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METALLURGICAL ABSTRACTS

APRIL, 1935

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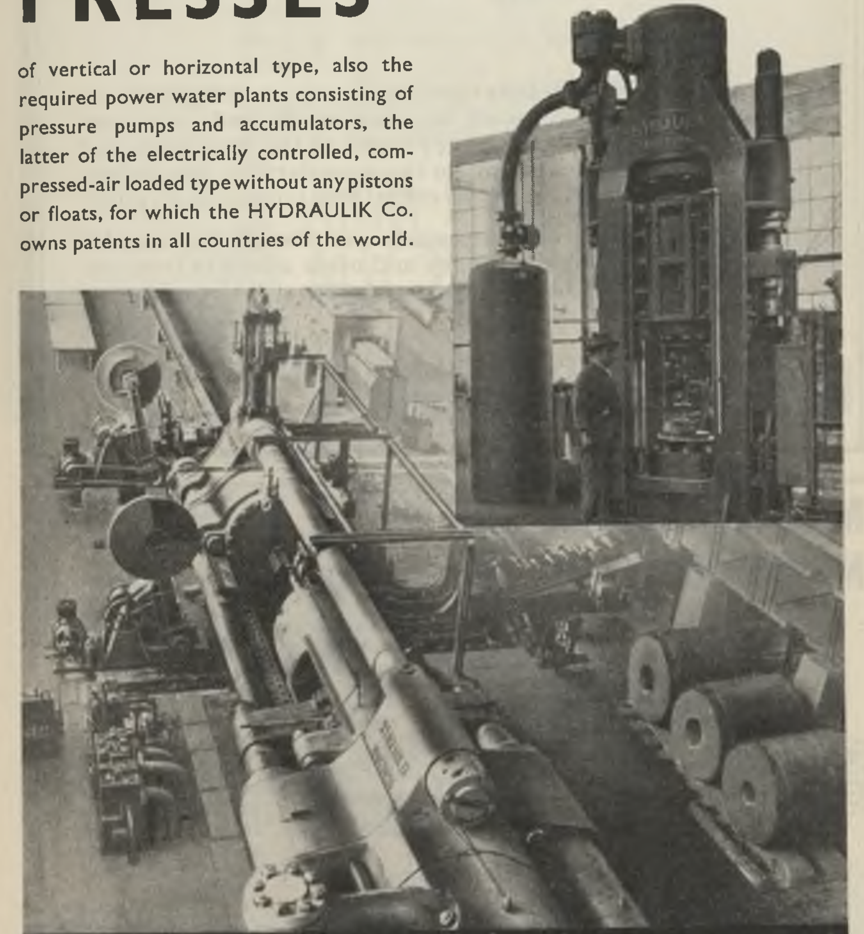

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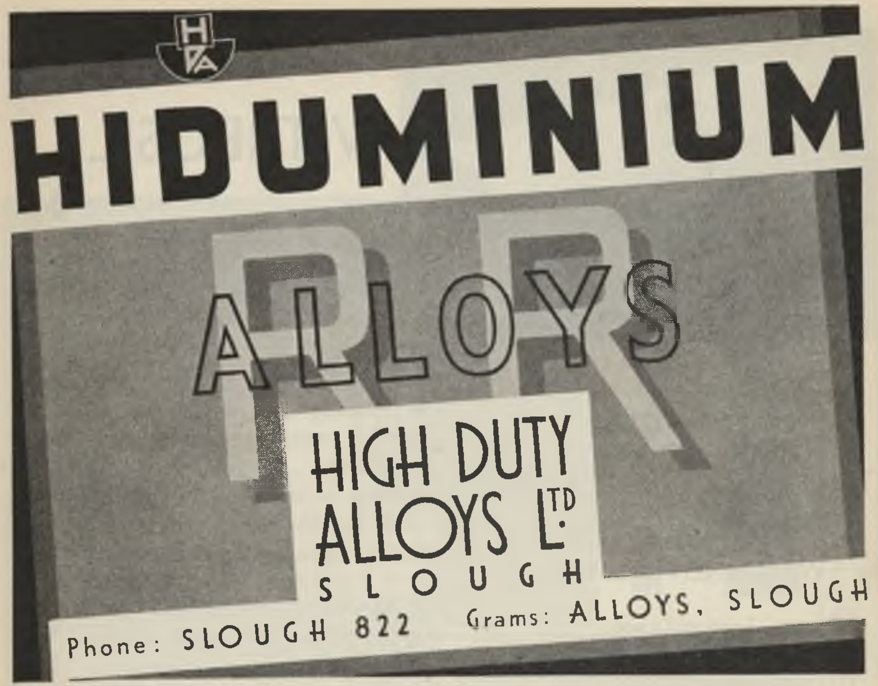

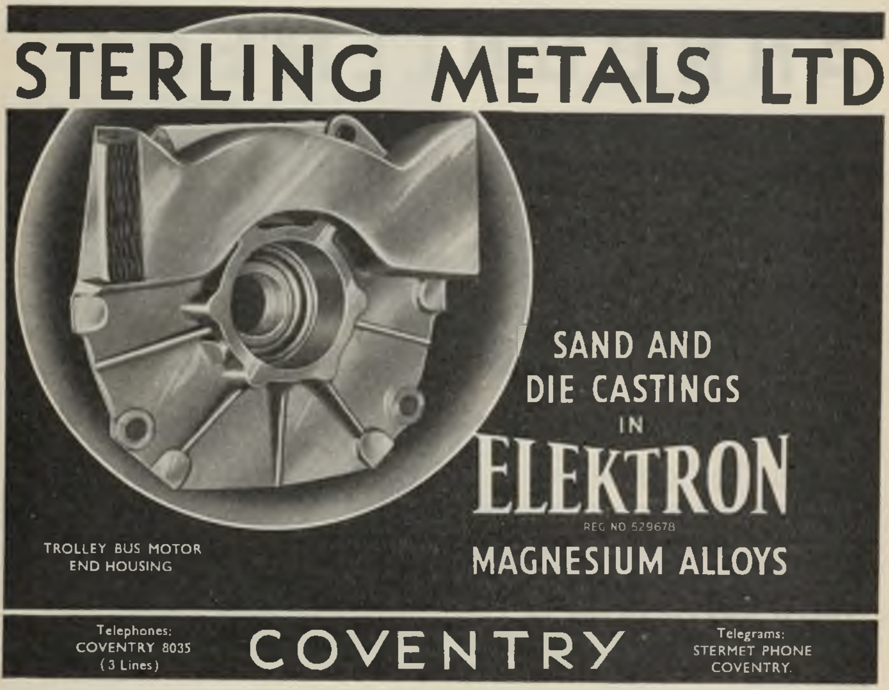

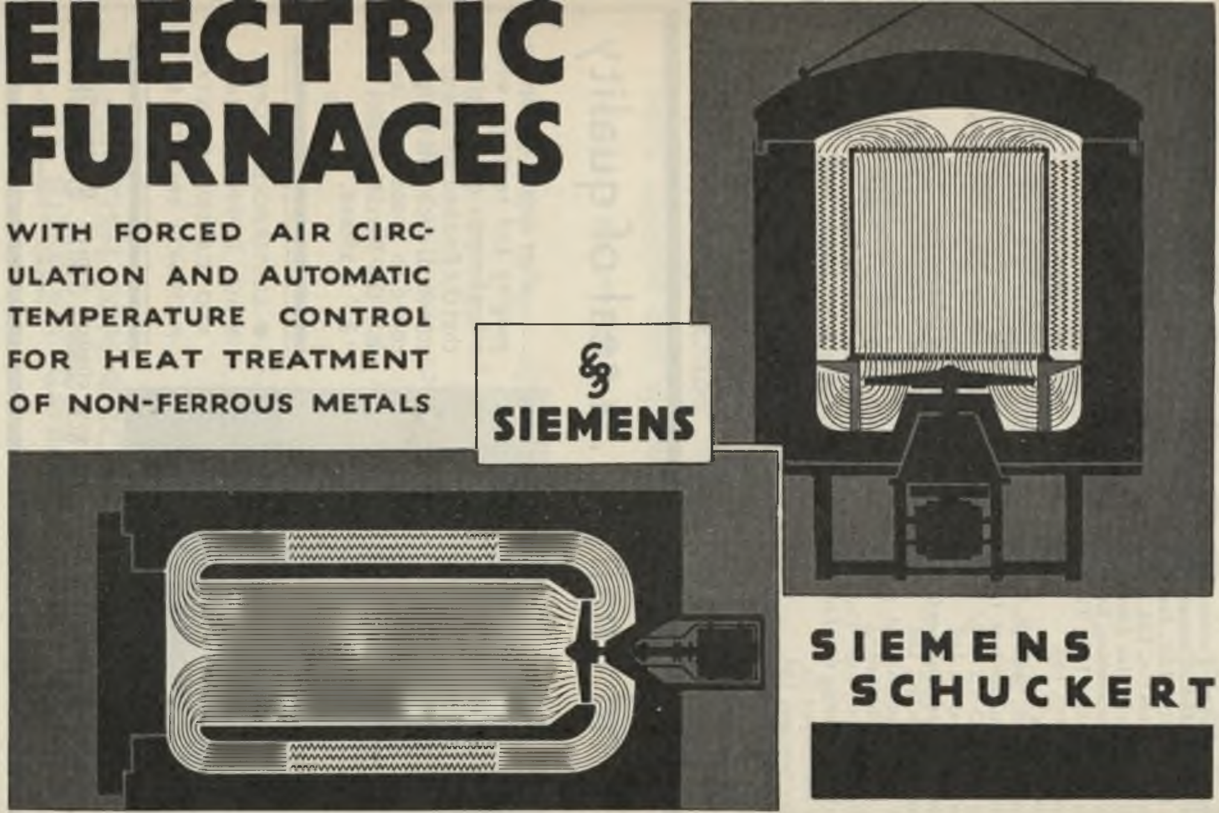

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METALLURGICAL ABSTRACTS

The monthly issue of *Metallurgical Abstracts* may be cut up for card indexes, as members will receive early in 1936 the year's abstracts in bound form.

INSTITUTE NEWS AND ANNOUNCEMENTS

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H. B. WEEKS.

Educational Tour to Germany.

The Institute's second annual Educational Tour is now nearing completion. The party of 40 student members and others left London for Germany on April 7, and is due to return on April 16. In the meantime the party has visited many works and educational institutions in the Rhineland and has had opportunities to meet German students. An account of the tour will appear in our next issue.

Easter Holidays.

The offices and library of the Institute will be closed at 5.30 p.m. on Thursday, April 18, and will re-open at 9.30 a.m. on Tuesday, April 23.

May Lecture.

The Annual May Lecture is to be given in the Hall of the Institution of Mechanical Engineers, Storey's Gate, Westminster, S.W.1 (by courtesy of the Council of the Institution), on Wednesday, May 8, at 8 p.m., by Professor W. L. Bragg, F.R.S., on "Atomic Arrangements in Metals and Alloys." Light refreshments will be provided at the conclusion of the lecture.

The Lecture will be published in the June volume of the *Journal* (Volume LVI).

Visitors are specially invited to the Lecture. A card of invitation, for the use of a visitor, is enclosed with this issue of the *Monthly Journal*. Additional cards can be obtained on application to the Secretary.

Autumn Meeting.

The Annual Autumn Meeting will be held in Newcastle-upon-Tyne from Monday, September 9, to Thursday, September 12. Several papers have already been received, and their publication begins in this month's issue of the *Monthly Journal*. Between April and August there will be printed in the *Monthly Journal* all the papers that are accepted by the Council for discussion at the Autumn Meeting.

Election of Members.

Applications for membership of the Institute will be considered by the Council at a meeting to be held on

THE INSTITUTE'S LIBRARY

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

Encyclopædia Britannica (latest issue).

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

"Brass World." Volumes 2–6.

Metallurgical and Chemical Engineering (Chemical and Metallurgical Engineering). Volumes 12–14; Volume 15, Nos. 1–8, 10–12; Volume 16, Nos. 1, 2, 4; Volume 17, No. 6; Volume 18, No. 1; Volume 21, No. 11.

Mineral Industry. Issues since 1932 (incl.)

Foundry Trade Journal. Volumes 1–25.

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

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

Metal Industry (London). Volumes 1–4.

Metallwirtschaft. Volumes 1–5.

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

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

Revue de Métallurgie. Volume 1.

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

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

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

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

NOTE ON THE EFFECT OF INTERRUPTED STRAINING ON THE ELONGATION OF LEAD.*

By J. C. CHASTON,† B.Sc., A.R.S.M., MEMBER.

SYNOPSIS.

It has been found that by interrupting a tensile test on commercially pure lead at intervals, during which the specimen is allowed to rest for a short time free from stress, abnormally high values of elongation are produced. These may be as much as five times those obtained in a normal tensile test. The influence on the elongation of the duration of the rest period, the rate of straining, the amount of elongation between successive rest periods, and the grain-size have been studied by tests on extruded cable-sheath samples. Abnormal elongations are not produced by interrupted straining on "hardened" lead alloys at room temperature, but it is suggested that such effects may be obtained in these and any other metals and alloys if they are tested above their recrystallization temperatures. The observations recorded may thus have a bearing in connection with high-temperature metallurgical research.

THE object of this note is to direct attention to the unusual behaviour of commercially pure lead when a tensile test is interrupted at intervals, *i.e.* when the specimen is stretched only part of the way to fracture and then allowed to rest free from stress for a short period before continuing with the test by similar steps. In these conditions, it is found that a specimen will elongate before fracture by an abnormally high amount, which may be as much as five times that observed under normal continuous testing conditions.

The effect is illustrated in Fig. 1 (Plate I), which shows the appearance after fracture of two solid lead specimens tested at the same pulling speed (2·1 in./in./minute), the one having been stretched steadily and continuously, and the other stretched in increments of 0·65 in. at a time and allowed to rest free from stress for 5 minutes between each stage of straining. The parallel portions of the test-pieces were originally 5 in. long and 0·75 in. in diameter. The elongations measured after fracture on the central 4 in. of each were 65 and 318 per cent., respectively.

A preliminary study of this effect has been carried out, using simple

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* Manuscript received March 4, 1935.

† Metallurgist, Standard Telephones and Cables, Ltd., North Woolwich.

Note to Abstractors and Other Readers.—This paper will be published, in permanent form, in the *Journal of the Institute of Metals*, Vol. LVII, 1935. Reference should accordingly be as follows: *J. Inst. Metals*, 1935, 57 (Advance copy).

test-pieces cut from extruded cable sheath having an outside diameter of 1 in. and a wall-thickness of $\frac{1}{8}$ in. The sheath was extruded in straight lengths from virgin refined lead, the principal impurities in which were kindly determined spectroscopically by Mr. D. M. Smith, A.R.C.S., B.Sc., D.I.C., of the British Non-Ferrous Metals Research Association, to be as follows :

	Per Cent.
Antimony	less than 0·002
Copper	0·001
Bismuth	0·025
Cadmium	0·005
Silver	0·001
Tin	less than 0·002

Specimens were cut with a length of 9 in., marked off at intervals of 0·5 in., closed at each end with slightly tapered steel plugs 2 in. long, and tested in a Buckton machine, using an initial jaw separation of 5 in. After each extension, the machine was run back for about 0·1 in. to release the load.

Some typical fractures are illustrated in Fig. 2 (Plate II). For the purposes of comparison, the percentage extension on a gauge-length of 4 in. has been chosen as a numerical index of elongation. This appears likely to be less influenced by such factors as multiple necking than the more usual value calculated on a length of $4\sqrt{A}$, which is 2·5 in. on these samples. The results obtained in this way are plotted in Figs. 3, 4, and 5, and demonstrate the relation between elongation and duration of rest period, rate of straining, and amount of extension at each application of strain, respectively.

INFLUENCE OF TIME OF REST.

From Fig. 3 it will be seen that whereas even short periods of rest of from 30 seconds to 4 minutes result in a definite small increase in elongation, there is a remarkable increase when the specimens are rested for more than about 4 minutes under the test conditions considered, *i.e.* when elongating in steps of 13 per cent. of the original length at a rate of 2·1 in./in./minute.

INFLUENCE OF TESTING SPEED.

From Fig. 4 it appears that, other conditions being fixed, a fast speed of pulling results in greater elongation than a slow speed. This is directly opposed to the effect of speed in a normal continuous test. In explanation, it seems possible that at the higher speeds the stress in the test-piece tends to be more uniformly distributed, and that the resting period intervenes before any pronounced local necking occurs.

PLATE I.

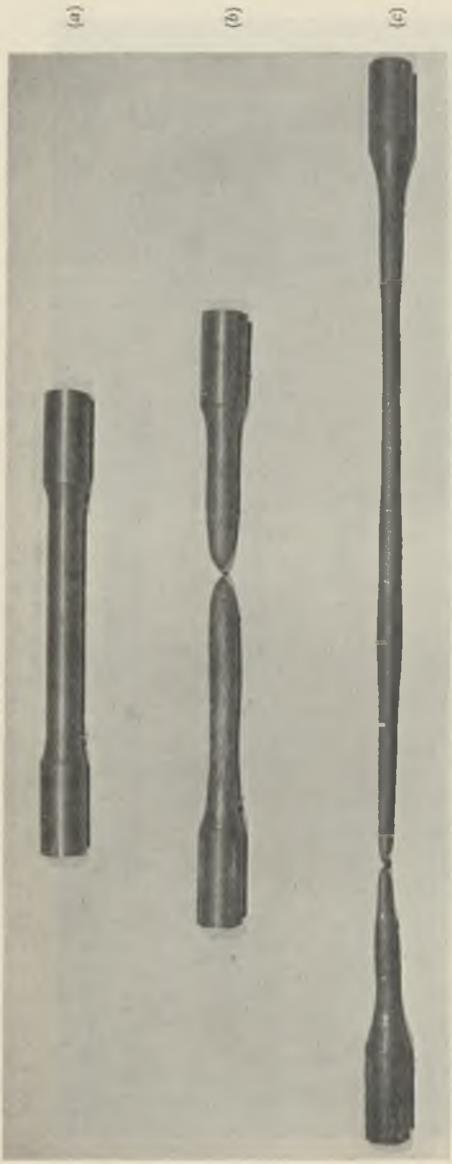


FIG. 1.—Elongation of Solid Lead Tensile Specimens after Continuous and Interrupted Straining.

(*a*) Sample before Testing; (*b*) After Normal Continuous Test at Steady Speed of 2·1 in./in./minute; (*c*) After Interrupted Test with Elongations of 13% at Same Speed with Intervening Rest Periods of 5 Minutes.

PLATE II.

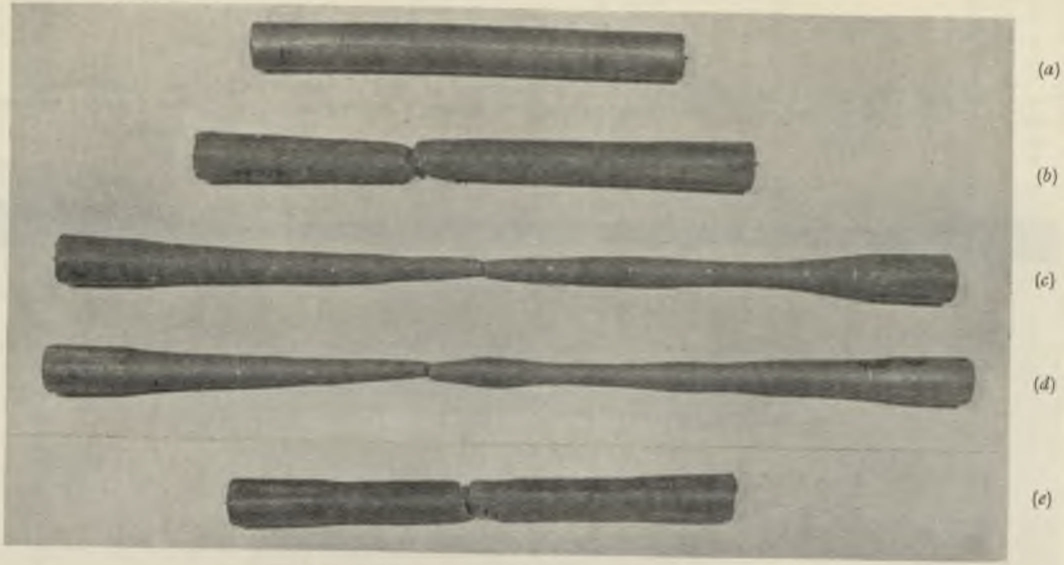
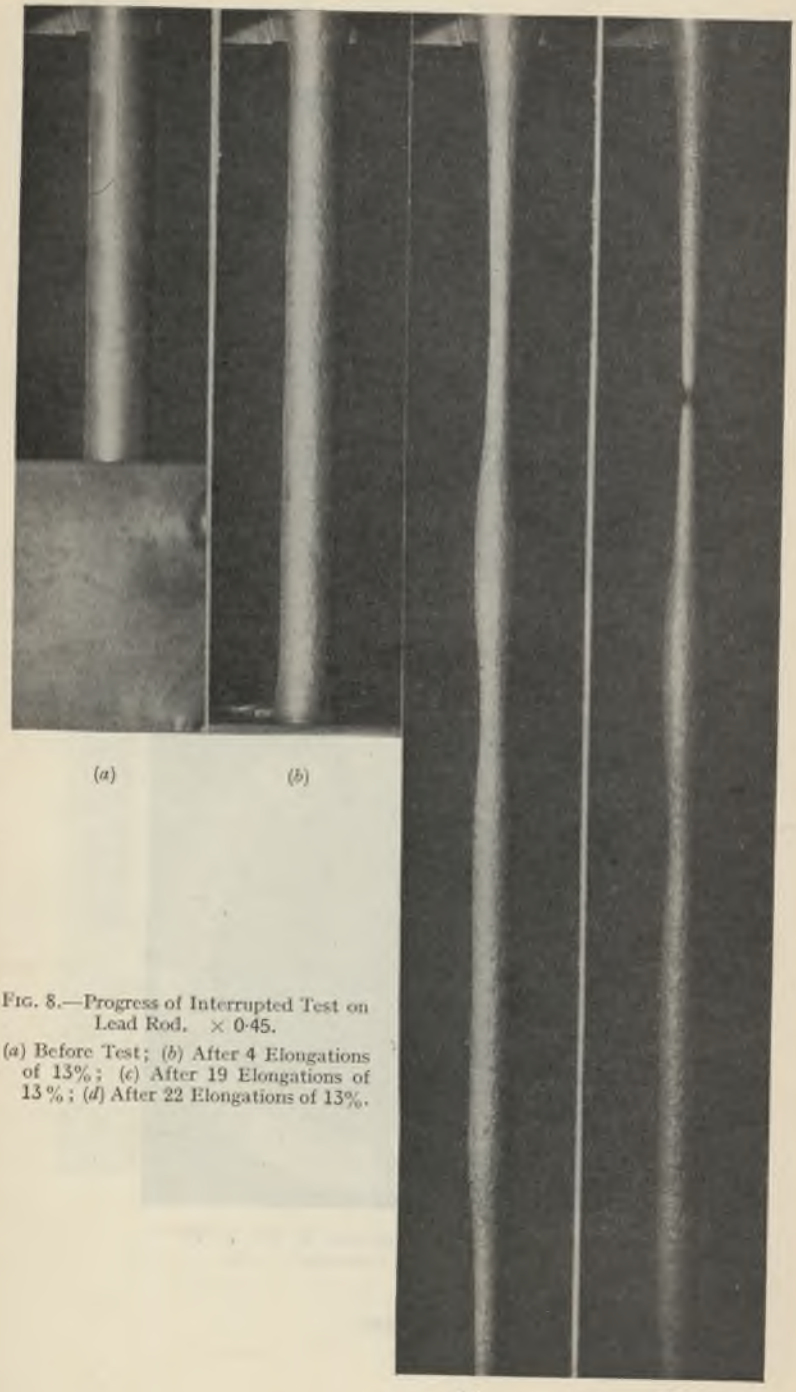


FIG. 2.—Elongation of Sheath Specimens.

(*a*) Before Testing; (*b*) Lead, After Normal Continuous Test at Steady Speed of 2·1 in./in./minute; (*c*) Lead, After Interrupted Test with Elongations of 13% at Same Speed with Rest Periods of 5 Minutes; (*d*) Lead Containing 0·05% Antimony, After Similar Interrupted Test; (*e*) Lead Annealed 20 Hrs. at 250° C., After Similar Interrupted Test.

FIG. 6.—Lead Sheath used in Tests Recorded in Figs. 3–5. Section Showing Grain-Size. × 2½.

FIG. 7.—Lead Sheath Annealed 20 Hrs. at 250° C. Section Showing Grain-Size. × 2½.



(*a*) (*b*) (*c*) (*d*)

FIG. 8.—Progress of Interrupted Test on Lead Rod. × 0·45.

(*a*) Before Test; (*b*) After 4 Elongations of 13%; (*c*) After 19 Elongations of 13%; (*d*) After 22 Elongations of 13%.

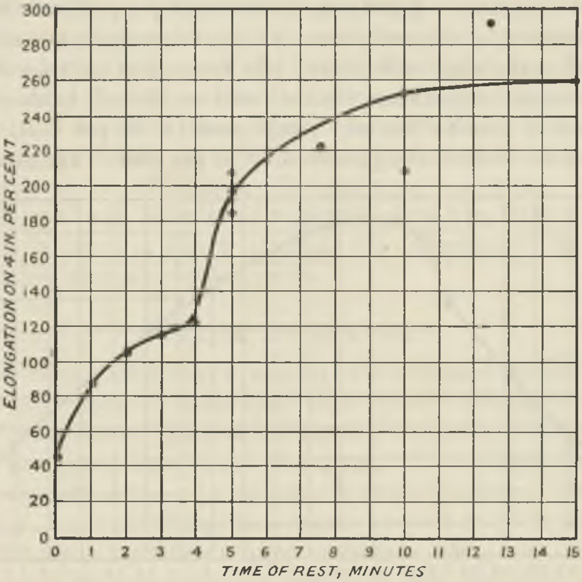


FIG. 3.—Effect of Time of Rest. Specimens Elongated in Steps of 0·65 in. (13%) at a Rate of 2·1 in./in./minute.

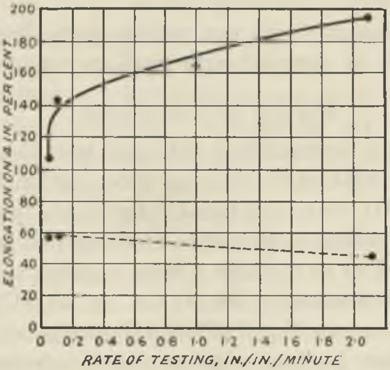


FIG. 4.—Effect of Testing Speed. Full Curve: Specimens Elongated in Steps of 0·65 in. (13%), with Rest Periods of 5 Minutes. Broken Curve: Specimens Elongated Continuously to Fracture.

INFLUENCE OF AMOUNT OF INCREMENTAL EXTENSION.

From Fig. 5, it will be seen that very short increments are not the most effective in producing high values of elongation with resting periods of 5 minutes. Extensions of about 15 per cent. of the initial length appear to be most effective. In this connection, attention may be directed to the work of Norbury,[1] who found that the time of anneal of lead at room temperature (as indicated by Brinell hardness tests) varied from 5 minutes for lead compressed by 30 per cent. to over 90 minutes for samples compressed only 15 per cent. Thus it appears possible that if sufficiently long rest periods were allowed, high values of elongation might be obtained with small incremental extensions.

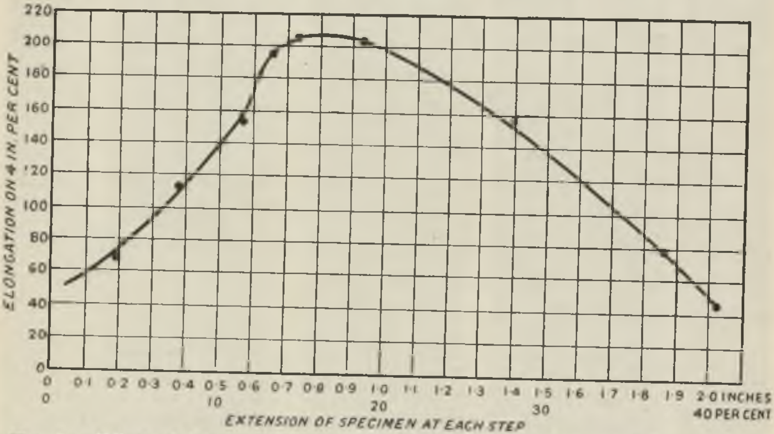


FIG. 5.—Effect of Amount of Incremental Extension. Specimens Elongated at a Rate of 2·1 in./in./minute with Rest Periods of 5 Minutes.

EFFECT OF GRAIN-SIZE.

In all the tests so far described, extruded specimens having a fairly small grain-size in relation to the total cross-sectional area, as shown in Fig. 6 (Plate III), were employed. Up to the present it has not been possible to produce large values of elongation in samples which have been annealed so as to cause a large increase in grain-size. For example, a specimen annealed for 20 hrs. at 250° C. to produce the large grain-size shown in Fig. 7 (Plate III) elongated by only 37 per cent. on 4 in. before fracture when stretched intermittently in steps of 13 per cent. of the original length with rest periods of 5 minutes. The appearance after fracture is shown in Fig. 2 (*e*) (Plate II).

EFFECT OF COMPOSITION.

Interrupted straining has only been observed to produce abnormal values of elongation with fairly pure lead. Tests on some of the common "hardened" lead alloys, including those with 0·06 per cent.

tellurium, 0·85 per cent. antimony, and 0·5 per cent. antimony plus 0·25 per cent. cadmium, have shown no abnormalities at all, the elongation values being the same as with continuous stretching. In general, it seems likely that abnormal elongation at room temperature will occur only in lead and those of its alloys which are self-annealing. Tests made on sheath extruded from one alloy containing 0·05 per cent. antimony are of interest. The grain-size was similar to that of extruded lead, and interrupted straining gave very high elongation values, as is shown in Fig. 2 (*d*) (Plate II). Presumably this alloy is self-annealing at room temperatures.

SUMMARY AND DISCUSSION.

It has been shown that a process of interrupted straining during a tensile test produces abnormally high values of elongation in pure lead. The maximum values are obtained when the specimen is rapidly strained in increments of about 15 per cent. of its original length, and allowed to rest at least 10 minutes between loadings. During the rest period, a critical change in structure appears to occur after about 4½ minutes, as indicated by a rapid increase in elongation. It appears that at room temperatures only relatively pure lead behaves in this abnormal manner under interrupted straining—the property is not shared by "hardened" lead alloys. This difference between lead and its alloys obviously may assume practical importance when their behaviour in plumbing operations or in service, in such forms as cable sheaths or water pipes, needs to be considered.

As a preliminary step towards obtaining a picture of the mechanism of elongation in these conditions, photographs were taken at intervals while testing a specimen similar to that of Fig. 1 (*c*) (Plate I). A selection of these is shown in Fig. 8 (Plate IV). The very uniform nature of the elongation in the early stages is of interest.

The photographs have been carefully examined in order to trace the changes in the surface markings during the progress of a test. No feature of significance has been noted, however, beyond a distinct formation of long flow-lines parallel to the axis. This observation admittedly throws little light on the problem, and it is with some reserve that the following suggestions are advanced. One possibility appears that the original crystals re-orient themselves during the rest periods, so that their planes of easy slip become parallel to the direction of elongation. This is conceived as being mainly a rearrangement in the original crystal grains, since from other evidence it is not believed that complete recrystallization occurs in the short rest periods considered. It is believed that such a change would produce an aggregate which would elongate uniformly and not be subject to local constrictions. Alternatively, if it were established that initial deformation in lead occurs mainly by intercrystalline slip—similar to that observed by Hanson and Wheeler [2] in aluminium under small stresses—then localized crystallization during rest periods might produce fresh crystal boundaries (mainly parallel to the original ones). On re-straining, slip would occur on the new boundaries. In this way, a considerable degree of distributed elongation might result.

Up to the present, facilities have not been available for the X-ray and microscopical work necessary to establish the mechanism of the effects described, but it is hoped that publication of this note may encourage investigation by those suitably equipped. Further, it is hoped that it may interest those engaged in high-temperature studies, since it seems possible that interrupted straining may produce abnormal elongations in other metals and alloys if carried out above their temperatures of recrystallization.

ACKNOWLEDGMENT.

The author's thanks are due to the Management of Messrs. Standard Telephones and Cables, Ltd., for permission to publish these results.

REFERENCES.

[1] A. L. Norbury, "The Hardness and Spontaneous Annealing of Lead," *Trans. Faraday Soc.*, 1923, **19**, 140–152.

[2] D. Hanson and M. A. Wheeler, "The Deformation of Metals Under Prolonged Loading. Part I.—The Flow and Fracture of Aluminium," *J. Inst. Metals*, 1931, **45**, 229–257.

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

X-RAY STUDY OF COPPER-SILVER ALLOYS.*

By Professor E. A OWEN,† M.A., D.Sc., Member, and
JOSEPH ROGERS,‡ Ph.D.

Synopsis.

The phase boundaries in the thermal diagram of copper–silver alloys have been determined by the X-ray method. A general survey showed that the phase fields were the same as those in the generally accepted diagram of the system. More detailed investigation with the precision X-ray camera yielded accurate values of the solubilities of copper and silver in each other. These values are compared with the more recently determined values, with which they are found to be in fair agreement. The solubilities of copper in silver and of silver in copper at 778° C. are found, respectively, to be 8·5 and 8·4 per cent. These solubilities decrease to 1·8 and 1·4 per cent. at 500° C., and to 0·2 and 0·1 per cent. at 200° C. The extrapolated experimental curves indicate that the one metal is almost insoluble in the other at room temperature.

The work on the copper–silver alloys to be described in this paper was completed before the end of 1930. Publication was delayed because several papers appeared dealing with the solubility of copper in silver and of silver in copper, which made it almost unnecessary to put forward the results which had been obtained, as they differed but little from those of Ageew, Hansen, and Sachs,[1] who published an account of their investigation on this alloy system just after the completion of the present work. These authors employed the X-ray method. Later Stockdale,[2] who employed the microscopic and the electrical resistance methods, published his results, which in certain details disagreed with the results of Ageew, Hansen, and Sachs. About a year later, a paper by Megaw [3] on the lattice dimensions in copper–silver alloys appeared, the conclusions of which did not decide definitely between the results of the previous workers, although they agreed more closely with the results of Stockdale than with those of the other investigators. It seemed worth while in the circumstances

* Manuscript received March 7, 1935.
† Professor of Physics, University College of North Wales, Bangor.
‡ University College of North Wales, Bangor.

Note to Abstractors and Other Readers.—This paper will be published, in permanent form, in the *Journal of the Institute of Metals*, Vol. LVII, 1935. Reference should accordingly be as follows: *J. Inst. Metals*, 1935, **57** (Advance copy).

to place on record the results which were obtained in the investigation carried out at this laboratory.

METHOD OF EXPERIMENT.

The procedure was on the lines explained in previous papers.[4, 5] Both the precision X-ray camera and the spectrum camera were used in the investigation. Particular attention was paid to the preparation of the alloys, all of which were submitted to heat-treatment in lump form before the annealing they received in powder form.

The precision camera provides a sensitive means of judging whether the material is in the equilibrium state. The lines that appear in the precision photographs are due to reflections at large glancing angles, and any irregularity in the reflecting planes such as is produced when the material has not reached its state of equilibrium, produces lines that are ill-defined. It was found that if the molten alloys were well stirred when prepared, annealing of the ingots for 14 hrs. at 750° C. sufficed to ensure uniform composition. This annealing was carried out in evacuated Pyrex tubes. The tubes at this temperature collapsed round the material, the surface of which was protected by this means from the atmosphere, and thus no oxidation occurred. After annealing, the material was allowed to cool slowly in the furnace to atmospheric temperature. Ingots produced in this way were, in general, free from blow-holes. They were chemically analyzed and numbered according to the percentage amount of copper they contained. Thus alloy 987 contained 98·7 per cent. copper and alloy 42, 4·2 per cent. copper. Initially six alloys were made, numbered 987, 898, 596, 393, 186, and 42. Powders were prepared from these by first removing the surface layer to a depth of at least 1 mm. The filings were powdered with a very fine file for the spectrum camera, a slightly coarser powder being suitable for the precision camera. These powders were annealed at 400° C. for 6 hrs. in evacuated glass tubes which, after this heat-treatment, were rapidly air-cooled.

A general survey of the structures in the alloy system was made by taking a series of spectrum photographs of all the alloys so far prepared, which extended from one end of the diagram to the other. The lines were exceedingly well defined, even to the largest glancing angles. The measurements of these photographs showed that at 400° C. there are only two phases in the system : the β-phase, consisting of a face-centred cubic lattice similar to the copper lattice, but with an increased parameter, and the α-phase, consisting of a face-centred cubic lattice similar to that of silver, but with a decreased parameter. The α and β regions are very limited in extent, and by far the greater

PLATE I.

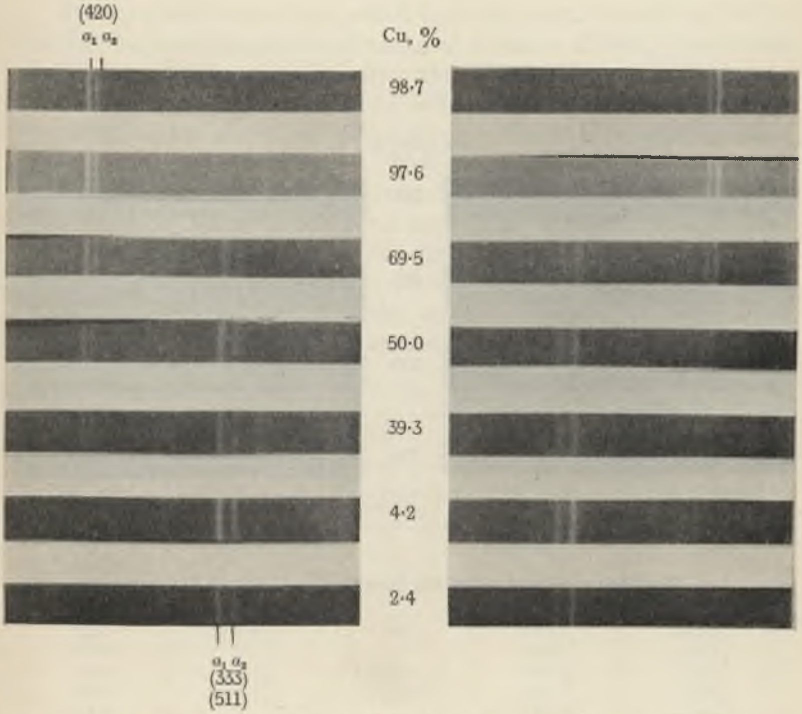

FIG. 1.—Photographs of Alloys of Different Compositions Annealed at 490° C.

PLATE II.

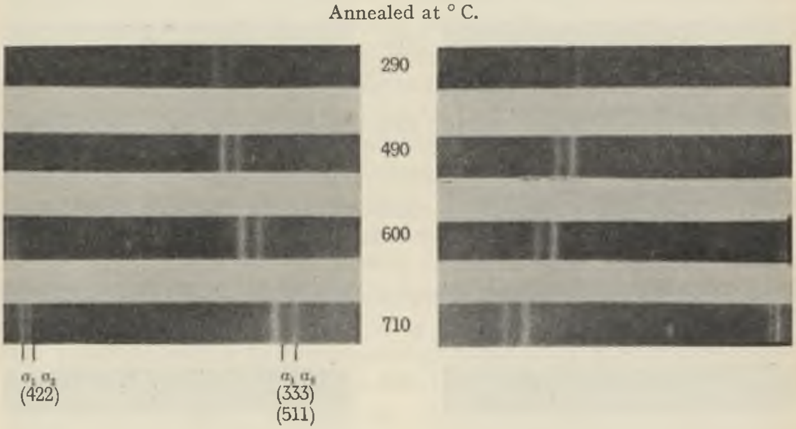

FIG. 3.—Photographs of Alloy 102 Annealed at Different Temperatures.

portion of the equilibrium diagram at this temperature consists of the duplex region (α + β). The results agreed with the thermal diagram put forward by Lepkowski,[6] but it was necessary to take a number of precision photographs before the boundaries of the α- and β-phases could be determined.

PRELIMINARY INVESTIGATION WITH THE PRECISION CAMERA.

Powders from nine alloys, which had been lump annealed at 750° C. for 14 hrs., were prepared and annealed *in vacuo* at 490° C. for 6 hrs. They were rapidly air-cooled after this treatment, as it had already been found that rapid air-cooling sufficed to retain the structure of the alloys at the annealing temperatures. The photographs obtained are shown in Fig. 1 (Plate I). Two doublets, one due to reflection from (420) planes of the copper lattice and the other due to reflection from the (333) planes of the silver lattice, are registered on each film. Each doublet is resolved, and the lines are well defined. A similar series of photographs was taken with alloys annealed at 600° C. for 6 hrs. and air-cooled. The results of the measurements of the films are shown in Table I. The parameter of alloy 987 is the same at 600° C. as at 490° C., so that this alloy is in the pure β-phase. The copper parameter for the rest of the alloys is constant at any given temperature, showing that these alloys are in the duplex (α + β) region. The silver parameters are constant for all the alloys at 490° C., but at 600° C. the value of the α-parameter in alloy 24 differs appreciably from the constant value of the α-parameters in the other alloys. The α-parameter becomes less as the temperature is increased, but the

TABLE I.

Alloy Composition. Copper, Per Cent.	Annealed at 490° C.		Annealed at 600° C.	
	Copper Parameter (β-Phase).	Silver Parameter (α-Phase).	Copper Parameter (β-Phase).	Silver Parameter (α-Phase).
100·0	$3{\cdot}607_8$	...	$3{\cdot}607_8$	...
98·7	$3{\cdot}611_8$	...	$3{\cdot}611_9$	...
97·6	$3{\cdot}612_0$	...	...	...
69·5	$3{\cdot}611_6$	$4{\cdot}067_4$	$3{\cdot}617_4$	$4{\cdot}058_2$
59·6	...	...	$3{\cdot}617_2$	$4{\cdot}057_8$
50·0	$3{\cdot}611_8$	$4{\cdot}067_3$	$3{\cdot}617_3$	$4{\cdot}057_8$
39·3	$3{\cdot}611_7$	$4{\cdot}067_8$	$3{\cdot}617_6$	$4{\cdot}058_0$
18·6	...	...	$3{\cdot}617_1$	$4{\cdot}057_8$
4·2	...	$4{\cdot}067_5$	...	$4{\cdot}058_4$
2·4	...	$4{\cdot}067_9$	...	$4{\cdot}062_9$
0·0	...	$4{\cdot}077_2$	...	$4{\cdot}077_2$

decrease in alloy 24 is not as much as it is in the other alloys. This means that at some temperature between 490° and 600° C., 2·4 per cent. of copper is soluble in silver.

Since all alloys in the duplex region have the same parameters at the same temperature, it is necessary only to investigate one alloy at different temperatures to find the parameters of the α- and β-phases corresponding to their respective boundaries. Alloy 695 was selected for this purpose, but as no silver parameter lines could be obtained with this alloy above 600° C., attention was directed in the first instance to the β-phase boundary.

DETERMINATION OF THE β-PHASE BOUNDARY.

Some difficulty was experienced in obtaining satisfactory powder specimens at the highest temperature (765° C.) at which the specimens were annealed. The powder tended to coke and, after removal from the tube in which it was annealed, it had to be broken up again. The lines on the photographs obtained with such specimens were somewhat blurred and not easy to measure. Precaution was taken, when preparing a powder specimen for annealing, to heat the container gently, whilst it was connected to the vacuum oil pump, in order to dry the powder thoroughly before sealing the tube, but in spite of these precautions the powder showed a tendency to "coke" when annealed at the highest temperature. It was desirable to avoid this effect, if possible, and experiments were conducted to find if the time of annealing could be reduced from 6 hrs. The experiments showed conclusively that annealing for ½ hr. at 490° C. was sufficient to bring the alloy into equilibrium at this temperature. To allow a margin of safety, the powdered alloy was always annealed, even at the higher temperatures, for not less than 1 hr. In this shortened period no coking of the samples took place, with the result that better photographs were obtained.

At lower temperatures the time of annealing was increased, as it was found that at these temperatures annealing for 6 hrs. was insufficient to bring the alloys into equilibrium; photographs taken of alloy 695 annealed at 307° C. for 6 hrs. and at 290° C. for 72 hrs., showed marked differences in the clearness of the lines, though the actual value of the parameter was the same in the two cases.

The results obtained with a series of specimens prepared from alloy 697 and subjected to various heat-treatments are collected in Table II.

The parameters of the two specimens annealed at 600° C., one being air-cooled and the other quenched in iced water, are the same.

TABLE II.

Annealing Temperature of Powder, ° C.	Time of Annealing, Hrs.	Remarks.	Parameter, A.
290	72	Air-cooled	$3{\cdot}608_5$
400	6	,,	$3{\cdot}609_3$
490	6	,,	$3{\cdot}611_9$
495	6	Quenched	$3{\cdot}612_2$
550	6	Air-cooled	$3{\cdot}613_9$
600	6	,,	$3{\cdot}617_4$
600	6	Quenched	$3{\cdot}617_1$
700	1	,,	$3{\cdot}625_2$
765	2	,,	$3{\cdot}633_0$

Thus, the cooling of these powder samples in air is rapid enough to retain the condition of equilibrium obtaining at the annealing temperature.

It is now necessary to find the relation between composition and parameter. For this purpose four alloys, containing, respectively, 98·7, 97·6, 95·6, and 93·1 per cent. copper, were examined at different temperatures. The measurements of the photographs yielded the results summarized in Table III.

TABLE III.

Alloy.	Annealing Temperature of Powder, ° C.	Time of Annealing, Hrs.	Remarks.	Parameter, A.
987	490	6	Air-cooled	$3{\cdot}611_8$
	600	6	,,	$3{\cdot}611_8$
	700	1	Quenched	$3{\cdot}611_9$
	765	1	,,	$3{\cdot}611_9$
976	470	6	Air-cooled	$3{\cdot}611_1$
	590	6	,,	$3{\cdot}615_0$
	660	6	,,	$3{\cdot}615_1$
	710	1	Quenched	$3{\cdot}615_1$
956	763	4	Quenched	$3{\cdot}622_7$
931	763	4	Quenched	$3{\cdot}629_8$

The annealing temperatures and parameters shown in Tables II and III are plotted in Fig. 2 (*a*). When the alloys show a constant parameter at different temperatures, they are in the pure phase at these temperatures, and the intersections of the horizontal lines with the curve showing the relation between temperature and parameter for alloy 695 give the temperatures at which the alloys enter the pure phase. From Fig. 2 (*a*), the relation between parameter and composition shown in Fig. 2 (*b*) is deduced. Combining these two figures, the relation between temperature and composition for the β-phase boundary shown in Fig. 2 (*c*) is obtained.

DETERMINATION OF THE α-PHASE BOUNDARY.

The same procedure as above described was repeated with alloys rich in silver. To establish the relation between parameter and temperature, the three alloys 695, 102, and 42 were used. These were subjected to various heat-treatments. The X-ray photographs obtained with these alloys yielded the results which are summarized in Table IV.

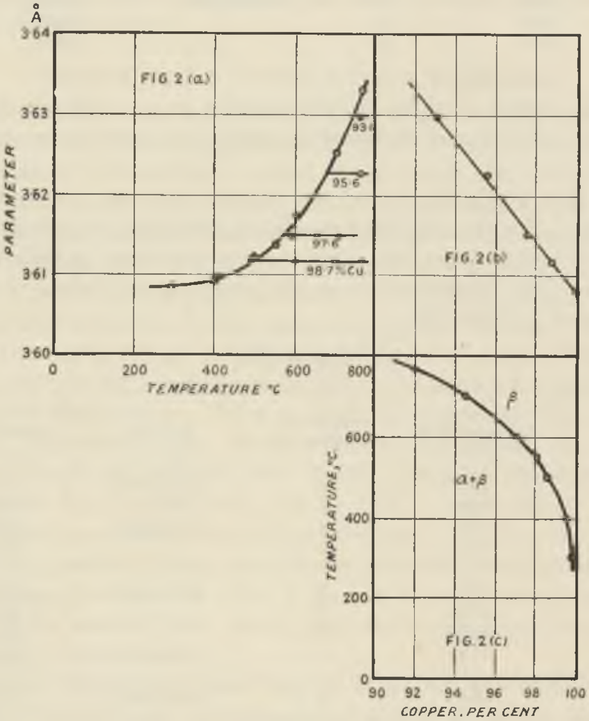

FIG. 2.

Some of the photographs taken with alloy 102 are shown in Fig. 3 (Plate II). When these parameter values are plotted against temperature, the curve shown in Fig. 4 (*a*) is obtained. The value of the parameter of pure silver is 4·0772 A. By extrapolation, the value of the pure α-phase lattice at 778° C. is 4·0272 A.

Further observations were taken with alloys 13, 25, 42, and 74

TABLE IV.

Composition of Alloy (Copper, Per Cent. by Weight).	Annealing Temperature, ° C.	Time of Annealing, Hrs.	Reflecting Planes.	Copper Line.	Parameter, A.	Mean Parameter, A.
69·5	180	65	(333) (511)	α_1 α_2	4·0761 4·0767	4·0764
"	245	72	"	α_1 α_2	4·0755 4·0757	4·0756
"	400	6	"	α_1 α_2	4·0730 4·0726	4·0728
"	490	6	"	α_1 α_2	4·0674 4·0674	4·0674
"	550	6	"	α_1 α_2	4·0636 4·0635	4·0636
"	600	6	"	α_1 α_2	4·0581 4·0574	4·0578
10·2	290	72	"	α_1 α_2	4·0751 4·0753	4·0752
"	490	6	"	α_1 α_2	4·0680 4·0682	4·0681
"	600	6	"	α_1 α_2	4·0570 4·0569	4·0570
"	710	6	(422)	α_1 α_2	4·0381 4·0376	4·0382
			(333) (511)	α_1 α_2	4·0386 4·0383	
"	760	4	(422)	α_1 α_2 α_2	4·0301 4·0296 4·0295	4·0297
4·2	490	6	(333) (511)	α_1 α_2	4·0676 4·0675	4·0676
"	590	6	"	α_1 α_2	4·0586 4·0589	4·0588

after various heat-treatments. The results were similar to those obtained with the copper-rich alloys, the parameter of each alloy varying with temperature up to a certain point and then maintaining

TABLE V.

Composition of Alloy (Copper, Per Cent. by Weight).	Annealing Temperature, ° C.	Time of Annealing, Hrs.	Parameter, A.
1·3	600	6	4·0687
1·3	765	1	4·0689
2·5	490	6	4·0679
2·5	600	6	4·0629
2·5	765	1	4·0628
4·2	490	6	4·0676
4·2	590	6	4·0588
4·2	765	1	4·0526
7·4	765	4	4·0331

a constant value. The transition from a variable to a constant parameter marks the crossing of the boundary from the mixed to the pure region. The results are summarized in Table V.

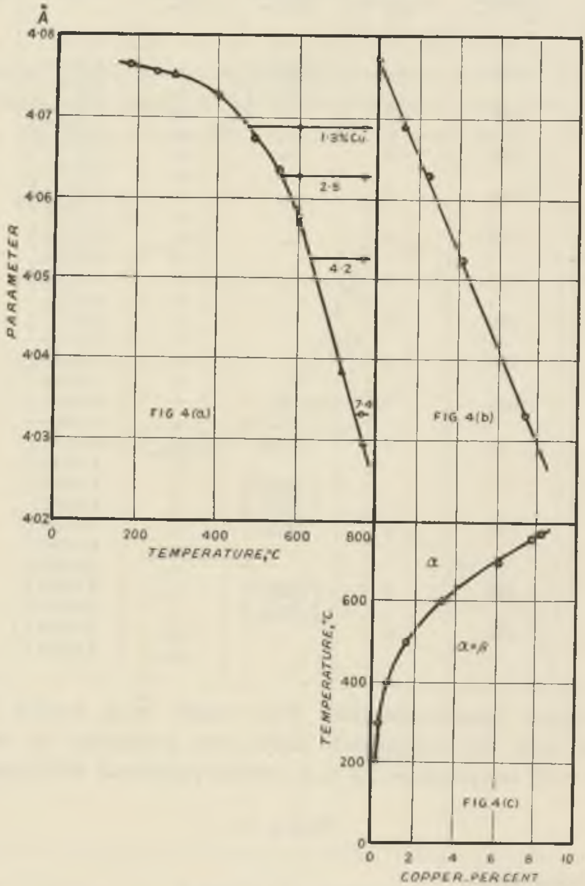

Fig. 4.

Thus we get the variations of parameter with composition in the pure region which is shown in Fig. 4 (*b*). By combining Figs. 4 (*a*) and 4 (*b*) we get as before the relation between the composition and temperature at the boundary, which is shown in Fig. 4 (*c*).

Conclusions.

The above results, which are in general agreement with those of Stockdale and of Ageew, Hansen, and Sachs, show that the limits of the solubilities of copper in silver and of silver in copper in the thermal diagram of the Lepkowski are much too low. The solubilities now obtained are compared with those of the above-mentioned investigators in Table VI.

TABLE VI.

Temperature, ° C.	α-Phase. Solubility of Copper in Silver (Copper, Per Cent. by Weight).			β-Phase. Solubility of Silver in Copper (Silver, Per Cent. by Weight).		
	Stockdale.	Ageew and others.	Present work.	Stockdale.	Ageew and others.	Present work.
778	8·8	8·8 *	8·5 *	8·2	7·0 *	8·4 *
700	5·8	5·3	6·1	4·7	4·6	5·5
600	3·4	3·2	3·3	2·5	2·1	2·9
500	1·8	1·7	1·8	1·3	1·4	1·4
400	1·1	0·8	0·7	0·7	0·6	0·5
300	1·1	0·5	0·4	0·3	0·1	0·2
200	1·1	0·3	0·2	...	0·1	0·1
0	1·0	0·12 *	0·1 *	...	almost * insoluble	almost * insoluble

* Extrapolated value.

The X-ray estimates of the solubilities of copper in silver agree closely except at 700° C.; the present figure at this temperature is higher than previous values. Stockdale's values are in good agreement with the X-ray values above 400° C., but at and below this temperature the solubility maintains a constant value of about 1 per cent., whereas the X-ray results show continuously decreasing values, the solubility at ordinary temperature being only 0·1 per cent. copper by weight.

The values of the solubility of silver in copper recorded here at the higher temperatures are slightly higher than those previously published. There are marked divergences between the values of the solubility of silver in copper obtained in the different investigations, particularly at the higher temperatures, but the trend of the values as the temperature is lowered is the same in all three investigations.

Megaw found that at 452° C. the solubility of copper in silver is 1·34 per cent., which agrees satisfactorily with the mean value of 1·25 recorded in Table VI. The solubility of silver in copper at this temperature was found to be 1·40 per cent. by weight, which differs appreciably from the value of 1·0 now recorded. It was also found by Megaw that the solubility of silver in copper at room temperature does not differ appreciably from that at 450° C., which is explained on the ground that equilibrium had not been reached by the alloys annealed at room temperature. The same remarks apply to the solubility of copper in silver. The present results, together with those of Ageew, Hansen, and Sachs, show a definite difference between the solubility at 400° and at 200° C., the solubility of silver in copper at 400° C. being six times as great as that at 200° C. A marked decrease is also observed in the solubility of copper in silver when the temperature decreases from 400° to 200° C. If the curves may be extrapolated, the one metal is found to be almost insoluble in the other at atmospheric temperature. It would be difficult to test this directly, as the alloys would need a very long time to reach the state of equilibrium when annealed at room temperature.

In the discussion of Stockdale's paper, Hume-Rothery criticized the work of Ageew, Hansen, and Sachs concerning the length of time of annealing employed at the lower temperatures. He was of opinion that annealing for 3–5 hrs. at 300° C. may be insufficient to obtain the true value of the limit of solid solubility at this temperature. The photographs taken in the course of the present investigation with alloy 695 annealed at 307° C. for 6 hrs. and at 290° C. for 72 hrs., when the latter yielded lines which were much better defined than the former, lend some support to this criticism. From the good definition of the lines obtained with this alloy after annealing for 72 hrs. it may be concluded that this amount of annealing has produced the equilibrium condition and that the true value of the solubility at this temperature is obtained with the alloy. The difference between the values of the solubilities at 300° C. recorded by Ageew, Hansen, and Sachs and the present values is, however, negligible, which shows that in this case, even though the lines in the photographs may be ill-defined and consequently their positions not so accurately determined, their mean position closely agrees with the mean position of the better defined lines obtained with the fully annealed alloy.

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AN X-RAY INVESTIGATION OF CERTAIN COPPER–TIN ALLOYS.*

By Professor E. A. OWEN,† M.A., D.Sc., Member, and JOHN IBALL,‡ Ph.D.

Synopsis.

The α-phase boundary of the copper–tin alloys has been determined by X-ray analysis between 750° and 300° C. Its position between 750° and 500° C. is moved in the direction of slightly higher tin content, but between 500° and 300° C. in the direction of lower tin content than that of the boundary as previously determined. The maximum solubility of tin in copper occurs at about 520° C., the temperature corresponding to the (β) to $(\alpha + \gamma)$ transformation. The parameter of the γ-phase is found to lie between 17·917 and 17·924 A. at 480° C., but the measurements are not considered sufficiently extensive to decide whether there exists a definite region of solubility for this phase. The ϵ-phase is a solid solution the range of which does not exceed 1·5 per cent. copper by weight at 380° C. The atomic volume of the copper-saturated ϵ-phase at this temperature is found to be 14·124 A.^{3} and that of the tin-saturated phase 14·177 A.^{3}. The results so far obtained suggest that a transformation of (γ) into $(\alpha + \epsilon)$ occurs at a temperature slightly higher than 300° C., and that the copper-saturated boundary of the ϵ-phase is not exactly vertical between 380° and 300° C.

Introduction.

The method of determining the positions of phase boundaries in thermal diagrams of alloy systems has been described in previous papers,[1] and is applied in the present investigation to study the α-phase boundary in the copper–tin system. The paper also contains a brief account of preliminary measurements on certain alloys in the γ and ε phases.||

The structures of all the main phases in the system have already been investigated by different workers with the aid of X-ray crystal analysis. The α-phase has a face-centred cubic structure containing four atoms to the unit cell; the γ-phase also possesses a face-centred cubic structure, but contains 416 atoms to the unit cell. The ε-phase has a close-packed hexagonal structure. Different investigators are at variance concerning

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|| Metallurgists call these the δ- and η-phases, respectively, but it is more consistent with other alloy systems to call them the γ- and ϵ-phases. This notation has already been used by Westgren and others.

Note to Abstractors and Other Readers.—This paper will be published, in permanent form, in the *Journal of the Institute of Metals*, Vol. LVII, 1935. Reference should accordingly be as follows: *J. Inst. Metals*, 1935, 57 (Advance copy).

this phase. Some conclude that it is a solid solution, *e.g.* Isihara,[2] from measurements of the electrical resistances of the alloys, suggests a range of solubility for the phase of about 3 per cent. from 59 to 62 per cent. copper. That it is a solution is confirmed by the X-ray measurements of Westgren and Phragmén,[3] who found different parameters for the tin-saturated and the copper-saturated phases. Others state that the phase is of unique composition represented by the formula Cu_3Sn.[4] Similar contradictory results have been recorded concerning the γ-phase.

The amount of published metallurgical data concerning the system is very great. Ever since the publication of the classic researches of Heycock and Neville, whose names will always be associated with this system of alloys, papers have frequently appeared dealing with the whole or with some section of the system. Haughton,[5] Bauer and Vollenbruck,[6] and Isihara [2] have produced equilibrium diagrams showing the main phase divisions. Bauer and Vollenbruck stated that from their results it is uncertain whether a small range of solubility exists for the γ-phase. Carson gave this phase a solubility over the range 32–33 per cent. tin at room temperature. Isihara, on the other hand, stated that the γ-phase is a "compound" and has no capacity for dissolving copper below 510° C.; he also drew the α-phase boundary vertical at about 11 per cent. tin from 600° C.

Stockdale [7] carried out a thorough investigation of the α-phase boundary, from which he concluded that the range of solubility of the pure α-phase must be extended beyond the boundary shown in the equilibrium diagram (Fig. 1) which is published in the International Critical Tables. The results of the present investigation confirm this conclusion. Stockdale did not investigate the structure of the alloys below 518° C., and he drew the α-phase boundary vertical below this temperature. Hansen [8] found a sudden change in the direction of the α-boundary at 518° C., and gave the limits of solubility at 500° and 400° C. as 15·3 and 14·3 per cent. tin, respectively. Matsuda,[9] in a later paper, gave the α-phase a vertical boundary at approximately 15 per cent. tin.

In the present investigation attention is directed mainly to the α-phase boundary, although several alloys in adjacent phases were examined during the course of the work. The results indicate that certain modifications are necessary in this section of the equilibrium diagram. Further investigation is required, however, to establish these changes, and for this purpose it is desirable to examine the alloys at high temperatures. The investigation is progressing along these lines, but it was considered that the data already obtained would be of interest as they support the conclusions of some of the previous workers and extend those of others. This paper is to be regarded, however, as a preliminary account of a more extensive survey on this system of alloys which is in progress at the authors' laboratory.

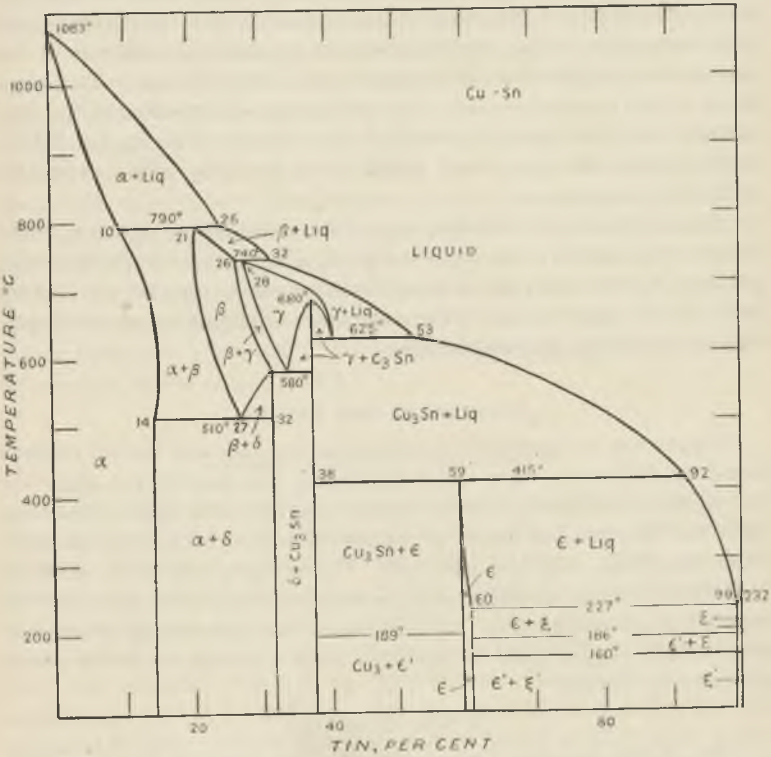

Fig. 1.—Equilibrium Diagram of Cu–Sn Alloys. (From the International Critical Tables.)

Preparation of the Alloys.

Two methods were used. In the first method the copper was melted under powdered graphite and the tin added. The molten alloy was stirred constantly and afterwards allowed to solidify in the crucible. Tin being non-volatile, it is possible to make these alloys to within 0·1–0·2 per cent. of the estimated composition. In melting, a loss of copper is more probable than a loss of tin. Nine alloys were prepared by this method, varying from 95 to 40 per cent. of copper.

After trying several variations of heat-treatment, it was concluded that the alloys could not be brought to a state of equilibrium without prolonged heating. To reduce the time and temperature of annealing, another method for preparing the alloys was adopted. This method, due to Haughton, has frequently been employed with alloys which are difficult to obtain in equilibrium. Haughton found that in order to obtain an alloy in equilibrium at comparatively low temperature, the most favourable initial condition is that in which the alloy is as far removed as possible from the desired state of equilibrium. To obtain alloys in this metastable state they were prepared according to the first method and then cast in a chilled iron mould. The ingots, which weighed about 25 grm., were found to be perfectly sound after this method of preparation.

Since, with alloys containing more than about 30 per cent. tin, there is risk of the outside of the ingot being richer in tin than the inside, when prepared by the chill-cast method, these higher content tin alloys were made by the first method. They are not so difficult to get into equilibrium as are the copper-rich alloys.

ANALYSIS OF THE ALLOYS.

Copper was estimated by a volumetric method, and the tin content found by difference. For alloys containing less than 20 per cent. tin, the ordinary iodometric method was satisfactory; for those containing more tin, this method gives low values for copper because the stannic oxide interferes with the titration. The method had to be slightly modified by using predetermined standard mixtures of copper and tin for purposes of comparison; by this means alloys containing as much as 50 per cent. copper could be analyzed to an accuracy of within about 0·3 per cent. copper.

X-RAY CAMERAS.

Two X-ray cameras were employed: the precision camera which has a limited range over large glancing angles, and the spectrum camera which covers the whole spectrum. The quantity of material required for the precision camera is about 0·3–0·4 grm., and it can be used in the form of either thin foil or powder. Powder gives the best results, provided that the lattice distortion produced in the preparation of the powder is eliminated by suitable heat-treatment. For the spectrum camera a much smaller quantity of finer-grade powder is needed.

METHOD OF ANNEALING AND PREPARATION OF SAMPLES.

The ingots were annealed in wide-bore Pyrex tubes, which were evacuated. Temperatures up to 700° C. could be reached with these tubes; the Pyrex collapsed round the ingots at these temperatures, but the vacuum was maintained.

For annealing temperatures up to 650° C., the powders were enclosed in small evacuated glass tubes, ordinary glass up to about 500° C. and Pyrex glass up to 650° C.; silica was used at still higher temperatures. As a rule the tubes were about 1·5 cm. long and 0·5 cm. in diameter, and had a wall-thickness not greater than 0·5 mm. During the annealing process they were embedded in numbered holes bored in an iron block which fitted closely into the furnace.

Special arrangements were made for rapid quenching of the powder specimens. The silica tube containing the sample was suspended in the middle of a vertical tube furnace, close to the pyrometer junction, and was firmly attached to a long piece of stiff Nichrome wire, which passed freely through a small hole in the top cover of the furnace. To quench the material, the lower asbestos bung was removed and the specimen plunged, by the aid of the Nichrome wire, into iced water placed below the lower end of the furnace; this arrangement provided an efficient means of quenching.

INVESTIGATION OF THE α-PHASE.

In the initial stages of the work, six alloys, ranging in composition from 95·4 to 70 per cent. copper, were prepared by the usual melting process. Filings were prepared from the "as cast" ingots and were annealed for periods of from 4 to 24 hrs. at 600° C. The definition of the lines obtained with nickel radiation in the precision camera was poor, and the measured α-parameters showed variations which proved that the material was not in equilibrium. The ingots were then annealed at 600° C. for 283 hrs. Powder prepared from each alloy was annealed at 480° C. for 6 hrs. and another batch at 650° C. for 4 hrs. The lines in the photographs were then much better defined and could be measured with accuracy. The position of the lines on the film was also such that would yield accurate values without having to measure the arc with very high precision. The results of these preliminary measurements are given in Table I.

The figures in this table show certain irregularities. Consider, for instance, alloy 901. The parameter values should be constant, but they show variations which exceed the experimental error. The variations in parameter values are even more pronounced for alloys 847 and 797. The parameter of alloy 74 is greater also than that of alloy 70, whereas the values should be equal since both the alloys are in the same mixed region $(\alpha + \gamma)$. Such irregularities made it doubtful whether the

TABLE I.

Alloy No.	Ingot "As Cast."		Ingot Annealed for 283 hrs. at 600° C.			
	Powder Annealed for 4 Hrs. at 480° C.	Powder Annealed for 4 Hrs. at 600° C.	Powder Annealed for 6 Hrs. at 480° C.		Powder Annealed for 4 Hrs. at 650° C.	
	Cu Radiation.	Cu Radiation.	Cu Radiation.	Ni Radiation.	Cu Radiation.	Ni Radiation.
		A.	A.	A.	A.	A.
954	No resolution of lines	3·6359	3·6357	3·6358	3·6366	3·6365
901	do.	3·6649	3·6643	3·6646	3·6653	3·6648
847	do.	3·6942	...	3·6939	3·6935	3·6930
797	...	3·6965	3·6955	3·6951	3·6936	...
74	...	...	...	3·6958	...	...
70	...	...	3·6945	3·6942	no α-phase lines	

alloys were in equilibrium. To make certain of this a considerably longer time of lump annealing would be necessary.

Alloys were then prepared by chill-casting, the first batch having estimated compositions 95, 90, 85, 80, and 70 per cent. copper.

Alloy 85 was first examined. Filings from the " as cast " ingot were annealed at 480° C. for 24 hrs. and for 48 hrs. The K_α nickel doublet was resolved after this comparatively short heat-treatment, but the lines were not well-defined. Different values of the parameter (see Table II) were obtained which indicated that the material was not in equilibrium.

TABLE II.—*Alloy* 85 *A*. *α-Phase Parameters* (A.).

Time of Annealing the Powder at 480° C., Hrs.	Ingot " as Cast."	Ingot Annealed for 24 Hrs. at 600° C.	Ingot Annealed for 84 Hrs. at 600° C.
4	...	3·6943	...
24	3·6956	3·6948	3·6946
48	3·6947	...	...

The ingot was then annealed at 600° C. for 24 hrs. Filings were taken from it, and were annealed at 480° C. for 4 hrs. and for 24 hrs., the ingot being further annealed for 60 hrs. at 600° C. The α-phase parameters obtained after these heat-treatments are shown in Table II. The lines were well-defined, and it is evident that after lump annealing the material has reached its equilibrium condition.

Further observations were made with alloy 70, in order to decide more definitely the amount of heat-treatment necessary to produce the equilibrium condition. Having found that 84 hrs. at 600° C. sufficed for an ingot of alloy 85, the same treatment was given to alloy 70 in lump form. Powders prepared from the latter were then annealed for different times at 480° C. The results of the measurements are shown in Table III. Annealing for 16 hrs. at 480° C. is sufficient to obtain equilibrium in the powder. The general procedure after this was to anneal the filings of all alloys for 24 hrs. at 480° C.

Table III.

Time of Annealing the Powder at 480° C., Hrs.	Phase Parameter (A.).
8	3·6956
16	3·6963
24	3·6963

The α-phase parameters were measured for nine alloys in equilibrium at 480° C. and containing from 95 to 70 per cent. copper. All the alloys except alloy 74 were prepared by chill-casting. Alloy 74 was prepared by melting copper and tin in the usual way and keeping it at the melting

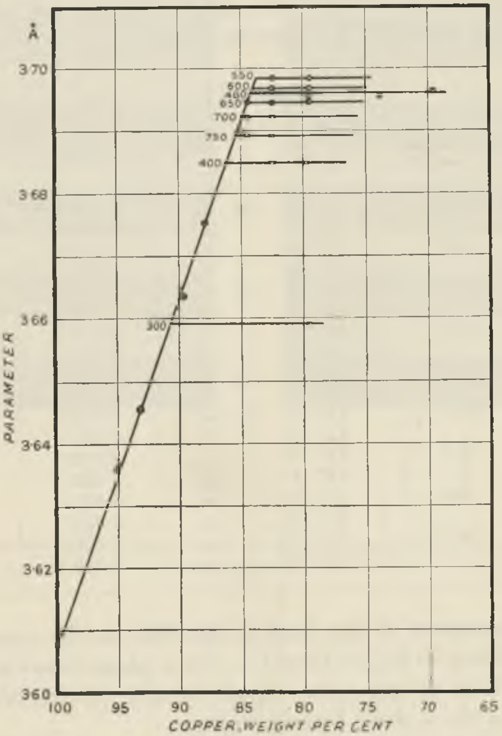

Fig. 2.

point of the alloy for a short time with constant stirring. It was then cooled very slowly and held at a temperature just below the solidus for about 1 hr. After this treatment it was allowed to cool, and was placed in an evacuated tube for lump annealing at 600° C. for 580 hrs. It was considered desirable to carry out this procedure with an alloy of composition in the vicinity of 70 per cent. copper as, with chill-cast alloys of this composition, there is risk that the tin may move towards the outside of the ingot and that the filings would then not represent the true composition, even though filings were taken from well within the material. The fact that the alloy yields an α-parameter agreeing, within experimental error, with those of other alloys in the mixed $(\alpha + \gamma)$ region shows that it is unlikely that this effect occurred with alloys 80 and 70.

The α-phase parameters of all the alloys annealed in powder form at 480° C. are shown in Table IV, and are represented graphically in Fig. 2. Alloys marked " A " were chill-cast.

TABLE IV.

Alloy No.	Copper, Weight % (by Analysis).	$\frac{\pi}{2} - \theta$	λ.	Parameter, A.	Mean Parameter, A.
95 A	95·1	7° 22′	α_1	3·6359	3·6359
		6° 15′	α_2	3·6359	
93 A	93·2	8° 28′	α_1	3·6456	3·6454
		7° 28′	α_2	3·6452	
90 A	89·7	10° 11′	α_1	3·6636	3·6635
		9° 23′	α_2	3·6633	
88 A	88·0	11° 10′	α_1	3·6755	3·6753
		10° 26′	α_2	3·6751	
85 A	84·5	12° 35′	α_1	3·6946	3·6946
		11° 58′	α_2	3·6946	
83 A	82·5	12° 42′	α_1	3·6963	3·6962
		12° 5′	α_2	3·6962	
80 A	79·6	12° 39′	α_1	3·6956	3·6955
		12° 1′	α_2	3·6953	
74	73·9	12° 38′	α_1	3·6954	3·6956
		12° 3′	α_2	3·6957	
70 A	69·6	12° 42′	α_1	3·6963	3·6963
		12° 5′	α_2	3·6962	

The displacement of the lines on the films as the copper content decreases is shown in Fig. 3 (Plate I). The α-phase lines for alloys containing less than 85 per cent. copper become progressively fainter, whilst those of the γ-phase become stronger.

It may be pointed out that the precision measurement of crystal parameters is a sensitive method in certain cases for testing the degree of equilibrium attained in an alloy. Its value in this connection depends,

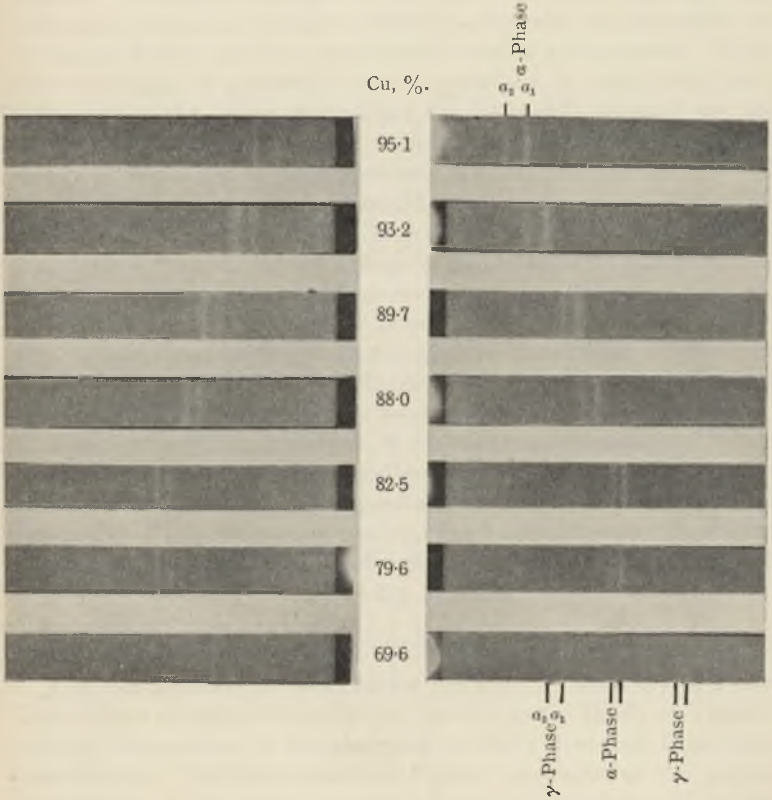

FIG. 3.—Showing the Displacement of α-Lines from Alloys of Different Compositions.

amongst other factors, on the rate of change of parameter with composition in a pure region. For an alloy in a mixed region, equilibrium of a particular phase can be said to exist when the lattice parameter is that corresponding to the limit of solubility at the temperature considered. The equilibrium state is assumed to have been reached when continued annealing produces no further change in the parameter, *i.e.* no change greater than the experimental error of measurement. If the rate of change of parameter with composition is great, then small differences in the limits of solubility can be readily detected and the degree of equilibrium estimated. The method fails when the rate of change of parameter with composition is small, and not far removed from the experimental error; it would then be impossible to state with certainty when equilibrium had been reached. In the α-phase of the copper–tin series, the rate of change in parameter with composition is constant, and is such that a change in composition of 15 per cent. copper by weight produces a change of 2·32 per cent. in the α-phase parameter. The precision measurements employed here are capable of detecting changes in parameter of about 0·02 per cent., so that very slight changes in composition of the α-phase can be observed.

From the results given above, it is clear that the method of " chill-casting " the alloys rich in copper is very effective for obtaining equilibrium at comparatively low temperatures without the need for prolonged annealing. The present work confirms Stockdale's statement that after chill-casting the equilibrium condition can be reached with copper-rich alloys after annealing for only 24 hrs. at 600° C.

DETERMINATION OF THE α-PHASE BOUNDARY.

Previous methods for ascertaining the limit of solubility of a particular phase at various temperatures have depended chiefly on a microscopical examination of the structure of alloys quenched from those temperatures. The determination of phase boundaries in the present investigation is dependent on the accurate measurement of crystal parameters, and probably yields more definite results than the microscopical method.

The alloys used for determining the α-phase boundary in the present case were those prepared by chill-casting, and the ingots had been annealed for about 80 hrs. at 600° C. It was concluded from the measurements already made (Fig. 2) that at 480° C. alloy 85 consisted entirely of α-solid solution, whereas alloys 83 and 80 were beyond the limit of solubility at this temperature. Filings from these three alloys were then examined.

For temperatures up to 650° C. it is not essential for the powders to be quenched in water in order to retain the structure at the annealing temperatures; rapid air cooling is adequate. To ascertain whether any difference could be detected between samples rapidly air-cooled and those quenched in iced water, photographs were taken of three samples annealed for 2 hrs. at 650° C. The results of the measurements are shown in Table V. No difference could be observed.

TABLE V.—*Reflections from* (331) *Planes with Nickel Radiation.*

Alloy No.	Treatment.	Glancing Angle.	λ.	Parameter, A.
83 A	Quenched in iced water	12° 34′	α_1	3·6944
		11° 58′	α_2	3·6946
80 A	Quenched in iced water	12° 35′	α_1	3·6946
		11° 59′	α_2	3·6948
80 A	Cooled in air	12° 34′	α_1	3·6944
		11° 59′	α_2	3·6948

As the making and sealing of tubes for quenching samples in water is a longer operation with silica than with glass, glass tubes rapidly air-cooled were used for all temperatures below 650° C.; above 650° C. quenching was carried out in silica tubes, which were dropped into iced water. A series of photographs was taken with alloys 85, 83, and 80 at different temperatures, the data concerning which are given in Table VI. The parameters show considerable changes as the temperature of annealing varies. Alloy 85 gave a constant parameter for temperatures between 650° and 480° C., showing that it was in the pure α-phase over this range of temperature. The parameters of alloys 83 and 80 were almost identical at each annealing temperature. Fig. 4 shows the variation of parameter with temperature very clearly. The values of the parameters at various temperatures are plotted also in Fig. 2, from which the limits of solubility at each temperature can be read. These values are shown

TABLE VI.

Temperature of Annealing, ° C.	Time of Annealing, Hrs.	α-Phase Parameter (A.).		
		Alloy 85 A.	Alloy 83 A.	Alloy 80 A.
750	½	3·6893	3·6891	...
700	½	3·6921	3·6923	...
650	2	3·6944	3·6945	3·6947
600	4	...	3·6967	3·6968
600	9½	...	...	3·6968
550	14	3·6949	3·6984	3·6985
480	24	3·6946	3·6962	3·6955
400	91	...	...	3·6852
400	180	...	3·6848	3·6849

in Table VII, together with the values deduced by Stockdale. The position of the boundary at 300° C., discussed later in this paper, is also included in this table. Owing to the rapidity with which the parameter alters with change in composition in the α-phase, the curvature of the parameter–temperature relation is much more marked than that of the composition–temperature relation. The form of the boundary is shown in Fig. 4, the dotted line being the boundary given on the diagram

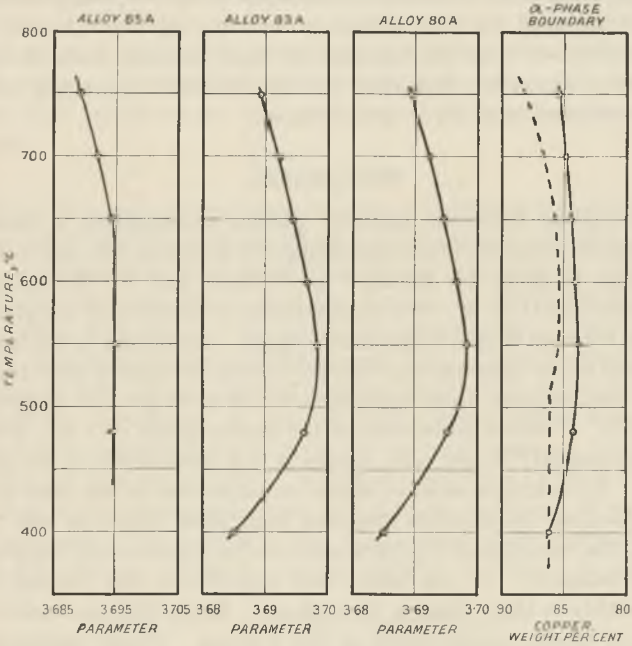

Fig. 4.

TABLE VII.

Temperature, ° C.	Composition (Tin, Per Cent. by Weight).	
	Present Work.	Stockdale.
750	14·6	14·0
700	15·1	14·4
650	15·5	15·0
600	15·9	15·3
550	16·2	15·7
480	$15{\cdot}7_5$	...
400	13·8	...
300	9·9	...

published in the International Critical Tables. The present results displace the α-phase boundary slightly further from the boundary as drawn in the I.C.T. diagram than do Stockdale's results.

In an attempt to extend the α-boundary to 300° C., samples of alloy 80 were annealed for long periods extending over many weeks. The results obtained from photographs of these samples were of so unexpected a character that they will be discussed separately after a brief consideration of the γ- and ε-phases.

THE γ-PHASE.

The γ-phase has been found by various investigators to possess a face-centred cubic structure containing 416 atoms to the unit cell; its parameter is given by Bernal[10] as 17·92 A. and by Westgren and Phragmén[3] as 17·91 A. It is a constituent of alloys with compositions ranging between 85 and 63 per cent. copper. According to the diagram published in the International Critical Tables, the pure γ alloy contains 68 per cent. copper; from approximately 85 to 68 per cent. copper and below 510° C. it is a constituent of the duplex phase (α + γ); from 68 to approximately 63 per cent. copper it is a constituent of the (γ + ε) region. By taking a series of alloys on either side of the pure γ alloy and annealing the powders obtained from these alloys at 480° C. for 24 hrs., the variation of the parameter of the γ-phase with composition was investigated. It was found that equilibrium was reached much more readily in the γ than in the α-phase. Table VIII summarizes the results of measurements made on the γ-phase. Nickel radiation was used throughout in obtaining the photographs. Alloys marked "A" were chill-cast, the others being prepared by the ordinary method.

TABLE VIII.

Alloy.	Composition (Copper, Per Cent. by Weight).	Lump Annealing.		Powder Annealing.		Parameter (A.).
		Time, Hrs.	Temperature, ° C.	Time, Hrs.	Temperature, ° C.	
80 A	70·6	84	600	24	480	17·917
74	73·9	580	600	24	480	17·917
70 A	69·6	283	600	6	480	17·916
68	68·1	260	600	6·5	480	17·919
68	68·1	580	600	24	480	17·917
66	66·0	330 24	400 600	24	480	17·924
65	65·1	283	600	6	480	17·924
80 A	79·6	84	600	91	400	17·919

In alloys containing from 79·6 to 68·1 per cent. copper by weight, the γ-phase has a constant parameter, the mean value of which is 17·917 A. There is a slight increase in the parameter as the composition changes from 68 to 66 per cent. copper. This increase is greater than the experimental error of measurement, but more evidence is needed before it can be stated definitely that a range of solubility exists in the γ-phase. A more detailed investigation of these alloys carried out at high temperatures, and with improved technique, is now in progress.

THE ε-PHASE.

In the diagrams of the copper–tin system published by Isihara [2] and by Matsuda,[9] the ε-phase is shown as a solid solution extending over a range of composition from about 59 to 62 per cent. copper. Westgren and Phragmén [3] also found that the dimensions of the tin-saturated lattice differ from those of the copper-saturated lattice. The ε alloys possess close-packed hexagonal structures [11] and are good reflectors, but they are so brittle that suitable powders could only be produced by grinding the material in an agate mortar. Seven ingots were made, ranging in composition from 66 to 54 per cent. copper; they were annealed for 318 hrs. at 350° C., and the powder for 11 hrs. at 380° C. The lines in the photographs were well-defined, and could be measured with accuracy. The results of the measurements are summarized in Table IX, and are shown graphically in Fig. 5. There is a definite change in atomic volume in the neighbourhood of alloy 62. The values of the parameters of the copper-saturated and the tin-saturated phases are compared in Table X with those recorded by Westgren and Phragmén.

TABLE IX.—*Annealing Temperature*, 380° C.

Alloy No.	Composition (Copper, Per Cent. by Weight).	Axial Ratio.	Base side (A.).	Atomic Volume (A.).
66	66·0	1·572	2·7479	14·124
65	65·1	1·572	2·7480	14·125
62	62·0	1·571	2·7497	14·143
61	61·0	1·569	2·7531	14·177
60	59·9	1·569	2·7532	14·179
58	58·1	1·569	2·7531	14·177
54	54·0	1·569	2·7529	14·174

From the discontinuities in the graphs it is clear that the range of solid solubility for the Cu_3Sn or ε-phase is very limited. With the methods employed it was found impossible to fix the limits of solution exactly, but it can be stated definitely that the range of solubility does not exceed 1·5 per cent. by weight. To determine the limits of solubility more nearly than this it will be necessary to prepare alloys at intervals of about 0·3 per cent. by weight between alloys 61 and 63, and to employ a more refined method of chemical analysis.

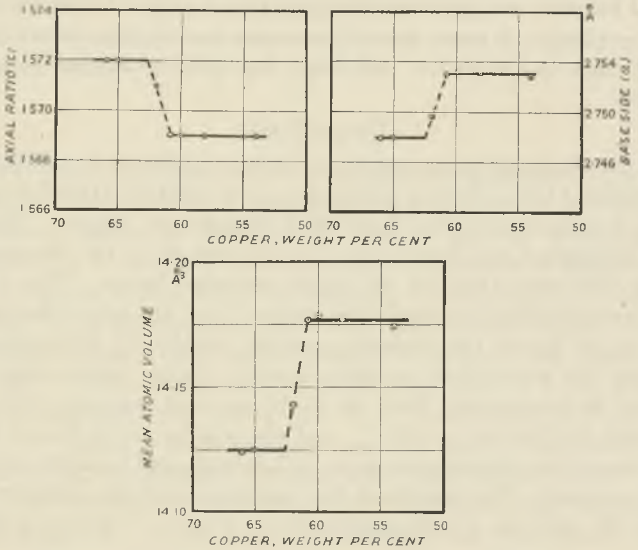

FIG. 5.—Variation of the Parameters and the Atomic Volume of the ε-Phase with Composition.

TABLE X.

	Axial Ratio.	Base Side (A.).	Atomic Volume (A.).
Westgren and Phragmén:			
Copper-saturated . .	1·572	2·747	14·110
Tin-saturated . . .	1·568	2·755	14·207
Present work:			
Copper-saturated . .	1·572	2·7479	14·124
Tin-saturated . . .	1·569	2·7531	14·177

The conclusion reached from this section of the work is that the ε-phase is a solid solution having a range not greater than 1·5 per cent. by weight at 380° C., the atomic volume of the copper-saturated phase at this temperature being 14·124 A.^{3}, and that of the tin-saturated phase 14·177 A.^{3}.

THE STRUCTURE OF ALLOY 80 AT 300° C.

The composition of this alloy was found by analysis to be 79·6 per cent. copper. The ingot, prepared by chill-casting, was annealed *in vacuo* for 84 hrs. at 600° C. Filings from the ingot were annealed for various times at 300° C., in an attempt to find the limit of solubility of the α-phase at this temperature. According to all the thermal diagrams the alloy should be in the $(\alpha + \gamma)$ region at 300° C.

The first two samples were annealed in powder form for 98 and 264 hrs., respectively, and photographs were taken with the precision camera. Three K_α nickel doublets were registered on each photograph. On that obtained with the sample annealed for 98 hrs., one doublet near the middle of the film was ill-defined, but the other two were fairly well defined; on the second photograph all were well defined. The lines were not in positions corresponding to those in any previous photographs taken with this alloy. It seemed that (i) the α-phase parameter had altered considerably from the value obtained at 400° C.; (ii) a new phase had formed; or (iii) a greatly modified α-lattice and a new phase were present together.

To avoid the possibility of complication when the transformation line at 520° C. was crossed, fresh powder samples were taken, these being first annealed at 480° C. for 16 hrs. It had previously been found that this treatment was sufficient to cause the $(\alpha + \gamma)$ structure to form and reach the equilibrium state. The temperature was then reduced from 480° to 300° C. in a period of 8 hrs., and the samples annealed at 300° C. for 1030 hrs. A precision photograph was taken of a portion of the powder, and the remainder further annealed for 528 hrs. at 300° C., so that altogether it received 1558 hrs. annealing at this temperature.

The photograph of the first portion showed again three doublets; two of these were in almost the same positions as before, but the other had moved considerably. This photograph showed very faint indications of some γ-lines.

The lines in the photograph of the sample annealed for 1558 hrs. were more intense, and the two doublets which gave the same arcs as before were well defined. The third doublet had moved still further, and the lines were rather broad, but were resolved. This photograph also showed very faint traces of lines belonging to the γ-phase.

These photographs showed that as the time of annealing was increased one doublet moved its position, but the other two doublets remained almost stationary.

To discover what structures were present, spectrum photographs were taken with two of the samples, the annealing times of which were 264 hrs. and 1558 hrs. Each photograph showed the presence of a face-centred cubic structure and a hexagonal structure, and there were no lines on these films that could not be accounted for in the two structures. The doublet on the precision photographs whose position varied with time of annealing represented the face-centred cubic structure, and the other two doublets represented a new close-packed hexagonal phase of axial ratio 1·570. The parameters of the cubic structures in the two photographs were 3·646 and 3·659 A., and were undoubtedly the values of the parameters of the unsaturated α-phase. The results of the measurements of the four precision photographs, together with those of the spectrum photographs, are collected in Table XI.

TABLE XI.

Time of Annealing, Hrs.	Parameters (A.).			
	α-Phase.		Close-Packed Hexagonal Lattice.	
	Precision.	Spectrum.	Precision.	Spectrum.
98	3·6479	...	$c = 1{\cdot}571$ $a = 2{\cdot}7494$	...
264	3·6529	3·646	$c = 1{\cdot}571$ $a = 2{\cdot}7491$	$c = 1{\cdot}570$ $a = 2{\cdot}746$
1030	3·6577	...	$c = 1{\cdot}571$ $a = 2{\cdot}7499$	...
1558	3·6590	3·659	$c = 1{\cdot}571$ $a = 2{\cdot}7495$	$c = 1{\cdot}570$ $a = 2{\cdot}749$

The values of the parameters obtained from the precision photographs are more accurate than those from the spectrum photographs;

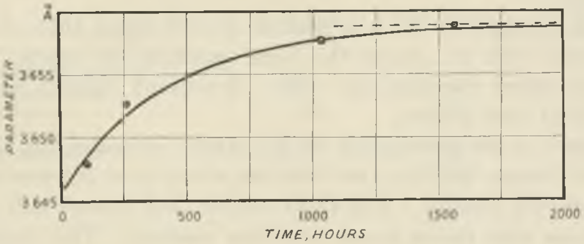

FIG. 6.

the latter are included to show that they agree with the precision measurements within the accuracy of measurement. The figures show that the hexagonal lattice remains constant, whilst the α-phase lattice increases as the time of annealing is increased.

The parameters of the ε-phase previously examined were found to vary between the following limits: axial ratio, 1·572 to 1·569; base side, 2·7479 to 2·7529 A. The parameters of the hexagonal phase now observed at 300° C. in alloy 80 are: axial ratio, 1·571, and base side, 2·7495 A. These are within the range of the above values of the ε-phase. Thus, it would appear that the γ-phase which is stable from 510° to 400° C. (see Table VIII) in alloy 80 changes over at some temperature between 400° and 300° C. into the ε-phase. The temperature of transformation is probably near 300° C., as there were faint indications of lines belonging to the γ-phase on some of the photographs. If this interpretation is correct the atomic volume of the copper-

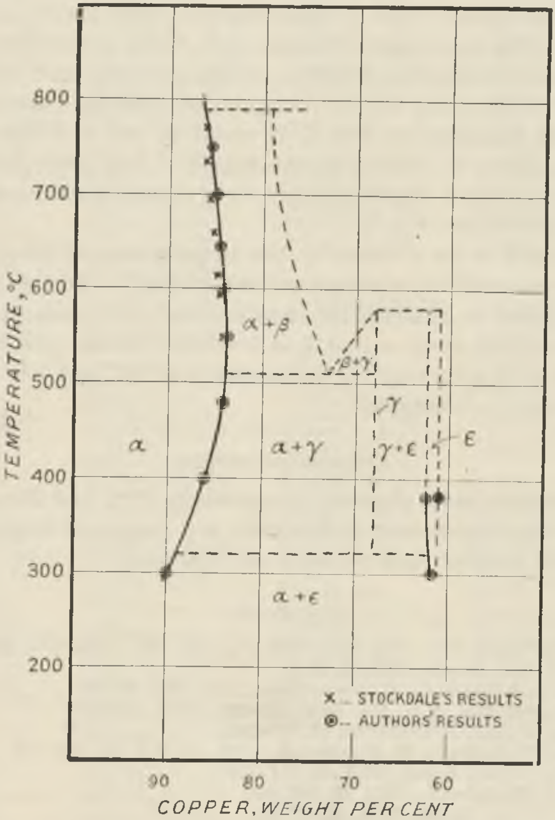

Fig. 7.—Showing the Modifications Introduced in the Copper-Rich End of the Equilibrium Diagram.

saturated ε-phase at 300° C. is 14·14 A.[3], so that the boundary of the ε-phase at this temperature is approximately at 62 per cent. copper, differing from that at 380° C. The copper-saturated ε-boundary is thus very slightly inclined to the vertical between these two temperatures.

The α-phase parameter has still to be explained. Plotting the values of parameter against times of annealing the curve shown in Fig. 6 is obtained. This is a typical diffusion curve,[12] the equilibrium value of the parameter being about 3·6590 A., which gives the limit of solubility at 300° C. Converting this into composition from the curve in Fig. 2, the α-phase boundary at 300° C. is obtained, and is found to occur at a composition of 90·08 per cent. copper. This point falls on the continuation of the α-phase boundary curve already determined between 750° and 400° C. (see Fig. 7).

The results so far obtained in this investigation of the copper–tin alloys are embodied in the diagram shown in Fig. 7. Further investigation is required to establish the transformation of (γ) into (α + ε) and the extent of the ε-region, but it is believed that the position of the α-phase boundary between the temperatures of 750° and 300° C. is now fairly accurately determined.

ACKNOWLEDGMENTS.

The authors have pleasure in expressing their indebtedness and thanks to the Department of Scientific and Industrial Research for a grant which enabled them to carry out this work.

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AUTHOR INDEX TO ABSTRACTS

Author Index to Abstracts

APPOINTMENT REQUIRED

Young Metallurgical Chemist, 21, desires to enter business of small firm (Midlands preferred) with view to gaining experience and eventual partnership. Could invest small amount of capital. Box No. 25, Institute of Metals.

APPOINTMENT VACANT

General Manager (Metallurgist) for a metal producing works, working an electrolytic process. The appointment includes full responsibility for the planning and construction of important extensions, as well as economical operation of all sections of the Works. Preference will be given to candidates under 45 years of age, speaking French or German fluently. Extensive theoretical knowledge, including the chemistry of metals, and wide practical experience in relation to the newly applied metals, are essential. Applications, which will be treated in confidence, should state age, experience, including names of firms and dates, and the expected remuneration should also be indicated. Box No. 26, Institute of Metals.

CORRIGENDUM

Metallurgical Abstracts, 1935, 2.

Page 87, first review, line 3. *After* "Dehlinger" *read* "Pp. 180, with 47 illustrations. 1935. Leipzig: Akademische Verlagsgesellschaft m.b.H. (R.M. 20.)"

METALLURGICAL ABSTRACTS

(GENERAL AND NON-FERROUS)

Volume 2 APRIL 1935 Part 4

I.—PROPERTIES OF METALS

(Continued from pp. 89–94.)

***The Annealing of Pure Aluminium and Its Possible Utilization as a Criterion of the Purity of This Metal.** Jean Calvet (*Compt. rend.*, 1935, **200**, 66–68).—The effect of impurities on the temperature of annealing of pure aluminium has been investigated, the rates of annealing being compared for a series of specimens ranging from 99·96% (Hoopes aluminium) to 99·9986%. The specimens, containing iron, silicon, and copper determinable colorimetrically and traces of magnesium detectable spectroscopically, were cold-rolled from 20·4 to 1·5 mm. in 10 passes. The breaking stress increased continuously from 12·68 kg./mm.^{2} for the purest metal to 15·98 kg./mm.^{2} for the Hoopes aluminium. In the given conditions of cold-rolling, pure aluminium (99·9986%) is completely annealed at 100° C. in 6–10 minutes, and the reduction of the breaking stress is probably considerable even below 0° C. As the amount of impurities increases, the rate of annealing diminishes to a remarkable extent, *e.g.* 99·997% aluminium is not completely annealed after 6 hrs. at 100° C., and 99·996% aluminium requires 48 hrs. at 175° C. Thus the presence of impurities to the extent of 1 part in 100,000 affects the rate of annealing. These results show that the rate of annealing after cold-working is a criterion of the purity of the metal, and that very pure aluminium spontaneously self-anneals at ordinary temperatures. [*Note by Abstractor:* The temperature of annealing is similarly used as an indication of the purity of fine gold.]—J. H. W.

***The Reflecting Properties of Aluminium-Surfaced Mirrors.** E. Pettit (*Astronomical Society of the Pacific Publications*, **1934**, Feb.; and *Light Metals Research*, 1935, **3**, 307–311).—The reflecting powers of aluminium- and silver-surfaced mirrors have been determined for wave-lengths between $\lambda = 0{\cdot}225\ \mu$ and $\lambda = 2{\cdot}3\ \mu$. From these results are computed the changes in photographic speed and visual sensitiveness when two silvered surfaces are exchanged for two aluminium or one aluminium and one silvered surface in the telescope.—J. C. C.

***On the Magneto-Resistance of Bismuth, Nickel, Iron, Cobalt, and Heusler Alloy by the Longitudinal Magnetic Field at Low and High Temperatures.** Yosiharu Matuyama (*Kinzoku no Kenkyu*, 1935, **12**, (1), 1–41 (in Japanese), and *Sci. Rep. Tôhoku Imp. Univ.*, 1934, [i], **23**, 537–588 (in English)).—The change of electrical resistance with longitudinal field up to 1700 gauss was measured for bismuth, nickel, iron, cobalt, and Heusler's alloy at various temperatures between − 196° and + 1200° C. With bismuth the magneto-resistance increases at high temperatures proportionally to the square of the magnetic field up to 1700 gauss. At very low temperatures the same ratio increases proportionally to the square of the field only in very weak fields, this rate of increase diminishing in stronger fields. In the cases of nickel and iron, the results of the present research are similar to those of other workers and in the magneto-resistance–temperature curve a sharp minimum is found at a temperature just below the critical point. With cobalt the magneto-resistance–field curves and the magneto-resistance–temperature curves differ from those of nickel and iron. Below 0° C. the resistance increases propor-

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* Denotes a paper describing the results of original research.

† Denotes a first-class critical review.

tionally with the magnetic field, at least up to 1600 gauss. When the temperature is increased its rate of increase diminishes gradually and the curve itself approaches saturation in a field of about 500 gauss at 261° C. The magneto-resistance/temperature curve has a maximum at 210° C. In the case of Heusler's alloy the sign of the magneto-resistance is negative for all ranges of temperature; its value is very large, but diminishes at first rapidly and then slowly as the temperature is increased.—S. G.

***Action of Mercury Vapour on Calcium at the Ordinary Temperature.** Paul Remy-Genneté (*Bull. Soc. chim. France,* 1934, [v], **1**, 1671–1674).—Pure redistilled calcium kept over mercury *in vacuo* for 4 months at the ordinary temperature absorbed 5% of its weight of mercury.—A. R. P.

Chromium: Its Sources and Uses. Maurice Déribéré (*Métaux et Machines,* 1934, **18**, 309–312; 1935, **19**, 45–48).—The opening sections describe the sources, occurrence, and principal ores of chromium. An account is then given of the principal ferrous and non-ferrous chromium alloys; among the latter the most important are the heat-resistant chrome-nickel series with minor additions (Nichrome, Chromel, Elinvar), and the corrosion-resistant light alloys containing chromium together with copper, nickel, magnesium, silicon, &c. Brief references to chromium plating and to the chromium refractories are supplemented by an extensive *bibliography.*—P. M. C. R.

***An Experiment on the Relation Between the Magnetic Susceptibility and the Elastic Stress [in Copper].** Yuzuru Watase (*Sci. Rep. Tôhoku Imp. Univ.,* 1934, [i], **23**, 208–212).—[In English.] The variation of the magnetic susceptibility of copper was measured under a homogeneous elastic stress.—S. G.

A Bibliography of Indium, 1863–1933. Herbert A. Potratz and John B. Ekeley (*Univ. Colorado Studies,* 1934, **21**, (3), 151–187).—A very full bibliography, classified as follows: reference books; chemical journals; discovery of the element—early researches 1863–1865; occurrence and extraction; physical properties; qualitative and quantitative analysis; alloys; chemical properties, compounds and properties of compounds; miscellaneous information: cost, commercial production, uses, physiological action, bibliographies, bulletins, general references.—S. G.

***An Interference Extensometer and Some Observations on the Elasticity of Lead.** Bruce Chalmers (*Proc. Phys. Soc.* (*Lond.*), 1935, **47**, 352–368; discussion, 368–370).—An extensometer employing interference fringes to measure elastic and plastic extensions of specimens of length about 3 cm. with an accuracy of 3×10^{-7} cm. is described. The following results relating to lead are obtained: (1) a specimen that has not recently been severely strained has a definite range in which Hooke's law is obeyed, and a definite elastic limit; (2) when the specimen has been recently severely strained, a new type of closed elastic hysteresis loop is obtained; (3) when the stress is below the elastic limit, the whole of the observed elastic after-effect can be accounted for thermodynamically; (4) the true plastic after-effect (creep) commences when the elastic limit is exceeded. The elastic limit was found to be of the order 30,000 grm./cm.^{2}, and the limit of the elastic extension was of the order 2×10^{-4} cm./cm. for a strained specimen. For an unstrained specimen, the corresponding values were 9000 grm./cm.^{2} and 4×10^{-5} cm./cm.—J. S. G. T.

***On the Chemical Activity of Redistilled Magnesium. Action of Water and Action of Carbon Dioxide on Mercury at the Ordinary Temperature.** Paul Remy-Genneté (*Bull. Soc. chim. France,* 1934, [v], **1**, 1674–1678).—A clean surface of vacuum-distilled magnesium reacts with water at room temperature, hydrogen being evolved for several hrs. until the surface of the metal is completely covered with magnesium hydroxide. In carbon dioxide the metal slowly absorbs the gas with the formation of oxide and carbide; reaction ceases in about 30 days, and on subsequent exposure to moist air a mixture of hydrogen and acetylene is evolved.—A. R. P.

***The Magnetic Properties of Amorphous Manganese.** L. F. Bates and D. V. Reddi Pantulu (*Proc. Phys. Soc.* (*Lond.*), 1935, 47, 197–204).—Pure amorphous manganese, prepared *in vacuo*, is found to be paramagnetic, without trace of ferromagnetism. It obeys the Curie–Weiss law in the form, $\chi = 2{\cdot}174 \times 10^{-2}/(T + 1540)$, χ denoting the magnetic susceptibility per grm. at T° abs. The experimental volume of χ at 20° C. is $11{\cdot}80 \times 10^{-6}$ e.m.u./grm.—J. S. G. T.

***Kinetics of Mercury Evaporation in the Presence of Thin Layers of Capillary-Active Substances.** S. L. Pupko and M. A. Proskurnin (*Zhurnal Fizicheskoy Khimii* (*J. Phys. Chem.*), 1933, **4**, 523–528 (in Russian), and *Acta Physicochim. U.R.S.S.*, 1934, **1**, 79–89 (in German); *Chem. Zentr.*, 1934, **105**, I, 3183–3184).—The rate of evaporation of mercury in the presence of oleic acid and of triolein has been determined with the aid of an ionization manometer. A monomolecular oil-film reduces very considerably the rate of evaporation, and with triolein even less than this is very effective.—A. R. P.

***Experimental Study of the Viscous Deformation of Iron and Nickel Wires.—I, II.** Pierre Chévenard (*Rev. Mét.*, 1934, 31, 473–486, 517–535).—(I.—) Specimens were investigated by means of a torsion pendulum, described in detail, at temperatures up to 400° C., and after heating to higher temperatures. Viscosity was studied in a specially designed tension apparatus having an optical lever system, to indicate the extension, and means of heating the specimen uniformly to the desired temperature. The significance of the properties studied is discussed. (II.—) The results of the experiments are given in the form of graphs and discussed in detail. The laws governing deformation of the annealed metal are only approximate and are limited to temperatures well below the temperature of annealing and to small deformations. In commercial metals the conditions are much more complicated, owing to simultaneous work-hardening and annealing. For reliable information on the practical value of a metal at elevated temperatures, tests of long duration are essential.—H. S.

***Permeability to Hydrogen of Nickel, Copper, and Some Alloys.** W. Baukloh and H. Kayser (*Z. Metallkunde*, 1934, **26**, 156–158).—Curves are given showing the permeability to hydrogen at high temperatures of pure nickel, nickel with 1% and with 2% chromium, a 33·3 : 66·7 nickel–copper alloy, a 75 : 25 copper–nickel alloy, Armco iron, and pure copper. The rate of diffusion of hydrogen through the metals increases almost linearly with the temperature from 600° to 800° C. and then more rapidly, the rates of diffusion and the slopes of the curves diminishing in the above order; thus nickel has a high permeability to hydrogen and copper only a very slight permeability, while additions either of chromium or of copper to nickel reduce its permeability appreciably.
—A. R. P.

***On the Sorption of Hydrogen by Reduced Nickel. IV.—On the Velocity of Sorption of Hydrogen at the Early Stage.** Shun-ichiro Iijima (*Sci. Papers Inst. Phys. Chem. Res. Tokyo*, 1934, **26**, (545), 45–69).—See also *Met. Abs.*, 1934, **1**, 286.—W. H.-R.

***Magnetic Properties of Thin Sheets of Nickel.** André Aron (*Compt. rend.*, 1935, **200**, 228–230).—The magnetic properties of nickel deposits, normally transparent, made on glass, quartz, or metal by cathodic disintegration, sublimation *in vacuo*, chemical reaction, or electrolysis, have been studied. This work is in the nature of a preliminary investigation to study the results obtained up to the present, with a view to studying the properties in a gas other than air or even *in vacuo*.—J. H. W.

***The Change in Thermal Energy which Accompanies a Change in Magnetization of Nickel.** Agnes Townsend (*Phys. Rev.*, 1935, [ii], **47**, 306–310).—The small changes in thermal energy occurring during the magnetization of a ferromagnetic substance have been measured by a new method, in which the change in temperature of the specimen is measured by thermocouples and compared with that produced by a known electric current for a known time, the resistance of the specimen being known. When hard-drawn nickel is carried through a half-cycle of magnetization the thermal energy decreases during the initial demagnetization until approximately the knee of the hysteresis curve is reached. This is followed by a large increase in thermal energy as the steep part of the curve is traversed, and then by a much smaller increase as the half-cycle of magnetization is completed. This is in contrast to carbon steel, for which the thermal energy increases on demagnetization and decreases on magnetization.—W. H.-R.

***Tribo- and Photo-Electric Effects for Palladium.** P. A. Mainstone (*Phil. Mag.*, 1935, [vii], **19**, 278–290).—Frictional and photoelectric isotherms for palladium in air and in hydrogen are investigated. Prolonged heating in hydrogen does not reverse the sign of the charge developed on the metal by friction; reversal of the charge is attributable to the presence of oxygen, and when produced, cannot be destroyed by heating the metal at 300° C. either *in vacuo* or in hydrogen. The form of the frictional isotherm at low pressures is approximately the same whether the metal contains gas or is in a de-gassed condition.—J. S. G. T.

***Properties of the Platinum Metals. I.—Strength and Annealing Characteristics of Platinum, Palladium, and Several of Their Commercial Alloys.** E. M. Wise and J. T. Eash (*Metals Technology*, **1934**, (Dec.), A.I.M.M.E. Tech. Publ. No. 584, 1–12).—The tensile properties of wires of the following materials have been studied in the " as drawn " state, and after annealing for 5 minutes at different temperatures: commercially pure platinum and palladium; iridium–platinum containing 5, 10, and 20% of iridium; rhodium–platinum with 10% rhodium; nickel–platinum with 4·5–5% nickel; ternary platinum–palladium–rhodium, and palladium–ruthenium–rhodium alloys. A table shows the optimum annealing temperature from the point of view of tensile strength, elongation, and surface appearance. With palladium, annealing above 1000° C. causes a decrease in elongation owing to marked selective grain-growth. The effects of annealing atmospheres of air, hydrogen, and nitrogen were studied for palladium and its alloys.—W. H.-R.

***Preparation of Thin Silver Single Crystals and Their Examination by Means of Electronic Rays.** H. Lassen and L. Brueck (*Ann. Physik*, 1935, [v], **22**, 65–72).—Single crystals of silver have been prepared by evaporation of the metal on to rock-salt in a vacuum.—v. G.

***Reflection of Light by Silver Mirrors, and the Transformation from the Amorphous to the Crystalline State at Low Temperatures.** R. Suhrmann and G. Barth (*Physikal. Z.*, 1934, **35**, 971–973).—From *Vorträge u. Diskussionen des X. Deutschen Physiker- u. Mathematiker-Tages*, **1934**, Sept. The decrease of resistance of a silver film, condensed in high vacuum, over the temperature range — 20° abs. to 390° abs. is determined. The decrease of resistance runs parallel with the increase of reflectivity of the film over the same range. The observations are interpreted on the assumption that in the transformation from the partly amorphous to the metallic condition of the film, first the weakly-bound electrons and then the more firmly-bound electrons are transformed into " metallic electrons."—J. S. G. T.

***The Hall Effect in Sodium, Potassium, and Cæsium.** F. J. Studer and W. D. Williams (*Phys. Rev.*, 1935, [ii], **47**, 291–295).—The Hall effect for these metals has been investigated by a method in which they were distilled in vacuum into thin flat moulds of Pyrex glass, the construction of which is described. The Hall constants obtained were: sodium, — 0·0021; potassium, — 0·0042; cæsium, — 0·0078 e.m.u. The constants for sodium and potassium were independent of the field strength from 2000 to 20,000 gauss, and of the primary current from 1 to 8 amp., whilst for potassium the constant the pure metals are obtained. Cerium has a cubic face-centred lattice with $a = 5{\cdot}14$ A., lanthanum a hexagonal lattice with $a = 3{\cdot}75$, $c = 6{\cdot}06$ A., and neodymium a hexagonal lattice with $a = 3{\cdot}65$, $c = 5{\cdot}88$ A.—v. G.

Review of Theoretical Metallurgy During 1934. Robert F. Mehl (*Metals Technology*, 1935, (Jan.) A.I.M.M.E. Tech. Publ. No. 594, 1–18).—A brief survey of papers published in 1934 (and 1933) summarized under the following headings: theories of states of aggregation, allotropy, growth and properties of metal crystals, deformation, recrystallization, crystal structure, electron diffraction, transformations in alloys, age-hardening, constitution of alloy systems, thermal properties and thermodynamics, diffusion, reactions with gases and corrosion, and electrical and magnetic properties. A *bibliography* of 382 papers is given, but the article is a brief series of references rather than a connected account.—W. H.-R.

Theoretical Strength of Materials. (Sir) William Bragg (*Engineering*, 1935, **139**, 178–179).—Account of a lecture on the discrepancy between the theoretical and practical strengths of materials.—W. P. R.

†The Recovery of Metallic Materials from the Consequences of Cold-Work. G. Tammann (*Z. Metallkunde*, 1934, **26**, 97–105).—A review of recent work on copper, silver, gold, aluminium, iron, nickel, palladium, platinum, magnesium, zinc, cadmium, lead, tin, thallium, and their alloys; contains a *bibliography* of 25 references.—A. R. P.

†Researches on Model Substances for Metal Mechanics. A. Smekal (*Z. Metallkunde*, 1934, **26**, 220–224).—The tensile properties of metals are so closely allied to those of salts that the latter may be used as model substances for elucidating the mechanism of deformation and recrystallization of metals. The application of this method for investigating the nature of the elastic limit and the causes of recrystallization is indicated by a review of the published work of S. on rock-salt.—A. R. P.

***The Use of Radioactive Alloys in the Study of Metals.** O. Werner (*Z. Metallkunde*, 1934, **26**, 265–268).—The effects of cold-work and heat-treatment on thallium, zinc, and aluminium can be studied by measurement of the radioactivity of alloys of the metals with minute traces of thorium-*X*. The allotropic transformation of thallium is shown plainly by a point of inflection in the radioactivity–temperature curve at 235° C.; the absence of such points in the corresponding curves for zinc and aluminium shows that these metals undergo no transformation on heating. The radioactivity of zinc changes during cold-rolling, increasing to a maximum at 20% reduction, decreasing again to the original value at 30–50% reduction, and then decreasing linearly with further reduction. On annealing cold-worked zinc the radioactivity–temperature curve shows a sharp maximum at 232° C.; in similar conditions aluminium shows a maximum at 33° C. after a reduction of 50%, at 150° C. after a reduction of 12·7%, and at 173° C. after a 62% reduction. If the maxima in these curves are plotted against the degree of reduction the resulting graph for zinc falls linearly from 232° C. with 11% reduction to 165° C. with 35% reduction, then rises linearly to above 250° C. with 55% reduction; the corresponding aluminium graph has four linear sections, maxima occurring at 200° C. with 18% reduction and at 162° C. with 61% reduction and a minimum at — 50° C. with 42% reduction. These graphs represent the temperature at which the metal recovers from the effects of cold-work after different degrees of reduction.—A. R. P.

Creep at Elevated Temperatures. Anon. (*Metallurgist* (Suppt. to *Engineer*), 1935, **11**, 3–7).—An up-to-date review of the subject referring to recent papers by Körber, Dustin, Ranque and Henry, and McVetty. The author disagrees with McVetty regarding the use of age-hardening alloys in creep conditions and considers that, in view of results obtained on nickel–chromium–iron alloys, such materials should not necessarily be classed as unsuitable.

the pure metals are obtained. Cerium has a cubic face-centred lattice with $a = 5{\cdot}14$ A., lanthanum a hexagonal lattice with $a = 3{\cdot}75$, $c = 6{\cdot}06$ A., and neodymium a hexagonal lattice with $a = 3{\cdot}65$, $c = 5{\cdot}88$ A.—v. G.

Review of Theoretical Metallurgy During 1934. Robert F. Mehl (*Metals Technology*, 1935, (Jan.) A.I.M.M.E. Tech. Publ. No. 594, 1–18).—A brief survey of papers published in 1934 (and 1933) summarized under the following headings: theories of states of aggregation, allotropy, growth and properties of metal crystals, deformation, recrystallization, crystal structure, electron diffraction, transformations in alloys, age-hardening, constitution of alloy systems, thermal properties and thermodynamics, diffusion, reactions with gases and corrosion, and electrical and magnetic properties. A *bibliography* of 382 papers is given, but the article is a brief series of references rather than a connected account.—W. H.-R.

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***The Use of Radioactive Alloys in the Study of Metals.** O. Werner (*Z. Metallkunde*, 1934, **26**, 265–268).—The effects of cold-work and heat-treatment on thallium, zinc, and aluminium can be studied by measurement of the radioactivity of alloys of the metals with minute traces of thorium-*X*. The allotropic transformation of thallium is shown plainly by a point of inflection in the radioactivity–temperature curve at 235° C.; the absence of such points in the corresponding curves for zinc and aluminium shows that these metals undergo no transformation on heating. The radioactivity of zinc changes during cold-rolling, increasing to a maximum at 20% reduction, decreasing again to the original value at 30–50% reduction, and then decreasing linearly with further reduction. On annealing cold-worked zinc the radioactivity–temperature curve shows a sharp maximum at 232° C.; in similar conditions aluminium shows a maximum at 33° C. after a reduction of 50%, at 150° C. after a reduction of 12·7%, and at 173° C. after a 62% reduction. If the maxima in these curves are plotted against the degree of reduction the resulting graph for zinc falls linearly from 232° C. with 11% reduction to 165° C. with 35% reduction, then rises linearly to above 250° C. with 55% reduction; the corresponding aluminium graph has four linear sections, maxima occurring at 200° C. with 18% reduction and at 162° C. with 61% reduction and a minimum at − 50° C. with 42% reduction. These graphs represent the temperature at which the metal recovers from the effects of cold-work after different degrees of reduction.—A. R. P.

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The various views regarding the utility of long- and short-time tests are discussed.—R. G.

***The Theory of the Specific Heat of Crystals. I.—Lattice Theory and Continuum Theory. II.—The Vibrational Spectrum of Cubical Lattices and Its Application to the Specific Heat of Crystals.** M. Blackman (*Proc. Roy. Soc.*, 1935, [A], **148**, 365–383, 384–406).—(I.—) Variations of the specific heat–temperature curves from the Debye curve are shown to be due, at least in part, to the difference between the characteristics of a lattice and a continuum. (II.—) The vibrational spectrum of a cubic crystal is investigated, and various theories of the specific heat of crystals are discussed from the point of view of the approximation made in each case to this spectrum. In particular, the theoretical justification of the Nernst–Lindemann theory, which represents the spectrum by 2 peaks, is established.—J. S. G. T.

Surface Friction and Adsorption on Metals. P. Rebinder, N. Kalinovskaya, and Hel. Michailova (*Acta Physicochim. U.R.S.S.*, 1934, **1**, 22–26; *C. Abs.*, 1935, **29**, 658).—[In German.] Water, paraffin oil, aniline, *p*-toluidine, and stearic acid adsorbed on copper, magnesium, and tin decrease the surface tangential friction as a function of the quantity adsorbed, reaching a limit as saturation is reached. With aluminium and aluminium-rich copper alloys friction increases with adsorption. The friction of a 5 : 95 aluminium–copper alloy is not affected by adsorption.—S. G.

***On the Structure of Thin Metal Films Produced by Cathodic Sputtering or Evaporation.** G. Tammann (*Ann. Physik*, 1935, [v], **22**, 73–76).—The properties of thin metal films obtained by evaporation *in vacuo* indicate that the metal is probably crystalline and never amorphous.—v. G.

***Researches on the Direct Determination of the Free Path of Electrons in Metals.** A. Eucken and F. Förster (*Z. Metallkunde*, 1934, **26**, 232–235).—The diameter of very thin metal wires can be deduced from measurements of the torsional vibration in a vacuum; an apparatus for carrying out this work and the method of calculation employed are described. If the specific electrical resistance of wire of diameter d is ρ_d then the mean free path of the electrons ($\bar{l}$) is given by the expression: $\rho_d = \rho_a\ (1 + 8\bar{l}/3\pi d)$. The value of $\bar{l}$ for bismuth at 0° C. is 11 μ, and hence the number of free electrons in bismuth at this temperature is only 1 in every 10^6 atoms; the value of $\bar{l}$ for silver at 0° C. is $57{\cdot}7 \times 10^{-7}$ cm., showing that every atom provides a free electron. Hence the classical theory applies to bismuth and the Sommerfeld–Fermi theory to silver. At temperatures in the region of absolute zero the above expression no longer applies, since the constant $8/3\pi$ is replaced by another factor which varies with the temperature.—A. R. P.

***[Theory of the] Effect of Pressure on the Electrical Conductivities of the Alkalis [Lithium and Sodium].** N. H. Frank (*Phys. Rev.*, 1935, [ii], **47**, 282–285).—Theoretical. The modern electron theory of conductivity is extended so as to take into account the effect of pressure on the characteristic temperature, and the firmness of binding of the conductivity electrons. When these factors are considered the observed behaviour of lithium and sodium can be predicted, and no special assumptions are necessary to account for the "abnormal" behaviour of lithium for which the conductivity decreases under pressure (cf. following abstract).—W. H.-R.

***Electronic Energy Bands in Metallic Lithium [Electron Theory of Metals].** J. Millman (*Phys. Rev.*, 1935, [ii], **47**, 286–290).—Theoretical. The theory of Slater (*Rev. Modern Physics*, 1934, **6**, 210) is extended and applied to metallic lithium. Energy and wave function diagrams are reproduced and discussed in detail. When compared with those in metallic sodium, the conductivity electrons in lithium are much more tightly bound.—W. H.-R.

Mechanism of Electrical Conductivity [in Metals]. R. W. Pohl (*Z. Metallkunde*, 1934, 26, 217–219).—A lecture on modern conceptions of the electronic theory of electrical conductivity.—A. R. P.

Electron- and Lattice-Conduction in the Case of Heat-Flow in Metals. E. Grüneisen and H. Reddemann (*Physikal. Z.*, 1934, **35**, 959–963).—From *Vorträge u. Diskussionen des X. Deutschen Physiker- u. Mathematiker-Tages*, **1934**, Sept. Experimental results relating to the thermal resistance of metals and alloys measured at temperatures down to – 251° C. and expressed as functions of the temperature are discussed. At very low temperatures and with small disturbances of the crystal lattice, electron conduction appears to become increasingly more important than lattice conduction.—J. S. G. T.

***The Thermal Behaviour of Metals at Extremely Low Temperatures.** W. H. Keesom (*Physikal. Z.*, 1934, **35**, 939–943; discussion, 943–944).—From *Vorträge u. Diskussionen des X. Deutschen Physiker- u. Mathematiker-Tages*, **1934**, Sept.—Silver and zinc, at the temperature of liquid helium, have been found to be characterized by a supplementary specific heat, which is attributed to the free electrons. The thermal behaviour of a metal in passing from the superconducting to the non-superconducting state is discussed and the result compared with that deduced by means of thermodynamics. A *bibliography* of 13 references is appended.—J. S. G. T.

†Recent Investigations Relating to Super-Conduction. W. Meissner (*Physikal. Z.*, 1934, **35**, 931–938).—From *Vorträge u. Diskussionen des X. Deutschen Physiker- u. Mathematiker-Tages*, **1934**, Sept. Recent investigations relating to the incidence of superconduction in metals and alloys and magnetic effects connected therewith are reviewed. A *bibliography* of 28 references is appended.—J. S. G. T.

***Thermodynamics of the Superconducting State.** C. J. Gorter and H. Casimir (*Physikal. Z.*, 1934, **35**, 963–966).—From *Vorträge u. Diskussionen des X. Deutschen Physiker- u. Mathematiker-Tages*, **1934**, Sept. Cf. *Met. Abs.*, 1934, **1**, 561. The thermodynamics of the superconducting state, considered as a two-phase system, is briefly developed.—J. S. G. T.

***Electron Theory of Superconduction.** R. Schachenmeier (*Physikal. Z.*, 1934, **35**, 966–968; discussion, 968–969).—From *Vorträge u. Diskussionen der X. Deutschen Physiker- u. Mathematiker-Tages*, **1934**, Sept. Cf. *Met. Abs.*, 1934, **1**, 484. A wave-mechanics theory of superconduction in metals and alloys is developed, in which superconduction is attributed entirely to conducting electrons.—J. S. G. T.

***Magnetic Effects in Superconductors.** F. G. A. Tarr and J. O. Wilhelm (*Canad. J. Research*, 1935, **12**, 265–271).—Deals with magnetic effects in metals cooled from above the transition temperature to below the superconducting temperature, while in an applied magnetic field. Previous work of Meissner and Ochsenfeld indicates that at the superconducting temperature the effective permeability of the metal became zero. It is found, however, that the effective permeability is greatly influenced by the composition and geometrical shape of the specimen. There is also, in general, a reduction in flux on removing the magnetic field after the superconducting temperature has been reached, but on re-establishing the field the flux through the specimen remains unchanged.—S. G.

†Ferromagnetism in Metallic Crystals. L. W. McKeehan (*Trans. Amer. Inst. Min. Met. Eng.*, 1934, **111**, Inst. Metals Div., 11–52; and *Metals Technology*, **1934**, (Aug.), *A.I.M.M.E. Tech. Publ.*, No. 554, 1–42).—The significance of the various symbols used in connection with curves of magnetization is briefly referred to, and then work on the magnetization of crystals, as follows, is discussed: (1) work on iron by Beck (which McK. considers has received less attention than it deserves), which shows that magnetization is easiest along the fourfold axes <100>, hardest along the threefold axes

<111>, and intermediate in difficulty along the two-fold axes <110>, and work by Heaps, Webster, Honda, Ruder, Gerlach; (2) work on nickel by Sucksmith and others, by Kaya and Masiyama, and by Sizoo; (3) work on Heusler's alloys by Potter, and work on cobalt by workers in Honda's laboratory. Various theories of crystal ferromagnetism in metallic crystals are briefly discussed; none is entirely satisfactory. A *bibliography* comprising 55 references is appended.—J. S. G. T.

Thermodynamics of Magnetization. Edmund C. Stoner (*Phil. Mag.*, 1935, [vii], 19, 565–588).—A systematic derivation is given of the more important thermodynamic relations relating to magnetization.—J. S. G. T.

The Chemical Elements and the Natural Types of Atom, from the Point of View of Isotope Research. Otto Hahn (*Ber. deut. chem. Ges.*, 1935, [A], 68, 1–15).—A summary, with *bibliography*, of the results of recent research on the isotopes of various elements. An appended table gives a complete list of known elements, together with the number of demonstrated or suspected isotopes, the approximate proportions in which the latter occur, and their individual atomic weights. The international atomic weights are compared with those determined by applying the results of isotope research.

—P. M. C. R.

II.—PROPERTIES OF ALLOYS

(Continued from pp. 91–99.)

***On the Equilibrium Diagram of [the] Copper–Aluminium Alloy System.** Chiuyō Hisatsune (*Mem. Coll. Eng. Kyoto Imp. Univ.*, 1934, 8, (2), 74–91).—[In English.] Aluminium 99·8% pure and electrolytic copper were used. Differential thermal analysis, measurements of electrical resistance, and microscopical examination have been employed in the determination of a new equilibrium curve. The freezing-point curve obtained agrees reasonably well with that previously published by Stockdale. H. believes, however, that a polymorphic change occurs in the ε phase at about 850° C. Peritectic reactions are assumed at 625° and 580° C. A γ_2 phase is observed and is said to be formed according to the following reactions: $\gamma_1 \rightleftharpoons \gamma_2$ (780°–873° C.; 84·5–82% copper) and $\gamma_1 + \varepsilon_1 \rightleftharpoons \gamma_2$ (873° C.; 82–80% copper). New phases are reported: δ, formed by $\gamma_2 + \varepsilon_2 \rightleftharpoons \delta$, 686° C., and ζ, formed by $\varepsilon_2 + \eta_1 \rightleftharpoons \zeta_1$, 590° C. The solubility of the solid solution formed by these phases decreases as the temperature falls. The eutectoid reactions $\varepsilon_2 \rightleftharpoons \delta + \zeta_1$ and $\zeta_1 \rightleftharpoons \delta + \zeta_2$ occur at 560° C. and 530° C., respectively. The ε and η phases each show polymorphic transformation. The θ phase crystallizes directly from the melt.—W. A. C. N.

***On the Improvement of High Copper–Aluminium Alloys by the Addition of Magnesium.** H. Bohner (*Aluminium*, 1935, 17, 72–73).—The mechanical properties of 6% copper–aluminium alloys containing 0–0·9% magnesium, 0, 0·33, or 0·66% manganese, and 0 or 0·3% titanium after quenching from 510°–540° C. and (*a*) ageing at room temperature, (*b*) ageing at 120° C., and (*c*) ageing at 140° C. are tabulated. The results show that the tensile strength increases with increase in quenching temperature, with increase in ageing temperature, with time of ageing, with increase in magnesium content, and with additions of manganese and titanium. Addition of magnesium to a 6% copper–aluminium alloy reduces the elongation after treatment (*c*) to a minimum at about 0·5% magnesium; further addition of magnesium or addition of manganese and titanium tends to increase the elongation again. The yield-point (0·2% elongation) of the alloys containing magnesium and manganese with or without titanium is less than the tensile strength by 12–14 kg./mm.^{2} after natural ageing, by 10–12 kg./mm.^{2} after ageing at

120° C., by 8–10 kg./mm.^{2} after ageing at 140° C., and by 7–9 kg./mm.^{2} after ageing first at 120° C. then at 140° C.; a further improvement in the yield point–tensile strength ratio is obtained by slight cold-working after ageing. —A. R. P.

***The Effect of Time of Annealing on the Solubility of Copper in Solid Aluminium.** A. T. Uljanov (*Metallurg* (*Metallurgist*), 1934, (7), 93–97).—[In Russian.]—N. A.

***The Dilatometric Study of Copper–Aluminium and Silver–Aluminium Alloys Rich in Aluminium.** Hiroshi Kawai (*Nippon Kwagaku Kwai Shi* (*J. Chem. Soc. Japan*), 1934, **55**, 1002–1012; *C. Abs.*, 1935, **29**, 713).—[In Japanese.] The dilatation of copper–aluminium alloys has been studied at various temperatures. The alloys show dilatation at 360° C., and the dilatation is maximum with a copper content of 8%. Quenched silver–aluminium alloy (silver 30%) shows dilatation at 300° C. Minute crystals of Ag_2Al begin to appear at the grain boundaries when the alloy is heated at 300° C.—S. G.

***On the Problem of the Mechanism of Ageing of Duralumin.** G. V. Akimow and A. S. Oleshko (*Zhurnal Tehnicheskoy Fiziki* (*J. Tech. Physics*), 1934, **4**, 547–567).—[In Russian.] The changes in hardness and electrode potential during ageing at 20° C. of 2 specimens of Duralumin (containing (*a*) copper 4·22, magnesium 0·63, manganese 0·67, iron 0·32, silicon 0·18% and (*b*) copper 3·84, magnesium 0·65, manganese 0·48, iron 0·38, silicon 0·19%) have been determined. The potential in *N*-potassium chloride and in 0·01*N*-potassium hydroxide solution against the *N*-calomel electrode decreases to a minimum 24 hrs. after quenching, then increases again. The maximum rate of increase in hardness corresponds with the maximum rate of fall in potential. Duralumin (*a*) differs from (*b*) in that during the first few hrs. after quenching the potential remains constant and the minimum in the curve occurs earlier. Analysis of the results indicates that the initial fall in potential occurs before precipitation commences, and that the subsequent increase of potential corresponds with the separation of one of the constituents. It is considered that normal ageing consists of two stages: (1) destruction of the space lattice, and (2) separation of the disperse constituents.—N. A.

***Copper Diffusion into Coating Layers on Hardenable Aluminium Alloys.** A. Burkhardt and G. Sachs (*Metallwirtschaft*, 1935, **14**, 1–3; and (translation) *Light Metals Research*, 1935, **3**, 287–290).—The diffusion of copper from copper–aluminium alloys into coatings of pure aluminium has been followed by X-ray and micrographic analysis. At 500° C. the rate of diffusion is so appreciable that after 2–3 hrs. a coating 0·5 mm. thick will contain sufficient copper to destroy its protective value. Magnesium in the base metal has no effect on the diffusion.—v. G.

***The Alloys of Aluminium with Gallium.** Ernst Jenckel (*Z. Metallkunde*, 1934, **26**, 249–251; and (translation) *Light Metals Research*, 1934, **3**, 248–251).—Thermal analysis of the system under carefully controlled conditions has failed to confirm the existence of the compounds reported by Puschin and Stajić (*Met. Abs.*, 1934, **1**, 119), the liquidus being a smooth curve joining the melting point of the 2 metals and concave to the axis of composition. The only eutectic has a composition very close to 100% gallium, and no solid solutions exist.—A. R. P.

***On the Decomposition of an Iron–Aluminium Alloy.** F. Roll (*Z. Metallkunde*, 1934, **26**, 210–211).—Iron–aluminium alloys containing 25–50% aluminium and more than 0·15% carbon disintegrate and fall to a powder when exposed to moist air; since gaseous and liquid hydrocarbons are formed during this process, it appears that the effect is due to the presence of an aluminium carbide in the alloy, and since acetylene is one of the reaction products the carbide is probably AlC_3. Addition of small amounts of copper to the alloys produces disintegration with less than 20% aluminium.—A. R. P.

***Resistance of Iron–Aluminium Alloys to Oxidation at High Temperatures.** N. A. Ziegler (*Trans. Amer. Inst. Min. Met. Eng.*, 1932, **100**, Iron and Steel Div., 267–270; discussion, 270–271).—See *J. Inst. Metals*, 1932, **50**, 222.—S. G.

***Investigation of Ternary Aluminium Alloy Systems. Al-Rich Al–Fe–Si System.** Hideo Nishimura (*Mem. Coll. Eng. Kyoto Imp. Univ.*, 1933, 7, (5), 285–303).—[In English.] The equilibrium diagram for aluminium-rich alloys containing up to 30% silicon and 32% iron has been reinvestigated. Three invariant reactions occur in this range: (1) liquid $\rightleftharpoons$ Al-rich solid solution + Si at 578° C.; (2) liquid + $FeAl_3 \rightleftharpoons FeAl_3.FeSi_2$ + Al-rich solid solution at 615° C. The composition of the ternary compound $FeAl_3.FeSi_2$ has only been determined hitherto by Fuss; (3) probably liquid + $\gamma \rightleftharpoons FeAl_2 + FeAl_3.FeSi_2$ 870° C.—W. A. C. N.

A New Method for the Improvement of High-Silicon Aluminium Alloys. Anon. (*Metallwirtschaft*, 1935, **14**, 134).—The tendency of silicon to segregate from hypereutectic silicon–aluminium alloys can be restrained by small additions of sulphur, selenium, arsenic, iodine, mercury, thallium, antimony, bismuth, or titanium.—v. G.

Nüral Cylinder Alloys. O. Summa (*Deut. Motor. Zeit.*, 1934, **11**, 194–200).—Nüral 132 is a high silicon–aluminium alloy improved by the addition of other elements (nature not stated) and modified in the usual way. The expansion on heating is normal and the metal reverts to its original dimensions on cooling, *i.e.* the phenomenon of "growth" is absent. The hot-hardness is intermediate between those of cast iron and Elektron and is retained at 160° C. for more than 300 hrs. The alloys can be cast readily and can also be worked after heat-treatment to refine the grain structure.—A. R. P.

***The Aluminium-Rich Alloys of the Ternary System Aluminium–Tin–Manganese.** Alfred Schück (*Z. Metallkunde*, 1935, **27**, 11–18).—A lengthy abstract from S.'s dissertation (see *Met. Abs.*, 1934, **1**, 537; this volume, p. 50).—A. R. P.

***Undercooling of High-Melting Intermetallic Compounds of Aluminium Alloys. Contribution to the Knowledge of the Aluminium–Titanium System.** H. Bohner (*Z. Metallkunde*, 1934, **26**, 268–271).—According to the latest determinations the solid solubility of titanium in aluminium is only 0·02%, but Bosshard (*ibid.*, 1927, **19**, 288) found that the electrical resistance of titanium–aluminium alloys increases with the titanium content up to 0·20% in a manner typical of a solid solution. These conflicting results are shown to be due to variations in the casting temperature and rate of cooling. When an alloy with 0·5% titanium is chilled rapidly from above 900° C. (*i.e.* above the liquidus) no needles of $TiAl_3$ can be detected in the microstructure, *i.e.* the $TiAl_3$ is so highly dispersed that the alloy behaves as a solid solution. Castings made at temperatures below the liquidus show the usual clusters of $TiAl_3$ needles, which are not affected by subsequent annealing. By maintaining the alloy for some time at just above the solidus the $TiAl_3$ settles to the bottom of the metal, and the top layer retains only 0·03–0·04% titanium in solid solution. The effects of various casting and cooling conditions on the microstructure of titanium–aluminium alloys with and without manganese are shown in a series of micrographs.—A. R. P.

***On the System Aluminium–Zinc.** E. Schmid and G. Wassermann (*Z. Metallkunde*, 1934, **26**, 146–150; and (translation) *Light Metals Research*, 1935, **3**, 266–278).—X-ray examination of aluminium–zinc alloys has shown that the solid solubility of zinc in aluminium increases from 5% at 160° to 48% at 350° C. The lattice constants of the face-centred cubic β-phase at 300° and at 350° C. are in agreement with the assumption that this phase is identical with the γ-phase, *i.e.* that it is a simple solid solution of zinc in aluminium and not the compound Al_2Zn_3. It appears, therefore, that the β-phase must be assumed to be a continuation of the γ-phase with the 2 fields of existence separated by a region of immiscibility; above 350° C., however, it is probable that the 2 fields merge into one another forming a single field, in which case modifications will be necessary in the accepted solidus line. The so-called eutectoid transformation of β is shown to be simply a process of recrystallization caused by an extensive and profound diffusion of the 2 constituent solid solutions produced by the decomposition of β; the rapidity of the decomposition of quenched β is explained by the fact that 76 of the 78% of zinc which it contains in solid solution is liberated in the process.—A. R. P.

Cast Aluminium Alloys Susceptible to Improvement by Heat-Treatment. F. Söhnchen (*Bull. Assoc. Tech. Fonderie*, 1934, 8, (6), 255–256).—Abstract of paper read to Institut de Fonderie at Aix-la-Chapelle, Feb., 1933.—R. B. D.

***Determination of the Melting Points of Some Chromium–Iron Resistance Alloys.** H. Hoffmann and A. Schulze (*Physikal. Z.*, 1934, 35, 881–884).—The following melting points of the respective chromium–iron alloys, all of approximately the same chemical composition, *viz.* iron about 65%, chromium about 30%, and aluminium about 5%, have been determined: Megapyr, 1501° C.; Kanthal, 1493° C.; Permatherm, 1499° C.; Alsichrom, 1497° C. The determinations were made in an atmosphere of argon, and are correct to within ± 5° C. The specific resistances of the alloys at room temperature are of the order 1·4 ohm mm.^{2}/m. (Cf. following abstract.)—J. S. G. T.

***On the Melting Points of Some Chromium–Iron Resistance Alloys.** A. Schulze (*Z. Metallkunde*, 1935, 27, 45–46).—Cf. preceding abstract. Megapyr, Kanthal, Permatherm, and Alsichrom, which are high chromium–iron alloys containing silicon and aluminium, all have a melting point of 1500° (± 10°) C. —A. R. P.

***On the Thermal Expansion of Alloys of Cobalt, Iron and Chromium, and a New Alloy "Stainless Invar."** Hakar Masumoto (*Sci. Rep. Tôhoku Imp. Univ.*, 1934, 23, 265–280).—[In English.] Following his theory of Invar, M. has measured the thermal expansion of ternary alloys of cobalt, iron, and chromium, and has found that an addition of a small quantity of chromium to cobalt–iron alloys containing more than 50% cobalt considerably reduces their expansibility. The measurement of the thermal expansion of alloys having small expansibility was made from the temperature of liquid air to the vicinity of the magnetic transformation point, and the range of temperature available for this small expansibility was examined. The smallest coeff. of linear expansion at 20° C. found in the present investigation was $-1{\cdot}2 \times 10^{-6}$. Further, it was found that alloys having small expansibility were practically non-corrodible in dilute solutions of sodium chloride. Some physical properties of these alloys were determined.—S. G.

Alloys of Low Thermal Expansibility. Anon. (*Metallurgist* (Suppt. to *Engineer*), 1935, 11, 14–16).—A brief review of the subject and a summary, with detailed results of a paper by Hakar Masumoto, "On the Thermal Expansion of Alloys of Cobalt, Iron, and Chromium," *Sci. Rep. Tôhoku Imp. Univ.*, 1934, 23, 265–280 (see preceding abstract).—R. G.

***Investigation of Alloys Prepared by Sintering.** N. Zarubin and L. Molkov (*Vestnik Metallopromishlennosti* (*Messenger Metal Ind.*), 1934, 14, (7), 59–68).—[In Russian.] The microstructure of the alloys of cobalt with the carbides of molybdenum, tantalum, and titanium prepared by sintering mixtures of the powdered constituents at 1450° C. for 1·5 hrs. has been examined. In the molybdenum carbide system the solid solution extends to 6% Mo_2C and the eutectic occurs at 30% Mo_2C. X-ray investigation indicates that up to 6% Mo_2C the cobalt exists in only one form, but with higher contents of Mo_2C a second modification of cobalt appears. Cobalt dissolves 6% of TaC and the eutectic occurs at 35% TaC. The alloys of the system TiC–Co within the limits of 5–90% of TiC consist of two phases.—D. N. S.

***On New K.S. Permanent Magnet [Alloy].** Kotarô Honda, Hakar Masumoto, and Yuki Shirakawa (*Sci. Rep. Tôhoku Imp. Univ.*, 1934, [i], 23, 365–373).—[In English.] The alloy contains cobalt 15–36, nickel 10–25, titanium 8–25% and the remainder iron with a small quantity of aluminium. The best magnetic properties are obtained by annealing chill-castings at 660° C. The alloys cannot be forged, but must be cast into shape and finished by grinding. The annealed alloys have a Rockwell C hardness of 60, a coercive force of 800–900 gauss, and a remanence of 7500–6400 c.g.s. units.—A. R. P.

Modifications of Aluminium–Bronze. S. W. Clapham (*Machinist* (*Eur. Edn.*), 1935, **79**, 51–52E).—" Aluminium-bronze," as manufactured at present, contains 7–10% of aluminium and 1–4% of total alloy additions, which may include iron, tin, nickel, silicon, and manganese. The effect of these various constituents, and also of cobalt, on the mechanical properties of the alloy is described. Reheating the quenched alloys has a hardening effect. The mechanical properties of the alloy in the form of large and small castings, after quenching at 900° C. and after slow cooling, are tabulated.—J. H. W.

The New Alloy " Corrix." J. F. Kesper (*Tech. Zentr. prakt. Metallbearbeitung*, 1934, **44**, 394–395).—Corrix, a copper–aluminium–iron alloy, is said to exhibit superior chemical and physical properties to those of similar alloys. It is also resistant to corrosion, is hard, and possesses a fine-grained structure. The working properties are good. The cast alloy has a sp. gr. of 7·6, an average tensile strength of 67·1 kg./mm.^{2}, an elongation of 25–35%, and Brinell hardness 190–195. Comparisons are made with the properties of other constructional materials.—W. A. C. N.

***The System Iron–Copper–Antimony.** Rudolf Vogel and Walter Dannöhl (*Arch. Eisenhüttenwesen*, 1934–1935, **8**, 83–92).—The complete ternary system has been investigated by thermal and micrographic methods, and the results are shown in a ternary diagram, a space model, and numerous sections of constant content of one constituent. There are 2 ternary compounds, *viz.* (*a*) FeCuSb formed at 780° C. by reaction between a liquid with a low iron content, α-iron saturated with copper and antimony, and FeSb–iron solid solution, and (*b*) $FeCu_4Sb_2$ formed at 758° C. by reaction between liquid with a low iron content, saturated α-iron, and FeCuSb; both compounds decompose on melting, and only the first is stable at room temperature. When liquid with up to 53% antimony is cooled the primary crystals consist of ternary α- or γ-iron solid solutions, whereas a solid solution of iron in FeSb (ρ-phase) separates primarily on cooling alloys with more than 53% antimony. The addition of even small quantities of antimony to iron–copper alloys displaces the miscibility gap to higher temperatures, and no layer formation occurs during the solidification of ternary alloys. The space model of the system contains 8 primary surfaces corresponding with the separation of ternary α-iron, ternary γ-iron, ρ, $FeSb_2$, copper saturated with iron and antimony (ε-phase), ternary ν (Cu_5Sb_2 saturated with $FeCu_4Sb_2$), ternary μ (Cu_5Sb_2 saturated with FeCuSb), and Cu_2Sb. A second phase separates when the composition of the liquid corresponds with any point on one of the 13 curves forming the boundaries of the primary surfaces. Of the points of intersection of these curves 7 correspond with non-variant four-phase equilibria in which one phase is liquid; one of these points represents the merging of two three-phase equilibria in the iron–copper system (liquid $+ \alpha \rightleftharpoons \gamma$ and $\gamma \rightleftharpoons \alpha + \varepsilon$) to the four-phase equilibrium: liquid $+ \gamma \rightleftharpoons \alpha + \varepsilon$. The equilibria in the solid state are highly complex, there being 17 curves of three-phase and 4 points of four-phase equilibria; in addition the system provides an example of 3 curves of univariant equilibrium in a ternary system merging at a temperature maximum of a curve of equilibrium of one of the component binary systems.—A. R. P.

***Solubility of Copper in Iron, and Lattice Changes During Ageing.** John T. Norton (*Metals Technology*, 1934, (Dec.), A.I.M.M.E. Tech. Publ. No. 586, 1–9).—The solid solubility of copper in iron has been redetermined by X-ray methods, and the maximum solubility has been set at 1·4% copper by weight. The solubility decreases with decreasing temperature and is constant below 650° C. at a value of 0·35%. Lattice changes during age-hardening have been correlated with hardness values and it is shown that the principal increase in hardness takes place prior to the precipitation of the copper-rich phase. At all temperatures at which hardening takes place the maximum hardness occurs when about 20% of the available copper has been precipitated. At all temperatures at which age-hardening can be observed, complete precipitation finally occurs accompanied by a decrease in hardness. It is concluded that the age-hardening is due to two factors: the pre-precipitation rearrangement of the solid solution, which is the principal cause, and actual precipitation, which is the secondary cause. The relative magnitude of these two factors is not dependent on the ageing temperature.—S. G.

***On the Reproducibility of the Electro-Physical Properties of Manganin.** N. A. Shalberov (*Zhurnal Tehnicheskoy Fiziki* (*J. Tech. Physics*), 1934, **4**, 1042–1056).—[In Russian.] Numerous ingots of Manganin were cast and annealed under conditions which excluded oxidation to determine the reproducibility of the chemical composition, specific electrical resistance, and e.m.f. in relation to copper.—N. A.

***Comparison of the Hardening of a Worked and a Cast [Silver–Copper] Alloy.** P. Wiest and U. Dehlinger (*Z. Metallkunde*, 1934, **26**, 150–152).—The fact that cast alloys harden more slowly, and to a smaller degree than worked alloys, when subjected to a precipitation-hardening treatment, is attributed to their less homogeneous structure and to the less ideal formation of their lattice. Hardness–time curves obtained on precipitation-hardening of a quenched 5% silver–copper alloy in the polycrystalline cast state are similar to those obtained with single crystals produced directly from the molten alloy, and are smoother and less complex than those obtained with the recrystallized alloy. Single crystals produced from the solid alloy harden to a greater extent than does the polycrystalline alloy. The hardening effect in quenched cast alloys is improved by cold-work after quenching.—A. R. P.

***On the Solubility Limits of the α-Phase in Copper–Tin Alloys.** S. T. Konobeevskiy and V. P. Tarasova (*Zhurnal eksperimentalnoy i teoreticheskoy Fiziki* (*J. Exper. and Theoret. Physics*), 1934, **4**, 272–291).—[In Russian.] Annealing of copper–tin alloys at 300° C. results in the decomposition of the α-solid solution with separation of a new phase and change in concentration from 8·5 to 4 atomic-% tin. The solubility of tin in the α solid solution at 650°, 500°, and 480° C. is 8·6, at 410° C. 8·0, at 385° C. 7·2, at 343° C. 6·5, at 325° C. 6·1, and at 300° C. 4·1 atomic-% tin. From the point of view of the mechanism of the diffusion process the presence of heterogeneous stresses in the deformed crystals must give rise in a certain temperature range to definite concentration currents and therefore to the separation of nuclei of the excess solute. The shape of the solubility curve obtained is explained by assuming that the solid solution of tin in copper in the equilibrium state must obey the general thermodynamic expression for solutions: $ln\ .\ S = \frac{Q}{RT} + C$ and that the boundary curve corresponds with the equilibrium of the δ (γ) phase with the α-solid solution of a definite degree of supersaturation determined by the size of the separated δ (γ) particles. On the basis of these hypotheses the size and number of the crystals formed during decomposition have been determined in relation to the annealing temperature and degree of supersaturation. Theoretical calculations have also been made of the rate of dissolution of the δ (γ) phase in relation to the annealing temperature and compared with the experimental figures.—N. A.

***Equilibrium Relations in the Copper Corner of the Ternary System Copper–Tin–Beryllium.** Elbert S. Rowland and Clair Upthegrove (*Metals Technology*, 1935, (Feb.), A.I.M.M.E. Tech. Publ. No. 613, 1–26).—The equilibrium diagram of the copper–tin–beryllium system has been investigated for alloys containing up to 32% tin and 1·0% beryllium by weight. For a constant percentage of tin, the liquidus and solidus temperatures decrease with increase in beryllium content, and the boundaries of the various phases shift toward lower tin contents as beryllium is added. The α, β, β′, γ, and δ phases of the copper–tin system give rise to corresponding ternary phases, whilst a phase believed to be the γ (body-centred cubic) phase of the copper–beryllium system is present in some of the alloys, but the relations are complex, and the original must be consulted. Diagrams are given for the sections containing 0·25, 0·50, and 1·0% beryllium by weight, and for 6 isothermal sections between 300° and 730° C.—W. H.-R.

Transformation of α- into β-Phase of Copper–Zinc Alloys. B. Petrenko (*Ukrainskii Khemichnii Zhurnal* (*J. Chim. Ukraine*), 1934, 9, (1), 17–23).—[In Ukrainian.] Earlier work on this subject is briefly summarized. It is concluded from investigation of the physical and mechanical properties of the alloys that the change occurs between 450° and 475° C. A *bibliography* is given.—M. Z.

***Tensile Tests [of Brass and Steel] with Plane Plastic Deformation.** Gerhard Baranski (*Z. Metallkunde*, 1934, **26**, 173–180).—Tensile tests have been made on 63 : 37 brass and on a mild steel using special flat test-pieces with side-flanges to prevent transverse contraction and to ensure fracture taking place perpendicularly across the specimen. A mathematical analysis of the stress distribution is given, and the experimental results are shown graphically. Using the stress intensity and the deformation deviator as co-ordinates the curves for brass under uniaxial stress and under plane plastic deformation are coincident almost up to the maximum stress.—A. R. P.

***Physical and Casting Properties of the Nickel–Silvers [Liquidus Points of Copper–Nickel–Zinc–Tin and Copper–Nickel–Zinc–Lead Alloys].** T. E. Kihlgren, N. B. Pilling, and E. M. Wise (*Metals Technology*, **1935**, (Feb.), A.I.M.M.E. Tech. Publ. No. 610, 1–31).—Copper–nickel–zinc alloys containing up to 30% nickel and 50% zinc, and also some quaternary alloys containing up to 8% tin and 20% lead were investigated; liquidus determinations were made for the copper-rich quaternary alloys. The effect of composition on the colour of cast and wrought alloys was examined, and tables are given to show which alloys will give harmonious colour "matches." Nickel is the most important element in determining the whiteness. Zinc has a slight decolorizing influence, but lead and tin in the amounts present in nickel–brasses have a relatively small effect. Indoor atmospheric and accelerated tarnish tests are described; nickel is the predominant element in determining tarnish resistance. The hardness of sand-cast alloys was measured, and the casting fluidity determined by measuring the length of a spiral that could be cast in green-sand from known temperatures. The shrinkage properties and the effect of deoxidation procedure on the soundness of ingots were examined; the most satisfactory deoxidizers were 0·10% manganese, 0·05% magnesium, or 0·02% phosphorus. Tensile, and hydraulic and fracture tests are also described.—W. H.-R.

***The Equilibrium Diagram of Iron–Manganese–Carbon Alloys of Commercial Purity.** E. C. Bain, E. S. Davenport, and W. S. N. Waring (*Trans. Amer. Inst. Min. Met. Eng.*, 1932, **100**, Iron and Steel Div., 228–249; discussion, 250–256).—See *J. Inst. Metals*, 1932, **50**, 226.—S. G.

***The Absorptive Power of Iron–Molybdenum Alloys for Hydrogen and Nitrogen.** A. Sieverts and K. Brüning (*Arch. Eisenhüttenwesen*, 1933–1934, 7, 641–645).—The solubility of hydrogen and nitrogen in iron–molybdenum alloys at 300°–1100° C. under pressures of 100–760 mm. of mercury has been determined; in all cases the amount of gas dissolved is, at constant temperature, approximately proportional to the square root of the pressure. The points of inflection in the solubility–composition curves correspond with phase changes in the equilibrium diagram. The amount of hydrogen absorbed at a given temperature is independent of the composition from 0 to 40 atomic-% molybdenum, then decreases almost linearly with increase in the molybdenum content. The amount of nitrogen absorbed by the α- and γ-phases is the same, whereas that absorbed by alloys containing the ε-phase (6–84 atomic-% molybdenum) is much greater, probably owing to the formation of a complex nitride which decomposes above 1350° C. It is suggested that determinations of the solubility of a gas in an alloy system provide a good guide to the phase changes which occur.—A. R. P.

***Dispersion-Hardening of Iron–Molybdenum Alloy.** O. N. Altgauzen and B. G. Lifschitz (*Zhurnal Tehnicheskoy Fiziki* (*J. Tech. Physics*), 1934, **4**, 1242–1245).—[In Russian.] The changes in electrical resistance, magnetic induction, and coercive force of an alloy of iron with 18·8% molybdenum and 0·06% carbon have been investigated during ageing at 300°–750° C. after quenching at 1350° C.—N. A.

***Special Magnetic Behaviour of Cold-Rolled Iron–Nickel Alloys (Development of Isoperm).** O. Dahl and J. Pfaffenberger (*Metallwirtschaft*, 1935, **14**, 25–28).—The magnetic properties of 40 : 60 nickel–iron alloys can be considerably changed by suitable cold-rolling and heat-treatment.—v. G.

***The System Iron–Nickel–Molybdenum.** Werner Köster (*Arch. Eisenhüttenwesen*, 1934–1935, **8**, 169–171).—The system has been examined by thermal and micrographic methods in the region iron–Fe_3Mo_2–MoNi–nickel. The 2 compounds form a continuous series of solid solutions (δ) with one another and the solubility of α and γ in δ increases with increase in temperature, hence precipitation-hardening is possible within certain ranges of composition. The Curie point of α-alloys with 4% nickel is 760°–720° C., but that of reversible iron–nickel alloys is lowered by addition of molybdenum. In the nickel–molybdenum system the Curie point reaches room temperature with 9% molybdenum, but with addition of iron progressively larger amounts of molybdenum are required to produce this effect, thus with 80% nickel and 8% molybdenum the Curie point is 375° C. and with 80% nickel and 15·5% molybdenum at 150° C. In the ternary system, the magnetic transformation surface intersects the γ-solid solution surface at 20° C. at the points nickel 60, molybdenum 17, iron 23% and nickel 19, molybdenum 10, iron 71%. Alloys in the range between the molybdenum corner and the iron–nickel side at 80% nickel are non-magnetic unless heterogeneous; by quenching from above 1300° C. and reheating at 700° C. Brinell hardnesses of more than 500 can be obtained.—A. R. P.

†The Latest Developments in the Field of Precious Metal Alloys. O. Feussner (*Z. Metallkunde*, 1934, **26**, 251–253).—Recent advances in the manufacture of precious metal alloys which can be hardened by heat-treatment and by cementation are reviewed, and the catalytic properties of the metals are briefly outlined.—A. R. P.

***Are Not Liquid Sodium-Amalgams Colloidal?** R. M. Joshi (*Indian J. Physics*, 1934, **9**, 153–159).—Cf. *Met. Abs.*, 1934, **1**, 297. J. advances arguments in reply to Bent's contention (*J. Inst. Metals*, 1933, **53**, 493) that liquid sodium amalgams are not colloidal in character.—J. S. G. T.

***Attrition Tests of Babbitt Metals.** N. M. Orlov (*Zavodskaya Lab.*, 1934, **3**, 851–856; *C. Abs.*, 1935, **29**, 711).—[In Russian.] Cf. *Met. Abs.*, this volume, p. 109. The results of testing various Babbitt metals in the Amsler machine are tabulated and discussed.—S. G.

***Comparative Tests on Zinc-Base Alloys Containing Copper, Aluminium and Manganese Using Refined Zinc and Electrolytic Zinc as the Base Metal.** W. Guertler, F. Kleweta, W. Claus, and E. Rickertsen (*Z. Metallkunde*, 1935, **27**, 1–10).—The mechanical properties of zinc alloys with aluminium 0–4 and copper 2–8% and of an alloy with aluminium 2, copper 4 and manganese

1% made with (*a*) electrolytic zinc (99·98%) and (*b*) refined zinc (zinc 98·86, lead 1·07, cadmium 0·052, and iron 0·016%) are tabulated; the tables give the results obtained on the sand-cast and chill-cast and on sheets rolled from the chill-cast alloys. In addition, the rate of corrosion of the alloys in salt solution with and without hydrogen peroxide, and with and without carbon dioxide are given. The results in all cases show the superiority of alloys made from electrolytic zinc, especially in the impact bending test and the tensile test. Rolled sheets of alloys made from refined zinc were generally as brittle as glass, whereas many of the alloys made from electrolytic zinc rolled into perfectly pliable sheets. All the alloys showed a poor resistance to corrosion by salt solutions and underwent deterioration when heated in wet steam at 95°–100° C., those made from refined zinc being worse in both tests than those made from electrolytic zinc.—A. R. P.

***Results of Investigations on Zinc Die-Casting Alloys Containing Aluminium.** W. Claus (*Metallwirtschaft*, 1935, 14, 67–68).—The influence of various grades of commercial zinc on the properties of die-castings of zinc alloys with (*A*) copper 2·5, aluminium 4·5% and (*B*) copper 4, aluminium 2·5% has been investigated (both alloys contained 0·1% magnesium). The best properties are obtained by using the purest zinc; alloy *A* has better tensile properties than alloy *B*. Addition of 0·03% lithium is advantageous. None of the alloys undergoes ageing within 7 months, and the better alloys can readily be rolled.—v. G.

†New Equilibrium Diagrams for the Systems Lead–Thallium and Lead–Thallium–Cadmium. Ernst Jänecke (*Z. Metallkunde*, 1934, 26, 153–155).—A review of published work on these systems indicates that the system lead–thallium contains 3 constituents, *viz.* a solid solution of lead in thallium, a solid solution of thallium in lead, and a solid solution of thallium in the compound $PbTl_2$.—A. R. P.

***Researches on the Tensile Properties of Metal Tubes Under Stresses Produced by Internal Pressure [Lautal, Copper, Brass, Lead, Steel].** E. Siebel and E. Kopf (*Z. Metallkunde*, 1934, 26, 169–172).—The yield-point, tensile strength, and elongation of mild steel, Lautal, copper, brass, and lead tubes have been determined in the ordinary tensile test and under hydraulic pressure applied internally until bursting ensues. The results obtained are given in the following table:

	Tensile Test.			Hydraulic Test.		
	Yield-Point, kg./mm.².	Breaking Stress, kg./mm.².	Elongation, %.	Yield-Point, kg./mm.².	Breaking Stress, kg./mm.².	Elongation, %.
Lautal, A	30	44·5	20	30·6	37·2	5·9
„ B	24·8	44·8	26	25·7	35·3	9·7
Copper, hard-drawn	34·1	35·0	7	...	34·5	2·4
„ annealed	...	23·0	45	6·4	18·7	25·7
Brass, hard-drawn	40·0	47·0	22·5	39·0	43·1	5·2
Lead, drawn	...	...	...	...	1·3	9·4

All the tests were carried out on tubes 38 mm. in diameter with 3 mm. walls. Lautal A was hardened and drawn into tube, Lautal B drawn into tube, quenched from 500° C. and aged at 130° C. It will be noticed that the breaking stress is 10–20% less in the hydraulic test than in the tensile test except for hard-drawn copper, and that the elongation in all cases is much less in the hydraulic test.—A. R. P.

Alloys that Age-Harden. P. D. Merica (*Metal Progress*, 1935, 27, (3), 46–50).—The mechanism of age-hardening is discussed in the cases of Duralumin, certain dental alloys of the gold–copper, palladium–copper, platinum–copper, and gold–silver–copper–palladium series, the copper–nickel–aluminium alloys, beryllium–" bronze," the nickel–bronzes, and such " hardeners " as nickel silicide.—P. M. C. R.

***Volume Changes by Diffusion in Relation to Inverse Segregation.—II.** C. Haase (*Z. Metallkunde*, 1934, 26, 181–185).—Cf. *J. Inst. Metals*, 1932, 50, 730. The degree of segregation which occurs in cast 10 and 20% tin–copper, 24% silver–copper, 11% manganese–copper, 5% silicon–copper, 8·5% aluminium–copper, 6% copper–aluminium, and 15% zinc–aluminium alloys has been determined by analysis of various parts of the casting, and the density of the castings after various heat-treatments has been measured. From the volume changes which occur during the solidification range in all the above alloys, it is shown that, except in the aluminium– and silicon–" bronzes," expansion occurs accompanied by inverse segregation. In some cases the volume changes are influenced by the gas content of the metal and the porosity of the castings, and in all cases the extent of the volume changes determines the piping. The segregation phenomena during rapid and slow cooling always occur with the same alloys, so that it is difficult to decide whether the gas content or the expansion caused by diffusion is the determining factor for inverse segregation.—A. R. P.

[Symposium on Grain-Size.] —— (*Trans. Amer. Soc. Metals*, 1934, 22, 861–1173).—The symposium is concerned almost entirely with the implications of grain-size in ferrous materials, but it contains a large amount of general discussion which will no doubt also be of interest to those working with non-ferrous metals and alloys. Principally the relationships between grain-size and the important physical properties are considered.—W. A. C. N.

Influence of Grain-Size on the High-Temperature Characteristics of Ferrous and Non-Ferrous Alloys. A. E. White and C. L. Clark (*Trans. Amer. Soc. Metals*, 1934, 22, 1069–1088; discussion, 1088–1098).—Two types of grain-size are considered: (1) the McQuaid–Ehn, or inherent, grain-size, and (2) that produced by heat-treatment, called " actual." Two pearlitic steels, one of the molybdenum type and the other a manganese–molybdenum type, were used in consideration of the former, and 2 non-ferrous alloys (77 : 22 : 1 and 59 : 40 : 1 copper–zinc–tin) were employed in investigation of the latter. It is concluded that the inherent grain-size appreciably influences the high-temperature characteristics of steel. From tensile tests it appears that coarse-grained materials, with certain exceptions, in general possess the greater strength, whilst the finer-grained material has the maximum impact strength and superior creep properties. Actual grain-size, as determined on the 2 non-ferrous alloys, also influences the high-temperature characteristics. In general, tensile tests indicate that fine-grained materials have greater strength over a range of temperatures up to 400° C. The coarse-grained structure appears to be associated with the greater elongation values, especially at the lower temperatures, but with the lesser reduction in area values. At temperatures below the lowest temperature of recrystallization fine-grained metal has the greater creep resistance, whilst at temperatures above that figure it has the lesser resistance. A comparison is made of the relative influence of grain-size as determined in the two ways. An appreciable discussion of the paper, and a reply by the authors are included.—W. A. C. N.

***The Effect of Pressure on Eutectic Mixtures.** H. A. C. McKay and B. Higman (*Phil. Mag.*, 1935, [vii], 19, 367–375).—Mathematical equations connecting eutectic temperature, eutectic composition, and pressure are derived, and the results applied to experimental data relating to eutectic mixtures of organic substances.—J. S. G. T.

†**Transformations in Eutectoid Alloys.** G. Wassermann (*Z. Metallkunde*, 1934, 26, 256–259; and (translation) *Light Metals Research*, 1934, 3, 259–265).—A review (19 references) of recent work on eutectoid transformations

in β-alloys of copper with aluminium, tin, and beryllium, and of the α–γ transformation in iron–carbon alloys, shows that there are many structural, crystallographic, and kinetic similarities in the various systems, but in no two cases is the transformation similar in all respects, so that it is impossible to predict the mechanism of the change in any system from observations made on another system. It is concluded that much more work must be done before a satisfactory explanation of the numerous phenomena observed can be advanced.—A. R. P.

***Methods for Investigating Thermal Changes Occurring During Transformations in a Solid Solution.** C. Sykes (*Proc. Roy. Soc.*, 1935, [A], **148**, 422–446).—A consideration of the standard cooling-curve methods shows that such methods may give unreliable results when applied to transformations consisting of atomic rearrangement in a homogeneous solid solution. A modified double differential cooling-curve method, which is considered to be more reliable than the usual methods, is described. In order to determine quantitatively the heat involved in the transformations, a specific heat-temperature curve is required; a new experimental method of determining this is described. The two experimental methods have been applied to investigate transformations in β-brass and iron–aluminium alloys.—J. S. G. T.

***Internal Equilibrium in Solid Phases.** (I.) A. Smits (*Physikal. Z.*, 1934, **35**, 914–918). (II.) K. Klusius and A. Perlick (*ibid.*, 918–919). (III.) Smits (*ibid.*, 919).—(I.—) S. discusses transformations of the second order, as defined by Ehrenfest (*Proc. K. Akad. Wet., Amsterdam*, 1933, **36**, 153), more especially with reference to the observations of Klusius and Perlick relating to a transformation occurring in solid methane at — 252·8° C. (*Z. physikal. Chem.*, 1934, (B), **24**, 313). Such transformations require for their investigation extreme purity of materials and a static experimental method of very great accuracy. A differentiation of such a transformation of the second order from an allotropic modification is probably possible by observation of the effect of pressure upon the transformation. (II.—) K. and P. reply to S.'s criticism of their results. (III.—) S. replies that no heterogeneous transformation other than that of the first order has yet been discovered.—J. S. G. T.

†The Nature of Metallic Solid Solutions and Compounds. U. Dehlinger (*Z. Metallkunde*, 1934, **26**, 227–230).—Modern concepts of the nature of metallic solid solutions and intermetallic compounds are reviewed. Affinity between the constituents exists in all metallic phases including solid solutions, but no phase has an infinitely small composition range; some of the phases have a regular atomic distribution in the lattice, but this is readily converted into random distribution, and the differences between the physical properties of an intermetallic compound and those of its components are frequently very slight.. In all these respects metallic phases differ from compounds produced by exertion of the principal valences of the constituents. A satisfactory theory to account for the affinity concept in metals must take into account the relation between magnetism and lattice structure.—A. R. P.

***Compression of Metals in the Formation of Intermetallic Compounds.** Wilhelm Biltz (*Z. Metallkunde*, 1934, **26**, 230–232).—Consideration of published data on the molecular volume of intermetallic compounds and on the atomic volume of the individual metals leads to the conclusion that metals which can be strongly compressed mechanically undergo a contraction when they enter into an intermetallic compound, whereas metals which are difficultly compressible do not.—A. R. P.

***Phase Equilibria of the Third Order.** E. Justi and M. v. Laue (*Physikal. Z.*, 1934, **35**, 945–952; discussion, 952–953).—From *Vorträge u. Diskussionen des X. Deutschen Physiker- u. Mathematiker-Tages*, **1934**, Sept. Three orders of phase equilibria are discussed in terms of the respective forms of their ϕ, T, diagrams, ϕ denoting the thermodynamic potential, expressed as a function of intrinsic energy, pressure, volume, entropy, and temperature, T. Equilibria of the third order between two different phases are exemplified and discussed.—J. S. G. T.

III.—STRUCTURE

(Metallography; Macrography; Crystal Structure.)

(Continued from pp. 99–101.)

***Theory and Use of the Metallurgical Polarization Microscope.** Russell W. Dayton (*Metals Technology*, **1935**, (Jan.), A.I.M.M.E. Tech. Publ. No. 593, 1–32).—The theory of the metallurgical polarization microscope is described, and its possible use in metallurgical problems examined by experiments with both ferrous and non-ferrous metals. Grain contrast can be obtained in unetched specimens of non-cubic metals which show nothing in ordinary light, but difficulties are caused by surface films, and the effects with opaque objects and reflected light are always less than those for transparent objects. The sensitivity was insufficient to detect anisotropy due to strain, and the most promising use of the instrument is for the identification of inclusions in metals. The results are complex owing to the existence of both surface and transmission effects, and the case of cuprous oxide inclusions in copper is discussed in detail.—W. H.-R.

Testing the Lead Coating of Cables. P. Wieghardt (*Elektrotech. Z.*, 1934, **55**, 339–340; *Chem. Zentr.*, 1934, **105**, I, 3631).—For polishing sections of lead cable the fine emery paper should be coated with paraffin wax and oil; for lead alloys elutriated alumina is the best polishing medium. Etching in 20% nitric acid at 40° C. is best for non-antimonial alloys, and hydrochloric acid (*d* 1·18) for antimonial lead. Micrographic examination of cable sheathing shows clearly joints produced in manufacture at each filling of the extrusion press, either by the presence of lead oxide films or by discontinuities in the crystal structure.—A. R. P.

†On the Structure of the Surface Layer of Polished Metal. V. I. Arharov (*Zhurnal Tehnicheskoy Fiziki* (*J. Tech. Physics*), 1934, **4**, (7), 1326–1331).—[In Russian.] A review.—N. A.

***Studies upon the Widmanstätten Structure. VII.—The Copper–Silver System.** Charles S. Barrett, Hermann F. Kaiser, and Robert F. Mehl (*Metals Technology*, **1935**, (Jan.), A.I.M.M.E. Tech. Publ. No. 595, 1–19).—A Widmanstätten structure is formed in copper-rich copper–silver alloys if these are very slowly cooled, the silver-rich precipitate lying in plates parallel to the (100) planes of the copper-rich matrix. With silver-rich alloys the precipitation of the copper-rich solid solution usually produces a pearlitic structure, but with extremely slow cooling a Widmanstätten structure is formed with the precipitate parallel to the (111) plane of the matrix. In this system both solid solutions have face-centred cubic structures, which differ in lattice parameter, and X-ray data show that in precipitation from both solid solutions, the matrix and precipitate lattices have identical orientations; this holds even for the pearlitic type of precipitate from the silver-rich solid solutions. With the silver-rich alloys precipitation is sometimes accompanied by a fragmentation of the matrix crystals, but in contrast to the results of previous work, the new orientations are not haphazard, but are derived from the original grain by rotations in two directions of 42° ± 5° about the [100], [010], and [001] directions of the original lattice as axes.—W. H.-R.

***Crystallographic Uniformity of Lineage Structure in Copper Single Crystals.** Alden B. Greninger (*Metals Technology*, **1935**, (Jan.), A.I.M.M.E. Tech. Publ. No. 596, 1–9).—Single crystals of copper were prepared by slowly cooling the molten metal, and were examined microscopically and by X-ray analysis.

Back-reflection Laue photographs gave spots with a fine structure, and their interpretation confirmed the views of Buerger (*Z. Krist.*, 1934, **89**, 195) that crystals possess a lineage structure in which the crystal is partitioned by discontinuities (lineage boundaries) so that the entire structure formed from a single nucleus is continuous but branched. Copper single crystals probably possess a network of mosaic structure predominantly delineating the (111) planes, any two neighbouring lineages having a [110] direction in common; a less frequent uniformity is a delineation of (110) or (100) planes with common [100] direction. These major lineages are then subdivided into finer networks of lineage structure. The deviation from exact parallelism of the major lineages varies from 5′ to 2°.—W. H.-R.

***X-Ray Analysis of the β-Phases in Copper–Beryllium and Aluminium–Zinc Alloys of High Temperatures.** G. F. Kossolapow and A. K. Trapesnikow (*Metallwirtschaft*, 1935, **14**, 45–46).—An alloy of copper with 7·2% beryllium shows in the X-ray photograms only lines due to the α- and γ-phases below 570° C., but at higher temperatures only the lines of the β-phase. The γ-phase has a CsCl structure with $a = 2·72$ A. at 570° C.; for the α-phase, $a = 3·62$ A. at 570° C. The β-phase is body-centred cubic without superstructure, $a = 2·72$ A. at 620° C. and 2·79 A. at 750° C. X-ray examination of a 40% zinc–aluminium alloy gave results in agreement with those of Schmid and Wassermann (*J. Inst. Metals*, 1932, **50**, 615) and of Owen and Iball (*Met. Abs.*, 1934, **1**, 127).—v. G.

***Hardness and Lattice-Distortion of Cold-Rolled α-Brass.** W. A. Wood (*Phil. Mag.*, 1935, [vii], **19**, 219–230).—Differences in the X-ray spectra of α-brass hardened to different degrees by cold-rolling are investigated. The increase of breadth of the diffraction lines is found to be proportional to the increase of hardness of the brass. The broadening of the lines is attributed to lattice distortion; measurements show that the unit cell of the brass ceases to be cubic after the material has been cold-worked.—J. S. G. T.

***On the Crystal Structure of the Phase $LaTl_3$.** Armando Rossi (*Gazz. chim. ital.*, 1934, **64**, 955–957).—$LaTl_3$ has an hexagonal lattice with $a = 3·45$ A., $c/a = 1·60$. The observed d is 10·92 and the calculated d 10·89, hence the mean atomic contraction is 2·2%.—A. R. P.

†Review of the New Determinations of Crystal Structure of Compounds of the Type AB_3. Werner Nowacki (*Z. Krist.*, 1934, **89**, 85–88).—A review of the results of X-ray crystal analysis of many compounds of formula AB_3. The lattice parameters and symmetry characteristics are given, and the different substances, which include many intermetallic compounds and superlattice structures, are grouped into classes to show how they are related. (Cf. Nowacki, *ibid.*, 1932, **82**, 355.)—W. H.-R.

***Determination of Orientations of Metallic Crystals by Means of Back-Reflection Laue Photographs.** Alden B. Greninger (*Metals Technology*, **1934**, (Dec.), A.I.M.M.E. Tech. Publ. No. 583, 1–11).—The orientation of metallic crystals can be determined quickly and easily by back-reflection Laue photographs; *i.e.* reflection photographs with white radiation as distinct from the ordinary transmission Laue photographs. The technique is described, and gives an accuracy of at least one half degree. Cubic crystals can be solved with only one photograph taken in 2 or 3 hrs., and interpreted in a few minutes. The construction and use of hyperbolic angular-co-ordinate plots are described.—W. H.-R.

X-Ray Diffraction Through Crystal Lattices and X-Ray Structural Analysis. V. Linitz'kii (*Ukrainskii Khemichnii Zhurnal* (*J. Chim. Ukraine*), 1934, **9**, Wiss.-techn. Teil, 46–60).—[In Ukrainian.] A review of the work of Laue, the Braggs, Debye, &c.—S. G.

***One-Dimensional Electron Diffraction.** J. R. Tillman (*Phil. Mag.*, 1935, [vii], **19**, 485–500).—The one-dimensional diffraction of fast electrons by zinc-blende is investigated. Electrons often become confined to potential tubes in the surface of the crystal which contain whole or parts of both zinc and sulphur ions. The diameter of the tubes is shown to be about that of a zinc ion, 1·6 A.—J. S. G. T.

***A Simplification of Prins' Formula for Diffraction of X-Rays by a Perfect Crystal.** Franklin Miller, Jr. (*Phys. Rev.*, 1935, [ii], 47, 209–212).—W. H.-R.

IV.—CORROSION

(Continued from pp. 102–103.)

***Memoranda of the "Commission Aéronautique pour l'Étude de la Corrosion."—II–IV.** Edited by R. Cazaud (*Rev. Mét.*, 1934, 31, 439–451; 487–494; 560–567).—See *Met. Abs.*, 1934, 1, 502. (II.—) *Study of the Homogeneity of Light Alloys by Coloured Indicators.* —— Prot and (Mlle.) Goldovsky (pp. 439–441). P. and G. studied the homogeneity of light alloys by means of a colour method. The specimens are sprayed with a solution of pure gelatine in sea-water (10 grm./litre) 3 times, each film being allowed to set before the next is applied. After several hrs. a universal indicator is applied. Washing in hot water removes the coloured film. *Effect of Corrosion on the Resistance to Fatigue of Duralumin.* R. Cazaud (p. 440). C. observed the effects of prior corrosion in rotating-beam fatigue tests of Duralumin. Test-pieces were immersed vertically in the standard artificial sea-water containing 2 parts per 100 of perhydrol by volume, for 18 hrs. Whilst the fatigue limit of the uncorroded Duralumin was 12·4 kg./mm.^{2} at 100 million cycles, that of corroded samples was 8·2 kg./mm.^{2}. *Analysis of Method of Protection by Oxide Deposits.* Charles Boulanger (pp. 441–442). B. investigated the production of metallic deposits on aluminium and aluminium alloys. Deposits are obtained by simple immersion in solutions of double or complex cyanides or of alkali cyanides and soluble salts of other metals. Details are given of solutions for producing cadmium deposits. Further deposits may be applied by similar methods or by electrodeposition. B. also studied the protection of aluminium and aluminium by "oxide" films, and recognizes 2 layers. The first, very thin, on the surface of the metal, independent of the electrolyte and of high resistance (Bengough); the second, much thicker, conducting and varying with the electrolyte (MOH). In practice, the best results are obtained with films of 0·03 to 0·05 grm./m.^{2}. *Standardization of the Corrosion Testing of Metals in Artificial Sea-Water.* —— Legendre (pp. 442–449). L. developed standard conditions of corrosion tests in artificial sea-water (*a*) alternate wet and dry test, (*b*) salt-spray, (*c*) rapid test in oxygenated solution. *Study of the Composition of Standardized Sea-Water and the Effect of Composition and Renewal of the Corrosive Liquid in Corrosion Testing.* —— Quillard (pp. 449–451). Q. studied the effect of composition and of renewal of the artificial sea-water used in corrosion tests. Results obtained indicate that there is no need to introduce magnesium ions but that renewal affects the results substantially. (III.—) *The Observation and Measurement of Corrosion.* Jean Cournot and Marcel Chaussain (pp. 487–490). C. and M. discuss methods of observing and measuring corrosion, under the headings: visual observation, loss of weight, reduction of mechanical properties, and microscopic examination. *Indices of Corrosion.* —— Prot and (Mlle.) Goldovsky (pp. 490–494). P. and G. discuss the factors involved in observing corrosion by loss of weight and describe procedure they have developed for tests of Duralumin. Specimens of 10 cm.^{2} surface are submitted to immersion tests for 20 hrs. and the corroding medium is supplied to the test-vessel at the rate of 100 c.c./hr. Results of tests are given to show the effect of composition, condition of surface, concentration of sodium chloride, oxygen concentration, p_H, temperature, rate of supply of the corroding medium, and quantity of the medium in the absence of continuous supply. (IV.—) *Accelerated Methods of Testing the Corrosion of Iron and Duralumin in Aerated Salt Solutions.* E. Herzog and G. Chaudron (pp. 560–566). H. and C. discuss accelerated corrosion tests of iron and Duralumin in saline solutions. The corrosive action of sea-water is different from that of sodium chloride solution. Salts of magnesium actually effect a partial protection of Duralumin, iron, and zinc. In no circumstances should sodium chloride solution be used as a substitute for sea-water in laboratory experiments. Tests in which corrosion was accelerated by pressure gave results which corresponded best with the results of " wet and dry " tests, the latter form of test being very slow. *Study of the Progress of the Corrosion of Small Plates of Pure Aluminium and Duralumin.* —— Canac and —— Granveaud (pp. 566–567). C. and G. employed reflectivity measurements to observe the progress of corrosion of aluminium and Duralumin sheet.—H. S.

On the Methods of Testing Light Metals for Corrosion. V. S. Zorin (*Metallurg* (*Metallurgist*), **1935**, (7), 74–80; (8), 87–106).—[In Russian.] A description of the various methods used in the study of the corrosion of light metals, both from published data and the author's own practice.
—N. A.

***Effect of Addition Agents Upon the Corrosion Rate of Aluminium by Alkalis. Effect of Various Substances.** F. H. Rhodes and F. W. Berner (*Indust. and Eng. Chem.*, 1933, **25** 1336–1337).—The rate of attack of alkalis on aluminium was determined by measuring the rate of evolution of hydrogen, and the effect of the following addition agents was investigated: potassium chromate and permanganate, sodium metasilicate, alcohols, glucose, phenols, and gelatin. The apparatus used is described; 6 references are given.—I. M.

***Galvanized Steel Wires for Steel-Cored Aluminium Transmission Lines with Brazed Joints.** M. Bosshard (*Aluminium*, 1935, **17**, 78–79).—The degree of corrosion of Aldrey wires around a galvanized steel core in a salt-spray is much greater than that of a bundle of the same wires without a steel core. When joints are made in the steel core by brazing, and these are then tinned, the corrosion of an Aldrey wire winding is markedly increased around the brazed joints.—A. R. P.

***Investigations on the Behaviour of Aluminium and Copper Electrical Transmission Lines Under Vibrational Stresses.** W. Schwinning and E. Dorgerloh (*Z. Metallkunde*, 1934, **26**, 162–164).—Fatigue tests have been made on stranded wire ropes of aluminium, Aldrey, and copper subjected to constant dripping of tap-water and sea-water. The results show that the individual wires should have a perfectly smooth surface to avoid notch effects, should be as thick as possible to give a minimum surface exposure, and should be covered with grease before stranding to prevent percolation of corrosive media into the interior of the rope.—A. R. P.

***Contribution to the Question of the Formation of Protective Films on Copper.** L. W. Haase (*Z. Metallkunde*, 1934, **26**, 185–188).—Cuprous oxide is the only effective protective film for copper, and is always found next to the metal in all cases of atmospheric or under-water corrosion as well as when the metal has been treated to produce an artificial patina. Apparently the cuprous oxide is a secondary product formed by reaction between the metal surface and the coating of basic carbonate, chloride or sulphate produced by the primary action of the corrosive agent on the metal.—A. R. P.

***The Rate of Dissolution of Copper in Copper Salt Solutions.** Antoni Basínski (*Roczniki Chem.*, 1934, **14**, 31–44; *Chem. Zentr.*, 1934, **105**, I, 3331).—The effects of temperature (10°–35° C.), rate of stirring (300–500 r.p.m.), and concentration of the solution on the rate of dissolution of copper in copper ammonium chloride and bromide solutions have been determined. The dissolution is a diffusion phenomenon of the first order, the reaction constant increasing by about 30% for a rise in temperature of 15° C. (10°–25° C.). Passage of carbon dioxide through the solution reduces the rate of reaction slightly, but changes in the concentration of copper or of ammonium chloride have little effect on the reaction constant.—A. R. P.

The Maintenance of Condenser Efficiency: Tube Troubles and Their Avoidance. Anon. (*Eng. Rev.*, 1935, **48**, 574–576, 642–644).—A review is given of the principal recognized causes of condenser-tube corrosion, and of improved materials for tubing, with some modifications in manufacturing methods. The conditions favouring the formation of a protective film are discussed, and several types of ferrule and packing are described and illustrated.—P. M. C. R.

†Prevention of Corrosion [Bronze Condensing Tubes] in Gas Condensers. J. A. Korany and E. M. Bliss (*Gas Age-Record*, 1935, **75**, 33–34).—Experience of corrosion in a water-cooled gas condenser fitted with bronze condensing tubes is referred to, and its reduction by 98·8% by means of the Kirkaldy system of protection is described. The Kirkaldy system comprises an a.c. motor driving a d.c. generator supplying a current density of 5 amp./1000 ft.^{2} of cooling surface.—J. S. G. T.

***Corrosion of Copper–Zinc Alloys.** H. Stäger and J. Biert (*Brown-Boveri Rev.*, 1934, **21**, 180–184).—[In English.] The corrosion of 63 : 37, 60 : 40, and 52 : 48 brass tubes after various mechanical and heat-treatments has been examined in 10% hydrochloric acid, 5% ammonia, and 5% sodium chloride solutions by measurements of the loss in weight and the reduction in tensile strength and elongation. Homogeneous α or β alloys are about equally resistant to corrosion, but duplex alloys are readily corroded owing to the electrochemical effect of the two constituents, the corrosion being characterized by dissolution of the zinc and the production of a porous structure. Corrosion is reduced by decreasing the grain-size and increased by cold-work; even homogeneous alloys are affected when internal stresses are present and, despite only a slight loss in weight, gradually become brittle. Brass tubes, therefore, should have a fine-grained single-phase structure and should be heat-treated to remove internal stress.—A. R. P.

***Mechanism of Dezincification. Corrosion of ε-Brass.** Charles W. Stillwell and Edward S. Turnipseed (*Indust. and Eng. Chem.*, 1934, **26**, 740–743).—In an attempt to establish the mechanism of dezincification, the corrosion of ε-brass has been studied by means of X-ray diffraction data. The corrosion of ε-brass may occur in at least 3 different ways: (1) in strong oxidizing agents (nitric acid) both copper and zinc are dissolved; a trace of copper is redeposited from very dilute nitric acid; (2) in acid of intermediate strength (normal sulphuric, concentrated hydrochloric) both copper and zinc are dissolved and copper is redeposited; (3) in very weak acids (dilute hydrochloric, acetic) only zinc is removed from the alloy, resulting in the successive formation of γ-brass, β-brass, and copper or α-brass. Dezincification may occur in 2 ways: (1) by the solution of copper and zinc and the redeposition of copper in strong corroding agents; (2) by the solution of zinc only, in weak corroding agents. Ten references are given.—I. M.

***Corrosion of Metal Fastenings [Brass, Galvanized Iron] in Zinc Chloride-Treated Wood.** R. H. Baechler (*Indust. and Eng. Chem.*, 1934, **26**, 1336–1338).—At the present stage of the tests described it appears that corrosion of wire nails in wood treated with zinc chloride and exposed to a moderately humid interior and to outside conditions such as prevail at Madison, Wis., U.S.A., is not appreciably greater than the corrosion occurring in untreated wood, provided that the wood is seasoned before the nails are driven. Wire nails driven into wet treated wood and exposed to the foregoing conditions corrode rapidly during the drying period. It seems inadvisable to use wire nails in zinc chloride-treated wood that is to be exposed to very humid conditions. Corrosion of wire nails in wood treated with zinc chloride is not greatly modified apparently by painting the wood or by adding sodium dichromate to the treating solution. The corrosion of brass and galvanized-iron fastenings in wood treated with zinc chloride is probably slight in all conditions of humidity.—S. G.

Metals and Flue Gas Washing [Barronia]. Anon. (*Eng. Rev.*, 1935, **48**, (8), 534).—A note on the satisfactory performance of Barronia under exposure to combined corrosion by sulphurous and sulphuric acids and abrasion by hard angular grit. Three instances are described in detail.—P. M. C. R.

***Corrosion [Iron, Aluminium-Plate, Tinplate, Copper].** T. N. Morris and J. M. Bryan (*Dept. Sci. Indust. Res., Rep. Food Invest. Board, 1933*, **1934**, 145–155; *C. Abs.*, 1935, **29**, 437).—The amount of iron dissolved from strips in acid solutions is greatly dependent on the p_H when in air, but almost independent of p_H in oxygen. In solutions more acid than p_H 5, oxygen depressed the production of hydrogen. Lacquered strips of iron produced more hydrogen per mg. iron dissolved than unlacquered, *i.e.* lacquering prevents subsequent combination of hydrogen with oxygen at the metal surface. Samples of aluminium plate were much less attacked by 0·5% citric acid in air than tinplate, but most of the corrosion was of the underlying iron, while in tinplate it was mostly of the tin itself. In the absence of air there was little difference between aluminium and tin. If it can be kept unscratched, aluminium plate may be useful in canning. Tin containing 0·86% impurities corroded less than a purer sample. Tarnish on copper acts as a corrosion catalyst.—S. G.

***Corrosion Activity Studies on Royal Cherries.** G. S. Bohart, C. E. Lachele, and L. G. Petree (*Canning Trade*, 1934, **56**, (27), 38–39; *C. Abs.*, 1935, **29**, 850).—Cherries obtained from different localities showed significantly different corrosion activities after canning. The lighter-coloured fruits showed the greatest amount of corrosion. Similarly, the larger sizes liberated more hydrogen gas in cans than the smaller sizes of fruit. Blanching of the cherries previous to filling in cans caused undue shrivelling of the fruit, but was serviceable in greatly delaying corrosion and hydrogen formation. The p_H values of 8 lots of Royal cherries varied from 3·66 to 3·76, and the total acidity from 0·37 to 0·47%, calculated as citric acid.—S. G.

Tinplate Corrosion in Canning. T. N. Morris (*Sheet Metal Ind.*, 1934, **8**, 171–172; and *Canning Trade*, 1934, **56**, (35), 13–16; *C. Abs.*, 1935, **29**, 850).—Because of slight porosity in tinplate used in canning foods, some iron is always exposed to the food. This exposed iron is the cause of many of the defects and discolorations of such foods. Lacquering the tinplate corrects many of the defects but increases the formation of hydrogen in cans of fruits as well as perforations in the plate itself. For the more troublesome fruits the use of 3 coats of lacquer on the tinplate is advocated. In most fruits immediately after canning, the iron of the tin–iron couple is anodic. A reversal occurs soon after canning in which the tin becomes anodic and remains so. Thorough lacquering greatly increases the ratio of relative anodic and cathodic areas, *e.g.* the area of tin exposed/area of iron exposed. The relationships of hydrogen-ion concentration and acidity to corrosion in canned fruits are complicated. Usually corrosion and hydrogen formation in the container are greatest at low acidities. Sometimes the addition of citric acid to fruits is beneficial in preventing detrimental changes. In the acid–metal corrosion reaction, hydrogen gas is evolved on both the wet and dry sides of the metal in spite of the hindering action of the tin coating.

Blisters are sometimes formed in the metal because of the pressure of hydrogen, but hydrogen springers in canned foods never burst.—S. G.

***Solution Rates of Zinc Electrodes in Acid Solutions.** H. Mouquin and W. A. Steitz (*Electrochem. Soc. Preprint*, **1935**, March, 35–40).—The effect of externally imposed potentials on the rate of solution of zinc anodes in acids has been studied in controlled conditions. A minimum rate is observed which is substantially identical for acids of widely differing degrees of ionization. Electrostatic attraction is suggested as an important rate-controlling factor in these experiments.—S. G.

Tube Corrosion and Oil. U. R. Evans (*Metallurgist* (Suppt. to *Engineer*), 1935, **11**, 16).—A letter on the cause of corrosion set up in condenser tubes by drops or patches of oil. It would appear that differential aeration, due to the lesser accessibility of the cranny round the globule to oxygen, is the most important cause, rather than rival interface action. The conditions favourable to the particular form of attack will not often arise, as a number of coincident conditions are necessary.—R. G.

The Corrosion of Metals Covered by Electro-Deposited Coatings. J. Liger (*Galvano*, **1935**, (33), 17–19; (34), 19–22).—A review of the various factors in the production of satisfactory coatings, and a discussion of the electrochemical principles of corrosion as applied to plated metals.—C. E. H.

***Metals and Condensed Milk. Corrosion of Metals in Manufacture of Evaporated and Sweetened Condensed Milk.** E. C. Thompson, R. P. Mears, H. E. Searle, and F. L. LaQue (*Indust. and Eng. Chem.*, 1933, **25**, 1311–1316).—The corrosion of metals in the manufacture of condensed and evaporated milk is studied by exposing metal specimens in equipment in operation. A novel specimen holder is used that facilitates testing routine. The extent of corrosion is determined by measuring the weight lost by each specimen and by examining it visually. Corrosion is most active in evaporators, hot wells, drop tanks, and preheaters. The estimated copper pick-up from typical evaporators is 2·5 p.p.m. for condensed, and 1·6 p.p.m. for evaporated, milk. At every point of test the resistance of copper is surpassed by other metals of good physical and fabricating properties. Hard films of protective nature form on the metals in certain equipment. The metals tested are copper, nickel, tin, bronze, Inconel, Monel, soft solder (lead 67, tin 33%), silver solder (silver 60, copper 25, zinc 15%), 17% chrome–iron, and 18 : 8 chrome–nickel–iron. A *bibliography* of 19 references is appended.—I. M.

Metals in the Food Industry. J. M. Bryan (*Food Manufacture*, 1935, **10**, 5–6).—A summarized account of the corrosion of nickel, nickel alloys, copper, copper alloys, tin, silver, and aluminium in dilute citric acid solutions in the presence and absence of oxygen.—C. E. H.

***The Corrosion of Various Metals and Alloys in Solutions Used in the Potash Industry.** Antoni Kusik (*Przemysl Chem.*, 1934, **18**, 28–41; *Chem. Zentr.*, 1934, **105**, I, 3256).—The behaviour of 32 metals and alloys in sylvinite, langbeinite and kainite solutions has been investigated at room temperature and at 87°–90° C., with and without stirring, and with and without free access of air; further the effects of partial immersion and of spray have been studied. The results are presented in a series of tables, graphs, and diagrams. The most resistant to corrosion were nickel–chromium steels, Thermisilid, "aluminium–bronze," nickel and Monel metal, and the most severely corroded were copper and iron (sheets) and Armco iron.—A. R. P.

Corrosion in the Petroleum Industry. O. A. Knight (*Mineral Industries, Pennsylvania State Coll.*, 1934, **4**, (2), 4; *C. Abs.*, 1935, **29**, 438).—Corrosion is caused by sulphur in oil, high temperatures of treatment, and chemicals used in refining (such as sulphuric acid). Methods for minimizing these various types of corrosion are discussed.—S. G.

***Motor-Electrolytic Current as a Factor in Corrosion.** E. Newbery (*Electrochem. Soc. Preprint*, **1935**, March, 25–33).—A case of severe corrosion in the brass pipe and driving rod of a deep-well pulsometer pump was investigated. It was found that the corrosion was caused by motor-electrolytic currents generated by the rapid motion of an electrolyte (diluted sea-water) over the surface of the rod and interior of the pipe. The outer surface of the pipe, being in contact with undisturbed electrolyte, formed the cathode of the motor-electrolytic cell and was quite uncorroded. It is suggested that this source of corrosion trouble has not been recognized sufficiently in the past. —S. G.

***Voltaic Cells and Corrosion.** Oliver P. Watts (*Electrochem. Soc. Preprint*, **1935**, March, 1–17).—W. presents his views on certain phases of corrosion, and in the experimental part of the paper gives the effect of the removal of air from electrolytes in which metallic couples are short-circuited. For the metals and couples used, removal of air stops corrosion.—S. G.

The Phenomena of Corrosion. J. Liger (*Galvano*, 1934, (30), 18–19; (31), 18–20).—See *Met. Abs.*, 1934, **1**, 426, 588. General discussion of the corrosion of copper, brass, zinc, aluminium, cadmium, chromium, and the precious metals, and remarks on corrosion testing.—C. E. H.

Metallic Corrosion. Emilio Jimeno Gil (*Mem. acad. cienc. artes Barcelona*, 1934, **23**, 441–471; *C. Abs.*, 1935, **29**, 714).—Nernst's electrochemical theory of corrosion and the many recently proposed amplifications of the original theory are considered in detail.—S. G.

Corrosion Problems. John Johnston (*Indust. and Eng. Chem.*, 1934, **26**, 1238–1244).—Some factors influencing the rate of corrosion and the formation of protective films are discussed.—S. G.

Application of a Few Statistical Principles to Corrosion Problems. Gordon N. Scott (*Oil and Gas J.*, 1934, **33**, (23), 74–76, 78, 80).—S. G.

***Note on the Preparation of Test-Pieces for Corrosion Tests of Sheet Materials.** Jean Cournot (*Rev. Mét.*, 1934, **31**, 514).—A. Portevin has criticized the practice of using, in tensile and cupping tests, test-pieces machined to dimensions before being subjected to corrosion test. C. agrees and mentions that he and H. Fournier have employed the K.W.I. test on test-pieces pierced after the corrosion test, and have found it more sensitive than other forms of test.—H. S.

Materials Recommended by Manufacturers for Use with Corrosive Chemicals. Anon. (*Chem. and Met. Eng.*, 1932, **39**, 497–512).—A list of chemicals with the metals and alloys recommended for use in contact with them. A succeeding section gives the composition of these alloys with some of their physical and mechanical properties, and the names and addresses of the American manufacturers.—I. M.

V.—PROTECTION

(Other than Electrodeposition.)

(Continued from pp. 103–105.)

The Eloxal Process. The Electrolytic Oxidation of Aluminium and Its Alloys. Properties and Uses. H. Schmitt, A. Jenny, and G. Elssner (*Z.V.d.I.*, 1934, **78**, 1499–1506).—A description is given of the 3 modifications of the Eloxal process and of the physical, mechanical, and thermal properties of the films produced.—K. S.

The Eloxal Process. G. Elssner (*Werkstatt u. Betrieb*, 1935, **68**, (5/6), 63–66).—The film produced by anodic oxidation, being derived from the oxidation of the basis material, does not, after the initial stages, cause continuous thickening: the finished product may be thinner than the original. The thickness of the layer of oxide depends on the time of oxidation and on the nature of the material, such alloys as Lautal, Duralumin and Silumin oxidizing more rapidly than commercially pure aluminium, although the deposits are less dense and hard than those formed on the pure metal. A brief description of the necessary plant is given, and the properties of the oxide film are considered: its absorptive power facilitates colouring, while impregnation with fats, waxes, &c., improves its protective quality. Other properties especially emphasized are hardness, elasticity, and insulating power with regard both to heat and to electricity.—P. M. C. R.

†**Chemical and Electrochemical Surface Treatment of Aluminium.** W. Wiederholt (*Chem. Fabrik*, 1934, **7**, 361–364).—A review of modern processes for producing protective oxide films on aluminium and its alloys.—A. R. P.

***Requirements of Airplane Coatings.** J. M. McCloud (*Indust. and Eng. Chem.*, 1931, **23**, 1334–1339).—Test-pieces of Alclad, Duralumin, aluminium–magnesium alloys, and steel were coated with various protective materials and subjected to long-time salt-spray corrosion tests and were exposed on a roof in Florida. Curves are given showing change of tensile strength (lb./in.^{2}) and elongation (in.%) with time of exposure.—I. M.

Non-Electrolytic Protective Coatings. Anon. (*Galvano*, **1934**, (32), 29–36).—A review of present practice in the application of hot-dipped coatings of zinc, tin, and lead, and a discussion of the value of various metallic coatings applied by spraying and cementation.—C. E. H.

†**Lead Plating as a Protection Against Corrosion and the Present Position of Lead-Plating Technique.** H. M. Forstner (*Oberflächentechnik*, 1934, **11**, 173–176, 187–190, 201, 213–217, 225–227, 235–237).—An extensive review of modern practice in lead-coating ferrous metals is given. Homogeneous lead coatings may be applied by hot-dipping, spraying, fusion with a hydrogen-rich flame, electrolysis in aqueous solutions, and electrolysis in fused salts. The last named has proved very successful for the continuous plating of wires. In all cases, previous tinning or galvanizing of the ferrous metal surface is recommended. To withstand atmospheric corrosion the lead coating should be at least 0·2 mm. thick, to withstand sea-water about 0·4 mm. thick, and to withstand sulphuric acid at least 2 mm. thick. The properties of lead for chemical purposes are discussed, and the value of lead-plated apparatus in the chemical and other industries is reviewed.—A. R. P.

Hot-Galvanizing. The Heating of the Bath. A. Forny (*Galvano*, **1934**, (30), 25–27).—Contrary to the usual opinion, it is considered that the optimum bath temperature decreases with increasing thickness of the articles treated, from a maximum of 470° to a minimum of 460° C. The arrangement of the bath for gas, coal, coke, oil, and electric heating is discussed. Heating by a system of flues, using solid, liquid, or gaseous fuel, is recommended.—C. E. H.

Hot-Galvanizing of Household Articles. A. Forny (*Galvano*, **1934**, (31), 24–26).—A practical account of the plant and process. The advantages and disadvantages of the 3 variations of the process—the sal ammoniac, zinc chloride, and simple immersion methods—are discussed, the latter being condemned for most purposes. A bright finish without spangles is considered to have the longest life.—C. E. H.

Hot-Galvanizing in Boiler-Making. A. Forny (*Galvano*, **1935**, (33), 28–30).—A description of the operation of galvanizing such large articles as boilers, and a discussion of the most suitable plant for this type of work.
—C. E. H.

Hot-Galvanizing. Galvanizing in Metal Constructional Work. A. Forny (*Galvano*, **1935**, (34), 22–25).—The operations of galvanizing, by hand operation, structural elements, fabricated sheet metal, and tubes are described with practical details. A diagram of a suitable plant lay-out is given. —C. E. H.

***Metallic Cementation. III.—Metallic Cementation by Means of Aluminium Powder.** Tsutomu Kase (*Kinzoku no Kenkyu*, 1935, **12**, (1), 49–66).—[In Japanese.] The cementation into iron, copper, and nickel by aluminium at various temperatures between 600° and 1200° C. was investigated, using commercial aluminium powder. Hardness and depth of penetration measurements, and microscopic and chemical analyses were carried out and studies of oxidation at high temperatures and corrosion by acids were made on the surface layers of the cemented specimens. Aluminium diffuses into the metals mentioned at a temperature above about 650° C. or the melting point of aluminium, and the rate of diffusion increases as the temperature increases. The rate of diffusion of aluminium into iron increases, however, almost abruptly at the A_1 point (906° C.). The relation between the increase of weight of the specimen (ΔW), or the depth of penetration (P) and the absolute temperature of cementation (T) is given by an exponential function ΔW (or P) $= ae^{-b/T}$. Also the relation between ΔW or P and the length of time of cementation (θ) is given by ΔW (or P) $= ae^{b/\theta}$, where a and b are different constants in each case. The cemented surfaces have a sturdy resistance to atmospheric oxidation and the attack of fused salts at high temperatures. The surfaces of iron and nickel cemented by aluminium are not easily attacked by concentrated nitric acid.—S. G.

***The Cementation of Copper by Aluminium.** Jean Cournot and Georges Méker (*Compt. rend.*, 1935, **200**, 125–126; and *Génie civil*, 1935, **106**, 69).—In continuation of an investigation begun by Léon Guillet (*J. Inst. Metals*, 1926, **36**, 475), the cementation of copper by aluminium has been studied at higher temperatures and with different cements. In the case of electrolytic copper, cathode pieces, 10 mm. thick, were treated for 9 hrs. at 600°, 700°, 800°, and 900° C., and the depth of penetration and the structure were examined. Cementation is considerably developed at the higher temperatures. The cementation of commercial copper was rather less rapid. The aluminium, as it penetrated the copper, reduced the oxide, and microexamination only revealed small cavities. The gaseous effects of cementation were also studied. One of the faces of a specimen treated for 7½ hrs. at 850° C. was protected by a filter paper, which caused the cementation to be noticeably less developed but more regular. The cementation of sheet copper by aluminium has important industrial applications.—J. H. W.

VI.—ELECTRODEPOSITION

(Continued from pp. 105–106.)

The Electrodeposition of Cadmium in Electrical Engineering. H. Marston (*J. Electrodepositors' Tech. Soc.*, 1935, **10**, 57–68).—The merits of cadmium and zinc for rust-proofing steel are discussed, and examples cited of the use of cadmium plating in electrical engineering. Details of electrolyte, plant, operating conditions, and methods of control are given.—A. I. W.-W.

Chromium Plating from Chromic Acid Solutions Containing Hydrofluoric Acid. K. Assmann (*Chem.-Zeit.*, 1935, **59**, 177–178).—The bath is made up by dissolving 350 grm. of chromic acid in 1 litre of water, adding barium carbonate to remove any sulphuric acid, settling, decanting, and adding 3 grm. of potassium fluoride per litre. When operated at 18°–20° C. with current at 3·8–4 v., a bright deposit of chromium is obtained with current densities of 4–6 amp./dm.^{2}. The throwing power is excellent, but the current efficiency is lower than that of warm (35°–40° C.) baths containing sulphuric acid, being only 9% at 20° C. with 6 amp./dm.^{2}.—A. R. P.

The Use of Porous Pots to Eliminate Chromates in Chromium Baths. Anon. (*Galvano*, **1934**, (30), 24).—A porous pot containing a cylinder of perforated sheet is immersed in the bath and filled with electrolyte. The cylinder is connected to the negative bar of the bath. The chromium chromate in the bath is oxidized by the oxygen liberated at the positive, whilst the hydrogen evolved at the negative reduces the chromic acid inside the pot to chromium cromate. This crystallizes inside the pot and may be removed.—C. E. H.

The Nickel- and Chromium-Plating of Aluminium and Its Alloys. H. Krause (*Illust. Zeit. Blechindustrie*, 1935, **64**, 14–16).—It has been shown that a more durable coating is obtained by lightly nickel-plating aluminium, with subsequent chromium plating, than by depositing a single thick coating of nickel. The tendency of aluminium to oxidize in either acid or alkaline baths can only be overcome by great care in cleaning and degreasing, and by rapid and efficient handling. Directions are given for all stages of the preliminary nickel plating, with a special method adapted to cast alloys and to rolled alloys containing much silicon. The adhesion of the nickel is improved by heat-treatment prior to chromium-plating.—P. M. C. R.

The Development of High Current Density. Deposition of Nickel in France. M. Bourgeois (*Rev. Nickel*, 1934, **5**, 165–171).—The rapid deposition of nickel in France dates from 1927. The baths usually contain chloride, to assist in the corrosion of the anode, boric acid as a buffering medium, and a small quantity of nickel nitrate to counter the evolution of hydrogen at the cathode. Compressed-air agitation is employed. In a cold-bath, with a current density of 0·5 amp./dm.^{2}, a thickness of 10 μ is obtained in 2 hrs. With rapid deposition a current density of 10 amp./dm.^{2} may be employed and a deposit 10 μ thick obtained in 6 minutes. The modern application of rapid deposition on a commercial scale, embodying automatic working, is described and illustrated by diagrams of lay-outs. There are also good illustrations of such plants.—W. A. C. N.

Thick Electrolytic Deposits of Nickel and Their Application. A. E. Wilson (*Rev. Nickel*, 1934, **5**, 173–177).—An illustrated article dealing with the application of the Fescol process for the deposition of heavy nickel coatings on machine parts to obtain one or other of the following benefits: (1) surface hardness; (2) resistance to chemical attack; (3) increase in resistance to corrosion-fatigue; (4) repairs; (5) resistance to erosion; (6) protection against atmospheric and marine corrosion.—W. A. C. N.

Purpose and Applications of Heavy Deposits of Nickel. —— (*Elektrotech. Anzeiger*, 1935, **52**, 141–142).—Dense, adherent nickel coatings of a thickness of 0·08 mm. are now being produced. They are used for improving the resistance to wear of moving parts, for building up worn surfaces, and for providing increased resistance to corrosion.—C. E. H.

***Electrolytic Deposition of Nickel in Baths with p_H Values Greater Than 7.0.** M. Ballay and L. Guillet (*Rev. Nickel*, 1934, **5**, 178–179).—Cf. *Met. Abs.*, 1934, **1**, 353. Normally the use of solutions having p_H values greater than 7·0 is prohibited on account of the precipitation of hydroxide which occurs. The effect of certain organic substances in inhibiting this precipitation has been studied. Among such materials were citric acid and its alkali salts, glycollic acid, lactic acid. A bath containing nickel 20·8 grm., NH_4 6 grm., chlorine 6 grm., neutral sodium citrate 150 grm./litre, p_H 9·5, at a temperature of 40° C. gave a good deposit 0·5 mm. thick., with a current density of 10 amp./dm.^{2}.
—W. A. C. N.

Some Remarks on the Part Played by p_H Value in Nickel-Plating, and on Obtaining Bright Electrolytic Deposits of Nickel. (*Bull. Soc. franç. Élect.*, 1935, [v], **5**, 155–158).—Discussion on the paper by M. Ballay (see *Met. Abs.*, 1934, **1**, 597).—P. M. C. R.

***Production of Bright Nickel Deposits in the Presence of Colloids.** M. Ballay and L. Guillet (*Rev. Nickel*, 1934, **5**, 179–181).—The addition of certain bodies such as sodium sulphate tends to enhance the brilliance of the deposit. Small quantities of cadmium (0·1–0·2 grm. per litre) in a solution with p_H 6·8 and fairly high current densities also increase the brightness of the cathode. The cadmium is deposited with the nickel. Organic colloids, including the following, have also been studied: amidon, dextrine, gum arabic, agar-agar, gelatine, egg albumen, casein. They all increase the brilliancy more or less. —W. A. C. N.

The Use of the Microscope in the Control of Heavy Deposition [of Nickel]. Importance of the Regularity of the Crystalline Structure. M. Cymboliste (*Rev. Nickel*, 1934, **5**, 160–164).—Attention is directed to the causes of the anomalies resulting from the irregular mechanical properties of practically all deposits and to the effects on the structure of deposits of cavities, inclusions, and fissures. Variation in dimensions of the crystals is attributed to changes in the electrochemical conditions during the deposition. Irregular crystalline orientation may be due to the effect of the foundation surface and to the presence of inclusions which are trapped in the deposit. Although such faults may not be evident on the surface, they may lead to weak mechanical properties. The following factors should be carefully controlled in order to obtain deposits of good quality: preparation of the surface, to obtain good adhesion and crystallization normal to the deposit; the composition of the bath; the conditions of deposition, which should be adapted to the quality of deposit required; the uniformity of working during actual deposition. —W. A. C. N.

Nickel Deposits on Aluminium. M. Ballay (*Rev. Nickel*, 1934, **5**, 182–183).—Cf. *Met. Abs.*, 1934, **1**, 353. The parts are degreased by means of trichlorethylene, electrolysis in cold sodium carbonate solution, and then dipping in trisodium phosphate. They are afterwards dipped in a hot solution of iron perchloride containing hydrochloric acid. The nickel deposition is carried out in any convenient bath.—W. A. C. N.

Some Considerations on Electrolytic Deposits of Rhodium. Anon. (*Galvano*, **1934**, (30), 20–23).—Very thin deposits of rhodium are liable to be slightly porous, unless the plating operation is very carefully controlled. Instructions are given for the preparation and plating of articles, and curves are shown to illustrate the effects of current density and temperature on the rate of deposition. A preliminary coating of nickel is recommended for most metals. Where the presence of nickel is undesirable, palladium may be substituted.—C. E. H.

***Studies in Zinc Electrodeposition: Deposition from Ammonium Sulphate–Zinc Baths.** Raymond R. Rogers and Edgar Bloom, Jr. (*Electrochem. Soc. Preprint*, **1935**, March, 65–75).—Aqueous solutions produced by combining zinc sulphate, zinc oxide, sulphuric acid, ammonium sulphate, and ammonium hydroxide were investigated to determine the range of compositions from which zinc may be electrodeposited. This range was plotted on a ternary diagram, using zinc sulphate, and hydroxide as the variables. Typical bath compositions in different parts of the range were investigated to determine the conditions which produce the best-looking deposits in each case. The method of using ternary diagrams is briefly discussed.—S. G.

***A Further Study of Cyanide Zinc Plating Baths Using Al–Hg–Zn Anodes.** A. Kenneth Graham (*Electrochem. Soc. Preprint*, **1935**, Mar., 119–129).—From 1·0 to 0·56N zinc cyanide baths containing from 3 to 7 oz./gall. (22·5 to 52·5 grm./litre) of sodium hydroxide were studied with respect to cathode efficiencies and character of deposits at 20, 40, and 60 amp./ft.^{2} (2·2, 4·4, and 6·6 amp./dm.^{2}) and 110° F. (43° C.). Using aluminium–mercury–zinc anodes, excellent deposits are obtained at all current densities with bath compositions other than those which have been shown previously to give the most ideal anode behaviour. The variation of cathode efficiency with time of plating, bath composition, solution concentration, and current density is noted.—S. G.

The Deposition of Zinc–Cadmium Alloys from Alkaline Cyanide Solutions. Leslie Wright and J. Riley (*J. Electrodepositors' Tech. Soc.*, 1935, **10**, 1–12).—Zinc–cadmium alloys of close-grained structure and adherent to the basis metal are obtained by electrolysis of solutions of their double potassium cyanides containing excess potassium cyanide, potassium hydroxide, and cerelose. Addition of cadmium salts is necessary to maintain the cadmium content of the electrolyte. The cadmium content of the deposit increases with temperature and cyanide content, and to a lesser extent with current density, and decreases with increase in alkali. Methods for estimating zinc and cadmium are given.—A. I. W.-W.

***The Adsorption of Certain Colloids by Metallic Surfaces and Its Effect on the Structure of Electrodeposits.** Pierre Jacquet (*Compt. rend.*, 1935, **200**, 226–227; and *Génie civil*, 1935, **106**, 95).—An investigation has been made of the effect of adsorbed films on copper supports of different physical natures, *e.g.* electrolytic copper, cast and rolled copper, and cast, rolled and annealed copper, the specimens being either highly polished or pickled in nitric acid. The polished specimens always had identical structures, very fine near the support, becoming coarser as a result of the growth of each initial crystal. With pickled cathodes, the crystal continuity of the base metal of the deposit was prevented by the colloidal film, except in the case of electrolytic copper. This was confirmed by experiments with rolled cathodes having an adsorbed film of serum-albumin or peptone. Micro-examination showed that each crystal continued beyond the second film of adsorption without any difference of shape or size. Only proteins and peptones produce this effect; the gums arabic and tragacanth have no effect, and are not adsorbed on the metallic surfaces.—J. H. W.

Action of Buffers on Electrolytic Metallic Deposits. (*Bull. Soc. franç. Élect.*, 1935, [v], **5**, 50.)—Discussion on a paper by J. Salauze (see *Met. Abs.*, 1934, **1**, 354).—P. M. C. R.

Electrolytic Protective Coatings. Anon. (*Galvano*, **1934**, (32), 22–28).—A review, dealing with the electrodeposition of copper, nickel, chromium, cobalt, zinc, cadmium, tin, lead, silver, gold, platinum, rhodium, and aluminium. The baths employed and the application of the various coatings are discussed.
—C. E. H.

The Testing of Electrodeposited Coatings. L. C. Bannister (*J. Electrodepositors' Tech. Soc.*, 1935, **10**, 97–108).—Tests are classified under appearance, composition, thickness, physical properties, and protective value. Physical properties include adherence, internal stress, hardness, wear resistance, and structure. Variations of salt-spray tests are given in detail. B. considers that thickness of the deposit is the most valuable single test. Standardization of the technique for carrying out tests is essential.
—A. I. W.-W.

Specifications for Anodic Deposits. S. Wernick (*J. Electrodepositors' Tech. Soc.*, 1935, **10**, 85–96).—Discusses process and purchasing specifications covering zinc and cadmium deposits on ferrous metals. Purchasing specifications should cover appearance, thickness or weight, distribution, adhesion, and protective property. A specification for a cadmium finish is given in detail, and includes tests for weight, corrosion, and adhesion.—A. I. W.-W.

Specifications for Cathodic Coatings. With Special Reference to Nickel and Chromium Deposits on Steel. C. F. J. Francis-Carter (*J. Electrodepositors' Tech. Soc.*, 1935, **10**, 69–84).—Deals chiefly with nickel, chromium, and silver, and enumerates the properties for which specifications are possible —appearance, adhesion, thickness, porosity, hardness. Details are given of 6 existing sets of specifications.—A. I. W.-W.

Methods of Suspension in Electrodeposition Practice. C. F. J. Francis-Carter and B. J. R. Evans (*J. Electrodepositors' Tech. Soc.*, 1935, **10**, 41–56).—The relative merits of various suspension methods are discussed and principles of design enunciated. Rubber and other forms of insulation of suspenders are described in detail. The peculiarities of chromium plating demand attention to suspension design.—A. I. W.-W.

Recent Developments in Electroplating. S. Wernick (*Chem. and Ind.*, 1934, **53**, 948–953).—S. G.

Electrodeposition Progress in 1934. S. Wernick (*Indust. Chemist*, 1935, **11**, 30–32).—A review, with references to the literature. Nickel, chromium, cadmium, zinc, tin, the platinum metals, and various alloys are dealt with.
—C. E. H.

VII.—ELECTROMETALLURGY AND ELECTROCHEMISTRY

(Other than Electrodeposition.)

(Continued from p. 61.)

***The Electrical Properties of the Oxide Insulating Layer on Aluminium.** S. S. Gutin (*Zhurnal Tehnicheskoi Fiziki* (*J. Tech. Physics*), 1933, **3**, 1185–1189; *Chem. Zentr.*, 1934, **105**, I, 309).—X-ray analysis of the films produced by anodic oxidation of aluminium in oxalic acid baths show them to consist of crystalloidal γ-Al_2O_3, whereas those produced in sulphuric acid baths are microcrystalline (grain-size about 10^{-6} cm.). Both films are very hygroscopic, absorbing up to 32·6 vol.-% of water, and their electrical properties are almost entirely dependent on their water content up to 120°–140° C. For insulating purposes, *e.g.* in the construction of condensers, the films should be completely dehydrated and filled with a water repellent material, *e.g.* paraffin wax and linseed oil.—A. R. P.

***The Hydrogen Overvoltage and the Anodic Behaviour of Tungsten in Aqueous Solutions of Potassium Hydroxide.** M. de Kay Thompson and C. W. Rice, Jr. (*Electrochem. Soc. Preprint*, **1935**, March, 41–48).—In an excess of potassium hydroxide, tungsten dissolves with close to 100% current efficiency in all conditions of current density and concentration investigated, even when polarization increases to 110 v. High polarization occurs the more readily the higher the current density, the more dilute the solution, and the lower the temperature. If electrolysis is carried out with high polarization, the anode always becomes burnished in appearance. If electrolysis continues after all hydride is converted to orthotungstate, the current efficiency gradually decreases, oxygen is evolved, the electrolyte turns blue, and paratungstate precipitates. The graphs of electrode potentials for a given current density against concentration of electrolyte are of the same form as those for molybdenum, but are limited to low current densities by high polarization. The hydrogen overvoltage is least in sulphuric acid; in potassium hydroxide it decreases with increasing concentration of the hydroxide.—S. G.

IX.—ANALYSIS

(Continued from pp. 106–108.)

†**Spectrographic Analysis in 1860 and 1935.** W. Gerlach, E. Riedl, and W. Rollwagen (*Metallwirtschaft*, 1935, **14**, 125–132).—An historical review of the development of spectrographic analysis. Difficulties associated with irregular distribution of the constituents of an alloy are discussed with special reference to zinc in cadmium and iron in silver–gold alloys.—v. G.

***Rapid Quantitative Microanalysis of Pure Aluminium. II.—Determination of Silicon and Phosphorus.** F. Pavelka and H. Morth (*Mikrochemie*, 1935, **10**, 239–246).—The sample (0·05 grm.) is dissolved in 5 c.c. of 1 : 1 HCl at

20° C. and the solution diluted to 10 c.c.; 0·5–2 c.c. of the liquid is pipetted into a colorimeter, 1 c.c. of 5% $(NH_4)_2MoO_4$ solution, 2 drops of 1% NaF solution, 3–4 drops of 1 : 5 H_2SO_4, and 1 c.c. of 2% hydroquinone solution are added in succession and, when the yellow colour has changed to blue (5 minutes), 2 c.c. of a solution containing 15 grm. of Na_2CO_3 and 10 grm. of Na_2SO_3 per 100 c.c. is added and the colour compared with that of a standard prepared similarly. This gives the sum of the P and Si; in a second trial the Si is removed by evaporation and P determined in the filtrate as above.
—A. R. P.

Tentative Methods of Chemical Analysis of Metallic Materials for Electrical Heating (B 71–34 T). —— (*Amer. Soc. Test. Mat. Tentative Standards*, 1934, 256–278; and *Proc. Amer. Soc. Test. Mat.*, 1934, **34**, (I), 710–732).—The following methods are recommended: *Nickel:* dissolution of the metal in *aqua regia* and precipitation in a neutral tartrate solution with dimethyl glyoxime (dissolved in 3% NaOH), or alternatively electrolysis after glyoxime precipitation using a larger sample; *Chromium:* dissolution of the metal in $HClO_4$ followed by the usual $(NH_4)_2S_2O_8$ process; *Iron:* titration with $KMnO_4$ after precipitation of $Fe(OH)_3$ in a solution oxidized with $(NH_4)_2S_2O_8$ and subsequent $SnCl_2$ reduction; *Manganese:* dissolution of the alloy in $HClO_4$, precipitation of the Fe and Mn with NH_4OH and $(NH_4)_2S_2O_8$, dissolution of the precipitate in HNO_3 and SO_2, oxidation of the solution with Na bismuthate and titration with $FeSO_4$ and $KMnO_4$; *Carbon:* combustion with Fe or Sn filings in O_2 at 1100° C.; *Sulphur:* dissolution of the alloy in HCl, absorption of the H_2S in $CdCl_2$ solution, and titration of the S with KIO_3; *Copper:* by electrolysis; *Aluminium:* removal of the interfering metals with cupferron, removal of the Cr as CrO_3 by $HClO_4$, evaporation and precipitation of the Al as $Al(OH)_3$; *Titanium:* precipitation with cupferron followed by dissolution in fused $KHSO_4$ and colorimetric determination with H_2O_2. Exact details of all the above procedures are given.—A. R. P.

***Microchemical Detection of Bismuth, Antimony, and Gold.** Adolfo Sá (*Anal. Farm. Bioquim.*, 1934, **5**, 3–7; *Chem. Zentr.*, 1934, **105**, II, 3531).—In the presence of KI, Bi gives a scarlet and Sb an orange-yellow crystalline precipitate with α-amidopyridine; the reaction will detect 1·2 γ Bi and 7·5 γ Sb in 1 drop of solution. In NaBr solution Au gives a yellow to red crystalline precipitate with the same reagent. To detect Bi in Ag, Pb, Hg, Cu, Cd, or Au the solution of the metal is treated with NaOH and KCN, the precipitate dissolved in H_2SO_4, and the solution tested as above.—A. R. P.

***Research Limits of Spectroscopic Detection of Cadmium and Palladium in Silver.** G. Baiersdorf (*Anzeiger Akad. Wiss. Wien*, 1934, **71**, 54).—An abstract. See *Met. Abs.*, this volume, p. 23.—W. A. C. N.

Spot Reaction for Cobalt. L. M. Kulberg (*Ukrainskii Khemichnii Zhurnal* (*J. Chim. Ukraine*), 1933, **8**, 133–139).—[In Ukrainian, with German summary.] The formation of CoHg $(CyS)_4$ is used to determine the presence of Co by means of a spot reaction. A drop of the solution is placed on filter paper and treated with a drop of the reagent $(NH_4)_2Hg(CyS)_4$, obtained by adding NH_4CNS to $HgCl_2$. On warming, a light blue colour is developed if Co is present. This reaction detects the presence of Co in the presence of the usual cations, even if preponderating quantities of Fe and Ni are present. It is one of the most sensitive reactions for the metal.—M. Z.

The Application of the Krumm–Vollhardt Reaction as a Fractional Reagent for the Manganese Ion. M. P. Babkiy (*Ukrainskii Khemichnii Zhurnal* (*J. Chim. Ukraine*), 1933, **8**, 179–181).—[In Ukrainian.] A method of detecting Mn in the presence of other ions by treating the solution to be tested with H_2O_2 and alkali, and then boiling the resulting precipitate with a mixture of HNO_3 and H_2SO_4. If Mn is present, the deep purple coloration of the MNO_4' is developed.—M. Z.

An Apparatus for the Volumetric Determination of Aluminium. P. Ya Ivannikov (*Zavodskaya Lab.*, 1934, **3**, 865; *C. Abs.*, 1935, **29**, 645).—[In Russian.] The determination of Al in pure and alloyed Al is based on the reaction $2Al + 2KOH + 2H_2O = 2KAlO_2 + 3H_2$, and is performed in a specially designed apparatus.—S. G.

***Fractional Analysis of Aluminium.** Ch. N. Potschinok (*Zhurnal prikladnoi Khimii* (*J. Applied Chem.*), 1933, **6**, 948–950).—[In Russian, with German summary.]—The presence of NH_4NO_3 interferes with the determination of small quantities of Al by Atack's method, since dissociation of the salt itself produces a colour with alizarin. Al may, however, be separated from all metals which interfere in the test by precipitation first with $(NH_4)_2S$ and then with $Na_2S_2O_3$ in dilute HCl in the presence of alizarin. A red colour develops with as little as 0·04 mg. of Al in 8 c.c.—M. Z.

Rapid Determination of Cadmium and Lead. F. I. Trishin (*Ukrainskii Khemichnii Zhurnal* (*J. Chim. Ukraine*), 1934, **9**, 29–33).—[In Ukrainian.] A solution containing Cd is treated with NH_4OH and a normal solution of KI. The mixture is filtered and treated with concentrated KCN, when all cations present are transformed into complex cyanides. On addition of Na_2S only CdS (yellow) is precipitated. The solution containing Pb is treated with HCl. The resultant precipitate is digested with CH_3COONa, and to the solution so obtained K_2CrO_4 is added, when a yellow precipitate of $PbCrO_4$ is obtained. The reactions are sensitive to about 0·005*N*.—M. Z.

***The Determination of Trivalent Chromium in Chromic Acid and in Chromium Plating Baths.** Hobart H. Willard and Philena Young (*Electrochem. Soc. Preprint*, **1935**, March, 55–64).—Trivalent chromium in chromium plating baths may be determined by oxidation with excess of standard ceric sulphate and titration of the excess with standard sodium nitrite in the presence of the large amount of chromic acid always present. The end-point is determined potentiometrically. Moderate amounts of iron, manganese, or other common metals cause no interference. The method is much more rapid and accurate than procedures in use at the present time. The same method may be applied in the determination of the % of trivalent chromium in chromic acid.—S. G.

The Iodometric Determination of Copper. John R. Caldwell (*J. Amer. Chem. Soc.*, 1935, **5**, 96–97).—The end-point of the iodometric copper titration is improved by addition of a solution of white shellac in alcohol (about 0·5–1 c.c. of 4% soln.) after partial titration. This gives a heavy cream-coloured precipitate with a clear blue solution containing practically all the iodo-starch colour. The presence of iron may inhibit to some extent the action of the shellac.—R. G.

***Chemical Analysis by Means of Organic Compounds. I.—Separation and Determination of Copper and Cadmium by Means of Salicylaldoxime and Electrolysis.** Masayoshi Ishibashi and Haruo Kishi (*Nippon Kwagaku Kwai Shi* (*J. Chem. Soc. Japan*), 1934, **55**, 1060–1064; *C. Abs.*, 1935, **29**, 702).—[In Japanese.] From the slightly acid mixture consisting of Cu and Cd, Cu can be precipitated by salicylaldoxime. The precipitate of Cu is filtered, dried, and weighed. The presence of a large amount of Cd does not disturb the precipitation of Cu as salicylaldoxime salt. From the filtrate, Cd is determined by electrolysis. The presence of salicylaldoxime in the filtrate is favourable for the deposition of Cd.—S. G.

***Chemical Analysis by Means of Organic Compounds. II.—Separation and Determination of Copper and Cadmium by Means of Salicylaldoxime and Hydroxyquinoline.** Masayoshi Ishibashi and Haruo Kishi (*Nippon Kwagaku Kwai Shi* (*J. Chem. Soc. Japan*), 1934, **55**, 1065–1066; *C. Abs.*, 1935, **29**, 702).—[In Japanese.] Cu is precipitated as salicylaldoxime salt. From the filtrate Cd is precipitated by hydroxyquinoline as Cd $(C_9H_6ON)_2$ which is dried at 128°–130° C. and weighed.—S. G.

***Chemical Analysis by Means of Organic Compounds. III.—Separation and Determination of Copper and Lead by Means of Salicylaldoxime.** Masayoshi Ishibashi and Haruo Kishi (*Nippon Kwagaku Kwai Shi* (*J. Chem. Soc. Japan*), 1934, **55**, 1067–1069; *C. Abs.*, 1935, **29**, 702).—[In Japanese.] From the slightly acid solution containing Cu and Pb, Cu is precipitated by salicylaldoxime, and then filtered off. Ammonia is added to the filtrate so that the p_H of the filtrate becomes greater than 6·5. Pb is then precipitated by the addition of salicylaldoxime. The precipitate is filtered and dried at 105° C. The composition of the precipitate is $(C_7H_5O_2N)Pb$.—S. G.

Fractional Determination of Magnesium by a Nephelometric Method. E. W. Vassilieva (*Ukrainskii Khemichnii Zhurnal* (*J. Chim. Ukraine*), 1934, **9**, 6–9).—[In Ukrainian.] A method for determining Mg has been developed, depending on a nephelometric comparison with a standard series of $MgNH_4PO_4$. The solution to be tested is saturated with $(NH_4)_2C_2O_4$, $K_4Fe(CN)_6$, and NH_4OH, which precipitate all cations except Mg. The solution is then filtered, and Mg is precipitated from the filtrate by Na_3PO_4. The complex magnesium–ammonium phosphate forms a suspension, the density of which is proportional to the amount of Mg present. The suspension is compared with the nephelometric standard. The accuracy of determination is within 10%.—M. Z.

***A Comparison of Certain Methods of Determining Manganese in Metallurgical Practice.** P. A. Epik (*Ukrainskii Khemichnii Zhurnal* (*J. Chim. Ukraine*), 1934, **9**, 79–85).—[In Russian.] The analytical method of Vollhardt–Wolf–Reinzer and Konrad and the silver persulphate and chlorimetric reaction of Krumm were compared for the determination of Mn in MnSO steel, cast iron, and ferro-manganese alloy. It is concluded that for salts which have no impurities when oxidized, the Vollhardt method is best. The solution must be neutral. For iron, steel, and cast iron the Reinzer method is preferable. The solution must be acid. The silver persulphate and chlorimetric method do not give satisfactory results.—M. Z.

***A New Process for the Fractional Determination of Zinc.** L. M. Kulberg (*Ukrainskii Khemichnii Zhurnal* (*J. Chim. Ukraine*), 1933, **8**, 190–192).—[In Ukrainian, with German summary.] A new method has been discovered for the fractional determination of Zn in the presence of all cations, especially Co. The method is based on the property of surface absorption by zinc mercury thiocyanate of mercury thiocyanate zinc–cobalt complex, and is extremely sensitive and simple. The zinc mercury thiocyanate is a white precipitate, and the absorbed Co complex develops a dark blue colour. Time of determination is 10 minutes.—M. Z.

X.—LABORATORY APPARATUS, INSTRUMENTS, &c.

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

(Continued from pp. 108–109.)

***Water-Cooled Resistors.** Edward M. Thorndike (*Science*, 1934, **80**, 619–620).—A note describing the construction of water-cooled resistances for use with electric furnaces, &c. The resistances, which may be either fixed or variable, are essentially Nichrome wires fixed inside tubes through which water flows.—W. H.-R.

A Reflection Meter and Its Applications. W. P. Digby (*Engineer*, 1935, **159**, 219–220).—A reflection meter, employing photoelectric cells, has been used for determining the amount of tarnishing on exposed metal surfaces. Tests on standard silver, fine silver, and silver–copper eutectic alloy show that under most conditions the fine silver suffered less tarnishing than either of the other two materials.—W. P. R.

†**The Design and Equipment of Photo-Elastic Laboratories.** E. G. Coker (*Engineering*, 1935, **139**, 183–185).—In addition to the special kind of optical bench, by means of which polarized light can be transmitted through transparent models which are stressed in various ways, special apparatus for imposing the stresses is required. A well-equipped workshop is a necessary adjunct to the photo-elastic laboratory.—W. P. R.

†**Magnetic Methods for Attaining Extremely Low Temperatures.** P. Debye (*Physikal. Z.*, 1934, **35**, 923–928).—From *Vorträge und Diskussionen des X. Deutschen Physiker- u. Mathematiker-Tages*, **1934**, Sept. The theory of magnetic methods of attaining extremely low temperatures and experimental results are briefly discussed. A temperature of 0·018° abs. had been attained by the date of the conference. Methods employed for measuring these low temperatures are briefly referred to; the unattainability of the absolute zero of temperature and the possibility of carrying out direct experimental investigations of nuclear magnetism are also briefly discussed.—J. S. G. T.

Devices for Ensuring Constancy in the Masses of Precision Weights. J. J. Manley (*Phil. Mag.*, 1935, [vii], **19**, 243–251).—Changes in precision weights stored in wooden boxes lined with velvet are attributed to the acid character of the glue used for securing the velvet linings and to incomplete cleansing of the velvet following the process of dyeing. Two methods of storage of weights, which have been found to be reliable over periods of about 70 weeks, are described. The preferred one depends on the absorptive power of cocoanut-shell charcoal.—J. S. G. T.

Adhesion and Adhesives. Some Mechanical Properties of Materials and Glued Metal Joints. W. B. Lee (*Indust. and Eng. Chem.*, 1930, **22**, 778–780).—Part of the article discusses, with diagram, the relative strengths of joints of various adhesives such as shellac, sealing wax, gum arabic, &c., between smooth nickel surfaces.—I. M.

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

(Continued from pp. 109–111.)

Modifications in Publication AI–I of the "Commission Permanente de Standardisation" by the "Commission des produits sidérurgiques de L'AFNOR." —— Lepan-Drevdal (*Rev. Mét.*, 1934, **31**, 495–506).—A *résumé* of the revised publication, giving details of the standardized forms of mechanical tests, definitions, and recommendations for calibration of testing machines.—H. S.

Some Aspects of the Testing of Materials. H. J. Gough (*Iron Steel Ind.*, 1935, **8**, 117–120, 237–239).—The necessity for full-scale testing as a check on commercial production and to assist development, or on account of lack of knowledge of service strains or of exact causes of failure, is discussed. Some typical practical cases are considered, each of which rendered necessary or desirable the testing to destruction of one or more full-sized components. —J. W. D.

***The Non-Destructive Testing of Metals by Mesothorium Radiation.** M. Widemann (*Z. Metallkunde*, 1934, **26**, 204–206).—The presence of internal flaws and cavities in fabricated metal parts may be detected by placing the parts on a photographic film and exposing them to the radiation from 18–35 mg. of mesothorium for a few days; on developing the film the faulty parts are disclosed by shadow effects. Parts which are much too thick for X-ray examination may be tested in this manner, and the procedure is also useful for examining the structure of articles built up of several parts of the same or different metals without the necessity of dismantling. Several photographs illustrating the use of the method are included.—A. R. P.

***A Micrometric Study of Welds.** A. Portevin and P. Chevenard (*Génie civil*, 1935, **106**, 118–119).—By means of a special testing machine (see following abstract) small test-specimens cut from the weld can be tested. Typical stress-strain diagrams so obtained are given.—W. P. R.

A Micro Machine for Mechanical Tests with Photographic Recording Device. Anon. (*Génie civil*, 1935, **106**, 188–189).—Describes a testing machine capable of giving an automatic record of tensile, bending, and shearing tests on specimens 1–1·5 mm. diameter.—W. P. R.

***Apparatus for Tests at Elevated Temperatures and Resistance of Several Steels to Creep.** I. Musatti and A. Reggiori (*Rev. Mét.*, 1934, **31**, 421–438).—Read before the third Congrès du Chauffage Industriel, October, 1933. See *Met. Abs.*, 1934, **1**, 360.—H. S.

***Strength Characteristics of Metals at Elevated Temperatures.** M. Roš and A. Eichinger (*Rev. Mét.*, 1934, **31**, 460–470).—Read before the third Congrès du Chauffage Industriel. See *Met. Abs.*, 1934, **1**, 313, and this volume. p. 110.—H. S.

Standard Values for the Testing of Metal Sheets by the Erichsen Method. A. H. F. Goederitz (*Maschinenbau*, 1934, (13/14); and (summary) *Z. Metallkunde*, 1934, **26**, 208–210).—Graphs are given showing standard Erichsen values for sheets of varying thicknesses, and with different degrees of work-hardness, of brass, nickel, copper, aluminium, tinplate, zinc, and silver of different finenesses.
—A. R. P.

***Determination of the Alternate Bending Strength of Thin Wires.** Werner Friedmann (*Metallwirtschaft*, 1935, **14**, 85–88).—A machine for measuring the endurance limit of wires under alternating bending stresses is described. The specimens should have a length of 50 mm. and a diameter of 1·5–3·5 mm. The results obtained with some aluminium and copper alloys are given. Welded wires fracture at the weld and have an endurance limit 30–50% less than that of unwelded wires.—v. G.

***The Bending–Tensile Test. A New Technological Method of Testing [Metallic] Materials.** Ewald Buschmann (*Z. Metallkunde*, 1934, **26**, 274–279).—The test comprises suspending a flat test-piece (150 × 8 × 0·5 mm.) between the holders of an Amsler machine and applying a load at the lower end in 1 kg./mm.^{2} increments whilst the upper half of the specimen is bent to and fro over 2 parallel rollers through an angle of 180°. The load-elongation curve of pure metals and single-phase alloys closely resembles that of the ordinary tensile test and gives only one point of inflection, *i.e.* that corresponding with the yield-point; that for heterogeneous alloys, on the other hand, shows 2 inflection points, the second corresponding with the static yield-point and the first with the endurance strength in the alternating fatigue test. Results obtained on a number of metals and alloys indicate that fatigue is governed by the weakest constituents, and therefore the endurance limit can be improved only by addition of constituents which form solid solutions with the weaker constituents and thus increase their strength.
—A. R. P.

The Physical Society's Exhibition. Anon. (*Engineer*, 1935, **159**, 11–12).—Describes a machine for making tensile tests on fine wires. A constant rate of straining, instead of the more usual constant rate of stressing, is employed.
—W. P. R.

Physical Society Exhibition. Anon. (*Engineering*, 1935, **139**, 1–4, 27–32, 79–82).—Description of exhibits, including thermostatic devices, testing machines, &c.—W. P. R.

***New Applications of the Pendulum to Industrial Problems, in Particular to the Control of Materials.** Paul Le Rolland (*Bull. Soc. d'Encour. Ind. nat.*, 1934, **133**, 317–347).—A comprehensive review, in which particular attention is given to the use of pendulum methods for measuring hardness and modulus of elasticity. After an historical introduction, the applications of the pendulum to the study of friction, the properties of lubricants, and the resistance of air are considered. The theoretical basis of the pendulum hardness tester employing a hard cylinder rolling on the surface under test is then examined in detail. Experiment shows that with large amplitudes, greater than 0·05 radian, the time of oscillation is independent of the hardness of the test surface, but with small amplitudes below 0·001 radian, the oscillation time is controlled by the deformation of the surface. Priority for the proposal to utilize this effect in hardness measurements is claimed over Herbert. The disadvantages of the Herbert pendulum are instability, due to the short pendulum length of 0·1 mm., and invisibility of the indenter when setting up a test. A new hardness tester, claimed to overcome these disadvantages, is described in detail. Two long pendulums are used, one supported by a diamond ball on the test-piece, the other being a comparison pendulum suspended by elastic strips and adjusted to have a frequency equivalent to that of a pendulum resting on an infinitely hard substance. The length of time between successive coincidences of the 2 pendulums is proportional to the hardness, the hardness of quartz being taken as 100. Advantages claimed for this tester are that the ball is accessible and easily placed in position, the imprint is invisible, and thin sheets down to 0·2 mm. in thickness, surface coatings, and fragile materials can be tested. The use of pendulum methods in studying the elastic properties of mechanical systems is considered, and methods described for measuring modulus of elasticity by observing the beats produced between 2 pendulum systems connected by a test-piece of the material under examination.—J. C. C.

A Machine for Measuring Hardness. —— Eugène (*Rev. Mét.*, 1934, 31, 507–513).—Read before the Association Français pour l'Essai des Matériaux. A small impression is made by a loaded ball or diamond of small size, and the depth of the indentation is indicated. Results are compared with results of Rockwell hardness tests.—H. S.

On the Cohesion Relations of Stretched and Compressed Tensile Specimens (The Problem of Cohesive Strength). N. N. Davidenkov and E. M. Schevandin (*Z. Metallkunde*, 1934, 26, 193–196).—A. R. P.

Relations Between Cohesion and Plasticity (On the Tensile Effect of Stretched and Compressed Specimens). W. Kuntze (*Z. Metallkunde*, 1934, 26, 197–198).—A reply to Davidenkov and Schevandin (preceding abstract).—A. R. P.

Hysteresis Curves Investigated by Means of the Ferrometer. W. Thal (*Arch. tech. Messen*, 1935, 4, (44), T21–T23).—Typical forms of hysteresis curve are correlated with magnetization and induction curves. A diagram shows the electrical and optical systems of the Ferrometer, an instrument which automatically records hysteresis curves. Small ring-shaped test-pieces are employed, and a series of specimen curves demonstrates the necessity for careful normalization of such pieces, the form of curve showing remarkable variations according to the condition of the material. Curves are also shown for alloys containing, respectively, 50, 65, and 80% of nickel, remainder iron, for "1040" alloy, for Thermalloy, and for a compound core containing 80% nickel–iron and a ferrous alloy.—P. M. C. R.

XII.—TEMPERATURE MEASUREMENT AND CONTROL

(Continued from p. 69.)

Chromel and Alumel: Alloys for Thermocouples. W. A. Gatward (*Metal Progress*, 1935, 27, (3), 31–35).—Thermocouples having the positive wire of Chromel and the negative wire of Alumel have been found to develop a considerable and steadily increasing e.m.f. from 0° to 1370° C. The preparation of the alloys, which must be such as to preserve the physical properties of the original standards, is described; some revision of the latter data has, however, become necessary, and a tabulated summary of corrections is given. The couples are very durable in oxidizing atmospheres; effective protection from reducing atmospheres must be provided. Methods of standardizing are described.—P. M. C. R.

Temperature-Recording Paints. Anon. (*Aircraft Eng.*, 1934, 6, 305).—A brief description of investigations in search of reliable temperature-indicating paints. The main difficulty is the possibility of decomposition.—H. S.

***The Temperature of the Copper Arc.** C. G. Suits (*Proc. Nat. Acad. Sci.*, 1935, 21, 48–50).—The principle of the method employed is that the velocity of sound through a gaseous medium depends upon the temperature. The source of sound was a condensed discharge between an electrode immersed in the arc and the cathode of the arc, whilst a non-oscillating spark discharge acted as the sound receiver. Values of 4000° ± 200° and 4200° ± 200° K. were obtained for long and short arcs, respectively.—C. E. H.

***High-Velocity Thermocouple for the Measurement of True Gas Temperatures. I.—Conditions Required for the Correct Measurement of Gas Temperatures.** Shun-ichi Uchida and Sutezo Tanabe (*Kōgyō Kwagaku Zasshi* (*J. Soc. Chem. Ind. Japan*), 1934, 37, (10); *C. Abs.*, 1935, 29, 647).—[In Japanese, with English summary in supplemental binding, pp. 552–555.] The effect of velocity of gas suction was studied by the use of a stack of thin iron plate 6 m. high and 12·5 cm. in diameter. A Chromel–Alumel couple was soldered to the outside of the stack to measure the stack-wall temperature. The high-velocity couple, a platinum/platinum–rhodium couple, was connected to a vacuum pump. Metallic suction pipes lagged on the outside and used with bare couples less than 0·5 mm. thick gave the best results. When the gas temperature was 666° C. and Δt between gas and stack wall was 378° C. this couple gave a constant reading at the suction velocity of 10 m./second. With no suction applied the reading was 488° C. and the error 178° C. Several plots of Δt against suction velocity are presented for different thermocouple constructions.—S. G.

***High-Velocity Thermocouple for the Measurement of True Gas Temperatures. II.—Portable High-Velocity Thermocouple and Some of Its Applications.** Shun-ichi Uchida, Sakae Yagi, Sutezo Tanabe, Kiyoshi Tezuka, and Shigefumi Fujita (*Kōgyō Kwagaku Zasshi* (*J. Soc. Chem. Ind. Japan*), 1934, 37, (10); *C. Abs.*, 1935, 29, 647).—[In Japanese, with English summary in supplemental binding, pp. 555–557.] Platinum/platinum–rhodium wires 0·3 and 0·2 mm. in diameter were used for couples 76 and 150 cm. long. Tests are presented on the gas temperatures in a furnace regenerator and a waste-heat boiler.—S. G.

***High-Velocity Thermocouple for the Measurement of True Gas Temperatures. III.—Errors of High-Velocity Thermocouples.** Shun-ichi Uchida and Sutezo Tanabe (*Kōgyō Kwagaku Zasshi* (*J. Soc. Chem. Ind. Japan*), 1934, 37, (10); *C. Abs.*, 1935, 29, 647).—[In Japanese, with English summary in supplemental binding, pp. 557–559.] Tests are reported in which the true gas temperature was measured by the method of H. Schmidt. It was found empirically that the function $\sqrt[3]{\Delta t}/\Delta T$ (%) is practically constant at 1, where Δt° is the error of the high-velocity couple and ΔT the temperature difference between gas and wall.—S. G.

XIII.—FOUNDRY PRACTICE AND APPLIANCES

(Continued from pp. 112–113.)

Vacuum-Casting. K. V. Peredelsky (*Legkie Metalli* (*Light Metals*), 1934, (7), 35–38).—[In Russian.] Methods and furnaces for the vacuum-casting of the aluminium alloys are described.—D. N. S.

***A Contribution to the Determination of the Castability of Aluminium Alloys.** A. von Zeerleder and R. Irmann (*Z. Metallkunde*, 1934, **26**, 271–274).—A fuller account is published of work the chief results of which have already been given in the discussion on Portevin and Bastien's paper (*Met. Abs.*, 1934, **1**, 457). Anticorodal alloys with up to 5% of antimony have a maximum castability when the silicon content is about 2%; castings of such alloys poured at 700° C. into a mould preheated to 300° C. have a tensile strength of about 27 kg./mm.^{2} with an elongation of more than 4%. Higher casting temperatures increase the castability, but have a deleterious effect on the mechanical properties.—A. R. P.

The Practice of Melting Aluminium. A. von Zeerleder (*Found. Trade J.*, 1935, **52**, 121–122).—A translation of Z.'s article in *Aluminium*, 1934, **17**, 196–201; from *Light Metals Review*, 1935, **1**, 279–291. See *Met. Abs.*, this volume, p. 30.—J. H. W.

Casting and Constructing. Oskar Summa (*Aluminium*, 1935, **17**, 73–74).—Brief practical hints are given for designing light metal castings so as to obtain soundness and freedom from porosity in the thin parts, and efficient filling of the mould.—A. R. P.

Vertical Castings of Copper at Carteret. B. H. Strom (*Eng. and Min. J.*, 1935, **136**, (2), 59–62).—Describes the plant and procedure for the production of vertical castings of copper. The set surface is confined to the end having the smallest dimensions, and the long sides are parallel. Castings weighing from 100 to 10,000 lb. have been produced by the method, with a paper-like smoothness of the surface.—R. Gr.

***A Study of Porosity in Tin–Bronze and the Effect of Casting Temperature on Its Properties.** M. Sh. Hashojeev (*Metallurg* (*Metallurgist*), **1934**, (7), 80–87).—[In Russian.] The most suitable temperature for casting thin-walled and complicated articles in bronze is 1180°–1220° C. Yellow and brown spots observed in the fracture of bronze are caused by interdendritic shrinkage and disappear with gas-free metal when the casting temperature is correct and the feeding and casting system is suitably selected. Casting at temperatures above 1220° C. decreases the hardness but increases the relative elongation. Dense castings are obtained by melting in a neutral or slightly oxidizing atmosphere.—N. A.

†Phosphor–Bronze Castings. Their Production. F. Hudson (*Metallurgia*, 1935, **11**, 95–99).—Some aspects of production which assist in developing adequate service life in the various applications of phosphor–bronze are discussed. These include variations in composition; melting practice, where rapid melting in a slightly oxidizing atmosphere is recommended; the effect of melting time and the form of test-bar on cast phosphor–bronze with new and secondary metal heats; the influence of casting temperatures varying from 1020° to 1100° C.; mould materials for cores, dry- and green-sand castings; and general casting production. Corrosion values for phosphor–bronze in tap, river, and sea-water are also given.—J. W. D.

Kirk Automatic Lead Trimmer. Anon. (*Eng. and Min. J.*, 1935, **136**, (2), 79–80).—Briefly describes a pneumatically operated chisel, which trims the just solidified pig cast on a revolving table.—R. Gr.

Investigation of Magnesium Alloy Castings Made in Chill-Moulds. A. S. Ball (*Tehnika Vosdushnogo Flota* (*Technol. Aerial Navy*), **1934**, (3), 56–66).—[In Russian.] The chill-casting of magnesium alloys is much more difficult than is the case with aluminium alloys. The metal must be fed to the body of the casting by a short, wide feeder and the air vent must be wider. To prevent the formation of cracks, the moulds must be preheated to 325°–375° C., and the castings must be removed from the moulds and slowly cooled in a hot oven. Heat-treatment has no noticeable influence on the mechanical properties of castings.—N. A.

The Manufacture of Pewter. F. Orme (*Met. Ind.* (*Lond.*), 1935, 46, 195–198, 222–224).—Read before the Sheffield Local Section of the Institute of Metals. A short history of pewter, the decline and revival in the use of the alloy, and early compositions and methods of assaying it are set out. Modern pewter contains tin 90–94, antimony 5–7, and copper 1–3%, lead being absent, except as an impurity. The method of melting, casting, refining, pouring, rolling and spinning the alloy is described. Blistering is primarily due to incorrect casting temperature. The hardness is increased by quenching. The physical properties of the rolled alloy, surface processes, corrosion and the structure of the cast, worked and heat-treated alloy are discussed.
—J. H. W.

Recent Die-Casting Developments. Sam Tour and F. J. Tobias (*Foundry*, 1934, 62, 21–23, 62).—Zinc-base alloys (*e.g.* Zamak No. 3 containing aluminium 4·0, magnesium 0·5%) with superior physical properties, high impact strengths, and negligible dimensional changes have opened up new fields for the die-casting industry, instances of which are cited. Brass pressure castings may now be cast at lower temperatures by employing higher pressures. In the new high-pressure machine (an illustration of which is given), the metal pot is separate from the actual machine, the molten metal being transferred into the cylinder of the machine by hand ladle, before every "shot." Data are also given on the effect of iron on the properties of silicon–aluminium alloys, and emphasis is laid on the need for new alloys and die-steels. The composition of an improved new die-steel is given.—F. J.

Die-Casting. H. Foster (*Found. Trade J.*, 1935, 52, 90).—Abstract of a paper read before the Middlesbrough Branch of the Institute of British Foundrymen. The operation and advantages of the process of die-casting as applied to aluminium alloys are briefly described.—J. H. W.

Operates Foundry On the Island of Madeira. J. H. Quicke (*Foundry*, 1934, 62, 20–44).—A description of the island of Madeira, its climate, local industries, and conditions, &c., is given to explain the variety of articles which a local foundry is called on to supply. A few details are given of one such foundry, in the non-ferrous department of which brass, gun-metal, copper, and aluminium castings are produced.—F. J.

Specializes in Small Castings. Pat Dwyer (*Foundry*, 1934, 62, 16–18, 58).—The system of producing small castings in the plant of the Electric Autolite Co., Fostoria, O., U.S.A., is illustrated and described. Sand characteristics and preparation, core-making, conveyor-handling of castings, cleaning and general lay-out are chiefly discussed.—F. J.

Calculate Weight on Chaplets. Warren A. Smith (*Foundry*, 1934, 62, 28, 56).—As a preliminary to formulating the simplified rules for estimating the size, shape, and number of chaplets required for holding any given core in place, observations have been made of the action of chaplets in molten iron, and a condensed account thereof is given.—F. J.

Humidity Affects Core Strength. F. G. Sefing and M. F. Surls (*Foundry*, 1934, 62, 14–15, 42).—A series of experiments is described, from the results of which it is concluded (*a*) that cores stored in a highly humid atmosphere suffer a loss in strength, which can be regained only partly by re-drying; (*b*) that cores standing in a green-sand mould for 1 hr. or more lose about 50% of their strength. Cores of large cross-section do not bake uniformly throughout, therefore the baking time must be arranged with this feature in view.—F. J.

Use of the Pipette Method in the Fineness Test of Moulding Sand. Clarence E. Jackson and C. M. Saeger, Jr. (*J. Research Nat. Bur. Stand.*, 1935, 14, 59–65; *Research Paper* No. 757).—The fineness, or the size distribution, of the constituent particles of a material is an important factor in determining many of the physical characteristics. No great difficulty is encountered in sizing the larger particles by the use of sieves, but for particles finer than 50 μ in diameter other methods must be employed. The pipette method has been used satisfactorily in analysis of particle sizes of soils. Details of the development and use of the pipette method in the fineness testing of moulding sands are outlined in this paper. The method of computation and scope of results are shown by typical examples. A rapid method suitable for foundry control work is suggested.—S. G.

The Testing of Foundry Sands for Permeability. J. Gould (*Found. Trade J.*, 1935, **52**, 90, 102).—Abstract of a paper read before the Middlesbrough Branch of the Institute of British Foundrymen. A new apparatus for testing foundry sands for permeability, reproducing the conditions of actual casting better than bench or laboratory tests, is suggested.—J. H. W.

The Foundry Industry. R. W. Stubbs (*Metallurgia*, 1935, **11**, 89).—A very brief review of new alloys made in the foundry and of recently developed processes and equipment used in their production.—J. W. D.

Foundry Plant and Machinery. Anon. (*Metallurgia*, 1935, **11**, 90–92).—Sand control and preparation, moulding machines, melting furnaces, and the cleaning of castings are discussed with special reference to recent developments.
—J. W. D.

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

(Continued from p. 114.)

On the Electrolytic Working-Up of Precious Metal Residues. G. Volkert (*Metallbörse*, 1934, **24**, 437–438).—Gold and silver may be recovered from ashes and melting dross by grinding the material finely and electrolyzing it in suspension in 2–4% sodium cyanide solution containing protective alkali. The solution is contained in an iron vessel, which acts as anode, and a concentric iron tube is used as cathode, while a current of finely divided air is blown through the electrolyte from a porous diaphragm at the bottom of the vessel. Current is supplied at 2·2–2·4 v. giving a current density of 0·2–0·6 amp./dm.^{2}. Over 90% of the gold and about 60% of the silver are removed from the material in 8–10 hrs., and of this 75–80% of the gold and 45–50% of the silver are deposited on the cathode, the remainder being recoverable from the solution in the usual way or the solution may be used over again in the process.—A. R. P.

Mixed White Metal and Brass Borings. C. C. Downie (*Machinist* (*Eur. Edn.*), 1935, **79**, 50E).—Mixed sweepings from turning shops are first passed through a magnetic separator. The normal method of separating the resulting borings, by placing them in a perforated ladle over a hot plate, is not very successful. Better results are obtained by treating them in a liquation-hearth type furnace with a sloping bed from which the light brass is skimmed off as it rises to the surface.—J. H. W.

Detinning of Scrap Tin Plate. Wilfred W. Scott and Nele E. Davis (*Indust. and Eng. Chem.*, 1930, **22**, 910–911).—A detinning process is described based on the fact that dilute solutions of tartaric acid dissolve tin in the presence of excess of air or oxygen, whilst iron is unattacked.—I. M.

XV.—FURNACES AND FUELS

(Continued from pp. 114–115.)

Electric Melting Furnaces for Aluminium and Aluminium Alloys. Carl Haaf (*Aluminium*, 1935, **17**, 75–77).—Two types of reverberatory tank furnaces, with sloping forehearth for preheating the charge, and a crucible furnace for melting aluminium and its alloys are described with reference to diagrams; the heating elements are arranged in the roof and sides and are protected from splashes of molten metal by suitably arranged protective shields (nature not stated).—A. R. P.

A Portable Babbitt Pot. H. K. Sellick (*Metals and Alloys*, 1935, 6, 52).—The apparatus comprises a 500-lb. electrically-heated melting pot mounted on a truck fitted with a control panel and thermostat and with power cables and plug for connecting to any power point in the works. An automatic time clock is also provided for ensuring the charge being molten at any desired time. The charge can be heated to 427° C. in 1½ hrs.—A. R. P.

[Furnace for] Stress-Relieving is Perfected for Large Welded Vessels. F. W. Thompson (*Gas Age-Record*, 1935, 75, 67–70).—A large gas-fired furnace for relieving strains in large welded vessels is described.—J. S. G. T.

Use of Electric Furnaces in Industrial Heat-Treatment.—II. A. Glynne Lobley (*Metallurgia*, 1935, 11, 117–120).—See *Met. Abs.*, this volume, p. 114. Various types of continuous furnaces in which the charge is mechanically handled are discussed, including rotary annular-hearth, double-deck driven roller-hearth; link-belt conveyor, pusher type, rotating drum, and continuous wire and strip furnaces.—J. W. D.

***Furnace Chambers and Furnace Chamber Walls.** A. J. ter Linden (*Feuerungstechnik*, 1935, 23, 14–20).—Simple practical formulæ are derived for the heating of furnace walls, heated by radiation, and which may or may not be provided with cooling devices.—J. S. G. T.

XVI.—REFRACTORIES AND FURNACE MATERIALS

(Continued from pp. 115–116.)

Sinterkorund. P. Riebensahm (*Tech. Zentr. prakt. Metallbearbeitung*, 1934, 44, 350–351).—A variety of almost pure corundum, having a very fine structure. Slightly basic in character, it appears to combine the excellent qualities of both silica and magnesia. The following are among the properties so far determined: sp. gr. 3·78; melting point 2050° C.; hardness 9; porosity nil up to 1720° C.; tensile strength, 350 kg./cm.^{2}. Various uses to which the material has been put are described.—W. A. C. N.

XVII.—HEAT-TREATMENT

(Continued from p. 116.)

†Some Factors Governing the Heat-Treatment of Aluminium Alloys. J. Towns Robinson (*Metallurgia*, 1935, 11, 129–132).—The factors governing the high temperature or solution treatment, and the dangers of overheating in the heat-treatment of aluminium alloys are dealt with, and it is stated that chemical tolerance has an important bearing and controlling influence on the temperatures employed. Close control of the soaking time and the quenching temperatures is essential, and the quenching temperature must be above that necessary to ensure complete solution in the solid state of the eutectic constituents. Once the maximum solution temperature is exceeded to an extent which causes fusion of the eutectic material, either during the soaking period or at the actual quenching temperature, permanent damage is done which cannot be repaired.—J. W. D.

XVIII.—WORKING

(Continued from pp. 116–118.)

Progress in the Sintering of Metal Powders. W. D. Jones (*Metallurgist* (Suppt. to *Engineer*), 1935, **11**, 10–13).—A review of present information on methods of production of metallic powders, the process of compression and the effects of purity and grain-size, and sintering. Some recent results obtained by different workers are given, including the making of alloys of iron with volatile metals, which could not be done by casting methods. Some distinctive advantages of the process are discussed.—R. G.

Recent Experience in the Working and Heat-Treatment of Copper and Its Alloys. Anon. (*Illust. Zeit. Blechindustrie*, 1934, **63**, 1478–1479).—In treating articles of relatively large surface area, a balance must be struck between ease of working and oxidation losses: the latter are in the case of copper 3 times as heavy at 800° as at 600° C. Many defects arising during hot-working are due to the fact that copper can be rolled or hammered much more readily than it can be pressed; the time required for pre-heating is therefore comparatively long. An account is given of the pre-heating, deoxidation, and further treatment of certain standard types of copper. Special conditions are then discussed with regard to brasses of differing compositions.—P. M. C. R.

A Modern Copper Wire-Drawing Plant. Anon. (*Tech. Blätter deut. Bergwerkszeit.*, 1934, **24**, 642–644).—See *Met. Abs.*, 1934, **1**, 459.—I. M.

Drawing of Fine Wires with Diamond Dies (continued). P. Grodzinski (*Tech. Zentr. Prakt. Metallbearbeitung*, 1934, **44**, 275–277).—See *Met. Abs.*, 1934, **1**, 630.—I. M.

***Influence of the Reduction in Area and Shape of the Die on the Internal Stress and Tensile Properties of Cold-Drawn Brass Rods.** H. Bühler and E. H. Schulz (*Z. Metallkunde*, 1934, **26**, 199–203).—The stress distribution during the cold-drawing of brass rod has been determined at various stages by Sachs' method (*ibid.*, 1927, **19**, 352). When only the outer layers have been subjected to plastic deformation by drawing, compression stresses are produced in these layers and tensile stresses in the core; with further drawing to produce plastic deformation in the intermediate layers these develop compression stresses, whilst the outer layers and the core develop tensile stresses, and finally when the whole rod has undergone plastic deformation the compression stresses are located in the core and the tensile stresses in the outer layers. Cylindrical dies produce higher stresses at high reductions in area than do normally shaped dies. Dies with a steep angle chiefly deform the outer layers and, since they produce only small residual stresses, they can be used satisfactorily for final bright-drawing when only small reductions are required; with large reductions normal dies produce much less stress than steep dies, and also require less power. A normal die gives a smooth surface free from blemishes, whereas a cylindrical die produces a streaky, porous surface. The yield-point and tensile strength increase slightly with increasing die angle.—A. R. P.

The Effect of Some Mill Variables on the Gauge of Sheet Brass. C. K. Skinner (*Met. Ind.* (*Lond.*), 1935, **46**, 219–221).—Under the same conditions, it is more difficult accurately to roll wide bars than narrow ones. A difference in speed of 50 ft. on the finishing mills has no effect on the resultant gauge. The average shape of rolls usually employed has no appreciable influence on the gauge of the sheet, but materially changes the degree of flatness and straightness of the metal. The greater the mass of the roll, the more accurate the gauge obtained. Lubrication of necks appears to affect end to end variation. In general, the material of the roll has no appreciable effect on the gauge of the sheet. Cf. *Met. Abs.*, this volume, p. 32.—J. H. W.

Forging of Certain Copper Alloys. E. Berthelman (*Heat-Treating and Forging*, 1935, 21, (1), 24–28).—Abstract of a paper read before the Mechanical Engineers of Poland. See *Met. Abs.*, this volume, p. 75.—J. H. W.

***Experimental Work on Stamping of Duralumin.** G. J. Liamin and M. S. Pudov (*Vestnik Metallopromishlennosti* (*Messenger Metal Ind.*), 1934, 14, (7), 68–81; (8/9), 153–174).—The experiments on producing various articles in Duralumin have been made with forging hammers, stamps, and presses, using the dies used in forming articles of steel. At the most suitable temperature for forming Duralumin, namely 460°–490° C., the alloy with a minimum content of copper (0·6%) possesses a maximum plasticity, the authors stating that the best results are obtained by working with forging hammers, the tup being held in guides to allow for the use of multi-impression dies, since this form of hammer admits of frequent weak blows being applied at the beginning of stamping, and heavier blows towards the end. For this reason drop-hammers, where the tup falls by gravity, are not so convenient. Experiments on horizontal upsetting machines are successful, but they require that the blank or dummy shall be of exact size. Comparison of the forgeability of Duralumin at 450°–490° C., with that of steel of medium hardness at 1150° C., for the same shaped article, has shown that Duralumin is more difficult of deformation than steel, and the power of the hammer should be 15–35% greater, depending on the size and configuration of the part. For working in Duralumin, the general radii of the dies and the draft should be larger than for steel. The deformation is on an average 2·5% smaller than that of steel with the same energy of the blow. —D. N. S.

Stamping Brass Caps. A. G. Arend (*Met. Ind.* (*Lond.*), 1935, 46, 189–190).—The grades and the action of the dies, the form of caps (clenched or curled), and the method of curling in the stamping of brass (usually about 65 : 35) caps are described.—J. H. W.

A Machine for Producing Airscrews. Anon. (*Aircraft Eng.*, 1934, 6, 333).—A profiling machine for making airscrews or single blades to a pattern. General features of the machine are mentioned briefly.—H. S.

Current Applications of Cemented Carbide Tooling. Roger D. Prosser (*Soc. Automotive Eng. Preprint*, 1932, 5 pp.).—S. G.

Note on Some Factors Affecting the Roughness of Turned Pieces. E. Bodart (*Rev. Univ. Mines*, 1934, 10, 565–572).—I. M.

XIX.—CLEANING AND FINISHING

(Continued from pp. 118–119.)

***The Rapid Development of Patina on Copper After Assembly.** J. R. Freeman and P. H. Kirby (*Cuivre et Laiton*, 1934, 7, 497–502).—See *Met. Abs.*, 1934, 1, 397.—W. A. C. N.

Pickling of Castings in Hydrofluoric Acid. Anon. (*Galvano*, 1934, (31), 22–24).—Deals with the action of the acid and the plant and precautions necessary for its use.—C. E. H.

[Discussion on] Pickling Problems. —— (*Met. Ind.* (*Lond.*), 1935, 46, 215–217).—Abstract of a discussion before the Midland Metallurgical Societies (Birmingham Local Section of the Institute of Metals, Birmingham Metallurgical Society, and the Staffordshire Iron and Steel Institute).—J. H. W.

Sandblasting. Kenneth Hill (*Found. Trade J.*, 1935, 52, 55–56; discussion, 91–92).—Read before the Institute of Vitreous Enamellers. Three systems of compressed-air sand blasting are used: (1) the direct pressure, (2) the suction or syphon, (3) the gravity system. The applications of these 3 systems, and the use of various accessories connected with sandblasting are described. In the discussion, H. stated that it is necessary to remove moisture from the compressed air before delivery and explained how this may be done. He also dealt with questions relating to cooling, the effect of surface dust, pore closing, surface changes, and oil elimination.—J. H. W.

Fettling Die-Castings. E. Stevan (*Met. Ind.* (*Lond.*), 1935, **46**, 165–167).—A description is given of the precautions to be observed so as to minimize the amount of dressing and trimming of die-castings.—J. H. W.

The Preparation of Surfaces. Anon. (*Galvano*, **1934**, (32), 17–21).—A review of the various methods of preparing metals for the application of protective coatings.—C. E. H.

Mechanical Treatment of Electro-Deposited Coating. Anon. (*Engineer*, 1935, **139**, 101).—Nickel and chromium deposits are used to build up worn surfaces, but the hard surfaces so obtained require specialized treatment if they are to be machined after deposition. Grinding is recommended, but turning and milling with cemented carbide tools is also successful.—W. P. R.

The Coloration of Copper, Brass, and Bronze. Anon. (*Cuivre et Laiton*, 1935, 8, 9–12).—Details of the methods advocated by the Copper and Brass Research Association of New York are given. A solution for treating 100 $m.^2$ of surface contains ammonium sulphate 2·9 kg., copper sulphate 90 grm., concentrated ammonia 38 grm., water 26·5 litres. A colour resembling the ordinary green patina is readily obtained. Recipes for the developing of other coloured patinas are also given.—W. A. C. N.

XX.—JOINING

(Continued from pp. 119–123.)

Metal Wires Sealed into Glass. —— Schad (*Glas u. Apparat*, 1934, **15**, (7), 49–50; *C. Abs.*, 1935, **29**, 898).—Metal wire sealed into glass must have the same expansion coeff. as the glass (0·000008). Platinum, though suitable, is expensive. Iron–nickel containing 45% nickel has the same expansion coeff. as glass, with a minimum specific resistivity. When heating by conduction is to be feared (heating filaments), it is best to use a wire having a core of iron–nickel, containing 35% nickel surrounded by a good conducting metal (copper; platinum if resistance to chemical action is necessary). Large glass bulbs (*e.g.* for X-rays) can also be connected to metal tubes by means of an iron–nickel element.—S. G.

***The Pressure, Tension, and Thrust Strength in Glasses with Glass–Metal Seals.** Lisa Honigmann (*Glastech. Ber.*, 1934, **12**, 372–380; *C. Abs.*, 1935, **29**, 897).—Only glasses with expansions smaller than the metal are to be chosen, when the wires increase in diameter very little by passing current. In these cases there is very complete equalization of strain in the radial direction through the now added pressure. In all bases carrying a heavy current, in which the wire becomes very warm, it is expedient to choose glasses with somewhat higher expansions. Indeed, the ideal case—no change in tension in the glass base with and without passage of current—would be reached if the glass were strained radially so strongly that the dimensions of the wire in the cold were so large that it could not expand further on the passage of current. Of course the permissible strain limits must be recognized in the manufacture of such bases. Considerable experimental data are presented. A *bibliography* of 25 references is given.—S. G.

The Soldering of Aluminium. Harold Silman (*Met. Ind.* (*Lond.*), 1935, **46**, 218).—Unless the risk of corrosion is considerable, when the work should be welded, there are 2 especially suitable methods of soldering aluminium. One is a high-temperature method with a 70–95% aluminium alloy as the solder, and the other is a low-temperature (250°–420° C.) method using as a solder an alloy such as zinc 50, tin 46·5, copper 2·5 and lead 1%, or tin 73·2, zinc 22, aluminium 1·8, bismuth 0·5 and phosphorus 2·5%, with possibly 0·5% of crystallized zirconium. A satisfactory flux for the high-temperature method consists of potassium chloride 45, sodium chloride 30, lithium chloride 15, potassium fluoride 7, and potassium bisulphate 3%; for low-temperature soldering, yellow dextrin and petroleum jelly mixed with magnesium and sodium halides, or a mixture of sodium sulphate and borate forms a useful flux. By using a mixture of zinc chloride 90, sodium fluoride 2, and ammonium bromide 8% as a solder, zinc can be deposited on aluminium without the aid of a flux.—J. H. W.

Soldering and Tinning of Copper Sheets, Copper to Steel, &c. G. Du Bois (*Cuivre et Laiton*, 1934, 7, 419–423).—The distribution of the stresses induced during welding is discussed and amplified in a number of curves. In brazing, owing to the usually large difference in melting points between the metals to be united and the actual brazing material, the ill effects due to expansion are not so great as in soldering or welding. The uses of ordinary solders are also reviewed. The melting points and corresponding applications of solders containing varying proportions of tin are tabulated.—W. A. C. N.

The Navy's Soldered Fittings. Mason S. Noyes (*J. Amer. Soc. Naval Eng.*, 1935, 47, 57–74).—The various solders used by the U.S. Bureau of Engineering for their standard soldered fittings are dealt with. These include 3 high-melting point solders, one of copper and phosphorus and two of copper and silver; and 3 low-melting point solders comprising a tin–lead (50 : 50), a tin–antimony (95 : 5), and a cadmium–silver (95 : 5). The composition, melting points, flow points, and fluxes used with these solders are given, and the various joints for which they are suitable and their methods of use are discussed, particular attention being given to soldering with the tin–lead and the silver solders. Selected data from various tests, both hydrostatic and tensile, made on fittings soldered with the tin–lead and copper–silver solders are also dealt with.—J. W. D.

Furnace Brazing for Refrigerator Parts. H. M. Webber (*Machinist (Eur. Edn.)*, 1935, 79, 44–48E).—Details of electric furnace brazing of the various parts of a refrigerating plant are given. In this process, the parts to be united are passed through an electric furnace in which a reducing atmosphere serves as a flux. There the brazing metals are applied in either solid or paste form, and melt and flow into the joints. They are solidified in an atmosphere-controlled cooling chamber.—J. H. W.

†**The Autogenous Welding of Copper.** Anon. (*Cuivre et Laiton*, 1934, 7, 471–476).—Autogenous welding of copper is dominated by the two major factors of conductivity and oxygen solubility. The latter is considered, and modern researches by English, American, and German workers are reviewed. The action of hydrogen and unsaturated hydrocarbon gases in promoting brittleness is discussed. This is ascribed to the reducing action of these gases and the liberation of steam within the metal. In oxy-acetylene welding further reducing action is to be anticipated from the presence of carbon monoxide resulting from the dissociation of carbon dioxide at the high temperatures used. Finally, the effect of arsenic, both alone and in the presence of oxygen, in the light of recent work is summarized.—W. A. C. N.

Autogenous Welding of Copper. IV.—By Oxy-Acetylene. Anon. (*Cuivre et Laiton*, 1934, 7, 519–527).—Deoxidized copper should be employed. The presence of arsenic is not an advantage. There is considerable divergence of opinion as to the efficiency of metallic alloying elements. Some suggest simply pure copper; others that 1–5% silver is beneficial. Canzler rods contain 1% silver and 0·2% other elements (phosphorus, vanadium, &c.). An alloy containing copper 96, silicon 3, manganese 1% is recommended. Borax is mostly used as a flux, although many aver that copper borate is an embrittling agent. Aluminium phosphate is sometimes added in small proportions. Care should be taken that all surfaces to be welded are clean. The method of procedure is described.—W. A. C. N.

Weldable Fittings for Copper Services. W. L. Kilburn (*Plumbing Trade J.*, 1935, **14**, 253–255).—Copper fittings are slipped over the pipe ends to join them, and are then welded at each end to the pipes by bronze welding. Diagrams of various modifications of this type of fitting, and instructions for making the joint, are given.—C. E. H.

Bronze Welding for Plumbers. W. L. Kilburn (*Plumbing Trade J.*, 1934, **14**, 190–193).—The various advantages of bronze-welded copper tubing for water supplies are discussed, and detailed instructions for the use of an oxy-acetylene welding outfit are given.—C. E. H.

Electrical, Thermal, and Mechanical Occurrences During Spot-Welding. Gotthard Müller (*Elektroschweissung*, 1935, **6**, 1–7).—Theoretical and practical considerations are discussed with particular reference to the projection-welding of copper and the effect of the projection in localizing the contact area. A radiation pyrometer, utilizing a cæsium photo-electric cell, is described, by which the surface temperature during welding is recorded on an oscillograph. An apparatus is also described by which the progress of the "upsetting" is similarly recorded. Typical records are shown, from which it is concluded that projection-welds in copper result by fusion and are not true pressure welds. The application of the pyrometer to control the welding process automatically is also described, and its advantages over current- or time-controllers are emphasized.—H. W. G. H.

Outline of Resistance Welding and Its Uses. Bela Ronay (*J. Amer. Soc. Naval Eng.*, 1935, **47**, 27–35).—In a discussion of spot-welding, butt-welding, and seam-welding, both axial and girth-wise, reference is made to the welding of non-ferrous metals in thin section. It is stated that Monel metal, copper, brass and bronze, tungsten (in wire form), gold, silver and their alloys, nickel–brass, and practically all copper–nickel and nickel–copper alloys are suitable for spot-welding. Certain metals, such as aluminium and magnesium, and low-temperature alloys require special chilling fixtures to be attached to the lower or both electrodes, to help heat concentration, especially when the work is done on heavier gauge material requiring a larger spot diameter.—J. W. D.

Oxy-Acetylene Welding and Its Applications. Oxy-Acetylene Committee (*Internat. Acet. Assoc.*, **1934**, 60 pp.).—Brief recommendations in technique are given for the welding, bronze-welding, and hard-facing of iron, steels, copper, brass, bronze, aluminium, nickel, and Monel metal. Weld tests commonly specified in U.S.A. are described.—H. W. G. H.

Suitable Procedure for Lifting-Out the Floating Gas-Bells of Small Acetylene Generators. E. Sauerbrei and G. Lottner (*Autogene Metallbearbeitung*, 1935, **28**, 6–8).—The causes of accidents are reviewed and precautions for avoiding them are explained.—H. W. G. H.

XXI.—INDUSTRIAL USES AND APPLICATIONS

(Continued from pp. 123–127.

The Use of Aluminium and Its Alloys. A. N. Belyaev (*Legkie Metalli* (*Light Metals*), **1934**, (7), 38–42).—[In Russian.] A review.—D. N. S.

The Wrapping of Apples in Aluminium Foils. Anon. (*Aluminium*, 1935, **17**, 84).—Comparative tests on 3 varieties of apples have shown the superiority of aluminium foil wrappers over oiled paper and other preservatives.—A. R. P.

The Use of Aluminium in Transport. M. I. Uspensky (*Legkie Metalli* (*Light Metals*), **1934**, (9), 48–49).—[In Russian.] A short review.—D. N. S.

†**Light Metals in the Transport Industry.** M. Koenig (*Aluminium*, 1935, 17, 53–71).—A review of the characteristic properties of aluminium constructional alloys is followed by a lengthy account of their use in vehicle construction; numerous illustrations of chassis and bodies of light alloys for all kinds of industrial vehicles are included.—A. R. P.

Pressed Light Metal Parts in Vehicle Construction. F. Isenrath (*A.E.G. Mitt.*, **1935**, (2), 53–54).—A table shows the tensile strength, percentage elongation, and hardness to be expected in pressed members of aluminium, Silumin, and alloys of the Anticorodal, Magnalium, and Duralumin groups; compositions are given in each case. Directions are given for the preparation of the material, on which uniformity of structure largely depends.—P. M. C. R.

Design of Metal Wing Spars [Duralumin]. C. J. McCarthy (*J. Aeronaut. Sci.*, 1935, **2**, 27–31).—A description is given of bending, axial, and combined bending and axial stress tests on single-web spars of 5 designs. Two alloys of the Duralumin type (17 S.T. and 24 S.T.) were selected for testing in preference to steel. The weights of light-alloy and of wooden spars of similar design are compared, a saving of about 35% being effected by employing the former.—P. M. C. R.

Light Alloy Propeller Blades. G. D. Welty and L. W. Davis (*J. Aeronaut. Sci.*, 1935, **2**, 35–38).—The early metal blades, of welded Duralumin sheet, have been superseded in turn by drop-forged and by rolled construction; the alloy employed in American practice has, however, substantially the same composition as that originally used (copper 4·5, silicon 0·8, manganese 0·8, aluminium (minimum) 92%). The mechanical properties of the material are stated, and the considerations governing ingot size are discussed. Rolling is preferred to extrusion or drawing as the cheapest method of producing a relatively uniform structure. The shaping process is described. A brief consideration of magnesium alloy blades is appended: hot-pressing is regarded as the most reliable method of production.—P. M. C. R.

***Evaporated Aluminium Films for Astronomical Mirrors.** J. Strong (*Astronomical Society of the Pacific Publications*, **1934**, Feb.; *Light Metals Research*, 1935, **3**, 302–306).—Compared with silvered mirrors, aluminium-coated glass mirrors reflect ultra-violet light better and visible light nearly as well; they will not tarnish, they can be cleaned with soap and water, and do not scatter light. The aluminium film is $\frac{1}{10}$ μ thick and is deposited by evaporation in a bell jar from aluminium-impregnated helical tungsten heating coils under a vacuum better than 10^{-1} cm. of mercury. The glass mirror is preferably cleaned during evacuation by the action of an electrical discharge from a supplementary electrode. The evaporated films are exceedingly uniform in thickness; and may possibly be applied with advantage also to speculum metal gratings.—J. C. C.

Aluminium Conductors. Anon. (*Bull. Assoc. Suisse Élect.*, 1935, **26**, (2), 46–47).—In the case of cables working at tensions above 200 kv. it is advisable to increase the diameter of the conductor, in order to minimize corona losses. An Aldrey conductor is described and illustrated which consists of several compound strands, each of which is made up of single wires laid spirally round a hollow supporting cylinder. Suitable connections are described. A table compares the breaking lengths of cables in copper, aluminium, bronze, steel-aluminium, and Aldrey.—P. M. C. R.

Aluminium as a Material for Lightning Conductors. Anon. (*Illust. Zeit. Blechindustrie*, 1935, **64**, 260–262).—Aluminium lightning conductors may safely be installed in connection with all types of roof, with the exception of copper. The metal should be at least 99·5% pure, and may be employed either as ribbon or wire. Minimum dimensions are stated. The material should present a clean, smooth surface, which rapidly becomes coated with a protective film of oxide. Connections should be made by riveting or by

constriction; soldering must be avoided, as the solders employed are insufficiently resistant to atmospheric corrosion. Where connection must be effected with copper, direct contact must be obviated by inserting a packing piece of "Cupolblech," a bi-metallic sheet. Instructions are given for the making of satisfactory joints and for avoiding direct contact with walls.
—P. M. C. R.

Aluminium Alloy Doors at the Central Electricity Station at Bissort. Anon. (*Génie civil*, 1935, **106**, 43–44).—The door made of steel faced with aluminium alloy contains 2 tons of light alloy.—W. P. R.

Ski-Stocks of Aluminium Alloys. R. Irmann (*Aluminium*, 1935, **17**, 80–83).—Anodically oxidized Anticorodal ski-stocks are much superior to wooden stocks; tubes 18–20 mm. in exterior diameter and 15–17 mm. in internal diameter are 10–15% lighter than wooden stocks, and since they will not break or bend under exceptional stresses they are much safer.—A. R. P.

Trolley Wire Research. A. G. Arend (*Transport World*, 1935, **77**, 75).—The electrical conductivity, tensile strength, uniformity, and power of resisting atmospheric corrosion of trolley wire prepared from electrodeposited copper are stated to be superior to those of the ordinary hard-drawn material. The comparatively high elongation of the "electrodeposited" copper wire (2·5%) constitutes a disadvantage, as it is likely to result in sagging.—P. R.

Resistant Copper Alloys for the Manufacture of Apparatus. Anon. (*Illust. Zeit. Blechindustrie*, 1935, **64**, 258–260).—The toughness and incorrodibility conferred on copper and certain of its alloys by additions of nickel render such alloys especially suitable for use in the food industries, and for the making of condenser tubing and of chemical apparatus. Chemical composition and mechanical properties after various specified thermal and mechanical treatments are given for a nickel–brass, for 3 types of cupro-nickel, and for a number of nickel–bronzes, with which ordinary bronzes are compared, and the special applications of the respective types are enumerated.
—P. M. C. R.

†**Developments in the Use of Copper Tubing for Gas Service.** E. A. Munyan (*Gas Age-Record*, 1935, **75**, 43–48).—The successful use of copper tubing and brass fittings for gas services in Cincinnati is described and illustrated.
—J. S. G. T.

Copper and Bronze in the Medallic Art. V. Briard (*Cuivre et Laiton*, 1934, **7**, 557–558).—A brief history of the development of medal manufacture.
—W. A. C. N.

The Manufacture of Lead-Covered Electric Cable at the Works of the Bell Telephone Co. Herbert R. Simonds (*Génie civil*, 1935, **106**, 44–45).—A full abstract of a paper in *Iron Age*. See *Met. Abs.*, 1934, **1**, 468.—W. P. R.

Ornamental Lead Work. Ernest Carr (*Plumbing Trade J.*, 1934, **14**, 103–104).—Historical.—C. E. H.

The Use of Chromium–Nickel Alloys in Chemical Technology. R. Hanel (*Chem. Fabrik*, 1935, **8**, 10–12).—A review of the properties of nickel, nickel–chromium, and nickel–chromium–iron alloys with especial reference to their resistance to corrosion and heat and their use in chemical industry.—A. R. P.

Palladium–Silver Alloys for Dental Plates. J. Spanner (*Metallwirtschaft*, 1935, **14**, 132–133).—Silver alloys with 20–30% palladium, up to 10% gold and copper and small amounts of other constituents have proved satisfactory for rolling and casting dental alloys: their melting points are between 1000° and 1200° C., they can be hardened by heat-treatment and have a sufficiently high chemical stability.—v. G.

Silver Proves Effective in Water Sterilization. Anon. (*Chem. and Met. Eng.*, 1934, **41**, 372).—The Katadyn process described in this article has been in use in Germany for 5 yrs. It is an electrochemical process for the sterilization of water by treatment with silver. Water thus treated takes on bactericidal properties, which persist as long as silver remains in solution. The quantity of silver required is small and has no harmful effect on the human system and does not impart any objectionable smell, taste, or colour to the water.—I. M.

***Tests on White Metals for Socketing Winding Ropes.** John Wilson (*Trans. Inst. Min. Eng.*, 1933, **85**, 292–297; and *Colliery Guardian*, 1933, **147**, 4–5).—The adhesion of white metals to steel wire ropes increases with the pouring temperature, the best adhesion being obtained by pouring at 650°–750° F. (343°–399° C.), although at this temperature there is a tendency for the strength of the wire to be reduced. Fine solder cast at 500°–600° F. (260°–315° C.) gives a stronger joint than any of the commercial white metals; plumber's solder also gives good joints and is less expensive. Cleaning the wire with emery after removing grease with petrol results in stronger joints at all pouring temperatures.—A. R. P.

Some Modern Uses of Tinplate. —— (*Bull. Internat. Tin Res. and Development Council*, 1935, (1), 57–65).—An illustrated review.—C. E. H.

The Evolution of the Sealed Tinplate Container. —— (*Bull. Internat. Tin Res. and Development Council*, 1935, (1), 40–56).—A review of developments in sealed tinplate containers from 1810 to the present day. Both design and methods of manufacture and sealing are dealt with, and the article is fully illustrated. References to the patent literature are given.—C. E. H.

The Development of the Tinplate Industry in Great Britain. —— (*Bull. Internat. Tin Res. and Development Council*, 1935, (1), 69–79).—A historical review, dealing with both technical and economic developments. A chronological table of events from 1240 to the present day is given.—C. E. H.

†Tungsten.—I. William O. Vanderburg (*U.S. Bur. Mines, Information Circ.* No. 6821, 1935, 30 pp.).—An account is given of the occurrence, production, and consumption of tungsten ores, of the manufacture of ferro-tungsten, tungsten trioxide, tungsten powder, ductile tungsten, and tungsten carbide, and of the uses of the metal and its alloys; there are 33 references.
—A. R. P.

Applications of Zinc Alloys. Anon. (*Metallurgist* (Suppt. to *Engineer*), 1935, **11**, 1–2).—A summary of a paper by R. Cazaud and H. Pétot in *Génie civil*, 1934, **105**, 34–37.—R. G.

Dye Industry Searches for Cheaper Plant Material. Hugh Miller (*Chem. and Met. Eng.*, 1932, **39**, 486–488).—Discusses the metals, ferrous and non-ferrous, suitable for use as plant in the dyeing industry. Next to iron and steel, lead is most commonly used, but aluminium-bronze and Everdur are also employed.—I. M.

Metal Foils. —— (*Food Ind.* (*N.Y.*), 1935, **7**, 112–114).—A review of developments in the use of metal foils in connection with the packaging of foods during the last 5 years.—C. E. H.

The Application of Metal Sheets for Surveying Plans. R. McAdam, John S. Reid, and James K. Templeton (*Trans. Inst. Min. Eng.*, 1933, **85**, 370–374; discussion, 374–376; and (summary) *Colliery Guardian*, 1933, **147**, (3785), 67–68).—Paper is an unsatisfactory medium for accurate planning purposes owing to its erratic shrinkage and expansion, and copper and aluminium sheets have been tested as substitutes. The former proved unsatisfactory because (1) of excessive weight; (2) the light reflected from the surface is trying to the eyes; (3) it tarnishes. Aluminium is satisfactory but has 2 disadvantages: (1) the glare of reflected light from the surface; (2) a polished surface does not take pencil marks. Both these difficulties were overcome by treating the metal with caustic or by abrasion with fine carborundum. Zinc has also proved satisfactory. The size of sheet recommended is 42 × 42 in. or 44 × 33 in. and a thickness of $\frac{1}{32}$ in. The cost and method of storing are also discussed.—I. M.

More Heads for Tanks and Heat Exchangers. C. O. Sandstrom (*Chem. and Met. Eng.*, 1933, 40, 138–141).—Cf. *J. Inst. Metals*, 1933, 53, 463.—I. M.

†**Resonance Between Mast and Conductor Line Vibrations and the Damping of the Vibrations with Resonance Dampers.** Otto-Heinrich Look (*Metallwirtschaft*, 1935, 14, 65–67).—The vibrations in electrical high-tension lines caused by the wind often lead to fracture of the wires near the points of suspension. By fastening a rubber cylinder on the mast to absorb the energy of the swing, the vibrations are damped and rendered harmless. A research outfit in which this method has been tested is described.—v. G.

XXII.—MISCELLANEOUS

(Continued from p. 127.)

Recent Developments in Metals. R. Hunter (*Trans. Inst. Eng. Ship. Scotland*, 1935, 78, xix–xx).—Abstract of a paper read to the Association of Students. It deals with the trend of modern developments in various engineering metals and alloys and refers to high-tensile non-ferrous alloys, light aluminium alloys, and a bearing metal of a nickel–cadmium alloy.—J. W. D.

Ancients Manipulated Metals. H. E. White (*Foundry*, 1934, 62, 36–38).—The history of the discovery and development of methods for obtaining metals from the earth's crust is briefly reviewed.—F. J.

A Weight Per Cent.–Mol. Per Cent. Nomograph. Herbert Waterman (*Indust. and Eng. Chem.*, 1931, 23, 803).—A nomograph is given facilitating the transformation mol. per cent.–weight per cent. for any binary system. It can also be used for ternary systems.—I. M.

XXIII.—BIBLIOGRAPHY

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(Continued from pp. 127–132.)

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[Gives, in a convenient form, information relating to brands, products, and plants of members of the industry in the U.S.A. The directory is divided into 3 sections: (1) alphabetical directory of brands; (2) alphabetical directory of members of the industry; (3) geographic location of manufacturers' plants.]

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[Reprinted in convenient form from the Society's Standard Specifications. The volume contains, in addition, a Manual for Interpretation of Refractory Test Data (1934) and industrial surveys of service conditions of refractories in open-hearth practice, the malleable iron industry, the copper industry, the lead industry, and in by-product coke ovens.]

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[These tables will be found most useful by builders, plumbers, and others in estimating the various sizes and strengths of lead pipes and sheet for their contracts. For easy reference, all dimensions are given in decimals of an inch and in the nearest fraction.]

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[Contains statistics regarding exports, imports, prices, &c., of: Aluminium; Antimony; Arsenic; Bauxite; Beryllium; Bismuth; Black Plates; Black Sheets; Brass; Cadmium; Chrome Ore; Chromium Metal; Cobalt; Copper; Ferro Alloys; Galvanized Sheets; Gold; Iron Ore; Iron and Steel; Lead; Magnesium; Manganese Ore; Molybdenum Ore; Nickel; Platinum Group; Pyrites; Quicksilver; Secondary Metals; Selenium; Silver; Spelter; Tin; Tinplates; Tungsten; Tungsten Ore; Vanadium Ore; Zinc Sheets. Information is given regarding Extreme Price Records, and London Metal Exchange Dealings. Conversion Tables are also included.]

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XXIV.—BOOK REVIEWS

(Continued from pp. 132–136.)

Praktische Metallkunde. Schmelzen und Giessen, Spanlose Formung, Wärmebehandlung. Dritter Teil: **Wärmebehandlung.** Von Georg Sachs. Mit einem Anhang: "Magnetische Eigenschaften," von A. Kussmann. Med. 8vo. Pp. v + 203, with 217 illustrations. 1935. Berlin: Julius Springer. (R.M. 17.)

The matter in this volume falls under three main headings: general laws underlying constitutional changes; alloys capable of improvement by heat-treatment; and a shorter section on magnetic properties. Under the first heading the importance of equilibrium diagrams for indicating phase changes, X-ray evidence of distortion and atom movement in the crystal lattice, precipitation and other phenomena due to heat-treatment, are fully dealt with. The second section is of more practical interest and gives details of the constitutional changes occurring in light alloys, copper alloys, rare metals, nickel and cobalt alloys, iron and steel, as well as low melting point alloys, as a result of heat-treatment. The last section takes the form of a short appendix on magnetic properties and outlines theories underlying these and their relationship to constitution, special reference being made to typical ferrous and non-ferrous magnetic alloys.

This volume maintains the very high standard set in the two earlier volumes, being concisely written with numerous graphs, illustrations, and full references. Anyone who has appreciated the wealth of information in the two earlier volumes will not hesitate to obtain this last one, which completes one of the most valuable additions to metallurgical literature made in recent years. The book should appeal strongly to members of the Institute of Metals, because it brings together under the different subject headings, much matter which is widely scattered throughout the pages of this *Journal*. In the Preface the author pays tribute to the great service the *Journal of the Institute of Metals* has been to him in the compilation of his work. It is a book which no metallurgist can afford to be without.

[For reviews of Volumes I and II see *Met. Abs.*, 1934, **1**, pp. 110 and 473, respectively.]

—H. W. Brownsdon.

Metallurgy. An Elementary Text-Book. By E. L. Rhead. New Revised and Enlarged Edition. Demy 8vo. Pp. xiv + 382, with 182 illustrations. 1935. London: Longmans, Green and Co., Ltd. (10*s.* 6*d.*)

The appearance of a new edition of "Rhead" is welcome. Not only does it maintain the standard of the former editions, but in many respects is their superior. The original intention—to inculcate and emphasize the importance of first principles—has been kept well in mind. New sections on pyrometry, metallography, and foundry work have been introduced, and these branches are dealt with simply, yet in such a manner as to develop basic ideas. Additions have been made also to the parts dealing with physical tests, fuel and electric furnaces for steel manufacture. The book naturally retains its elementary character, but still serves as an excellent introduction to the subject. At the same time one wonders why some indication has not been given of more modern developments in extraction methods. No mention is made, for instance, of the substitution of blankets for the old copper amalgamation plates in many mills or of the almost universal adoption of the chlorine process in place of the Wohlwill process for the refining of gold. The Hybinette process for the production of nickel is also omitted. Apart from omissions such as these, which could easily be rectified in a subsequent edition, the volume is a useful one for the student at the outset of his acquaintance with the subject.

—W. A. C. NEWMAN.

Physical Metallurgy. Volume I.—Introduction to Physical Metallurgy. [In Russian.] By S. S. Steinberg. Roy. 8vo. Second Edition. Pp. 264, with 279 illustrations. 1934. Swerdlowsk, Moscow and Leningrad; Metallurgisdat. (Rbl. 3.40.)

As the author states in his preface, his book should be considered as an introduction to the "Science of Metals" series—what Rosenhain would have called "Physical Metallurgy." Such a treatise must not encroach on either chemistry or physics, but must be based on the studies of the macro- and micro-structure and of the atomic constitution of metals and alloys. The present volume constitutes a general introduction to the subject, and 2 more volumes are to follow, one dealing with the iron–carbon alloys and the other with the special steels.

The first chapter deals with the historical aspect of the development of metallography, with special reference to the work of Tschernoff, Osmond, Le Chatelier, Tammann, Roberts-Austen, and Sir William Bragg; while the second chapter reviews the standard methods of metallographic testing; these two chapters form Part I, or the introductory part. Parts 2, 3, and 4 (Chapters III, IV, V, VI, VII, VIII, and IX) deal with systems of one, two, and three components; Chapter V is devoted to the study of deformation and recrystallization of metals, whereas Chapters III and VI deal with the crystallization and structure of the metals and of the binary alloys; Chapter IX is devoted to ternary systems. Part V deals with inclusions and gases; a detailed analysis of the recrystallization within a solid phase and of the grain-growth and grain-size is given in Part VI, where the problems of ageing and diffusion are also dealt with. In Part VII (Chapter XIII) are discussed the deformation of the lattice in relation to grain-size and ageing, and, finally, Chapter XIV deals with the mechanical properties of the metals. It is here that the problem of fatigue is introduced, and ageing is discussed in its relation to metals and alloys as building materials. Thus, problems which—as that of ageing and of atomic structure—are now very much "in the engineer's eye" are dealt with several times, in different chapters, introducing the problem under its various aspects and gradually acquainting the reader with its more difficult and complicated sides.

The treatment is clear, interesting and fair, and follows the principles taught by Tschernoff and his school. There are numerous diagrams and photomicrographs in the text. The book can be thoroughly recommended to the student and to the practical engineer.—N. T. BELAIEW.

Die Wärmeausdehnung der Aluminium-Gusslegierungen mit Zusatzmetallen von verschiedener Art und Menge. Von Eugen Nitzsche. Med. 8vo. Pp. iii + 60, with 1 plate and 15 illustrations in the text. 1934. Würzburg: Konrad Triltsch. (R.M. 2.50.)

A detailed account is given of an investigation, with the Chevenard dilatometer, of the effect of alloying elements on the thermal expansion of aluminium in the ranges 15°–100° C., 15°–200° C., and 15°–300° C. The alloys investigated were aluminium–copper (up to 25% Cu); aluminium–silicon (up to 23% Si), both modified and unmodified; aluminium–iron (up to 6% Fe); aluminium–cobalt (up to 10% Co); aluminium–chromium (up to 6% Cr); aluminium–nickel (up to 16% Ni); aluminium–zinc (up to 25% Zn); and some aluminium–nickel–chromium alloys. The samples were chill-cast under controlled conditions, and were annealed until all "growth" ceased. The amount of "growth" was noted. The results are given in tabular form and in curves which are poorly drawn and badly reproduced. The elements which have a lower coefficient of expansion than aluminium, reduce its coefficient of expansion proportionally to the amount added. Zinc, on the other hand, with a higher expansion

coefficient, increases that of aluminium. In general, the effect of the additional element is greater than would be expected by calculation. These results are of interest mainly in connection with the use of light alloys for the pistons of internal combustion engines.
—H. W. G. Hignett.

Die Bearbeitung des Aluminiums. Von E. Herrmann und E. Zurbrügg. Pp. viii + 106. 1935. Leipzig: Akademische Verlagsgesellschaft m.b.H. (R.M. 4.)

This booklet is written primarily for craftsmen engaged in fabrication processes. The properties of the wrought aluminium alloys, commonly used in Germany, are briefly explained with a minimum use of theory, and instructions are given for the forming, jointing, and surface treatment of these materials. A great deal of information is given in small space and the theoretical man may obtain from it a useful glimpse of practical considerations.
—H. W. G. Hignett.

Metallic Arc Welding. By H. Harris. Med. 8vo. Pp. viii + 199, with 99 illustrations. 1935. London: Edward Arnold and Co. (16*s*. net.)

After a somewhat sketchy discussion of the theory of the electric arc, the phenomena of the metallic-arc welding process—transfer of metal, crater formation, efficiency of the arc, rate of weld metal deposition, adhesion between weld and base metal, stresses and crystallization of weld metal—are considered. Then follows a chapter on electrodes, bare and coated, the latter being subdivided into slag-producing and gas-producing types. The effect of metallic-arc welding on the base metal (steel) and the properties of the deposit are next discussed. Four pages are deemed sufficient to dispose of d.c. and a.c. welding machines and automatic welding heads. The testing of welds is also passed over in haste, the author clearly being anxious to arrive at his pet subject—the metallurgy of steel welds—to which the following 6 fascinating chapters are devoted. Unfortunately these are of little or no interest to the non-ferrous welder, for whom the information which is given on copper, brass, Everdur, nickel, and Monel metal, is a fairly comprehensive summary of recently published papers and cruel emphasis of their paucity. The remainder of the book deals with the applications of metallic-arc welding to the manufacture of pressure vessels, boiler drums, large diameter pipes; in ship construction; and to replace castings and riveted structures.

As a text-book on ferrous welding from a metallurgist's point of view, this is a most excellent work, to which the publishers have done full justice. The price is extremely reasonable.—
—H. W. G. Hignett.

Die Drahtseile, ihre Konstruktion und Herstellung. Von Hermann Altpeter. Zweite verbesserte und erweiterte Auflage. Demy 8vo. Pp. v + 152, with 58 illustrations. 1931. Halle (Saale): Martin Boerner. (R.M. 6.50.)

The author attempts, and with considerable success, to give in this small book a short but comprehensive account of the production, properties, and testing of wire ropes and cables. Commencing with a short historical introduction in which wire ropes are traced back to Roman times (such a rope consisting of 15 bronze wires having been found in Pompeii), the author proceeds to describe the construction of such ropes and the different types of lay which are employed. Locked-coil ropes of various types are described, and the reasons which determine the choice of any one particular construction are outlined. In the portion of the book dealing with the manufacture of wire rope a short, but probably adequate, treatment is first given of the testing of the wire and the ropes themselves. Passing on, the author describes the machines on which the ropes are produced, splicing, and the various methods of making the ends, together with a treatment of the danger of breaking. An attempt is made to deal mathematically with the calculations involved in the design of such ropes, particularly in an appendix by K. Reisch. A short account of the causes of defects in wire and wire ropes concludes the main portion of the book. In the appendices are given certain German regulations and standards.

This work is a well-balanced, short account of the whole subject and should be of interest to engineers, though it is doubtful whether actual manufacturers will find in it very much with which they are not already fully acquainted.—F. C. Thompson.

Reports on the Progress of Applied Chemistry. Volume XIX, 1934. Demy 8vo. Pp. 836. [1935.] London: Society of Chemical Industry. (Members, 7*s*. 6*d*.; non-members, 12*s*. 6*d*.)

The nineteenth volume of the annual reports on applied chemistry gives a review of the work published during 1934. This is arranged in twenty-six sections, each of which is compiled by a specialist in the particular branch of chemical industry. The usual sections appear in the present volume, and this year the section on explosives reappears, the report in this case covering the years 1933–1934. The reports presented include: fuel—22 pages, by A. H. Raine and L. E. Winterbottom; acids, bases, and salts—35 pages, by J. W. Parkes; glass—18 pages, by D. Robertson; refractories, ceramics, and cements—27 pages, by T. R. Lynam and W. J. Rees; non-ferrous metals—45 pages, by A. R. Powell; electro-chemical and electro-metallurgical industries—21 pages, by J. W. Cuthbertson.

As is customary with these reports, the work has been carried out conscientiously and well; discretion has been used in all cases and the reports presented are both informative and readable. A great deal of really valuable information, both for the industrial chemist and the academic chemist, is gathered together in a very accessible form. The reports are to be whole-heartedly recommended to all chemists.—JAMES F. SPENCER.

Müller–Pouillets Lehrbuch der Physik. Elfte Auflage, Vierter Band.—Vierter Teil: **Elektrische Eigenschaften der Metalle und Elektrolyte; magnetische Eigenschaften der Materie.** Herausgegeben von Arnold Eucken. Med. 8vo. Pp. xx + 906, with 400 illustrations in the text. 1934. Braunschweig: Friedr. Vieweg & Sohn A.G. (Geh., R.M. 62; geb., R.M. 66.)

On a recent occasion in the Church of Notre Dame in Paris I listened to a "guide" explain how Napoleon summoned the Pope to Paris to officiate at his (Napoleon's) coronation at that church, and how Napoleon crowned himself after taking the crown from the Pope's hands. An American tourist near me remarked, "Say, but he was *some* guy was Nap." Müller–Pouillet's "Text-Book of Physics" is the Napoleon of books on physics and, in the sense of the word as used by the American tourist, can only be adequately described as *some* book. It is a monumental, indispensable work. All physicists worthy of the name are thoroughly familiar with it. In the last twenty years or so I have referred to it far more frequently than to any other half-dozen books on physics; it has never failed to supply more than the information sought. Metallurgists interested in the theory of metals are probably not very familiar with the work. Well, here is their opportunity. The eleventh edition (yes, the *eleventh* edition, mark you) is now being published in 5 volumes. The present book, the 4th part of volume 4, deals with the electrical properties of metals and electrolytes, and the magnetic properties of matter—just those very subjects that are in the forefront of metallurgical theory at the present time. There is no need to refer to the contents of the book in detail—nothing of consequence seems to have been missed. The only small section that is somewhat disappointing is that devoted to electrocapillarity. For the rest, so far as my opinion is worth anything, I have nothing but unqualified praise. How could it be otherwise? Look at the list of contributors: v. Auwers, Coehn, Etzrodt, Eucken, Jost, Jung, Nordheim, and Suhrmann. Experimental work is, as in all previous editions, stressed and rightly so. For such work can at least be presented intelligibly, and in "Müller–Pouillet" that has always been the case. In addition, some of the newer theoretical work on metals is here included, after much consideration by the authors. Their decision on this matter is, no doubt, a right one, as the book can, only in these circumstances, be described as complete. But don't let the metallurgist, armed with "algebra to quadratics and the first four books of Euclid," be dismayed. He is adequately provided for on the experimental side, and has no need for "mathematical physics on stilts" in order to profit from the book. I recommend the book to all serious students of physics, and to all metallurgists interested in the theory of their science. Electrical research laboratories will need a copy. Purchasers should order the *bound* volume. The extra four marks is a good investment, for the book will have to stand constant handling—the paper covered edition will not stand the strain.—J. S. G. THOMAS.

The Electronic Structure and Properties of Matter. By C. H. Douglas Clark. Pp. xxv + 374, with 33 illustrations. 1934. New York: John Wiley and Sons, Inc. ($5.50); London: Chapman and Hall, Ltd. (21*s*. net).

"Some books," wrote Francis Bacon, "are to be tasted, others to be swallowed, and some few to be chewed and digested." This book deserves to be tasted and nothing more. Its natural place is in that great welter of publications called by Lamb, *biblia abiblia*, books that are not books. In my student days it would be called a "pot-boiler." Matters relating to periodic classification, line spectra, valency and chemical combination, atomic and molecular volumes, atomic and ionic radii, magnetic susceptibility, cohesion, entropy, &c., are here dealt with in almost breathless sequence. All is apparently good fish to the author's net, which he has cast wide and far—about a thousand original papers are referred to. There has been no apparent selection of subject matter—the author index contains more references to the work of C. H. D. Clark than to the papers of Aston and Bohr together! Brevity of treatment is the marked feature of the book; accuracy and clarity are too often lacking. Physicists in their attempts to explain atomic structures and properties are at present walking on stilts; the author, it seems to me, has here attempted to occupy the foot-rests of some of the stilts with their present tenants. A really good book, explaining clearly the present position of atomic theory, is very much needed. Can Mr. Clark provide such a book? If he can, then he would render science a far greater service by producing such a work than by devoting his energies to the production of the further 2 volumes (and possibly more) of the present series.

—J. S. G. Thomas.

Reports on Progress in Physics, 1934. 4to. Pp. 371. 1934. London: The Physical Society, 1 Lowther Gardens, S.W.7. (12*s.* 6*d.* net.)

Annual reports on the progress of pure and applied chemistry have been published for many years by the Chemical Society and the Society of Chemical Industry. Now the Physical Society commences its series of (presumably) annual reports, although there is no indication in this volume that this is No. 1 of an annual series. The subjects reviewed comprise quantum and wave mechanics, the expansion of the universe, surface tension, Burgers's theory of turbulence, spectroscopy, X-rays, physics of the atom, electric and magnetic measurements, and, what will be of most interest to metallurgists, heat, and electrical phenomena at extremely low temperatures. There is quite a lot that I would like to say about a good many of the individual reports. They have their good points; they are not without their faults. Here I wish rather to congratulate the Physical Society on having set its hand to what must be a difficult task. If a mixed metaphor be permitted, it were surely unkind to look a gift horse in the mouth until it is past its teething troubles, lest we drain the goose, which lays the golden eggs, of its last drop of blood. For indeed this volume of reports is a gift to physicists and the world of physics, and we look forward to the appearance of future volumes.

I commend the series to all physicists (including metallurgical physicists) and chemists. Volume 1 is well printed on good paper and is nicely bound. Its price is extremely reasonable.

—J. S. G. Thomas.

V.D.I. Jahrbuch, 1935. Die Chronik der Technik. Verein deutscher Ingenieure. 5¾ in. × 8¼ in. Pp. xii + 183. 1935. Berlin: VDI-Verlag G.m.b.H. (R.M. 3.50; VDI-Mitgl., R.M. 3.15.)

This book essays to be a summary of important publications on various technical subjects. Primarily the references, and there are some 5000 of them, relate to books or articles issued in 1934, but a number refer to matter two or three years old. The subjects dealt with range from purely theoretical science to all branches of engineering, textiles, agriculture, hygiene, &c. Each branch is reviewed in a short summary, and the references are inserted at the side. Foreign journals are freely quoted. The intention is, in brief, to offer the reader an abridged account of the important advances that have been made during the previous year in most branches of technical activity.

In the section dealing with non-ferrous metals (G. Masing) attention is directed to the increasing use of X-rays; to a new tensile bending test which appears to have some claim to be a substitute for the tedious long-time fatigue test; to the threatened substitution of aluminium– for tin–bronze in several instances; to the preparation of copper sheets electrolytically; to the development of γ-Silumin; to the wider use of "Y" and "R.R." alloys; to the expansion in America of higher cupriferous alloys that need a minimum of heat-treatment; to the use of bearing metals deficient in tin; to a series of new alloys with special magnetic properties, and to the extension of hardening processes to many materials hitherto not thought amenable to treatment commercially—W. A. C. Newman.


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