	28,900	53,100	48,000
6	28,560	53,400	52,000

A. Rolled and self-annealed.
B. Annealed 24 hrs. at 160° C. Quenched.
C. Quenched from 160° C., and annealed for 4 hrs. at 100° C.

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AUTHOR INDEX TO ABSTRACTS

METALLURGICAL ABSTRACTS

(GENERAL AND NON-FERROUS)

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I.—PROPERTIES OF METALS

(Continued from pp. 409–413.)

***The Latent Energy in Cold-Worked Iron and Copper as Estimated by Determination of Heats of Solution.** R. W. France (*Trans. Faraday Soc.*, 1934, **30**, 450–460).—Experiments on the heat of dissolution of soft and hard-drawn copper in bromine solution indicate that the latent energy even in specimens reduced 95% in area is not greater than 0·5 cal./grm.—A. R. P.

Longitudinal and Transverse Magnetoresistance and Magnetic Structure of Ferromagnetic Substances [Nickel]. Guilia Alocco (*Atti R. Ist. Veneto Sci., Lettere, Arti*, 1932–1933, **92**, 1353–1371; *Chem. Zentr.*, 1934, **105**, I, 3446).—The magnetoresistance of polycrystalline nickel sheets shows an analogy to that of single nickel crystals which indicates magnetic anisotropy in certain directions. Apparently the elementary moment of the nickel sheets tested had a spatial orientation.—A. R. P.

***The Electrothermal Homogeneous Effect in Liquid (and in Solid) Metal.—III.** C. Benedicks and G. Siljeholm (*Arkiv Mat. Astron. Fysik*, 1933, [A], **24**, 36 pp.; *Chem. Zentr.*, 1934, **105**, I, 3178).—Cf. *Met. Abs.*, this volume, p. 230. The efficiency of the electrothermal homogeneous effect in a metal may be very considerably improved by increasing the length of the conductor. The temperature changes required by the phoretic theory have been confirmed with long conductors of Constantan, copper, and mercury; the sign and magnitude of the effect in all cases agree closely with the theoretical. The effect is proportional to the current density, and increases rapidly with increase in temperature. In mercury the effect can be greatly increased by introducing a constriction in the conducting column.—A. R. P.

***The Malleability of Nickel and Monel Metal.** Owen W. Ellis (*J. Inst. Metals*, 1934, **54**, 145–160).—The graph showing the relation between malleability and temperature for cold-drawn nickel rods is a straight line between 20° and 500° C. and again between 840° and 1100° C., but between 500° and 840° C. it is a curve convex to the temperature axis. The curved portion corresponds with the range during which rapid softening occurs, the points of intersection with the straight lines (500° and 840° C.) corresponding with the beginning and ending of this range, respectively. No simple relation between the energy of blow and the reduction of height on forging could be established at any temperature. The malleability of cold-drawn nickel is increased rapidly by annealing at temperatures above 750° C., and reaches a well-defined maximum after annealing at 820° C., at which temperature softening is most rapid. Annealing at any temperature above 500° C. increases the malleability at all temperatures up to the annealing temperature, beyond which the relation between malleability and temperature is the same for annealed as for hard-drawn metal. The upper limit of the softening range of Monel metal (nickel 67·59, manganese 1·26, iron 1·05, silicon 0·05, copper 30·15%) is 780° C. Over the range 600°–825° C. the malleability of cold-drawn nickel is somewhat less than that of Monel metal, but is appreciably greater at high temperatures.
—A. R. P.

†On the Internal Mechanics of Metals. W. Kuntze (*Z. Metallkunde*, 1934, **26**, 106–112).—Translation and cohesion play an important part in the plastic

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* Denotes a paper describing the results of original research.

† Denotes a first-class critical review.

deformation of metals; the visible slip-lines are really the ends of slip planes which appear one after the other from one side of a tensile test-piece to the other, and then run across the lines first formed. The intensity of the lines bears a close relation to the internal cohesion fracture, which corresponds to stress variations. If the latter are small and frequent, the stress–elongation curve is continuous. The structure of slip planes can readily be seen by examination of pressed wooden cubes, which show the transition from elastic to plastic deformation, the development of hollow spaces inside the slip planes, at the intersection of two slip planes and at the boundaries of two lamellæ. A slip plane cannot terminate in the middle of a specimen without the development of a crack, and it has always the tendency to spread as widely as possible through a specimen. Slip fracture, even in pure shear, is a cohesion fracture, the surface of fracture always being in the direction of maximum shear stress. The course of the deformation in slip planes and cohesion fractures reduces the stress level from the theoretical deduced from the lattice distortion to a value corresponding with the actual tensile strength. The strengthening of a metal by deformation is attributed to the action of boundary surfaces; the increase in resistance to slip by these surfaces opposes the reduction in strength caused by hollow spaces. Elongation and cohesion are of equal technical significance. In opposition to the accepted view that the yield-point is exceeded at places of maximum stress, it is pointed out that the flow of a material under anisotropic stress distribution in the cross-section occurs only when the mean stress measured over the whole cross-section exceeds the yield-point, hence the peak stress should considerably exceed the yield-point, but it should never exceed the cohesion. The relation between cohesion resistance and slip resistance determines the plastic behaviour of a metal. The effect of high temperature is as follows: whilst slip produces a strengthening of the material which is opposed by the effect of heat, exceeding the cohesion produces a softening which also is opposed by heating.—B. Bl.

†**Gases and Metal Surfaces.** E. K. Rideal (*J. Inst. Metals*, 1934, **54**, 287–312).—1934 May Lecture. Recent work, in all its aspects, is summarized, reviewed, and critically discussed. The complex nature of the surface structure of a metal has a profound effect on the equilibria between the metal and a gas and on the rate of attainment of equilibrium. A distinction is drawn between van der Waals' adsorption and chemi-adsorption involving an electron switch in which the existence of an energy of activation may produce a slow process of activated adsorption of gas. Bimolecular layer formation frequently occurs, and a high surface mobility in the second adsorbed layer determines to a great extent the dynamics of formation of the surface phase. Evidence for assuming the existence of an internal surface between the individual crystallites of the metal is put forward, and it is shown that such surfaces play an important part in adsorption processes. The heats of adsorption and energies of activated migration on this internal surface are quite distinct from the heats of formation of compounds and the energies of activated solution in the lattice. The properties of surface compounds between gas and metal and the effects of metallic dispersion and lattice spacing are discussed.—A. R. P.

II.—PROPERTIES OF ALLOYS

(Continued from pp. 414–419.)

***On the Relation Between the Diffusion Coefficients and Concentrations of Solid Metals (The Nickel–Copper System).** Chujiro Matano (*Jap. J. Physics*, 1933, **8**, 109–113).—[In English.] The coeff. of diffusion *D* being considered as a function of the concentration *c*, Grube and Jedele's results (*Z. Elektrochem.*, 1932, **38**, 799) with regard to the nickel–copper system at 1025° C. were analyzed by Boltzmann's method. It is concluded that from the value of above 8×10^{-5} cm.^{2}/day at $c = 0\%$ of nickel, D decreases rapidly to about 1×10^{-5} cm.^{2}/day at $c = 30\%$ of nickel, and then keeps its value when c increases to 100% nickel.—S. G.

***Further X-Ray Studies in the Diffusion of the Nickel–Copper System.** Chujiro Matano (*Mem. Coll. Sci. Kyoto Imp. Univ.*, 1933, [A], **16**, 249–259).—The diffusion phenomena of the nickel–copper system were studied by the X-ray method for (*a*) a thin copper deposit on a nickel plate; (*b*) a thin nickel deposit on a copper plate; and (*c*) thin alternate layers of electrodeposited nickel and copper, the samples being heated at 500°, 650°, and 900° C. for various periods of time. It is concluded that in a wide range of concentrations the value of the coeff. of diffusion cannot be a constant but varies from 10^{-7} to 10^{-9} cm.^{2}/day or more widely at 500° C.; but if the experiments are carried out under the same conditions with regard to the state of the samples the coeff. of diffusion D can be expressed roughly by the formula $D = Ae^{\frac{-\beta}{T}}$, where T is the abs. temperature, and A and β are constants independent of T, although they depend on the concentration.—S. G.

***X-Ray Studies on the Diffusion of Metals in Copper.** Chujiro Matano (*Jap. J. Physics*, 1934, **9**, (2), 41–47).—[In English.] The coeff. of diffusion of aluminium, manganese, nickel, zinc, palladium, tin, platinum, and gold in copper were determined by the X-ray method between 400° and 950° C. While at the higher temperature the coeff. does not depend on the previous treatment of the alloys, at the lower temperature it does so very greatly.—S. G.

***Determination of Upper Critical Points in Antifriction Alloys.** F. A. Borin and A. A. Botchvar (*Zvetnye Metally* (*The Non-Ferrous Metals*), **1933**, (2/3), 101–106; *C. Abs.*, 1934, **28**, 4353).—[In Russian.] The "upper critical points" (the minimum temperatures of quenching at which no separation of hard crystals from liquid metal occurs) were determined for several Babbitt metals by microscopic examination of specimens quenched in copper moulds. In all cases the critical points were found to be higher than the values given in the literature.—S. G.

Reactions in Intermetallic Solid Systems. André Hone (*Rev. trimest. canadienne*, 1933, **19**, 396–407; *C. Abs.*, 1934, **28**, 4346).—The heat-treatment of steel and of aluminium–magnesium alloys such as Duralumin, and the application of the theories of mechanical statistics are discussed.—S. G.

***The Constitution of Copper–Iron–Silicon Alloys.** D. Hanson and E. G. West (*J. Inst. Metals*, 1934, **54**, 229–248; discussion, 248–253).—The system has been examined by thermal analysis and micrographic examination up to 8% silicon and 8% iron. Addition of silicon to copper–iron alloys reduces the solid solubility of iron, and over the greater portion of the field examined the iron exists in the alloys as pure metal (containing only small amounts of copper and silicon in solid solution), since its solid solubility decreases rapidly with decrease in temperature and is very small below 700° C. When the silicon content exceeds about 5%, addition of iron causes the formation of another constituent, probably FeSi, which forms alloy systems with the α, β, γ, δ, and ϵ phases of the copper–silicon system. Ternary diagrams showing the shape of the liquidus and solidus curves and the changes which occur during solidification are given. Copper-rich alloys in the α-range solidify by deposition of primary copper-rich solid solution and concentration of the iron and silicon in the residual liquid; on further cooling iron is precipitated from solid solution, indicating the possibility of age-hardening by heat-treatment. In alloys outside the α-field FeSi or iron forms the primary crystals, the liquid then becomes enriched in silicon and impoverished in iron, whilst the α-phase crystallizes, and finally silicon-rich phases solidify. In the discussion *J. L. Haughton* referred to the possibility of obtaining liquidus points, where normally the arrests are small, by stirring the alloys. *E. H. Bucknall* expressed surprise that the η-phase of the iron–silicon system did not appear to be isomorphous with or to form solid solutions with the γ-phase of the copper–silicon system. *A. J. Murphy* pointed out that the heat-treatment necessary to produce maximum hardening involves annealing the alloys at above the liquidus point. *Marie L. V. Gayler* mentioned that the α–γ change in iron had been omitted from the diagrams. *Cyril S. Smith* stated that there is no two-liquid field in the iron–copper system when the metals are pure, but that less than 1% of silicon in the 50 : 50 alloy causes separation into two liquids at all temperatures above the liquidus; carbon is even more effective in this respect. *E. Voce* confirmed the statement of C. S. S. that 50 : 50 copper–iron alloys do not separate into two layers on melting. In reply D. H. stated that the method of determining the liquidus by noting the temperature at which crystals float to the surface when the metal is allowed to solidify in an inert atmosphere is better than the thermal method when the arrest is small, provided that the difference in density between the crystals and liquid is large. He stated that the ternary alloys are sluggish at high temperatures and that, therefore, annealing must be prolonged to obtain equilibrium, after which diffusion is rapid.—A. R. P.

***Transformations in the Copper–Palladium Alloys.** R. Taylor (*J. Inst. Metals*, 1934, **54**, 255–272; discussion, 272–273).—The electrical resistance–temperature curves for the transformation of copper–palladium alloys with 10–30% palladium from an irregular to a regular distribution of the atoms on the points of a face-centred cubic lattice indicate that the change takes place in two stages: in the first, the highest temperature for the commencement of which is about 570° C. in the alloy with 22% palladium, distortion of the lattice producing a small increase in resistance occurs, and in the second, the highest temperature for the commencement of which is 500° C. at 15% palladium, ordering of the atoms producing a large decrease in resistance occurs. The minimum specific resistance in the ordered state is $8\cdot1 \times 10^{-6}$ ohm.-cm. at 20° C. in the 15% palladium alloy, and the increase in resistance due to transformation is greatest in the 25% palladium alloy. The transformation from a randomly-oriented face-centred cubic lattice to a regularly-oriented body-centred cubic lattice of alloys in the range 35–55% palladium is complete at 40% palladium, but only partial in alloys on either side of this composition; in alloys showing this partial change quenching from 600° C., cold-rolling and annealing at 450° C. tends to make the change more nearly complete. The change never takes place at constant temperature, but the range is smallest and the temperature highest at 40% palladium, although the minimum specific resistance in the ordered state ($3\cdot1 \times 10^{-6}$ ohm-cm. at 20° C.) occurs in the 47% palladium alloy. The specific resistance–temperature curve of the randomly oriented alloys shows two breaks at 32·5 and 42% palladium, respectively. In the discussion *J. L. Haughton* criticized the arrangements used in the determination of resistance, and in reply R. T. stated that any errors made in the determination of resistance were due to inaccuracies in the measurement of the diameter of the wires, and not to unsuitable set-up of the apparatus.—A. R. P.

***Alloys of Silver and Beryllium.** H. A. Sloman (*J. Inst. Metals*, 1934, **54**, 161–176; discussion, 176–181).—The system silver–beryllium has been examined by thermal and micrographic methods using alloys made from the purest metals melted in a beryllia crucible *in vacuo*. The eutectic point is at 881° C. with 10·49 atomic-% beryllium and the solid solubility of beryllium in silver is 3·5 atomic-% at the eutectic temperature, and decreases slightly with decrease in temperature. The equilibria at the beryllium end of the system has not been exhaustively investigated, but alloys with more than 90 atomic-% beryllium are homogeneous β solid solutions after heat-treatment at temperatures up to 900° C. followed by quenching. A thermal arrest point occurs at 750° C. in all alloys containing the β-phase, but no micrographic, X-ray, or other evidence has been found to confirm this; it is attributed to a polymorphic change in β which would indicate that beryllium itself must exist in two modifications. Addition of copper to beryllium–silver alloys causes separation into two layers, the upper rich in copper and beryllium, and the lower rich in silver and poor in beryllium; addition of 6–7% of nickel prevents this separation. Standard silver alloys in which 0·5–1% of copper is replaced by beryllium are much more resistant to sulphide tarnishing and to the action of vinegar and fruit and vegetable juices than is the ordinary copper standard silver alloy. The beryllium alloy is readily prepared by first making a beryllium–copper alloy by electrolytic deposition of beryllium into a molten copper cathode, then adding this alloy to molten silver in a graphite crucible with a protective layer of graphite over the metal. Casting and working are just as easily done as with ordinary standard silver; small age-hardening effects can be obtained by suitable heat-treatment. In the discussion *R. S. Hutton* outlined the requirements of a non-tarnishing silver demanded by the trade, and stressed the importance of ready workability, capacity for taking a high polish, and need for measuring the reflectivity over the whole spectrum range. *R. H. Atkinson* considered that the presence of a hard constituent in beryllium–copper standard silver would make it impossible to get a real "mirror" finish. *C. J. Smithells* mentioned the difficulty of obtaining perfect bright-annealing of silver–copper alloys, and inquired whether addition of beryllium improved the alloy in this respect. *W. H. J. Vernon* gave details of tests showing the importance of the nature of the polishing on the loss of reflectivity during tarnishing. *C. H. Desch* said that work on beryllium had so far produced results of little technical interest, and was now being abandoned both in Germany and in this country. *Marie L. V. Gayler* suggested that there was a certain amount of evidence from the micrographs and from the shape of the liquidus surface to indicate the existence of an intermediate phase at somewhere above 20 atomic-% beryllium. In reply H. A. S. said that further reflectivity tests were in hand, but no results were yet available. The ternary alloy does tarnish considerably on annealing in air. Since there is a gradual change in the shape of the primary crystals as the diagram is crossed, the question of the existence of an intermediate phase should be answered negatively.—A. R. P.

III.—STRUCTURE

(Metallography; Macrography; Crystal Structure.)

(Continued from pp. 420–421.)

***Fractures of Metals and Alloys. III.—Casting Conditions and Fractures.** Ichirô Iitaka (*Tetsu to Hagane* (*J. Iron. Steel Inst. Japan*), 1934, **20**, 99–106; *C. Abs.*, 1934, **28**, 4346).—[In Japanese.] Cf. *J. Inst. Metals*, 1933, **53**, 351. Cast metals and alloys show fractures of the third type, *i.e.* the fineness of fracture is equal to the fineness of dendrite and there is no relation between fineness and grain-size. The influences of casting conditions on the fineness of fracture or dendrite were studied on gun-metal, 10% tin–bronze and Constantan.—S. G.

***X-Ray Investigation of the Effect of Rate of Deformation on the Structure of a [Duralumin] Alloy Forged at High Temperatures.** E. F. Bachmetew (*Trudi Vsesoyuznogo Nautchno-Issledovatelskogo Instituta Aviatsonnykh Materialov* (*Mitt. Forschungsinst. Luftfahrtmaterialprüfung*), **1933**, (1), 5–33).—[In Russian, with German summary.] X-ray examination of the structure of cylinders of rolled Duralumin (copper 4–5, magnesium 0·5, manganese 0·5%) after compression at temperatures between 300° and 500° C. at rates of 0·6–2000 mm./second shows that whether recrystallization occurs at a given temperature or not depends on the rate of deformation. The anisotropy of alloys after deformations of 60–70% has been determined at 20°–500° C. at low speeds of deformation and at high (hammer-blow), both before and after recrystallization. After deformation at low speeds and high temperatures the X-ray pattern of the recrystallized alloy consists of a "flocculated" mass of interference points, quite distinct from the usual sharply outlined interference points shown by a recrystallized alloy.—A. R. P.

***The Examination of the Structure [of Duralumin] at High Temperatures by Means of X-Rays.** E. F. Bachmetew and S. I. Gubkin (*Trudi Vsesoyuznogo Nautchno-Issledovatelskogo Instituta Aviatsonnykh Materialov* (*Mitt. Forschungsinst. Luftfahrtmaterialprüfung*), **1933**, (1), 34–49).—[In Russian, with German summary.] Duralumin forged at 450° C. shows at that temperature an X-ray structure closely resembling that of cold-worked Duralumin.—A. R. P.

***The Structure of Hot-Forged Duralumin after Heat-Treatment.** E. F. Bachmetew and M. D. Wosdwischenski (*Trudi Vsesoyuznogo Nautchno-Issledovatelskogo Instituta Aviatsonnykh Materialov* (*Mitt. Forschungsinst. Luftfahrtmaterialprüfung*), **1933**, (1), 50–60).—[In Russian, with German summary.] Duralumin which has been forged at 450° C. only partly recrystallizes on subsequently annealing at 450° C.; complete recrystallization requires a temperature of at least 500° C. After cold-deformation the recrystallization of the same alloy commences at 350° C. and is complete at 450° C. Hot-worked Duralumin with a "flocculated" recrystallization structure retains this structure after annealing at 535° C.; the flocculated effect is attributed to the presence of groups of crystallites the individual members of which show small differences in their orientation after recrystallization. To induce secondary recrystallization of metal with this structure only a small cold-deformation (0·4%) is required prior to annealing.—A. R. P.

***Investigation of the Heat Effect in Duralumin During Deformation by Forging.** E. F. Bachmetew and B. M. Rowinski (*Trudi Vsesoyuznogo Nautchno-Issledovatelskogo Instituta Aviatsonnykh Materialov* (*Mitt. Forschungsinst. Luftfahrtmaterialprüfung*), **1933**, (1), 61–73).—[In Russian, with German summary.] On forging Duralumin at 20° C. with a deformation of 89·2% the temperature of the specimen may increase to 317° C., about 77% of the applied energy appearing as heat. With increasing deformation temperature the increase in temperature produced by the work decreases. Only 1–2% of the energy remains as internal stress in the metal. With deformations of up to 18·8% no deformation texture can be detected; only after a deformation of 32·5% can the texture axis be determined. A curve is given showing the dependence of the specific work required to produce deformation on the magnitude of the relative deformation.—A. R. P.

***X-Ray Determination of the Residual Lattice Stress in Pressed Duralumin.** E. F. Bachmetew and G. F. Kossolapow (*Trudi Vsesoyuznogo Nautchno-Issledovatelskogo Instituta Aviatsonnykh Materialov* (*Mitt. Forschungsinst. Luftfahrtmaterialprüfung*), **1933**, (1), 74–85).—[In Russian, with German summary.] The internal stresses in cold-worked Duralumin disappear in 15 minutes at 200° C. and in less than half a minute at 300° C.; at 100° C., however, even 5 hrs. is insufficient to alleviate lattice distortion completely. By cold-forging the stresses can be much reduced owing to the heat evolved by the work; thus the residual internal stress after 86% reduction in one blow is much less than that after a 56% reduction. Deformation at 0·0015 to 1·14 mm./second at 300° C. or higher produces no detectable lattice distortion.—A. R. P.

***The Recrystallization Structure of Duralumin.** E. F. Bachmetew (*Trudi Vsesoyuznogo Nautchno-Issledovatelskogo Instituta Aviatsonnykh Materialov* (*Mitt. Forschungsinst. Luftfahrtmaterialprüfung*), **1933**, (1), 86–106).—[In Russian, with German summary.] X-ray examination has demonstrated the existence of several types of recrystallization structure in Duralumin and that there is a relation between the recrystallization texture and the degree of cold-rolling to which the metal has been subjected. The decrease in tensile strength after heating at 300° C. is due, not to recrystallization phenomena, but to the combined effect of the decomposition of the solid solution and the recovery from stresses induced by cold-work. The increase in strength on quenching from 500° C. is conversely due to the retention of the copper in solid solution; at 450° C., however, an appreciable amount of copper fails to redissolve and hence the alloy is harder than that quenched from 500° C. owing to the presence of a fine dispersion of $CuAl_2$. The state of the alloy after various heat-treatments can be ascertained by the nature of the $CuAl_2$ lines in the X-ray diagram. —A. R. P.

Examples of the Structural Analysis of Aluminium Alloys by Means of X-Rays after Heat-Treatment in Technical Practice. E. F. Bachmetew and G. F. Kossolapow (*Trudi Vsesoyuznogo Nautchno-Issledovatelskogo Instituta Aviatsonnykh Materialov* (*Mitt. Forschungsinst. Luftfahrtmaterialprüfung*), **1933,** (1), 107–113).—[In Russian, with German summary.] The rate and temperature of hot-working of Duralumin are frequently such that the rate of deformation is greater than the rate of recrystallization, so that the phenomena of cold-deformation appear rather than those of hot-deformation. This has been found to apply to many other light alloys.—A. R. P.

On the Mechanism of the Changes of Structure [in Duralumin] Which Depend on the Temperature, Rate of Deformation, and Degree of Deformation. E. F. Bachmetew (*Trudi Vsesoyuznogo Nautchno-Issledovatelskogo Instituta Aviatsonnykh Materialov* (*Mitt. Forschungsinst. Luftfahrtmaterialprüfung*), **1933,** (1), 114–121).—[In Russian, with German summary.] A theoretical discussion of the results obtained in work described in the previous papers (preceding abstracts).—A. R. P.

Some Preliminary Remarks on the Application of the Results of X-Ray Structural Analysis of Pressed Duralumin in Technical Practice. E. F. Bachmetew (*Trudi Vsesoyuznogo Nautchno-Issledovatelskogo Instituta Aviatsonnykh Materialov* (*Mitt. Forschungsinst. Luftfahrtmaterialprüfung*), **1933,** (1), 122–128).—[In Russian, with German summary.] On the basis of the work described in previous papers (preceding abstracts) practical directions are given for the manufacture of high-grade Duralumin parts. The various structures which can be developed by heat and mechanical treatment are described, and precautions to be taken to avoid undesirable structures are detailed.—A. R. P.

X-Ray Investigation of Microstructure. W. E. Schmid (*Arch. tech. Messen,* 1934, **3,** (36), T76–T77).—Modern applications of X-ray examination include the measurement of elastic deformation and of internal stresses, and the investigation of microscopic and sub-microscopic structural disturbances. The position, sharpness, and intensity of interference patterns, and the significance of the Laue image are discussed and methods of observation are described.—P. R.

Electronic Waves and Investigation of Metals. A. A. Shternov (*Vestnick Ingenerov i Tehnikov* (*Messenger of Engineers and Technologists*), **1934,** (5), 216–219).—[In Russian.] A review.—N. A.

The Width of X-Ray Bands in Solids [Electron Theory of Metals]. John Rehner, Jr. (*Phys. Rev.*, 1934, [ii], **45,** 735).—Theoretical.—W. H.-R.

Electronic Energy Bands in Metals [Electron Theory of Metals]. J. C. Slater (*Phys. Rev.*, 1934, [ii], **45,** (11), 794–801).—The method of Wigner and Seitz (*ibid.*, 1933, [ii], **43,** 804) is extended to the computation of the excited bands of electrons in a metal with particular application to sodium. The calculations show that when the valency electrons are not actually penetrating the core of an atom, their wave-functions are very like those of free electrons, and their energies are given with remarkable accuracy by the Fermi–Sommerfeld theory.—W. H.-R.

IV.—CORROSION

(Continued from pp. 422–426.)

***The Use of Aluminium for Kitchen Utensils.** Vincente Colobraro (*Rev. farm.* (*Buenos Aires*), 1931, **73**, 75–87; *C. Abs.*, 1931, **25**, 2772).—The quantity of aluminium dissolved from an aluminium container of 1400 c.c. capacity, when 1000 c.c. of substance was boiled for 1 hr. was determined. In 100 grm. of substance the following values for aluminium (in mg.) were found: distilled water, none; tap water, 0·94; 7% acetic acid, 15·66; 0·25% tartaric acid, 6·11; 3% citric acid, 6·47; 4% sodium chloride solution, 2·35; 4% sodium chloride solution and 7% acetic acid, 13·15; milk, 1·69; olive oil, 5; sugar solution, 2; compote, 9·54; tomato preserves, 45·6; broth, 1·2; and white wine, 1·83. The present knowledge of the toxicity of aluminium does not permit conclusions concerning the innocuousness of its use in the kitchen.—S. G.

Blackening of Tin Foil. István Jakóby (*Anyagvizsgálók Közlönye*, 1933, **11**, 11–16; *C. Abs.*, 1934, **28**, 4348).—The black colours observed on cheese packed in tin foil result from electrolytic corrosion. The electric couple tin–antimony produces an anodic oxidation zone and film consisting of antimony and stannous oxide is formed. The composition of tin foil is of secondary importance, the blackening being dependent on the composition of the agents used in making process cheeses.—S. G.

***Anomalies Observed in the Rate of Corrosion of Zinc.** J. E. Maconachie (*Electrochem. Soc. Preprint*, **1934**, Oct., 9–16).—In the course of an investigation of the corrosion of galvanized-iron hot-water storage tanks, two anomalies were found in the rate of corrosion of zinc in distilled water: the presence of maxima in the loss in weight with time curves at temperatures above 50° C., and the occurrence of specimens which showed marked passivity. Apparatus and technique which gave a large amount of reproducible data are described. The initial corrosion rate of zinc in distilled water is greatly increased by increasing temperature up to about 60° C., above which the rate decreases. The corrosion rate at 60° C. appears subject to an anomalous fluctuation which can only be explained on the basis of a reversal of the corrosion reaction. There appears to be a surface condition, not affected by pickling for half a minute in *N* hydrochloric acid, which causes zinc to be extraordinarily resistant to attack by distilled water. The occurrence of this condition is infrequent in fresh sheet, but it appears to a considerable extent after ageing. Individual specimens cut from one sheet show differences in their susceptibility to corrosion which appear to be independent of the method of measurement.—S. G.

The Question of Metals in Town Milk Equipment in Regard to the Action on the Milk and to Cleansing Agents. ——Miethke (*Z. angew. Chem.*, 1931, **44**, 34).—An address at the 3rd Dairy Week of the Prussian Experimental and Research Station for Dairying, Kiel. Vessels of different metals were exposed to the action of milk. Certain steels, aluminium, both of 99·5 and 90% purity, heat-treated and polished Duralumin and Anticorodal were not attacked by the milk. Tinned copper and tinned iron were slightly attacked; nickel was considerably corroded but the taste of the milk was not affected. Copper, Argentan, nickel–brass, brass–iron, and zinc were found not to be usable.—S. G.

***Corrosion-Protection and Alternating Stress.** P. Ludwik and J. Krystof (*Mitt. tech. Versuchsamtes* (*Wien*), 1933, **22**, 42–49; *C. Abs.*, 1934, **28**, 4360).—The influences of distilled water and sea-water on the fatigue properties of steels and non-ferrous metals were investigated. The action of different corrosion-protective means such as oils, electrodeposited metals, nitriding, zinc plating, and galvanizing are discussed. The results are summarized in tabular form. —S. G.

The Mechanism of Metallic Corrosion. A View Suggested by Whitby's Recent Papers. U. R. Evans and T. P. Hoar (*Trans. Faraday Soc.*, 1934, **30**, 424–432).—Theoretical. The choice of a frame of reference is the chief difference between the two theories which attribute anodic corrosion to the departure of cations or to the arrival of anions. Whether the metal is passivated or corroded frequently depends on whether the anodic product is a solid hydroxide or a soluble salt, and this is generally determined by the p_H of the electrolyte and by the tendency of the salt of the metal to hydrolyze. In natural corrosion passivity and corrosion phenomena are affected by removal of the soluble anodic products from certain points by gravity, stirring, thermal convection, or contact with alkali from the cathodic areas. In some cases the rate of corrosion is governed by the cathodic reaction, which is stimulated by the presence of oxygen or of impurities in the metal which assist in the liberation of hydrogen, whereas in other cases it is controlled by the anodic reaction being stimulated by substances which dissolve, peptize, or penetrate the hydroxide corrosion product. Most commonly, however, both anodic and cathodic polarization curves affect the rate of corrosion, which must be equivalent to the value of the current which reduces the e.m.f. to a value just sufficient to force the current through the resistance of the corrosion-circuit.—A. R. P.

How to Avoid Corrosion of Air-Conditioning Equipment. Wayne H. Carter (*Chem. and Met. Eng.*, 1934, **41**, 140–142).—The corrosion of air-conditioning equipment depends on the following factors: (1) fresh-water composition; (2) absorption of impurities by the circulating water and the resultant catalytic effect of iron and copper sulphates on the oxidation of sulphur dioxide to trioxide. The main impurities are CO_2, SO_2, and SO_3, all of which are acidic and cause low p_H values in the water; (3) practically complete saturation of the water with air; (4) impingement of the high-velocity spray on the metal surface; (5) dissimilar metals in contact. Practically all central station equipment is made of galvanized iron, copper, or sheet iron. Copper equipment, although required in some cases, is generally not necessary. Maintenance of the correct p_H value, the use of chemicals, *e.g.* sodium dichromate or preferably chromate, the maintenance of the protective coating, if applied to the use of rubber, asbestos, &c., in isolating dissimilar metals, the pitting action of iron oxide (carried over from the boiler) on copper tubes, &c., are discussed, as well as one or two special cases.—F. J.

V.—PROTECTION

(Other than Electrodeposition.)

(Continued from pp. 427–429.)

Standard Methods of Determining Weight and Uniformity of Coating on Zinc-Coated (Galvanized) Iron or Steel Articles (A 90–33). —— (*Amer. Soc. Test. Mat. Standards*, **1933**, (I), 317–323).—Includes appendices on the determination of iron in zinc (galvanized) coatings, and the Preece or copper sulphate dip test for uniformity of coating on zinc-coated articles.—S. G.

Standard Specifications for Zinc-Coated (Galvanized) Iron or Steel Telephone and Telegraph Line Wire (A 111–33). —— (*Amer. Soc. Test. Mat. Standards*, **1933**, (I), 287–292).—S. G.

Standard Specifications for Zinc-Coated (Galvanized) Iron and Steel Tie Wires (A 112–33). —— (*Amer. Soc. Test. Mat. Standards*, **1933**, (I), 293–296).—S. G.

Standard Specifications for Zinc-Coated Iron or Steel Chain-Link Ferric Fabric Galvanized After Weaving (A 117–33). —— (*Amer. Soc. Test. Mat. Standards*, **1933**, (I), 281–283).—S. G.

Standard Specifications for Zinc-Coated (Galvanized) Iron or Steel Wire Strand (Cable) (A 122–33). —— (*Amer. Soc. Test. Mat. Standards*, **1933**, (I), 297–302).—S. G.

Standard Specifications for Zinc (Hot-Galvanized) Coatings on Structural Steel Shapes, Plates, and Bars, and Their Products (A 123–33). —— (*Amer. Soc. Test. Mat. Standards*, **1933**, (I), 309–312).—S. G.

***Investigation of Mineral Paints and Varnishes Used for Metals in Aircraft Building.** E. S. Tichonov (*U.S.S.R. Sci. Res. Inst. Publ.* No. **457**; *Trans. Central Aero-Hydrodynamical Inst.* No. **88**; *Res. Assoc. Brit. Paint Manuf. Rev.*, 1934, (**37**), 58).—[In Russian.] The decraftometer was used to determine the covering power of paints to be applied to aluminium alloys. Sea-water and fresh-water experimental tests of the films were also carried out. The laboratory tests could be correlated with tests conducted under practical conditions in the Black Sea. Other tests are required for resistance to the action of liquid fuels and lubricating oils. The best white pigment was white lead and the best black was lampblack; the greater protection was afforded by a mixture of zinc chromate, ferric oxide, lampblack, and Prussian blue. Zinc sulphide was entirely unsatisfactory. Bituminous varnishes are recommended for underwater protection, but deteriorate rapidly if exposed to the weather.—S. G.

***Experiments on the Durability of Paints Carried Out in the Accelerated Weathering Tank.** J. L. Matthijsen (*Verfkroniek*, 1933, **6**, 127–134; *Res. Assoc. Brit. Paint Manuf. Rev.*, 1933, (**36**), 304).—Aluminium paint is considerably more stable than grey or yellow paints containing white lead. Aluminium paints are superior to all others as top coats.—S. G.

The Use of Metallic Zinc Paint for the Protection of Metal Surfaces. H. P. Fritsch (*Amer. Paint J.*, 1934, **18**, (26), 14, 40–41; *Res. Assoc. Brit. Paint Manuf. Rev.*, 1934, (**39**), 249).—A paint composition of zinc dust (containing 20% zinc oxide), linseed oil, and thinners forms an excellent anti-rust paint for iron, suitable for primer or finish coat. The surface of zinc or galvanized iron should be pretreated by one of the following methods: (1) 6 months' weathering; (2) brush over with copper acetate, cupric chloride, or copper sulphate solution (4 oz. per gall.), any deposit formed being brushed off after drying; (3) liberal application of a mixture of 60 vol. industrial methylated spirit, 30 vol. toluol, 5 vol. carbon tetrachloride, and 5 vol. concentrated hydrochloric acid.—S. G.

Practical Experience with Modern Coatings for Metals Based on Oils, Nitrocelluloses, and Synthetic Resins. E. Krumbhaar (*Farbe u. Lack*, **1933**, (22), 257–259; *Res. Assoc. Brit. Paint Manuf. Rev.*, 1933, (**34**), 207).—K. considers that white lead and red lead are the safest pigments for all surfaces, particularly where there is exposure to water. White lead requires only 12–18% vehicle to make a good paint and the film is durable. Micaceous iron ore also has good properties but tends to become lumpy in paints. Iron oxide paint carefully prepared may be superior to red lead for metal surfaces, but much depends on the vehicle. Iron oxide forms an essential constituent of nitrocellulose and oil primers and is particularly useful in the tropics. Commercial zinc oxide is also useful in an anti-corrosion paint. Linseed oil is the best vehicle. The priming system may have an oil or nitrocellulose base and combination oil–nitrocellulose bases show promise. Modern synthetic resin varnishes are very satisfactory anti-corrosion materials, but they are too costly for ordinary use. These varnishes are quick drying and the resultant film is durable. Anti-corrosion varnishes for aircraft are very important, particularly in the tropics. Experiments are in progress with aluminium paints for wood as well as metal. Questions of price and stability of anti-corrosion coatings and the use of wax are discussed.—S. G.

Red Lead Oxide as Corrosion-Resistant Pigment. C. P. A. Kappelmeir (*Verfkroniek*, 1933, **6**, 189; *C. Abs.*, 1933, **27**, 5556).—Good results were obtained with red lead oxide paints.—S. G.

On the Selective Drainage Method for Preventing the Electrolytic Corrosion of Underground Telephone Cable in Yokohama. Mosaku Iwasa and Koei Sasaki (*J. Inst. Elect. Eng. Japan*, 1929, (**496**), 1277–1294; *Japanese J. Eng. Abs.*, 1933, (**9**), 30).—[In Japanese.] Cf. *J. Inst. Metals*, 1932, **50**, 305. Describes certain features of the underground cable installed at Tan-machi and Tsuruya-chō in Yokohama, with the measures taken to mitigate corrosion. As a result of certain measurements, I. and S. have recommended Mitsuda's selective drainage method as being the most effective for the mitigation of the electrolysis of the cable.—S. G.

***An Experimental Study of the Corrosion Due to Leakage Current.** Teiichi Hattori (*J. Inst. Elect. Eng. Japan*, 1930, (**505**), 830–846; *Japanese J. Eng. Abs.*, 1934, (**10**), 17).—[In Japanese.] Using a model, an experimental study was made of the corrosion due to leakage of current from railway tracks. The principal subjects dealt with are (1) the effect on the corrosive current in the underground structure of the existence of rails not being worked; (2) what happens when the current in the underground structure is drained into the rail; (3) the effect on the current in the underground structure affected of any point of the rail being earthed; (4) how the contact resistance between rails and soil is to be dealt with, if at all; (5) the relation between the current and the specific resistance in the underground structure.—S. G.

On the Application of the Oxidized Copper Drainer to the Mitigation of Electrolytic Corrosion. Shichijirō Numata and Masahiko Tomatsuri (*J. Inst. Elect. Eng. Japan*, 1930, (**508**), 1269–1280; *Japanese J. Eng. Abs.*, 1934, (**10**), 22).—[In Japanese.]—S. G.

***The Effect of Drainage and Insulating Joint Methods for the Prevention of Electrolytic Corrosion of Underground Metallic Structures [—I].** Masaie Horioka and Mosaku Iwasa (*Res. Electrotech. Lab. Tokyo*, 1930, (**288**), 1–82; *Sci. Abs.*, 1931, [B], **34**, 53).—[In Japanese.] H. and I. discuss the effects of drainage connections and insulating joints as alternative methods for preventing electrolytic corrosion of underground metallic structures. Laboratory tests on the range and degree of electrolytic corrosion were carried out by observing the colouring of phenolphthalein for given positions of models of rails and underground structures immersed in a neutral electrolyte stiffened by gelatin. Having thus obtained a general idea of the distribution of leakage current, H. and I. investigated the problem with greater accuracy by tracing equipotential surfaces in the electrolytic bath, using a telephone receiver as detector and passing a current of 1000 ~ through the rail. Field surveys were also made on communication and power cables, with insulating joints, normal and selective drainage connections. The conclusions reached are: (1) insulating joints, when suitably located, decrease the sheath current and, therefore, the electrolytic corrosion; recommendations are made concerning the most favourable location of insulating joints; as the number of the latter increases the sheath current tends to reach a minimum value; (2) a drainage connection eliminates electrolytic corrosion within a certain region, whereas a certain amount of local corrosion always occurs on the higher potential side of an insulating joint; the extent of the space protected by the drainage connection increases as the resistance of the metallic structure decreases and as the resistance of the path of leakage current flowing into the rail return increases; (3) drainage of the metallic structure nearest to the rail return shields more distant structures to some extent, but an opposite effect is produced by an insulating joint. Cf. *J. Inst. Metals*, 1932, **50**, 305.—S. G.

VI.—ELECTRODEPOSITION

(Continued from pp. 430–431.)

Tank Equipment for Electroplating. L. C. Pan (*Metal Cleaning and Finishing*, 1934, **6**, 123–126, 130; *C. Abs.*, 1934, **28**, 3666).—A discussion of materials of construction for plating tanks and the calculation of plating tank capacity. —S. G.

Low-Voltage Motor Generator Sets. George L. Nankervis (*Monthly Rev. Amer. Electroplaters' Soc.*, 1934, **20**, (11), 14–23).—A description of modern low-voltage generator sets for electroplating.—A. R. P.

VII.—ELECTROMETALLURGY AND ELECTROCHEMISTRY

(Other than Electrodeposition and Electro-Refining.)

(Continued from p. 432.)

***Potentiometric Studies of Passivity.** John Steiner and Louis Kahlenberg (*Electrochem. Soc. Preprint*, **1934**, Oct., 1–8).—The electrode potentials of various samples of iron, of certain ferrous alloys, of aluminium, tungsten, chromium, platinum, and 2 varieties of carbon were measured in nitric acid of varying concentrations from dilute to fuming. By means of the potentiometer the passive state was readily distinguished from the active and the minimum concentration of acid that will cause passivity accurately determined. The results are given in the form of curves. Direct evidenee for the support of the oxide theory of passivity was found only in the case of tungsten. Alternating activity and passivity is observed only when part of the electrode is immersed in the nitric acid; it does not occur when the metal is completely immersed. The addition to iron of easily passivated metals, such as chromium and nickel, yields alloys which are more readily passivated than iron itself, whilst the addition of a less easily passivated metal like copper causes the alloy to be less readily passivated than iron.—S. G.

***The Electromotive Force Produced by Movement of [Metal] Electrodes in Various Solutions, Changes in the Phenomenon as a Function of the Concentration, the Time, and the Pressure of Dissolved Gases.** Virgiliu G. Gheorghiu (*Ann. Sci. Univ. Jassy*, 1933, **18**, 337–384; *Chem. Zentr.*, 1934, **105**, I, 3320–3321).—The potentials of platinum, gold, silver, copper, iron, and zinc have been determined in various inorganic and organic acids, in alkalis, and in neutral nitrate solutions, and the effect thereon of movement, concentration, and time of immersion studied; the results are shown in tables and graphs. The electropositive metals in acid solutions show a negative e.m.f. of movement which is greater the stronger (chemically) is the acid; in strong acids this e.m.f. decreases with time, but in the weaker acids it increases. The electronegative metals give a positive e.m.f. of movement which is greater in the weaker acids than in the stronger. The e.m.f. decreases with increase in the concentration of the electrolyte in all cases, except in boric and acetic acids, in which it rises. In the alkaline solutions the electropositive metals give a negative e.m.f. which except in ammonia amounts to only a few thousandths of a volt. Zinc in all alkalis gives a positive e.m.f. of movement at first, but this slowly becomes negative; this effect increases with the concentration to a maximum, then falls again. The behaviour in various nitrate solutions shows no effect of the valency of the cations. Pressure changes produce considerable effects on the phenomenon. The theory of the subject is discussed at length.—A. R. P.

The Definition of Polarization, Overvoltage, and Decomposition Potential. W. Blum and G. W. Vinal (*Electrochem. Soc. Preprint*, **1934**, Oct., 17–24).—Taking the case of the electrolysis of water, with smooth platinum electrodes, as a typical example, the fundamental components of the cell or bath voltage are interpreted. Revised definitions are proposed and are discussed at length. Finally, the following recommendations are submitted: (1) the "equilibrium reaction potential" is preferably used to refer to the potential based on the free energy of the process; (2) the "decomposition potential" is the minimum potential required for continuous electrolysis; (3) the term "polarization" includes all departures of the potential from the equilibrium potential, and is a measure of irreversibility (excluding IR drop) regardless of whether the products are solid, liquid, or gaseous; (4) the term "overvoltage" preferably refers to the minimum polarization required for any electrode process to occur at an appreciable rate under given conditions.—S. G.

***Electrochemical Properties of Smooth Electrolytically Deposited Metals of the Platinum Group.** I. I. Zhukov (*J. Gen. Chem.* (*U.S.S.R.*), 1933, **3**, 958–962; *C. Abs.*, 1934, **28**, 3666).—[In Russian.] Electrodes were prepared by depositing electrolytically on platinum first a thin layer of gold and then a thin smooth layer of platinum, iridium, rhodium, or palladium. With these electrodes equilibrium in potential measurements is obtained much more quickly than with platinum electrodes covered with platinum black. Detailed instructions are given for the preparation of such electrodes.—S. G.

***Comparative Study of Deposits of Silver and Colloidal Silver.** José Piazza (*Anales inst. investigaciones cient. tecnol.* (*Univ. nac. litoral*), 1933, **2**, 50–52; *C. Abs.*, 1934, **28**, 3309).—On heating a suspension of silver oxide in an alcoholic solution of sodium glycotaurocholate to 50°–60° C., colloidal silver is formed. The cathodic deposit formed by silver electrodes in an electric discharge tube on a film of sodium glycotaurocholate does not have colloidal properties; an alcoholic suspension of this cathodic deposit, in the presence of bile salts, when heated shows no colloidal silver. The two products appear to be distinct. —S. G.

***On the Extraction of Metallic Bismuth and Lead–Tin Alloy from the Flue Dust Collected in Cottrell Chambers at the Ashio Mine.** Jūrō Shimono (*Suiyôkwai-Shi*, 1930, **6**, (5), 405–462; *Japanese J. Eng. Abs.*, 1934, **(10)**, 48).—[In Japanese.]—S. G.

***Influence of Magnetic Field on Electrolysis.** Mata Prasad and N. B. Choksey (*Current Sci.*, 1934, **2**, 345; *C. Abs.*, 1934, **28**, 3667).—A magnetic field of 3700 gauss applied normal to a 60–150 ma. current passing between platinum electrodes in an electrolyte caused an increase or decrease in the value of the current depending on the solution. The amount of change was small in concentrated solutions but increased rapidly with dilution, and increased linearly with current and field. The motion of the gases liberated at the electrodes was also affected by the field.—S. G.

IX.—ANALYSIS

(Continued from pp. 433–434.)

Standard Methods of Chemical Analysis of Silver Solders (B 81–33). —— (*Amer. Soc. Test. Mat. Standards*, **1933**, (I), 831–840).—In the analysis of silver solder the usual determinations are Ag, Cu, Cd, and Zn. In routine analysis, however, it is customary to take Zn by difference. Methods are provided for the determination of Pb, Sn, Fe, and Ni as impurities starting with a separate 5 grm. sample.—S. G.

†The Volumetric Determination of Copper with Iodide and Thiocyanate. D. Krüger and E. Tschirch (*Z. anal. Chem.*, 1934, **97**, 166–171).—The method is critically reviewed. Good results are obtained only when the amount of KI used is not less than 8–10% of the KCNS. The $Na_2S_2O_3$ used should be standardized against pure Cu under similar conditions to the analysis.—A. R. P.

***A Colour Reaction for Bismuth.** (*Chem. Obzor*, 1934, **9**, 3–4). **Qualitative Detection of Bismuth with Sulphur-containing Reagents.—I. Detection with Dimercaptothiodiazole.** (*Z. anal. Chem.*, 1934, **96**, 267–270). J. V. Dubský and A. Okáč.—Bi in acid solution gives a red precipitate with a 1% solution of dimercaptothiodiazole in 0·1*N*-KOH; sensitivity 1 : 28,000, limit of detectability 0·0012 mg. In the usual group analysis the Bi is first separated as BiOCl, and the solution of this in dilute HCl is used for the test. Other organic compounds with the group NH·C·SH give yellow to orange colorations with Bi solutions.—R. P.

X.—LABORATORY APPARATUS, INSTRUMENTS, &c.

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

(Continued from pp. 391–392.)

Two New Universal Microscopes. Anon. (*Metallurgia*, 1934, **10**, 55–56).—The trend in the design of universal microscopes, to enable all methods of examination to be utilized in microscopic research work on materials, is indicated by two new instruments—a vertical microscope " MeF " and a horizontal microscope " MeA." These instruments, which are very fully described, are designed for microscopy and photomicrography in incident and transmitted light (in both cases using either bright or dark ground illumination), and in polarized light. They also enable photomicrographs or photomacrographs to be taken as required.—J. W. D.

Thermionic Triode Thermostat. Anon. (*J. Sci. Instruments*, 1934, **11**, (7), 227–229).—Describes a triode valve relay outfit for controlling thermostats with a very small current across the mercury contacts, so that no sparking takes place.—W. H.-R.

***Preparation of Thin Metallic Films by Cathodic Dispersion.** O. G. Keyko (*Zhurnal Tehnicheskoy Fiziki* (*Journal of Technical Physics*), 1933, **3**, (4), 653–656).—[In Russian.] Simple apparatus is described for obtaining by cathodic dispersion thin films of pure metals and mixtures of metals. The apparatus has been used in the production of films of copper, silver, nickel, platinum, cadmium, lead, tin, and bismuth, and mixtures of silver with copper with and without cadmium.—N. A.

***Camera for Accurate Measurement of the Parameters of Crystal Lattices.** P. A. Polibin (*Zhurnal Tehnicheskoy Fiziki* (*Journal of Technical Physics*), 1933, **3**, (4), 645–652).—[In Russian.] The theory of Preston's camera is given and a camera designed by the State Physico-Technical Institute of Leningrad is described. The lattice parameter of aluminium found with this camera is $a = 4{\cdot}0411 \pm 0{\cdot}0008$ A. The influence of the size of slit on the accuracy of the method is discussed.—N. A.

Comparison of Constancy of Gold- and Chromium-Plated Analytical Weights. Harvey V. Moyer and Paul K. Winter (*Indust. and Eng. Chem.*, 1934, **26**, 238).—A comparison was made between 3 sets of chromium-plated weights in use in the students' laboratory under the same general conditions as gold-plated ones. The results showed that the chromium-plated weights were close to their adjusted values, whereas most of the gold-plated ones were seriously in error. The superiority of the chromium is attributed to its greater resistance to scratching and abrasion. The corrosion of the brass where the gold had worn off would explain the positive errors among the gold-plated weights.
—F. J.

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

(Continued from pp. 435–436.)

The Interpretation of Creep Tests. P. G. McVetty (*Amer. Soc. Test. Mat. Preprint,* **1934,** June, 1–12).—McV. discusses the fundamental nature of the creep curve and the probable effect on it of strain-hardening, annealing, age-hardening, and other phenomena associated with the long exposure of complex alloys to stress at elevated temperatures. The possible effects of "creep-recovery" are mentioned. Examples are given to show how, in suitable conditions, published creep data may be correlated. An attempt is made to stimulate interest in the general subject of the interpretation of creep data in the hope that a more intensive study will develop better methods than those commonly used.—S. G.

***Crystal Lattice Distortion and Distribution in Tensile and Fatigue Test-Pieces.** Fritz Regler (*Mitt. tech. Versuchsamtes* (*Wien*), 1933, **22,** 49–60; *C. Abs.*, 1934, **28,** 4346).—A discussion of the fundamental structure of metallic atoms and the behaviour on stress applications, both tensile and fatigue. Work is based on the interference line widths as influenced by stress conditions. Curves showing the distribution of stored energy along a test-piece indicate that the method of loading is an important factor. On a notched-bar the curves show the energy concentrated at the notch.—S. G.

Depth of Action in Brinell Testing. Alfred Krüger (*Kalt-Walz-Welt* (Suppt. to *Draht-Welt*), **1934,** Jan., 1–6).—The extent of the recrystallized zone apparent on etched annealed sections through Brinell impressions was taken as a measure of the extent to which the test had produced deformation. It was shown that for each thickness of test-piece and ball diameter there was a definite limiting load above which the results of tests would be influenced by the underlying material. For a 10-mm. ball and 3000-kg. load the limiting thickness was about 7 mm.—A. B. W.

Defects of the Spherical Indentation Form and Advantages of the Pyramidal Form in the Brinell Hardness Test. C. Montini (*Metallurgia italiana*, 1934, **26,** 172–179).—The errors associated with ball impressions are discussed and the advantages of pyramids are outlined.—G. G.

Standard Accelerated Life Test for Metallic Materials for Electrical Heating (B 76–33). —— (*Amer. Soc. Test. Mat. Standards,* **1933,** (I), 877–887).—Covers the determination of the resistance to oxidation at high temperatures under intermittent heating of metallic materials for electrical heating. The method is applicable to 2 general classes of materials: A.—alloys suitable for commercial service up to 1100° C.; B.—alloys suitable for commercial service up to 900° C.—S. G.

***On the Chemical Composition of Heating Wires and the Method of Testing their Qualities.** Shinji Togō (*J. Illuminating Eng. Soc. Japan*, 1929, **13,** (10), 582–592; also (abstract) *Japan Nickel Rev.*, 1933, **1,** 383; *Japanese J. Eng. Abs.*, 1933, (**9**), 36).—[In Japanese.] T. proposes a method for the investigation of the qualities of heating wires which is derived from the results of previous experiments as well as those reported in the present paper. The dimensional irregularity of the wire, the amount of oxidation and certain other known facts like chemical heterogeneity are supposed to affect the life of a wire. The effect of oxidation may be either (*a*) from the uniform oxidation during continuous heating; or (*b*) from the oxidation at the beginning of preheating after a period of cooling. A number of repeated heatings should therefore be considered in determining the life, as well as the total heating time. The amount of oxidation, except in extreme cases such as in Chromel C, does not provide an estimate of the life, as it gives only the average amount of oxidation and not the special oxidation at some particular weak point, which seems a more important factor, as it is a hot spot. The change of resistance in such stages, on the contrary, shows the total effect resulting from every cause, and not oxidation only, so that the measurement of the resistance in air gives a much better indication of the life. The slope of the resistance–time curve at a given temperature and the change of resistance on a number of heatings can determine the life of a wire, not taking into consideration the effect of hot spots. The resistance–temperature curve in air gives the actual resistance for design, and the temperature coeff. of resistance obtained from this curve distinguishes the wire for low-temperature use from that for high-temperature use. A very large % of iron caused great oxidation, but T. could find no definite result with a moderate % of iron and no reason why the iron content of wire for high-temperature use should be less than 1%. The wires containing a higher % of silicon seemed to have the greater life.—S. G.

Standard Specifications for Round-Hole Screens for Testing Purposes (E 17–33). —— (*Amer. Soc. Test. Mat. Standards*, **1933**, (II), 1242–1243). —S. G.

RADIOLOGY.

***On the Measurement of Elastic Stresses with X-Rays.** Hermann Möller and Josef Barbers (*Mitt. K.W.-Inst. Eisenforschung*, 1934, **16**, 21–31).—Tests on iron and Duralumin have shown the great accuracy of the X-ray method, which is especially suitable for the detection of anisotropic stresses, *e.g.* in and around welds, in the neighbourhood of unsound parts of the metal, and in highly stressed parts. Conclusions as to the mean stress distribution throughout a cross-section cannot, however, be reached directly from the results of the examination of surface layers.—J. W.

***Improvement of X- and Gamma-Ray Photographs by the Use of Heavy Metal Filters.** Rudolf Berthold (*Arch. Eisenhüttenwesen*, 1934, **8**, 21–24).—Tin or lead and tin filters improve the sharpness of photographs of faults in heavy or light metals taken by X-rays by equalizing differences in the thickness of the specimens and reducing the effect of diffused rays. The use and efficiency of the filters are illustrated by examples.—J. W.

Comments on the Technique of X-Ray Testing of Materials.—III. A. Herr (*Mitt. tech. Versuchsamtes* (*Wien*), 1932, **21**, 46–59).—S. G.

X-Ray of Code Welds. [R.] Notvest and —— Poole (*Industry and Welding*, **1932**, (July), 37; (Aug.), 20).—S. G.

Design is Safeguarded by X-Ray Testing. H. H. Lurie (*Mach. Design*, 1932, **4**, 20–23).—S. G.

The Equipment of an Industrial X-Ray Laboratory. C. O. Herb (*Machinery* (*N.Y.*), 1932, **38**, 408–411).—S. G.

XIII.—FOUNDRY PRACTICE AND APPLIANCES

(Continued from pp. 437–438.)

Manufacture of Pistons for Internal Combustion Engines and Heat-Treatment of Aluminium Alloy Castings. C. Panseri (*Metallurgia italiana*, 1931, **23**, 500–522, 624–643, 732–752; also (full abstract) *Technique moderne*, 1931, **23**, 699–701; *Eng. Index*, **1932**).—The physical properties, composition, and crystal structure of aluminium–copper, aluminium–copper–silicon, and magnesium alloys are dealt with and data are given on light alloys used in the manufacture of representative makes of pistons.—S. G.

The Influence of Design on Brass and Bronze Castings. Lewis H. Fawcett (*Trans. Amer. Found. Assoc.*, 1932, **40**, 360–374).—F. stresses the attention which should be given to the design of castings in relation to foundry production. The composition of some brasses and bronzes used by the U.S. Navy Dept. are given, together with the required physical properties.—S. G.

Solving Problems in Foundry Ventilation. C. R. Chadbourne (*Canad. Mach.*, 1932, **43**, 46, 48; *Eng. Index*, **1932**).—Cites various types of common ventilation methods for foundries and discusses their defects and advantages. —S. G.

***Castability of Ternary Alloys.** A. Portevin and P. Bastien (*J. Inst. Metals*, 1934, **54**, 45–56; discussion, 56–58).—The " castability " of a metal or alloy can be determined by measuring the length of a spiral cast-iron mould filled by the metal under standard conditions of casting. For a pure metal the castability is linearly proportional to the difference between the casting temperature and the melting point of the metal, and the slopes of the graphs for different metals vary with the viscosity. The castability of binary alloys is greater when the primary crystals are polyhedral than when they are dendritic, since in the latter case free flow of the metal is retarded by the crystal network as soon as partial solidification occurs. Maximum castability of binary alloys occurs at the eutectic composition and minimum at the limits of solid solubility; for intermediate compositions the castability depends on the solidification range. In ternary alloys castability varies inversely with the primary solidification range, except along binary eutectic lines in the ternary system, where it varies with the secondary solidification range, the minimum value being reached at compositions corresponding with the transition from 2-phase to 3-phase fields. These laws are confirmed by experiments on the antimony–lead, antimony–cadmium, tin–bismuth, bismuth–lead, lead–tin, tin–lead–bismuth, and iron–carbon–phosphorus systems. By the help of these laws it is shown to be possible to establish doubtful points in the equilibria in metal systems, *e.g.* the composition of eutectics and of saturated solid solutions at the solidus temperature. In the discussion, *A. von Zeerleder* described some results obtained in Germany on aluminium alloys by the aid of P. and B.'s method. The castability of Alpax (13% silicon) is much greater than that of pure aluminium or of Anticorodal. For Anticorodal with 5% silicon mould temperatures of up to 300° C. do not reduce the tensile strength or elongation, but increase of the mould temperature from 200° to 300° C. improves appreciably the castability. The results indicate that the optimum casting temperature for this alloy is 700°–750° C. with a mould temperature of 300° C. A modification in the casting apparatus for the tests is described and illustrated. P. and B., in reply, emphasize the importance of a study of casting conditions on the mechanical and physical properties of an alloy.—A. R. P.

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

(Continued from p. 395.)

Extraction of Secondary Copper from Low-Grade Scrap and Slags. P. P. Belonogov (*Zvetnye Metally* (*The Non-Ferrous Metals*), **1933**, (2/3), 94–101; *C. Abs.*, 1934, **28**, 4342).—[In Russian.] A description of the process for the recovery of copper from slags and scrap at the Krasnuii Vuiborzhetz works (U.S.S.R.).—S. G.

Melting Copper Waste at Moscow Molotov Works. G. A. Shakhov (*Zvetnye Metally* (*The Non-Ferrous Metals*), **1933**, (5), 37–51; *C. Abs.*, 1934, **28**, 4342).—[In Russian.] Test melts made for the purpose of recovering copper from scrap, waste metal, copper-bearing refuse, &c., are described.—S. G.

XVII.—HEAT-TREATMENT

(Continued from p. 396.)

On the Theory of Quenching and Ageing of Aluminium Alloys. A. P. Gulyayev (*Vestnick Ingenerov i Tehnikov* (*Messenger of Engineers and Technologists*), **1934**, (4), 185–187).—[In Russian.] A review of modern knowledge of this subject.—N. A.

***Some Factors Influencing the Thermal Treatment of Sheet Duralumin.** P. A. Vargunin (*Tehnika Vosdushnogo Flota* (*Technics of Aerial Navy*), **1933**, (5), 58–78).—[In Russian.] Higher mechanical properties for Duralumin can be obtained on quenching if the general and final degree of reduction by previous cold-rolling is greater. In this case (great degree of reduction) the quenching temperature can be lower and the annealing period shorter. The influence of the composition of alloy is discussed.—N. A.

A Study of the Reheating of Duralumin Ingots. M. Chartron (*Rev. Aluminium*, 1934, **11**, 2487–2498).—The construction and applications of electric air heating furnaces, direct gas heating furnaces, coal-fired hearth furnaces, and salt-baths are described. The uniformity of heating in the ingots is discussed, and the performances of the different types of furnace are compared.—J. H. W.

Temper-Hardening Copper Alloys. Maurice Cook (*Met. Ind.* (*Lond.*), 1934, **45**, 83–87, 101–105, 134–136).—Read before the Midland Metallurgical Societies (Birmingham Local Section of the Institute of Metals, Birmingham Metallurgical Society, and Staffordshire Iron and Steel Institute). Theories of age-hardening, hardening not accompanied by precipitation, and abnormalities in age-hardening are discussed. The age-hardening of the following copper alloys is described: copper and cobalt, chromium, aluminium–manganese, magnesium, titanium, aluminium–cobalt, nickel–tin, silicon, beryllium, and copper alloys containing nickel and aluminium. A *bibliography* of 39 references is given.—J. H. W.

Standard Definitions of Terms Relating to Heat-Treatment Operations (Especially as Related to Ferrous Alloys) (A 119–33). —— (*Amer. Soc. Test. Mat. Standards*, **1933**, (I), 425–428).—The following terms are defined: heat-treatment; quenching; hardening; annealing (including full annealing, process annealing, normalizing, patenting, spheroidizing, tempering, malleableizing, graphitizing); carburizing (cementation); case-hardening; cyaniding; nitriding.—S. G.

XVIII.—WORKING

(Continued from pp. 396–397.)

***Relation Between Specific Pressure and Temperature During Extrusion of Aluminium.** V. A. Bobrov (*Trudi Nautchno-Issledovatelskogo Instituta Legkih Metallov—"Niisalumini"* (*Transactions of the Scientific Research Institute for Light Metals—"Niisalumini"*), **1933**, (1–2), 63–73).—[In Russian.] Specific pressure is defined as the average value of the power which must be applied per unit area of the specimen in contact with the ram during extrusion. The apparatus used gave results for the simultaneous determination of three curves: (*a*) $P = f(h)$, where P is the pressure and h the length of specimen extruded; (*b*) $P = f(H_p)$, where H_p is the stroke of the ram; and (*c*) $h = f(H_p)$, which characterizes the regularity of the extrusion process. The specific pressure (p) can be calculated from the expression $p = K_1(P_{cp} - 1)S_0/S$, where K_1 is the coeff. of friction in the press, P_{cp} is calculated from the area of the curve $P = f(h)$, S_0 is the area of the ram, and S the area of contact between the ram and the specimen. The relation between the specific resistance and the tem-

perature between 92° and 500° C. in extruding Duralumin with an elongation factor $\mu = 4{\cdot}16$ has been determined; it cannot be represented by a single function for all temperatures. In temperatures below the beginning of recrystallization the following expression is suggested: $(p)_{\mu_t} = a \log^m \mu / t^n$, where a, n, m are constants and μ is the elongation factor (less than 10).
—D. N. S.

***The Mechanics of Plastic Deformation: The Flow of Duralumin Through Orifices.** S. I. Goubkin (*J. Rheology*, 1932, **3**, 501–548).—Apparently similar to a paper published in the Russian language, see *J. Inst. Metals*, 1933, **53**, 48.—S. G.

***On the Effect of Friction and Cross-Sectional Dimensions on the Flow of Metals in Rolling.** Erich Siebel and Egon Osenberg (*Mitt. K.W.-Inst. Eisenforschung*, 1934, **16**, 33–50).—The following points have been investigated: the flow of lead during compression with different tools with plane and curved, smooth and rough surfaces, the effect of friction on the broadening and lengthening of lead, copper, and aluminium in cold-rolling with various reductions, and cross-sections, the relative displacement of the surface and inner layers, the distribution of stress in the roll-gap and the causes of cracking and splitting during rolling of strip. Friction is the principal cause of the different behaviour of metals in plastic deformation; in rolling its effect is the greater the thinner the sheet compared with the diameter of the rolls. Generally the broadening and lengthening of the sheet increase with increasing friction, but the latter is the best criterion of the frictional conditions. Internal cracking, edge cracks, and splitting are due to excessive friction and can therefore be mitigated by the use of smooth rolls and suitable lubrication.—J. W.

†Influence of the Size of a Duralumin Billet for Rolling on the Efficiency of Integrated Works and Individual Units. A. F. Belov (*Legkie Metalli* (*Light Metals*), **1932**, (9), 34–40).—[In Russian.] Substitution of 500-kg. ingots for the usual 80-kg. Duralumin ingots increases the efficiency of the melting furnace by 21%, and the output of the rolling mill by 380%. For successful plating thick billets are preferable.—D. N. S.

Tubing from Strip Metal. H. C. Peterson (*Inco*, 1930, **10**, (1), 13, 19).—A description of the Bundy method of manufacturing tubing by the rolling of strip metal into a solid double-walled tube.—R. G.

Wire-Drawing at the Higher Speeds. J. B. Nealey (*Wire and Wire Products*, 1934, **9**, 213–215).—A condensed description is given of the application of high-speed machines to the drawing of fine copper wire through the adaptation of a multi-die system, and of the various processes involved.—J. H. W.

A Modern [Copper] Wire-Drawing Plant in Italy. E. Kaestel (*Metallurgia italiana*, 1934, **26**, 180–183; and *Met. Ind.* (*Lond.*), 1934, **45**, 51–53, 54).—A description is given of the new Pirelli plant, near Milan, for drawing copper wire.
—G. G.

***Thermo-Mechanical Treatment of Thorio-Tungsten (Tungsten with Addition of Thorium Oxide).** A. N. Koptsik (*Redkie Metalli* (*Rare Metals*), **1933**, (1), 31–38).—[In Russian.] The swaging, drawing, and heat-treatment of tungsten wire containing thorium are discussed. Swaged wire drawn down from 0·79 mm. to 0·18 mm. in 6 passes had a tensile strength of 292 kg./mm.^{2}, compared with 161·6 kg./mm.^{2} for pure tungsten wire. The corresponding elongations were 3·10 and 2·65%.—D. N. S.

The Construction of a Slide Rule for the Easy Reckoning of Essential Data for Steel Wire-Drawing, as Well as the Necessary Initial Cross-Section and Number of Passes. K. Wiegert (*Draht-Welt*, 1934, **27**, 340–341).—Describes a slide rule relating ratio of diameters, reduction in area, increase in length, and increase in strength. The latter scale is based on the results of Pomp and others (Kaiser-Wilhelm Institut, 1929), in which it was shown that the increase in strength on drawing was proportional to the logarithm of the longitudinal strain, and that the constant of proportionality depended on the carbon content in the case of steels.—A. B. W.

The Plastic Forming of Metals. Erich Siebel (*Steel*, 1934, **94**, (2), 24–25, 43; (3), 27–29; (4), 30–32; (5), 27–30; (6), 36–40; (7), 29–32; (8), 35–37; (9), 27–32; (10), 37–42; (11), 34–38; *C. Abs.*, 1934, **28**, 3355).—Forces and flow of materials in technical forming processes are discussed: (*a*) useful and friction work in rolling; (*b*) forming by means of drawing; (*c*) force required for extrusion; (*d*) force required for piercing, and (*e*) force relations in deep-drawing.—S. G.

***Forging of "Y" Alloy.** Tsunekichi Watase (*Suiyôkwai-Shi*, 1931, **6**, (7), 631–638; *Japanese J. Eng. Abs.*, 1934, (**11**), 57).—[In Japanese.] A "Y" alloy ingot containing copper 4, nickel 3, and magnesium 1·5% was poured at the proper temperature in an iron mould the section of which was 3 times that of the ingot. Sheets were made by hot-rolling the ingot 6 × 40 × 95 mm. to different thicknesses, and they were heated for 1 hr. at 500° C., quenched in boiling water, and aged for 5 days. Tensile tests were carried out on these materials. "Y" alloy should be worked to $\frac{1}{3}$ of the original section of the ingot to obtain sheet with a strength of 40 kg./mm.^{2} and an elongation of more than 15%. The addition of silicon up to 0·67% lowers the ductility and gives a tendency to crack at the first stage of rolling.—S. G.

***Introduction of Other Elements into Pressed Hard Alloys by Precipitation from Salt Solutions.** V. D. Romanov and V. I. Tretiakov (*Redkie Metallic Rare Metals*), **1933**, (4), 32–34).—[In Russian.] In the preparation of the hard alloy Pobedit thorough mixing of the cobalt with the powdered tungsten carbide is essential to ensure that the grains of the latter are coated with an even and dense layer of cobalt. A new method of depositing cobalt has been studied: a powdered mixture of tungsten carbide and zinc dust is moistened with water, and then with a cobalt salt solution whereby vigorous displacement of the cobalt by zinc occurs. Cutting tools made of the alloy thus obtained were superior to Pobedit produced by the usual mixing method.—D. N. S.

***The Hard Alloy Elvotit.** I. Golub (*Vestnick Metallopromishlennosti* (*Messenger of the Metal Industry*), **1933**, (8), 65–69).—[In Russian.] The properties of the new hard alloy Elvotit, manufactured at the Elektrozavod works, Moscow, are compared with those of the cobalt–tungsten carbide alloy Pobedit. The latter is unsuitable for cutting tools to work cast and alloy steels. Elvotit contains 30% of titanium and 70% of tungsten carbide: it has a density of 8·7–9, Rockwell hardness 88–91; a tensile strength less than that of Pobedit, specific resistance to cutting 275 kg. (Pobedit 380 kg.).—D. N. S.

XIX.—CLEANING AND FINISHING

(Continued from pp. 397–398.)

***Pickling Blisters on Zinc and Steel Sheets.** Otto Vogel (*Stahl u. Eisen*, 1934, **54**, 446–449).—Zinc sheets containing lead develop small blisters in dilute acid solutions similar to those observed on steel sheets after pickling; in both cases the blisters are particularly numerous in places to which the hydrogen bubbles adhered during pickling, *e.g.* on the underside of the sheets and on greasy spots. —J. W.

Some New Developments in Buffing Compositions. G. M. Cunningham (*Monthly Rev. Amer. Electroplaters' Soc.*, 1934, **21**, (1), 25–30; discussion, 30–32).—Modern buffing compositions consist of abrasives, such as tripoli powder, with a binder composed of tallow, double-pressed stearic acid, rosin, and petrolatum. The functions of these components are briefly outlined, and the requisites of an ideal buffing composition are outlined.—A. R. P.

The Lacquering of Metal [Collapsible] Tubes. W. Huth (*Indust.-Lackier-Betrieb*, **1933**, (17), 197; (18), 211; *Res. Assoc. Brit. Paint Manuf. Rev.*, 1933, (**34**), 176, (**35**), 278).—(1) The type of tube (aluminium, tin, alloy, &c.) and the contents (cream, emulsions, &c.) determine the coating to be used. (2) The enamel lacquer applied to such tubes should not dry completely, as it would then not take the print. After printing, drying needs special care as regards temperature and air circulation in the drying chamber. In the case of paints in tubes a serious fault is " crumbling " of the contents. This may be obviated by lining the tubes with a lacquer coat which prevents discharge of the electrically-charged colloidal particles on the metal wall of the tube. Similarly, tubes containing foodstuffs should be lacquered inside as a protective measure. —S. G.

Stoving Enamels on Aluminium Alloys. Anon. (*Indust.-Lackier-Betrieb*, 1934, **10**, 29).—S. G.

Stoving Lacquers for Tin Containers and the Tinplate Industry. F. Zimmer (*Farben-Zeit.*, 1933, **38**, 1530–1531).—Lacquering of domestic articles made of good quality tinplate is described.—S. G.

The Lacquering and Enamelling of Rolled Zinc and Zinc Die-Castings. Anon. (*Paint & Varnish Prod. Manager*, 1933, **9**, (6), 28–29, 32).—S. G.

Electroplate Metal Undercoatings for Organic Finishes. Anon. (*Synthetic and Applied Finishes*, 1933, **4**, 242–248; *Res. Assoc. Brit. Paint Manuf. Rev.*, 1933, (**36**), 350).—Metal parts are first plated to ensure a continuous film to which the organic finish can be applied and to give greater protection at the edges, &c. The testing of different combinations of metal undercoating and finish coat is described and some results are tabulated.—S. G.

XX.—JOINING

(Continued from p. 398.)

***Solder. Effect of Impurities on Its Appearance and Microstructure.** Clifford L. Barber (*Indust. and Eng. Chem.*, 1934, **26**, 685–687).—The influence of impurities on the surface appearance and microstructure of 50 : 50 tin–lead solder was examined, using an iron mould having a mass about 8 times that of the cast bar which was 4 in. long by $\frac{5}{8}$ in. square. The main conclusions were : antimony, bismuth, copper, silver, nickel, and arsenic have no part in the frostiness which appears on the surface of bar-solder. In amounts in which these elements are ordinarily present in solder, none (with the possible exception of arsenic) can be detected by microscopic examination. The round, raised, " cooling spots " usually attributed to antimony are really caused by arsenic or nickel, which are about 100 times more active in producing this curious effect. Zinc in amounts as low as 0·001% and aluminium and cadmium in amounts as low as 0·01% produce a noticeable roughness and frostiness on bar solder. They also produce a dendritic network in the microstructure, and doubtless alter the fluidity of the solder. One or more of these three elements is responsible for the persistent frostiness which occasionally prevails on apparently " pure " solder.—F. J.

***Soldering and Brazing [Use of Fluxes].** S. F. Barclay (*J. Sci. Instruments*, 1934, **11**, 200).—A note. A solution of pure zinc chloride in water is advocated instead of " killed spirits of salts," because the latter contains both free acid, and impurities such as arsenic, &c., which produce skin trouble on the hands of operatives.—W. H.-R.

Tinning and Soldering Solution. —— ((*British*) *Air Min. General Specification* No. **D.T.D. 81**, 1930, 1 p.).—S. G.

Silver Brazing of Monel Metal and Nickel. R. J. McKay (*Inco*, 1931, **10**, (4), 26–27).—A description of industrial practice.—R. G.

Aluminium Rivets. —— (*Provisional* (*British*) *Air Min. Aircraft Specification* No. **D.T.D. 148,** 1930, 2 pp.).—S. G.

Light Alloy Rivets. —— (*Provisional* (*British*) *Air Min. Aircraft Specification* No. **D.T.D. 110,** 1929, 1 p.).—S. G.

Arc Welding Aluminium. A. F. Davis (*Machinist* (*Eur. Edn.*), 1934, **78,** 438–439).—Suitable types of weld are illustrated and data for the process are tabulated. If porosity is so bad as to be objectionable, it can be entirely eliminated by heating the plates for some distance on each side of the seam to a temperature of 600°–700° F. (315°–370° C.). Vertical and overhead welding should be kept to a minimum with aluminium.—J. H. W.

Aluminium Welding Flux. —— ((*British*) *Air Min. General Specification* No. **D.T.D. 119,** 1930, 1 p.).—S. G.

Contribution to the Knowledge of Electric Arc Welding of Hydronalium. L. Anastasiadis (*Elektroschweissung*, 1934, **5,** 96–99).—Hydronalium (aluminium with 5–10% magnesium) does not require heat-treatment, and therefore presents advantages for welded construction. It may be arc welded as easily as pure aluminium, the process being very similar. The flux coating on the electrodes is of the same nature, but gives a more fluid slag, and the electrode is connected to the negative pole of the generator, whereas, for aluminium welding, it is usually connected to the positive pole. Welded joints have mechanical properties similar to the cast alloy, and lose practically no strength after 12 days' immersion in a solution of 3% sodium chloride with 1% hydrogen peroxide. The article includes a table giving the electrode sizes and welding currents recommended for various thicknesses of material.—H. W. G. H.

Stelliting Valve Steels. F. R. Banks (*Mech. World*, 1934, **95,** 71–72).—A special technique for applying Stellite to the faces of internal-combustion engine valves and valve-seats by the oxy-acetylene flame is illustrated and described. The grade of Stellite welding rod recommended is No. 6, containing cobalt 65, chromium 27, tungsten 4, carbon 1·25, and silicon 2·7%. The process at present increases the cost of the finished valve by 10%.—F. J.

The Welding of Copper. J. F. Springer (*Met. Ind.* (*N.Y.*), 1934, **32,** 205–206).—Hints on welding copper with the oxy-acetylene torch.—A. R. P.

Welding Copper for the Chemical and Allied Industries. Werner Frölich (*Canad. Chem. and Met.*, 1934, **18,** 13–15).—Mechanical stresses in the weld are avoided by starting the job some inches away from one end of the joint, working forward to the other end, and then returning to the first end. The flux required should be sprinkled over the metal only after it has reached a red heat. Welds should be hammered if possible, otherwise they must be annealed and quenched to balance the mechanical and chemical properties of the weld metal.—A. R. P.

Copper Welding Applied to Locomotive Repairs. Frank Hugh Harrison (*J. Inst. Eng. Australia*, 1933, **5,** 332–340).—A description of the method of welding in the repair of locomotive fireboxes used at the Islington workshops of the South Australian Railways. Following an examination of the practices in France and Germany, a modified procedure was developed; considerable savings were effected. Reference is made to the necessary precautions and the mechanical and microscopic features of the welds. Illustrations are given showing various types of repairs.—R. G.

***Electric-Welding of Bronze with Alternating Current.** A. Kurdin (*Avtogennoe delo* (*Autogenous Practice*), **1933,** (9), 15–16).—[In Russian.] Preliminary results of experiments on the electric welding of bronze with a.c. are recorded. Of the 4 electrodes tested, the best was an alloy containing copper 83·46, tin 5·59, zinc 5·04, lead 3·5, iron 2·24, sulphur 0·08, silicon 0·1, and phosphorus 0·003%.—D. N. S.

The Welding of Nickel. Anon. (*Welder*, 1934, **6,** 184–185).—Brief practical details are given for arc and oxy-acetylene welding. Reversed polarity is recommended for the former process.—H. W. G. H.

Chromium-Nickel Non-Corrosive Welding Rod. —— ((*British*) *Air Min. General Specification* No. **D.T.D. 61,** 1931, 1 p.).—Except as to composition (chromium 15·5–19, nickel 24–28, manganese 0·60–1·25, silicon 2·0–3·5, carbon 0·25–0·55%) all the usual British Standards Institution clauses in regard to this class of material will be deemed to be operative.—S. G.

***Welding the Alloy " Vokar " in Strips.** V. D. Romanov and P. F. Roshtshin (*Redkie Metalli* (*Rare Metals*), **1933,** (3), 10–16).—[In Russian.] Welding of the hard alloy Vokar on to the drills used in the petroleum industry by means of separate vertical strips instead of in one continuous layer doubles the drilling speed and reduces the consumption of the alloy by 30%.—D. N. S.

***On the Electrical Welding of Hard Alloys [on Drills].** G. E. Varshavskiy (*Neftjanoe Khoziastvo* (*Oil Economy*), **1933,** (8), 146–153).—[In Russian.] Various methods of welding hard alloys on to rotary drills have been examined, together with the behaviour of tools welded by the different methods. The points investigated include resistance to wear, hardness, composition, micro-, macro-, and crystallographic structure, resistance to bending, and compression stresses. The tests were carried out before and after welding. The results are tabulated.—N. A.

***On the Method of Welding Pieces of Super-Hard Alloys on to Drills by Means of Copper and Natural Gas.** D. Krepkov (*Neftjanoe Khoziastvo* (*Oil Economy*), 1934, **26,** (2), 35–37).—[In Russian.] The causes of defects (cracks) in drills have been investigated, and a method of welding super-hard alloy tips to drills with the aid of natural gas and copper (as a solder) is described which prevents the developments of these defects.—N. A.

Fusion Welding of Alloy Steels and Non-Ferrous Metals. Hugo Schröder (*Werkstoffe u. Korrosion*, 1934, **9,** 1–2, 5–6; *C. Abs.*, 1934, **28,** 3043).—Methods of welding various alloys, compositions, patent protection, apparatus, &c., are given for chromium-nickel steels, copper, aluminium, silver, nickel, lead, Monel metal, and others.—S. G.

Welding Rod Coatings. L. G. Bliss (*Welding*, 1934, **5,** 203–206, 208, 242–243, 255).—The composition of coatings, coating methods, and factors governing electrode behaviour are discussed, and a list of selected patents from different countries is given. Electrodes for ferrous welding are mainly considered, but the article is of wider interest.—H. W. G. H.

Types of Resistance Welds.—I, II. F. S. Stickney (*Machinist* (*Eur. Edn.*), 1934, **78,** 345–346E, 358–359E).—(I.—) The applications, advantages, and limitations of resistance welds are discussed, and the operations of flash or butt welding both ferrous and non-ferrous alloys are described. (II.—) A description is given of projection, ridge, or button welding as applied to sheets too thick to be readily spot or seam welded. For metals having low electric resistance and high heat conductivity and for those which rapidly oxidize at the welding temperature, heavier currents for shorter time intervals are necessary.
—J. H. W.

Recent Progress in Oxy-Acetylene and Electric Arc Welding. R. Granjon (*Rev. soudure autogène*, 1934, **26,** (243), 2–5).—The two processes, both of which should be called " autogenous welding," are compared, and the progress made in equipment, technique, and materials is reviewed. Less decisive, it is thought, is the progress made in methods of supervision and control, the need for which is emphasized.—H. W. G. H.

The Tamrarc System of Electric Arc Welding. Motoharu Tamura (*Zassan* (*J. Japanese Soc. Naval Arch.*), 1931, **(109),** 1–15).—[In Japanese.]—S. G.

Welding Methods Coming Forward. W. von Bleichert (*Anz. Berg.-, Hütten- u. Masch.*, 1934, **56,** (24), 4–7).—Some new welding machines and accessories are described.—B. Bl.

XXI.—INDUSTRIAL USES AND APPLICATIONS

(Continued from pp. 439–440.)

Is the Use of Aluminium Utensils Injurious to Health? R. Braungard (*Aluminium*, 1931, **13**, (5), 3–7).—Cider and black-currant wine were prepared and kept in aluminium vessels. They were not impaired and no harm resulted when they were drunk. Gravimetric analysis (estimation as oxide) showed the aluminium content to be extremely small. Different waters and dilute solutions of "Aktivin" cleanser were also experimented with, with equally good results.—S. G.

***Studies on the Destruction of Vitamin C in the Boiling of Milk. [Use of Aluminium Utensils.]** E. W. Schwartze, F. J. Murphy, and R. M. Hann (*J. Nutrition*, 1930, **2**, 325–352).—The change in aluminium contents of milk on boiling in an aluminium vessel was from 0·5 to 0·6 p.p.m. (5 minutes' boiling) and from 0·6 to 1·0 p.p.m. (30 minutes' boiling); Pittsburgh tap-water changed from 0·6 to 0·8 p.p.m. by boiling for 1 minute.—S. G.

***The Effect of Pasteurization upon the Vitamin C Content of Milk in the Presence of Certain Metals.** E. W. Schwartze, F. J. Murphy, and Gerald J. Cox (*J. Nutrition*, 1931, **4**, 211–225).—The degree of destruction of vitamin C in milk by aerobic pasteurization for 30 minutes at 60°–60·5° C. was determined for pasteurizing equipments of copper, tinned copper, and aluminium. Pasteurization with copper equipment destroyed from 80 to 90%, with tinned copper, and with aluminium equipment from 20 to 40%, of the vitamin C content. Slightly less destruction occurred with aluminium than with tinned copper, presumably due to some exposure to copper in the tinned-copper pasteurizer. During the process milk took up 0·6 p.p.m. of aluminium and from 7 to 8 p.p.m. of copper in the respective equipments. A certain part of the vitamin C destruction was attributed to aerobic pasteurization *per se*, and not to the involved metals, and the results were considered not inconsistent with the theory that the anaerobic process might cause no destruction even in the presence of copper. Copper is entirely unsuitable for construction of dairy equipment; likewise tinned copper is unsatisfactory due to the wearing off of the tin with exposure of copper. For this purpose aluminium is as satisfactory a material as is at present available.—S. G.

†The Rôle of Metals and More Particularly of Aluminium in the Pathogeny of Cancer. Marcel Maire-Amero (*Bull. soc. sci. hyg. aliment.*, 1930, **18**, 42; *C. Abs.*, 1930, **24**, 3270).—As regards aluminium, which has been claimed to be one of the causes of cancer, its function has been considerably exaggerated. At the present time no data permit of attributing intoxication solely to the use of aluminium utensils.—S. G.

***The Question of the Harmfulness of Aluminium Cooking Utensils from the Point of View of Homeopathy.** —— Bastanier (*Allg. Homöopath. Zeit.*, **1931**, (2)).—B. first examines the various subjective symptoms classified by leading homeopathic authorities as indications for treatment with homeopathic doses of aluminium compounds, such symptoms being according to homeopathic theories, caused by aluminium compounds (like cures like). He then reports the results of his investigations by questionnaire to 400 employees of aluminium works in different parts of Germany and to 74 children at a boarding school. The workers were in some cases exposed to aluminium dust, and some used aluminium cooking utensils from the factories; the school children did not use aluminium cooking utensils at all. The answers showed that about one-third of all those questioned have in greater or less degree the symptoms characteristic of alumina in the homeopathic sense; but they also revealed the surprising result that these symptoms were not necessarily associated with contact with or ingestion (with the food) of aluminium. Analysis of the figures showed that the taking into the system of aluminium with the food had no effect whatever. B. is accordingly forced to conclusions which he admits must seem heresy from the point of view of orthodox homeopathy, and of which he leaves the explanation an open question for further investigation.—S. G.

Checking Corrosion [Use of Aluminium and Its Alloys in Sewage Plant]. R. C. Wilson (*Municipal Sanitation*, 1933, **4**, 375–377; (*U.S.*) *Public Health Eng. Abs.*, 1934, **14**).—Aluminium and its alloys possess many definite possibilities in sewage disposal operations. As early as 1916 in Hamburg several units of the Brunotte Intake Screens were permanently equipped with cast aluminium link-bars. The earliest known application in the U.S.A. was at Gastonia, N.C. Extensive use of aluminium for doors, screens, electrical conduits, &c., has been made at the Easterly plant at Cleveland, O. Conditions developed by the average sewage treatment plant impose an abnormally severe corrosion burden on the metals of construction. In the past corrosive influences have been combated mainly by the use of paints, and in many cases even the best paints have failed. Corrosion-resistant metals developed during the past 5 years will play an important part in preserving structure stability of exposed metal units. Aluminium alloys possess the essential corrosion-resistance and being available in every form at low cost will assume a conspicuous rôle in meeting the rigorous demands of the sanitary engineering field. —S. G.

Non-Corrodible Materials are Desirable in Sewerage Construction [Aluminium Alloys, &c.]. —— (*Public Works*, 1933, **64**, 21–22; (*U.S.*) *Public Health Eng. Abs.*, 1934, **14**).—Wider use of steel substitutes such as Armco and Toncan iron, Monel metal, copper-bearing steel, tin, nickel, brass, non-corroding irons and steels, aluminium, &c., in sewerage construction is suggested. One of the earliest uses of aluminium in treatment plants was for diffuser plate holders; other uses include sludge ploughs on classifier equipment, sludge removing devices and rotary distributor for trickling filters. Tests at Cleveland (U.S.A.) including immersion in sewage for 360 days of aluminium alloy indicates satisfactory life under adverse conditions.—S. G.

Aluminium and Zinc as Water Softeners. B. S. Srikantan (*Current Science*, 1933, **1**, 291; (*U.S.*) *Public Health Eng. Abs.*, 1934, **14**).—Aluminium powder and mixtures of aluminium and zinc powders when shaken with hard water soften it. Aluminium removes only the temporary hardness within 2 hrs., carbon dioxide being evolved and a white precipitate formed. Mixtures of aluminium and zinc remove permanent hardness due to calcium and magnesium sulphates, hydrogen being liberated. A mixture of aluminium and zinc in the ratio of 1 : 10 proved best. The reaction may be due to the incipient electrolytic action of the aluminium–zinc couple resulting finally in the adsorption of the sulphate ions on the metal surfaces. In laboratory tests with 10 grm. of softener and 2 litres of hard water, aluminium reduced the magnesium bicarbonate hardness from 50·5 to 1·2° and an aluminium–zinc mixture reduced the calcium sulphate hardness from 61·6 to 1·0° and the magnesium sulphate hardness from 62·5 to 1·5°. Technical details are being worked out. —S. G.

Fighting Corrosion [in Artificial Silk Plant]. S. Oguri (*Silk and Rayon*, 1933, **7**, 411–413).—The possibilities of aluminium as a corrosion-resistant material are discussed.—S. G.

Aluminium Electric Transmission Cable. F. Reade Dallye (*Wire and Wire Products*, 1934, **9**, 171–173, 189).—Describes the development of aluminium stranded power transmission cable and the processes entering into its manufacture. (Cf. *Met. Ind.* (*Lond.*), 1934, **45**, 125–128, 130. Under the heading: "Aluminium for Transmission Lines," an abstract is given of a brochure, published by the British Aluminium Co., Ltd., on "Overhead Transmission Lines.")—J. H. W.

***The Maximum Permissible Tension of Steel-Reinforced Aluminium Cables.** Fumio Shida and Jōji Kameyama (*J. Inst. Elect. Eng. Japan*, 1929, (**490**), 532–551; *Japanese J. Eng. Abs.*, 1933, **9**, 19).—[In Japanese.] The authors have conducted a series of carefully prepared experiments in order to secure information on the distribution of stress in steel-reinforced aluminium cables in which the two different metals are employed to form a composite strand and have obtained results which appear to be in accordance with fundamental theory and common reasoning. They state that the elastic limit of the aluminium of the cable or the maximum tension of the cable can be regulated to a certain extent by the selection of correct lengths of lay for the aluminium and steel wires composing the strand; in other words, by correct design and proper manufacturing processes. With a proper set up of machine the tensile strength of this composite cable can be measured quite accurately. For this reason the authors advocate simplification in the consideration and determination of the quality of the cable as in the case of hard-drawn copper wire cables. —S. G.

Aluminium Powder as a Paint Pigment. Karel Vnuk (*Chem. Obzor*, 1934, **9**, 7–9, 30–32).—For the manufacture of aluminium paints only very pure aluminium can be used that can readily be hammered to a powder, preferably with the addition of a lubricant. The characteristic properties of aluminium paints are great hardness, resistance to weathering, opacity to light, and high reflecting power for light; they are suitable for use on objects which must be protected against sunlight, *e.g.* gasometers, petrol tanks, &c., and on objects which must have a low heat radiation, *e.g.* electric furnaces, cookers, boilers, and steam-pipes.—R. P.

***Aluminium Priming Paint. Effect on the Durability of House Paints on Wood.** F. L. Browne (*Indust. and Eng. Chem.*, 1934, **26**, 369–376).—The effect of aluminium priming paint on the durability of house paints on wood as determined by test fence exposures is described. As compared with the durability of the same paints, applied without the aluminium primer, an improvement is manifested by a retardation in the rate at which age-embrittled paint coatings flake from the bands of dense, horny summerwood present in softwood lumber. The benefit gained by the aluminium primer was greatest for woods that have much summerwood, such as southern yellow pine and Douglas fir. When repainting was neglected for some time, coatings applied over aluminium primer suffered less damage, and the surfaces were then more easily and durably repainted.—F. J.

Aluminium Paint for Exterior and Interior Use. R. Schwarz (*Decorator*, 1934, **32**, 67–78).—The properties and modes of application of, and suitable vehicles for, aluminium paints are discussed. Cf. *Met. Abs.*, this volume, p. 47.—S. G.

Aluminium as Protective Paint Pigment. P. Urech (*Schweiz. tech. Z.*, 1932, **29**, 614–616).—S. G.

Evaluating Aluminium–Bronze Powder. W. B. Roberts and J. D. Edwards (*Official Digest Fed. Paint Clubs Amer.*, 1934, (**134**), 61; *Res. Assoc. Brit. Paint Manuf. Rev.*, 1934, (**39**), 170).—Aluminium–bronze powders are evaluated from analysis of purity and tests of mesh size, leafing power, colour, brilliancy, apparent density (rate of settling in alcohol), and covering power (by sifting on to a clean water surface). Opacities of finished paints are compared on films produced by flowing on to inclined glass panels. Aluminium pastes are evaluated by slight modifications of the powder tests.—S. G.

Aluminium in the Cylinder-Heads of Automobile Engines. G. Piantanida (*Alluminio*, 1934, **3**, 64–67).—The new constructive tendencies in the automobile industry, and the advantages of certain aluminium alloys for cylinder-heads, are discussed.—G. G.

Novelties in Piston Construction. Ernst Mahle (*Automobiltech. Z.*, 1934, **37**, 316–324).—Modern practice demands a combination of maximum performance with speed, lightness, strength, high thermal conductivity, hardness, and stability at high temperatures, resistance to wear even under imperfect lubrication, and silent running. Failures are described and illustrated, the causes being faulty power transmission, inexact workmanship, burning out due to low conductivity, and seizing up owing to carbonization. Testing methods are summarized, and the production on testing machines of failures closely resembling the foregoing is described. It is stated that a new proprietary alloy, containing 12–13% silicon in addition to copper, combines the useful properties of the aluminium–copper and aluminium–silicon alloys. A photomicrograph shows its structure. The use of light metal pistons with Invar inserts is recommended as combining lightness with decreased play on the base, hence involving less wear. Some recent modifications in design are shown and discussed.—P. M. C. R.

Heat Insulation with Aluminium Foil. J. F. O. Stratton (*Paper Trade J.*, 1934, **98**, 37–39).—The properties of aluminium foil as a heat insulator are described and the uses of the material in technology are discussed.—A. R. P.

†**What Can Be Expected from Beryllium ?** Josef Verö (*Bányászati kohászati Lapok*, 1934, **67**, 33–38, 58–63; *Chem. Zentr.*, 1934, **105**, I, 3109–3110).—A critical review of the metallurgy and the uses of beryllium in alloying. It is concluded that the chief uses of beryllium are as a deoxidizer for copper and nickel and as a hardener for copper, nickel, and iron alloys; in all cases, however, cheaper and just as efficient substitutes are known.—A. R. P.

Standard Specifications for Seamless Copper Tubing, Bright-Annealed (B 68–33). —— (*Amer. Soc. Test. Mat. Standards*, **1933**, (I), 743–745).—Cover annealed copper tubing suitable for use in refrigerators, oil-lines, petrol-lines, &c., where tubing absolutely free from scale and dirt is required.—S. G.

Standard Specifications for Copper Water Tube (B 88–33). —— (*Amer. Soc. Test. Mat. Standards*, **1933**, (I), 734–738).—Cover tubes specially designed for plumbing purposes, underground water services, &c., but also suitable for copper coil water heaters, fuel-oil lines, gas lines, &c.—S. G.

Standard Specifications for Copper Pipe, Standard Sizes (B 42–33). —— (*Amer. Soc. Test. Mat. Standards*, **1933**, (I), 705–708).—Cover seamless tubes and pipe suitable for use in plumbing, boiler feed lines, &c.—S. G.

Copper Pipes for House Water Supplies. A. Schimmel (*Gesundheits-Ing.*, 1932, **55**, 603; (*U.S.*) *Public Health Eng. Abs.*, 1934, **14**).—Although copper pipes are initially more costly than galvanized iron, they are more economical when maintenance also is considered. Copper is more resistant to corrosive waters than iron, and whereas hard waters form an adherent scale in iron pipes, only sludge is deposited in copper; copper pipes of relatively small diameter can therefore be used. The cost of joints, &c., for copper pipes is a little higher than for iron.—S. G.

Aluminium–Bronze for Valve Seats. —— (*Provisional* (*British*) *Air Min. Aircraft Specification* No. **D.T.D. 160**, 1931, 2 pp.).—S. G.

Aluminium–Nickel[–Copper] " Bronze " Forgings for Exhaust Valve Seats. —— (*Provisional* (*British*) *Air Min. Aircraft Specification* No. **D.T.D. 135**, 1930, 1 p.).—Covers the alloy containing aluminium 9·75–10·5, nickel 1·0–1·5%, total impurities not more than 0·3%, with remainder copper.—S. G.

Aluminium–Nickel–Iron[–Copper] " Bronze " Bars, Forgings, and Stampings. —— (*Provisional* (*British*) *Air Min. Aircraft Specification* No. **D.T.D. 164**, 1931, 3 pp.).—S. G.

Bronze Bars for Carburettor Needle Seatings. —— ((*British*) *Air Min. General Specification* No. **D.T.D. 30A**, 1929, 2 pp.).—Supersedes specification No. D.T.D. 30.—S. G.

Hard-Rolled Bronze (Gun Metal) Bars. —— (*Provisional* (*British*) *Air Min. Specification* No. **D.T.D. 155,** 1931, 4 pp.).—Supersedes specification No. D.T.D. 117.—S. G.

N.M. Bronze (a High-Tensile Bronze) as a Material for Marine Propellers. Shinya Ogata (*Zassan* (*J. Japanese Soc. Naval Arch.*), 1931, **48,** 39–60).—[In Japanese.]—S. G.

Standard Specifications for Sheet High Brass (B 36–33). —— (*Amer. Soc. Test. Mat. Standards,* **1933,** (I), 728–733).—Cover two grades of commercial sheet brass commonly used for drawing, forming, stamping, and bending. —S. G.

Standard Specifications for Brass Pipe, Standard Sizes (B 43–33). —— (*Amer. Soc. Test. Mat. Standards,* **1933,** (I), 709–712).—Cover pipe suitable for use in plumbing, boiler feed lines, &c.—S. G.

Standard Specifications for Seamless Admiralty Condenser Tubes and Ferrule Stock (B 44–33). —— (*Amer. Soc. Test. Mat. Standards,* **1933,** (I), 693–696).—Cover tubes and stock made from Admiralty alloy (copper not less than 70·00, tin 0·90–1·20, lead not over 0·075, iron not over 0·06%, and zinc remainder). —S. G.

Standard Specifications for Seamless 70 : 30 Brass Condenser Tubes and Ferrule Stock (B 55–33). —— (*Amer. Soc. Test. Mat. Standards,* **1933,** (I), 697–700).—S. G.

Standard Specifications for Seamless Muntz Metal Condenser Tubes and Ferrule Stock (B 56–33). —— (*Amer. Soc. Test. Mat. Standards,* **1933,** (I), 701–704).—S. G.

[Brass] Wind Instruments. Marjorie M. Rud (*Metal Progress,* 1934, **26,** (1), 41–44).—Brass of 2 types is used for wind instruments : bodies for horns, &c., are of 75 : 25 sheets, which does not soften when seams are brazed. Rods and tubing for levers are of average composition : copper 62, zinc 34·5, lead 3·5%. Other metals used are nickel–brass for small instruments and high-precision work, bronze and sterling silver; plating is in silver or gold, with a variety of finishes, the application of which is described. Chromium plating, while resisting corrosion well, is found too hard, and has a tendency to peel. Organ pipes are of lead–tin alloy of one of three types : "common," with 20–30% tin; "spotted metal," with 45% tin; and "pure tin" (90–95%). Casting and forming are described.—P. M. C. R.

Dental Gold Alloys. Crown-Ring Gold. Deutscher Normenausschuss E 1720 (*Z. Metallkunde,* 1934, **26,** 47–48).—Standard specifications for 18-, 20-, and 22-carat dental gold alloys with details of colour and mechanical properties are given.—B. Bl.

Lead Poisoning and a Rare Case of Non-Occupational Lead Paralysis. A. Strotmeyer (*Zentr. Gewerbehyg. u. Unfallverhutung,* 1931, **18,** 234; (*U.S.*) *Public Health Eng. Abs.,* 1934, **14**).—A man who had drunk water from an old lead pipe for 27 years developed internal symptoms of lead poisoning followed by paralysis. Water which had lain in the pipe overnight was found to contain 1·5–4·5 mg. of lead per litre. Other members of the family who did not drink this first-drawn water showed the presence of lead in blood tests but suffered no illness. About the time when symptoms first appeared a radio set had been earthed by attachment to the house pump.—S. G.

New Methods of Extrusion Improve Lead Sheath. Herbert R. Simonds (*Iron Age,* 1934, **134,** (3), 18–21).—There are two processes for the extrusion of lead in general use at the present time : the poured-in and the slug processes. A summary of the research work that has been and is being done to improve the products of the former process is given.—J. H. W.

Magnesium Alloy Castings (Suitable for Pressure Work). —— ((*British*) *Air Min. General Specification* No. **D.T.D. 40,** 130, 2 pp.).—The sp. gr. of this alloy is between 1·80 and 1·83.—S. G.

Magnesium Alloy Forgings, Stampings, or Pressings. —— (*Provisional* (*British*) *Air Min. General Specification* No. **D.T.D. 90,** 1929, 2 pp.).—The sp. gr. of this alloy is 1·82; it is suitable for pressings.—S. G.

Magnesium Alloy Sheets (Suitable for Welding). —— ((*British*) *Air Min. General Specifications* No. **D.T.D. 118,** 1930, 2 pp.).—S. G.

Hard-Rolled Magnesium Alloy Sheets (Not Suitable for Welding). —— ((*British*) *Air Min. General Specification,* No. **D.T.D. 125,** 1930, 2 pp.).—S. G.

Magnesium Alloy Bars (16 Tons Tensile Strength). —— ((*British*) *Air Min. General Specification* No. **D.T.D. 127,** 1932, 2 pp.).—The sp. gr. of this alloy is between 1·81 and 1·83.—S. G.

Magnesium Alloy Bars (20 Tons Tensile Strength). —— ((*British*) *Air Min. General Specification* No. **D.T.D. 129,** 1929, 2 pp.).—The sp. gr. of this alloy is between 1·81 and 1·83.—S. G.

Magnesium Alloy Castings (Suitable for Pressure Work). —— ((*British*) *Air Min. General Specification* No. **D.T.D. 136,** 1930, 2 pp.).—The sp. gr. of this alloy is between 1·80 and 1·83.—S. G.

Magnesium Alloy Castings (for Lightly-Stressed Parts). —— ((*British*) *Air Min. General Specification* No. **D.T.D. 140,** 1930, 2 pp.).—The sp. gr. of this alloy is between 1·8 and 1·83.—S. G.

Magnesium Alloy Bars (15 Tons Tensile Strength). —— ((*British*) *Air Min. General Specification* No. **D.T.D. 142,** 1930, 2 pp.).—The sp. gr. of this alloy is between 1·81 and 1·83.—S. G.

Prevention of Crusting on Boiler Safety Plugs. H. N. Bassett (*Mech. World,* 1934, **95,** 275–276).—The causes of the failure of safety plugs are discussed. The tin plug may pick up zinc from the plug body which leads to progressive oxidation and the formation of an infusible network. The body, therefore, should be free from zinc. The tin filling, however, can pick up copper, which if present above 1%, raises the melting point. Low pouring temperature and careful tinning of the bore of the plug body are advocated to mitigate this trouble. The analysis of crusts which had been responsible for failure of plugs to function revealed the presence of oxide of copper and sulphate and carbonate of lime, the balance being mainly tin oxide. The lime salts had been derived from water leaking through to the fire-end. Other factors are ash from the coal used and excessive projection of the plug into the combustion space. Frequent inspection of plugs is desirable.—F. J.

Standard Specifications for Slab Zinc (Spelter) (B 6–33). —— (*Amer. Soc. Test. Mat. Standards,* **1933,** (I), 858–860).—Cover virgin spelter, *i.e.* slab zinc made from ore or similar material by a process of reduction and distillation or by electrolysis and not produced from reworked metal, in 6 grades: (1*a*) special high grade; (1) high grade; (2) intermediate; (3) brass special; (4) selected; (5) prime Western.—S. G.

XXII.—MISCELLANEOUS

(Continued from pp. 370–371.)

Problems of Non-Ferrous Metallurgy in 1933. D. I. Shteinbok (*Zvetnye Metally* (*The Non-Ferrous Metals*), **1933,** (2/3), 5–14; (4), 12–23; *C. Abs.,* 1934, **28,** 4340).—[In Russian.] A summary of the programme of development of the Russian non-ferrous industry for 1933. This programme includes: (1) improvement of quality of product, plant efficiency, recovery of metals, and lowering of production costs; (2) the completion of plants and smelters under construction; and (3) exploration of new non-ferrous mineral deposits and construction of new plant. The attainment and failures of the five-year plan are pointed out, and the programme for the production of gold, lead, zinc, aluminium, nickel, tin, and other metals in 1933 is described.—S. G.

†**General Considerations of the Requirements and Possible Production of Aluminium and Magnesium under the [Russian] Second Five-Year Plan.** B. P. Rolshtshikov (*Legkie Metalli* (*Light Metals*), **1932**, (9), 5–11).—[In Russian.] With the energy resources available under the second five-year plan, it is concluded that 200,000 tons of aluminium and magnesium can be produced in 1937; the problem of providing sufficient plant and apparatus for dealing with this amount is examined. New applications of light alloys, which must be developed under the second five-year plan, are mentioned.—D. N. S.

Poisoning Caused by Cadmium [in Preparation of Cadmium–Copper Alloys]. —— Wahle (*Zentr. Gewerbehyg. Unfallverh.*, 1932, **19**, 223–226; *Res. Assoc. Brit. Paint Manuf. Rev.*, 1933, (33), 145).—Symptoms, which are described, of cadmium poisoning occurred while making copper–cadmium alloys.—S. G.

Lead Poisoning in a Storage Battery Plant. Anon. ((*U.S.*) *Public Health Rep.*, 1933, **48**, 1043–1045; *U.S. Public Health Eng. Abs.*, 1933, **13**).—The U.S. Public Health Service recently issued a Bulletin (No. 205) on a study of the lead hazard in a storage battery plant. This investigation included a plant survey, the determination of lead dust and fumes in the air, a record of employment and of disabling illness (especially compensation cases of plumbism), physical examinations, and blood and urine analyses. A correlation was shown between lead exposure and the risk of developing lead poisoning. Except for prolonged exposure it appears that the limit of safety under the conditions encountered in this study is an atmospheric concentration of lead dust or fumes of less than 1·5 mg. per 10 $m.^3$ of air.—S. G.

First Soviet Nickel. D. M. Chizhikov (*Zventye Metally* (*The Non-Ferrous Metals*), **1933**, (6), 3–16).—[In Russian.] The first Soviet nickel plant at Ufaley, Ural, is described. It commenced operation at the end of 1933.—S. G.

Work of the [Russian] Platinum Institute in the Field of Metal Alloys. W. A. Nemilov (*Izvestia Platinago Instituta* (*Annales de l'Institut de Platine*), 1932, (**10**), 1–13).—[In Russian.] A review of the development of the Institute, and an account of its work on binary systems, containing platinum or palladium with copper, iron, and iridium.—N. A.

Presidential Address [to the Institute of Metals]. H. Moore (*J. Inst. Metals*, 1934, **54**, 29–44).—The work of the Institute is reviewed and a plea is made for closer collaboration between all the Societies and Associations engaged in furthering the science of metallurgy, especially as regards publications. The ideal arrangement would seem to be a combined metallurgical society, but this should be preceded by the publication of an abstract journal covering the whole field of ferrous and non-ferrous metallurgy.—A. R. P.

Tin Research and Development. D. J. Macnaughtan (*Misc. Publ. Internat. Tin Res. & Development Council* No. **1**, 1934, 1–10).—An address to the American Tin Trade Association.—S. G.

Research in the Nickel Industry. P. D. Merica (*Inco*, 1932, **11**, 14–16).—An account of the organization and scope of the Development and Research Department of the International Nickel Company.—R. G.

Research in American Industry. H. J. Gough (*Bull. Brit. N.F. Metals Res. Assoc.*, 1934, (66), 4–5).—A note giving impressions gained in a tour of American research laboratories and industrial plants. The large-scale American research organizations are contrasted with the group system underlying Research Associations in Great Britain.—W. H.-R.

Metallurgy from the Standpoint of the Chemical Engineer. L. Singlehurst-Ward (*Trans. Inst. Chem. Eng.*, 1933, **11**, 75–82).—A brief survey of metallic materials and their selection, fabrication, and protection, concluding with references to modern developments in special cast irons and bronzes and to the place of metallurgy in the training of the chemical engineer.—A. B. W.

†**Recent Advances in the Application of Chemistry to Engineering.** (Sir) Harold Hartley (*Proc. Inst. Civil Eng.*, 1933, **236**, 429–470).—The James

Forrest Lecture, 1933. The chemistry of metals is discussed in relation to the number of new metals and alloys that have become of importance in engineering, the improved methods for the purification and melting of metals and alloys, and the advance in our knowledge of metals and alloys due to the Phase Rule, metallographic, and X-ray investigations. The light alloys of aluminium and magnesium and the process of age-hardening are specially referred to.—J. D.

Chemistry and Art. Colin G. Fink (*Indust. and Eng. Chem.*, 1934, **26**, 234–238).—Methods for the preservation of objects of art in museums are described. Bronze articles are restored by reversing the electro-chemical action whereby natural corrosion functions, the products of corrosion being reduced back to metal. Two methods are described whereby copper can be plated with antimony and it is suggested that one of these was used by the Egyptians. In method 1, a solution of " natron " and antimony sulphide is brought to boiling and bright copper articles are immersed in it. In method 2, the copper articles, held in contact with iron, are immersed in a solution of sodium chloride and antimony oxide in vinegar. The prevention of " bronze disease " and the preservation of metal articles so as to obviate frequent cleaning are also described.—F. J.

XXIII.—BIBLIOGRAPHY

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***Periodicals.** *A World List of Periodicals Published in the Years 1900–1933.* Second Edition. Pp. 780. 1934. Oxford: University Press; London: Humphrey Milford. (63*s.* net.)

Pewsner, R. L. *Refractory Materials in Metallurgy.* [In Russian.] Pp. 256. 1933. Moscow, Leningrad, and Swerdlowsk: Metallurgisdat. (Rbl. 3.20.)

***Research.** *The Control of Industrial Research.* 4to. [Mimeographed.] Pp. 31, with 4 illustrations. 1934. New York: Policyholders Service Bureau, Group Insurance Division, Metropolitan Life Insurance Co.

Shelobow, J. S. *Fundamentals of Hot-Working of Metals.* [In Russian.] Pp. 104, 1933. Gorki: Gorki Krajew. isd. (Rbl. 2.10.)

Steinberg, S. S. *Metallurgy.* [In Russian.] Part II. Pp. ii + 333. 1933. Swerdlowsk, Moscow, and Leningrad: Metallurgisdat. (Rbl. 4.50.)

Tscheljustkin, A. N. *The Theory of Cutting.* [In Russian.] Second, revised edition. Pp. ii + 270. 1933. Leningrad and Moscow: Gosmaschmetisdat. (Rbl. 3.)

***Wol, A. E.** *Zinc and Its Alloys.* [In Russian.] Edited by M. Slavinsky. 5 in. × 7½ in. Pp. 260 + 104 pp. illustrations. 1933. Moscow and Leningrad: Standardisatija i rationalisatija. (Rbl. 6.)

XXIV.—BOOK REVIEWS

(Continued from pp. 402–408.)

The Hardness of Metals and Its Measurement. By Hugh O'Neill. Roy. 8vo. Pp. xiv + 292, with 119 illustrations. 1934. London: Chapman & Hall, Ltd. (25*s*. net.)

Dr. O'Neill's own researches on hardness of metals and its measurement are so well known to metallurgists that it is not in the least surprising that he is the author of the first comprehensive book on the subject which has been published in this country. All those immediately interested in the hardness and plasticity of metals should feel indebted to Dr. O'Neill for undertaking this task, for he has examined in detail practically every publication on the subject of indentation hardness of metals and gathered together the results in a convenient form. Furthermore, he has treated the subject on a broad basis, since, in addition to detailed descriptions of the features of recognized hardness tests and the apparatus used in such work, matters such as the relation of hardness to deformation and strain-hardening, the crystallinity of metals and its bearing on hardness, alloying and heat-treatment as related to hardness, are considered in considerable detail. These subjects are treated in an able manner, and the book will undoubtedly be of value not only to students, but also to the many practising metallurgists and engineers who have neither the time nor the opportunity to consult the voluminous scattered literature of the original publications.

Possibly the insistence on the great value of Meyer's index "n" in the ball hardness tests is overdone in one or two sections, and the more or less unavoidable multitude of symbols used in the book becomes a little wearisome at times; it must also be admitted that the final chapter, on abrasion, machinability, and cutting hardness, is scarcely up to the standard of the earlier chapters on indentation hardness and its related subjects. In general, however, the author must be congratulated on the production of a treatise which has long been wanted on a peculiarly difficult subject.—G. A. HANKINS.

Praktische Metallkunde. Schmelzen und Giessen, Spanlose Formung, Wärmebehandlung. Zweiter Teil: **Spanlose Formung.** Von Georg Sachs. Med. 8vo. Pp. viii + 238, with 275 illustrations. 1934. Berlin: Julius Springer. (R.M. 18.50.)

This book is of outstanding value to anyone interested in the working of metals, and the author is to be congratulated on the clear and concise manner in which he has presented the many aspects of the subject. There are three main headings—General Rules Governing Deformation, Stresses in Deformed Metals, and Manufacturing Processes involving Deformation. Slightly more than half the book of 230 pages is devoted to the general principles involved, subheadings of this section being Cold-Working, Annealing and Heat-Treatment, Hot-Working, and the Mechanics of Deformation Processes, under which detailed information is given in short chapters, each dealing with some specific aspect of the subject. These short chapters, often not more than a couple of pages in length, are models of clear presentation, there being many graphs and illustrations to help the reader. What is more important and valuable are the numerous references to original papers given as footnotes. These references will be considered by many as the most valuable feature of the book, Dr. Sachs' text serving as a delightful frame to the original work of others. The book is a veritable small encyclopædia, excellently arranged, well printed and illustrated, and all metallurgists owe much to the author for the service he has rendered them. Looked at in another way, the book serves as an index to all important literature on the subject, and it is interesting to note the numerous references to papers that have appeared in the *Journal* of the Institute of Metals. No review can possibly do justice to this book, which must be read fully to appreciate its value.—H. W. BROWNSDON.

Nichteisenmetalle. Zweiter Teil: **Leichtmetalle.** Von R. Hinzmann. (Werkstattsbücher für Betriebsbeamte, Konstrukteure und Facharbeiter. Herausgeber Eugen Simon. Heft 53.) Med. 8vo. Pp. 59, with 34 illustrations. 1934. Berlin: Julius Springer. (R.M. 2.)

This is one of a series of small handbooks intended rather as reference books for engineers than as text-books of value to metallurgists. Those of the latter. however, who specialize in other branches may find this booklet useful as an up-to-date summary of the technology of aluminium and magnesium alloys. Physical and chemical properties of the metals and most of the useful alloys are given. Brief, but remarkably comprehensive information is to be found on corrosion-resistance, casting, working, machining, soldering, welding, and surface treatment. The composition and physical properties of almost all the well-known light alloys are tabulated in the last 9 pages. An omission is the R.R. group of alloys.—H. W. G. HIGNETT.

Elektrische Schmelzöfen. Von Rudolf Taussig. Imp. 8vo. Pp. vi + 241, with 214 illustrations. 1933. Wien: Julius Springer. (Geh., R.M. 39; geb., R.M. 40.50.)

Dr. Taussig has compiled an interesting and authoritative book on electric smelting and melting furnaces in which the construction of modern arc furnace plant is very ably and comprehensively described. The book will be of more value, however, to the furnace designer and to the student seeking a fundamental and complete knowledge of the subject than to the furnace user or works metallurgist.

The book begins with an interesting review of the chemical and physical characteristics of the components of charges, slags, and also of the actual furnaces, more particularly with reference to smelting furnaces for iron, ferro-alloys, and carbide. This data will be invaluable as an aid to the calculation of charges and furnace efficiencies. The theory of arc furnaces and their electrical characteristics are then dealt with in considerable detail, after which the design of transformers, various forms of electrodes, and other auxiliary equipment, is described in an exhaustive manner, possibly to the exclusion of more relevant matter pertaining to the operation of this type of plant.

All types of arc furnaces, especially those used for smelting processes, which are of little other than academic interest to metallurgists in Great Britain, are treated at some length in so far as their mechanical and electrical features are concerned.

Normal frequency induction furnaces employing a vertical secondary channel, which are so widely used in the wrought-brass industry, are given but scant attention, 4 pages being sufficient to describe an appliance which is responsible for probably 90 per cent. of the world's output of rolled and extruded brass. High-frequency or coreless induction furnaces, which are finding an increasing application for the melting of special steels, nickel alloys, and for accurate research work, receive little better treatment, some 12 pages being accorded to a consideration of their development.

This is an excellent reference book, written by an experienced engineer fully conversant with the design and construction of arc furnaces, but it contains little material which will be of service to the user or producer of non-ferrous metals. The book would have had a much wider appeal had it embodied complete information on the processes and operations conducted in the furnaces which Dr. Taussig has so admirably illustrated and described.—A. G. Robiette.

Engineering Radiography. By V. E. Pullin. 4to. Pp. vii + 136, with numerous illustrations. 1934. London: G. Bell and Sons, Ltd. (45*s.*)

This monograph deals with the inspection of steel structures, cast, forged, or welded, by means of the X-rays and radium. It is divided into six chapters, concerning (1) radiographic examination in general, (2) types of apparatus used and recommended, (3) radiographic technique, (4) a very valuable chapter on the interpretation of radiographs, (5) radiographs of welds, and (6) radiography by radium—this final chapter being the reproduction of a paper read before the Institution of Mechanical Engineers.

The first three chapters are brief, and the author soon comes to the main theme of the book, namely the interpretation of engineering radiographs. This chapter, occupying about 70 pages, is copiously illustrated, and we have unfolded before us the X-ray appearances of "cracks, pipes, voids and light inclusions, folds, remains of chaplets with associated voids and inclusions, and surface irregularities." This book should be of great value to all those entrusted with the reading of radiographs of iron and steel structures. The method of differentiating between a "pipe" and a crack is very instructive.

The chapter on the X-ray examination of welds includes a magnetic method for the examination of welded structures.

The chapter on radiography by radium contains some excellent pictures contrasting the type of picture obtained through the use of X-rays with that obtained by the use of radium. The author shows that X-radiation is superior to gamma radiation for thicknesses up to 3 in. of steel, but after this thickness and with irregular objects radium is of special value. The whole work has been carried out on art paper, and the illustrations are therefore of the highest degree of clarity obtainable by modern methods of printing and block-making.

—N. C. Hypher.

Industrial Radiography. By Ancel St. John and Herbert R. Isenburger. Med. 8vo. Pp. ix + 232, with 70 illustrations in the text and 6 charts. 1934. New York: John Wiley and Sons, Inc. ($ 3.50); London: Chapman and Hall, Ltd. (21*s.* 6*d.* net.)

This valuable book is a survey of X-ray applications in industry made by persons who are not merely experts in the physics of X-rays, but also practising radiologists. One obtains here a thorough and understandable introduction to the science of X-rays and its practical application to industrial problems. The authors take great pains to express themselves clearly and in ample detail—a very difficult matter in our " technically " overburdened age. This book can be cordially recommended to the industrial research worker coming face to face with X-ray inspection and desirous of knowing " what it all means " and " how it is done."

Each chapter forms the subject-matter of a definite essay, and the titles indicate what an extensive field has been covered; for instance, we have, " The Infancy of Radiography," " The Early Years of Radiography," " The Present Status of Industrial Radiography," " The Nature and Properties of X-rays," and so on. Practically every phase of industrial radiography is dealt with until we come to the now inevitable chapter on " Radiography by Gamma-rays." The authors have skimped nothing, and have provided us with a first-class text-book which is second to none.

At the end of the work there is provided a comprehensive bibliography, which should be of great value in directing the research worker to papers and published works on special subjects. —N. C. HYPHER.

Deutsch–Englisches Fachwörterbuch der Metallurgie. Von Henry Freeman. **Erster Teil: Deutsch–Englisch.** 327 pp. 1933. **English–German Dictionary for Metallurgists.** By Henry Freeman. **Part II: English–German.** 347 pp. 1934. Leipzig: Otto Spamer Verlag G.m.b.H. (R.M. 25 per volume.)

The scope of these valuable dictionaries covers the following subjects: ores, fuels, refractories, blast-furnace smelting of ores, manufacture and working of steel and non-ferrous metals and alloys, testing of materials, economics of metallurgical operations. In addition, there are an extensive series of conversion tables from the metric into the English systems of weights and measures, and a list of engineering letter symbols and abbreviations.

The vocabularies are, on the whole, extraordinarily good, and comprise a far wider range of words than we have yet seen in any pocket English–German dictionary. The number of non-technical words included has been kept at a minimum, in order to allow of the inclusion of a large number of compound technical words and phrases without making the books unwieldy. The names of chemical compounds and minerals cover all that are likely to be required, and, broadly speaking, the translations of these follow the generally accepted nomenclature, although some deviations have been noticed. Metallurgical terms are well represented and engineering terms are extremely numerous, so that the books should prove as useful to the engineer as to the metallurgist and chemist. A few of the English terms are strange to the reviewer, but this may possibly be due to their being confined to local use or to a subject with which he is unfamiliar. Taken together, the books can be thoroughly recommended to all who have to make translations from English into German (or *vice versa*) of books or articles of a metallurgical or engineering nature. The printing, paper, and general arrangement are all that can be desired of books to which constant reference has to be made. It is unfortunate that the price of each volume (nearly £2 at the present rate of exchange) is so high as to preclude the possibility of large sales in this country.—A. R. POWELL.

Association Internationale pour l'Essai des Matériaux. (International Association for Testing Materials.) Congrès de Zürich, 6–12 Septembre 1931. Tome I, pp. xviii + 1213. Tome II, pp. xviii + 707. 1932. Zürich: Editions A.I.E.M., 27, Leonhardstrasse.

These two handsome volumes contain a complete account of the proceedings of the Association at the Congress in Zürich, including all the papers read and the discussions that took place at the meeting. The Congress covered a very wide field of constructional materials, including metals, natural building stone, cement, concrete, ferro-concrete, asphalt, and bitumen, timber, resins and other organic materials. Sections of the Congress were also concerned with the testing of fuels, the measurement of particle size in loose materials, and the design and calibration of testing machines. Among the subjects discussed by the metals section were the testing of cast iron, the strength of materials at high temperature, fatigue of metals, the notched-bar impact test, and the progress of metallography, 33 papers in all being presented to this section out of 80 presented to the entire Congress.

The papers and discussions (of which abstracts have been published in *J. Inst. Metals* during the last two years) are printed in English, French, or German. The authors of the various papers are all well-known authorities on the subjects which they discuss, so that the reader is presented with an up-to-date review of the present position and trend of the important subject of material testing in all its various aspects.

The books are beautifully printed in a large clear type on excellent paper, the illustrations are reproduced in a manner which leaves nothing to be desired, and the number of misprints noticed are remarkably few considering the diversity of the subject matter and language. The editor and publisher are to be congratulated on such a splendid production, which should be in the hands of all interested in any way in the testing of materials.—A. R. POWELL.

Thermionic Emission. By Arnold L. Reimann. Med. 8vo. Pp. xi + 324, with 64 illustrations. 1934. London: Chapman & Hall, Ltd. (21*s.* net.)

The subject of thermionic emission, *i.e.*, the emission of charged particles from heated bodies, has made tremendous progress during the last fifteen years or so. On the practical side this development is largely due to the employment of modern high-vacuum technique; on the theoretical side development is attributable to the replacement of the classical theory of electrons in metals by quantum statistics and the application of the wave-mechanical theory of the transmission of electrons through potential barriers. This book is eminently successful in meeting the demand for a comprehensive work dealing with the older and more recent developments. The author, a member of the research staff of the General Electric Co., has had access to a considerable amount of work on the subject, hitherto unpublished, carried out in the laboratories of that Company; the value of the book is considerably enhanced by the present publication of such work relating to emission of electrons from thin films of barium and oxygen adsorbed on tungsten. The book includes sections devoted to a general survey of the subject, the emission of electrons and positive ions from clean and contaminated metals, and the modern general theory of electron emission. A fair balance is maintained in the treatments of the theoretical and practical aspects of the various topics. In general, theoretical results are stated without being actually derived. This, I think, is a good point, and should commend the work to those who find modern mathematical physics beyond their grasp. The book will probably be a standard work on the subject for some time. It is well printed on good paper, and is altogether a good production. Its price is reasonable. I recommend it to the attention of all students of advanced physics.—J. S. G. Thomas.

Book of A.S.T.M. Standards. Issued Triennially. Med. 8vo. Part I.—Metals. Pp. xx + 1002, illustrated. Part II.—Non-Metallic Materials. Pp. xxvii + 1298, illustrated. 1933. Philadelphia, Pa.: American Society for Testing Materials, 260 South Broad Street. (Cloth, $7.50; half-leather, $9.00, per part.)

The American Society for Testing Materials' "Book of A.S.T.M. Standards," a triennial publication containing all of the standard specifications, methods of test, recommended practices, and definitions formally adopted by the Society, is composed of two parts—Part I covering metallic materials, and Part II non-metallic materials. The two parts aggregate 2300 pages. A complete subject index is included, together with two tables of contents, one listing standards by the materials covered, the other in order of numeric sequence of the designations, which greatly facilitate the use of the book.

Of the 185 standards in Part I on Metals, 104 cover the ferrous metals, steel, wrought iron, pig iron and iron castings, and ferro-alloys, whilst 70 relate to non-ferrous materials, and are grouped according to the following classifications: aluminium and magnesium alloys; copper and copper alloys (copper ingot; brass and bronze; copper and brass plates, tubes, rods, &c.; copper wire and cable); lead; nickel; solder metal; white metal (bearing metal); zinc; deoxidizers; electrical-heating and electrical-resistance alloys. Eleven of the standards involve metallography and general testing methods.

Other standards in Part I cover grain-size for classification of steels, metallographic testing of steel and of non-ferrous metals and alloys, thermal analysis of steel, radiographic testing of metal castings, Brinell hardness testing and tension testing of metallic materials, and definitions of terms relating to (1) metallography, (2) methods of testing, and (3) specific gravity. During 1933 many new standards were adopted relating to widely used materials. In Part I, the following non-ferrous materials are covered by new specifications: fire-refined copper other than Lake; silver solders (chemical analysis); electrical-resistance alloys (accelerated life test, test for thermo-electric power); seamless copper tubing, copper water tube; also the following zinc-coated (galvanized) iron or steel products: telephone and telegraph line wire, tie wires, wire strand (cable), and chain-link fence fabric.

Revisions in some 40 of the existing standards covering metallic products were adopted during 1933. Materials covered by these standards include: zinc (hot-galvanized) coatings on structural steel shapes; zinc-coated articles (determining weight of coating); slab zinc spelter; brass pipe (standard sizes); sheet high brass.

The volumes are produced in that excellent manner which we have now come to expect from the A.S.T.M. The publication of the standards in volume form is a most convenient method, and one which all standardizing bodies might adopt with advantage.