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The Monthly Journal of the
INSTITUTE OF METALS

and

METALLURGICAL ABSTRACTS

JUNE, 1934

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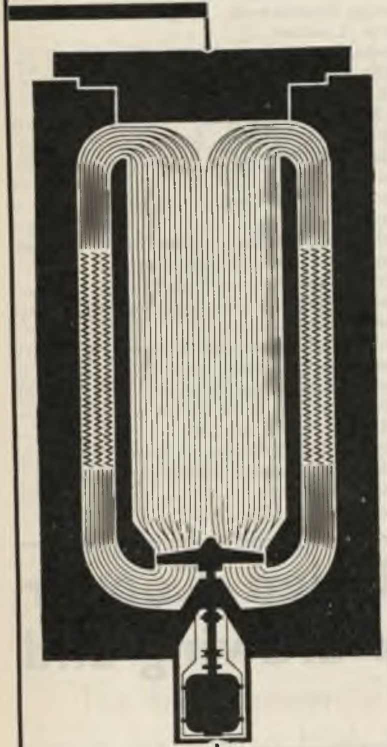

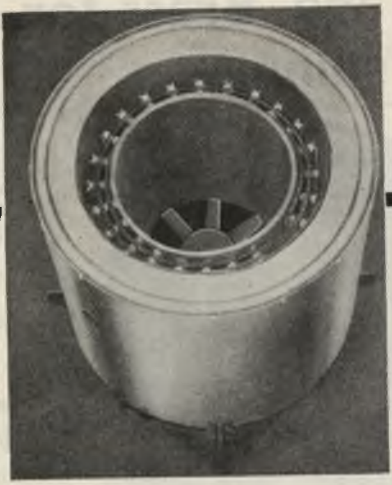

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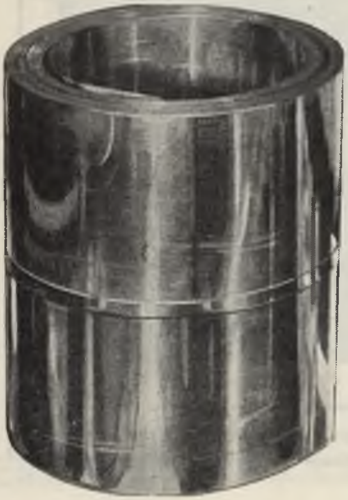

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Volume 1 **JUNE, 1934** **Part 6**

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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 1935 the year's abstracts in bound form.

Gauge cases and thermometer housings—Zinc die cast.

INSTITUTE NEWS AND ANNOUNCEMENTS

Twenty-Sixth Autumn Meeting, Manchester, September 3–6, 1934.

Provisional Outline Programme.

In arranging for the Autumn Meeting to be held in Manchester this year, the Institute is planning its third visit to that city, previous Autumn Meetings having been held in Manchester in 1909 and 1923. On each occasion a highly successful meeting took place. The Local Executive Committee, under the chairmanship of Dr. A. G. C. Gwyer, Vice-President, has plans well in hand for what promises to be another very interesting and instructive meeting.

The chief events in the programme are as follow :—

Monday, Sept. 3.

Autumn Lecture at 7.30 p.m. in the Great Hall of the College of Technology. The lecture will be delivered by Dr. J. L. Haughton and will deal with the work of the late Dr. Walter Rosenhain, F.Inst.Met., F.R.S.

Tuesday, Sept. 4.

10.0 a.m. Civic welcome by the Lord Mayor of Manchester, in the College of Technology, followed by the presentation and discussion of papers.

1.0 p.m. Members will be entertained to luncheon at the Midland Hotel by the Local Reception Committee.

2.30 p.m. Works Visits.

7.30 p.m. Evening function (to be arranged).

Wednesday, Sept. 5.

10.0 a.m. Presentation and discussion of papers.

2.30 p.m. Works Visits.

7.30 p.m. Reception at the University of Manchester.

Thursday, Sept. 6.

All-day excursion to Froghall, North Staffordshire, visiting in the afternoon (by kind permission) the works of Messrs. Thomas Bolton & Sons, Ltd. A full description of this excursion will appear in the July issue of the *Monthly Journal*.

Works Visits.

The following firms have kindly promised to allow members (*except members from competitor-firms*) to visit their works :

The Broughton Copper Co., Ltd.
The British Copper Refiners, Ltd.
British Insulated Cables, Ltd.
Mather & Platt, Ltd. (*no reservations*).
W. T. Glover & Co., Ltd.
Callenders Cable & Construction Co., Ltd.

It is expected to add to this list of works to be visited.

Hostel Accommodation.

The University Hostel, Ashbourne Hall, has been reserved for the use of members of the Institute. It is the hope of the Council of the Institute that many members will avail themselves of this hostel accommodation.

The price for dinner, bed and breakfast, for those staying for at least three days, is 10*s.* 6*d.*; or, for a shorter period, 12*s.* per head per day. Accommodation can be offered to about 100 members, for whom 25 double rooms are available.

Ashbourne Hall is a modern, well-built, and very attractive hostel with excellent common room accommodation. Situated on a tramway route into town, it has large open spaces in nearly all directions. Members staying there should be very comfortable.

Final Programme.

The final programme of the Manchester Meeting, including a list of papers to be presented, will be issued to all members next month, together with a reply form which should be promptly returned by those intending to take part in the gathering.

Membership.

As only members are permitted to take part in the social functions and works visits connected with the Manchester Meeting, an election is being arranged on July 12 for the benefit of those who desire to participate in the Autumn Meeting but are not yet members. As this election occurs at the beginning of a new financial year, the Council expects that there will be many membership applications to be considered at its meeting. The Secretary will be glad to forward particulars of the Institute, and, if desired, a specimen copy of the *Monthly Journal*, to any potential member on receipt of name and address.

Annual Subscriptions, 1934–1935.

Members and student members are reminded that their annual subscriptions, of £3 3*s*. and £1 1*s*., respectively, become payable, according to the Rules, " in advance on July 1." If they will be good enough, therefore, to send their remittances to the Secretary, the Institute will be saved the expense of forwarding " reminders," which cost more than £50 a year and involve much clerical labour that might be more usefully employed. Delay in the payment of subscriptions is not only unnecessarily costly to the Institute, but it also prevents members from seeing their *Monthly Journals* promptly. The Institute's publications are not sent to members whose subscriptions are in arrear.

The use of Banker's Orders for the payment of subscriptions is strongly urged on members by the Finance Committee. Already more than 500 members use these orders, with resulting appreciable saving in time and money to themselves and to the Institute. Printed Banker's Order forms are now available, and will be gladly forwarded to any member by the Secretary.

PERSONAL NOTES

Engineer Vice-Admiral Harold A. Brown, Engineer-in-Chief of the Fleet, was gazetted K.C.B. in the Birthday Honours List. He was recently elected a Member of Council.

Monsieur P. Chevenard, Professor at the École des Mines de Saint-Etienne, has been elected Vice-President of the Société de l'Industrie Minérale.

Commander C. W. Craven, O.B.E., R.N., received a Knighthood in the recent Honours List. A member of the Institute since 1924, he is Managing Director of Messrs. Vickers-Armstrongs, Ltd.

Monsieur C. E. Guillaume, the well-known scientist, inventor of Invar and of Elinvar, and the author of many papers on ferro–nickel and on the stability of quenched steels, has just been awarded a doctorate (*honoris causa*) of the University of Paris.

Mr. Isaac Lubbock, M.A., of the Fuel Oil Technical Department of Messrs. Shell-Mex, Limited, has been elected a Member of Council of the Institute of Fuel.

Monsieur Albert Portevin, Professor at the École Centrale des Arts et Manufactures, at the École Supérieure de Fonderie, and at the École Supérieure de la Soudure Autogène, has been created an Officer of the Legion d'Honneur.

Dr. C. J. Smithells, M.C., has been appointed as the representative of the Local Sections on the Council of the Institute. He was recently elected Chairman of the London Local Section for the session 1934–1935.

Obituary.

Professor Camille Matignon died in Paris on March 18 during a reunion of the professors of the Collège de France, at which he was professor of chemistry. He was born at Sainte-Maurice-aux-Riches-Hommes (Yonne) on January 3, 1867. Having been professor of physical sciences at the École Normale Supèrieure he was attached, in 1889, to the Berthelot Laboratory at the Collège de France. Later he was professor of chemistry at the Faculté des Sciences at Lille, and was subsequently called to the Sorbonne in 1898 to supplant M. Berthelot in the organic chemistry chair. In 1908 he was nominated professor of mining at the Collège de France. A member of the Academie des Sciences since 1926, on February 1 last he was awarded the Legion of Honour. He was devoted to the study of thermal transformations in chemical systems as well as to the thermochemistry of rare metals and the fixation of nitrogen. For many years Professor Matignon had acted as Editor-in-Chief of the journal *Chimie et Industrie.*

PAPER No. 668. This paper is not to be reprinted, wholly or in part, until presented (and then only with due acknowledgment) at a meeting to be held on September 3–6, 1934, in Manchester. The Institute as a body is not responsible for the statements or opinions expressed in this paper, on which **written discussion** may be sent to the Secretary not later than October 1, 1934.

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

THE INFLUENCE OF PICKLING ON THE FATIGUE-STRENGTH OF DURALUMIN.*

By H. SUTTON,† M.Sc., Member, and W. J. TAYLOR.‡

Synopsis.

In order to assist in the detection of flaws, manufacturing defects, and fatigue cracks in aluminium alloy components it has been customary to pickle or etch the components in various solutions, the main etching usually being effected in an aqueous solution of caustic soda. Wöhler-type fatigue tests were made on test-pieces machined from Duralumin bar and the effect of various pickling treatments on the fatigue-strength was investigated.

Pickling Treatment A (2½ minutes in 10 per cent. caustic soda solution at 60° to 70° C.; rinse: 1 minute in 10 per cent. nitric acid, 10 per cent. sulphuric acid) lowered the fatigue limit by 31 per cent., but the reduction was very much less after immersion of the test-pieces in boiling water. After a layer 0·0025 in. thick had been machined off, the pickled test-pieces showed normal fatigue properties.

Pickling Treatment B (2 minutes in 10 per cent. hydrofluoric acid, 10 per cent. nitric acid) lowered the fatigue limit by 15 per cent.

Pickling Treatment C (3 minutes in 10 per cent. sulphuric acid 4 parts, hydrofluoric acid 1 part; rinse: 1 minute in 50 per cent. nitric acid) only lowered the fatigue limit by about 6 per cent. and the reduction was less still, *i.e.*, within the limits of experimental error, when the specimens had been immersed in boiling water after being pickled. This treatment appears suitable for pickling new components to reveal macrostructure and defects, or for etching used components for the detection of fatigue cracks, stress-corrosion cracks, &c.

Introduction.

The experiments described in this paper were made to ascertain the effect of various etching or pickling processes on the fatigue properties of Duralumin. Pickling and etching treatments have commonly been used on manufactured pieces for the detection of defects of manufacture such as laps and forging cracks, as well as for the detection of fatigue cracks in used components.

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* Manuscript received March 24, 1934. Air Ministry official report: Crown copyright reserved.

† Senior Scientific Officer and Head of Metallurgical Department, Royal Aircraft Establishment, South Farnborough.

‡ Technical Officer, Royal Aircraft Establishment, South Farnborough.

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

Professor A. von Zeerleder had drawn the attention of the authors to the harmful effect of pickling treatments on the fatigue properties of high-strength wrought aluminium alloys. Professor von Zeerleder in collaboration with Dr. M. Bosshard had shown * that in material of the Duralumin type the number of stress cycles to fracture in fatigue tests was much reduced after the test-pieces had been given a normal etching treatment in caustic soda solution.

INDUSTRIAL PRACTICE.

Enquiries were made to ascertain details of the procedure followed with regard to pickling of light aluminium alloys at various works. It was found that caustic soda solutions of 10 to 25 per cent. concentration were being used at temperatures from normal to 70° C. and periods of immersion of up to 3 minutes. Usually the pickling in caustic soda solution was followed by rinsing, immersing in nitric acid or nitric–sulphuric acid solutions, to remove the dark slime left on the surface after the caustic soda pickling.

As the pickling in caustic soda solution is more vigorous than the second pickling operation in the acid bath it was decided to employ, in the first experiments, a caustic soda solution in the highest temperature range of those used in industry.

MATERIAL.

The experiments were made on Duralumin bar, ¾ in. in diameter, prepared to British Standard Specification No. 3L1. By arrangement with the manufacturer, the entire consignment (40 ft.) was extruded from the same billet. The material was supplied in the heat-treated and aged condition, in straight lengths which were marked A, B, C, D, and E for identification.

LOSS OF METAL BY PICKLING.

The loss of metal due to pickling was observed in some preliminary experiments by change of diameter and of weight of carefully machined cylinders.

(1) *Samples Pickled for* 2½ *minutes in Cold* 25 *per cent. Caustic Soda Solution, Rinsed, and Cleaned in Cold* 50 *per cent. Nitric Acid Solution.*—The loss of metal as observed by direct measurement was less than 0·00005 in. and the loss of weight was equivalent to removal of a layer 0·00005 in. thick.

(2) *Samples Pickled for* 2½ *minutes in Cold* 10 *per cent. Caustic Soda*

---

* Communicated privately to the authors: this information is gratefully acknowledged.

Solution, Rinsed, and Cleaned in a Cold Solution containing 2 *parts Nitric Acid,* 1 *part Sulphuric Acid,* 3 *parts Water.*—The loss of metal as observed by direct measurement was less than 0·00005 in. The loss of weight corresponded to removal of a layer 0·00003 in. thick.

(3) *Samples Pickled in* 10 *per cent. Caustic Soda Solution at* 60°–70° *C. for* 2½ *minutes, Rinsed and Cleaned in Cold* 10 *per cent. Nitric Acid,* 10 *per cent. Suphuric Acid.*—The loss of metal as observed by direct measurement was 0·0003 to 0·0005 in., and that calculated from loss of weight was 0·00094 in.

The results obtained show that the most vigorous of these three pickling treatments resulted in a loss of metal sufficiently small to be negligible from the point of view of reduction of section of the pickled fatigue test-pieces.

In the case of other methods of pickling employed in later stages of the work the diameters of test-pieces were measured before and after pickling for information on loss of metal by pickling.

TENSILE TESTS.

The material was supplied in the form of five bars in straight lengths and marked A, B, C, D, and E.

The results of tensile tests on samples from bars A, B, C, and E are given in Table I. These results indicate that the material is fairly uniform in mechanical properties.

TABLE I.—*Control Tensile Tests.*

Mark.	Diam., In.	L.P. Tons/in.².	0·1% P.S. Tons/in.².	0·5% P.S. Tons/in.².	Maximum Stress, Tons/in.².	Elongation, Per Cent. on 4 $\sqrt{A}$.
A	0·493	12·8	17·6	18·8	28·0	21·0
B.7	0·494	12·1	17·1	18·9	27·8	23·0
C.19	0·494	12·8	17·2	18·9	28·2	24·6
E.17	0·494	11·9	17·3	18·9	28·1	23·0

FATIGUE TESTS.

Wöhler fatigue tests were made on machined specimens of the type illustrated in Fig. 5.

Pickling Treatment A.

This treatment, intended to represent the most vigorous pickling employed in industry, was as follows:—(1) immerse in 10 per cent. caustic soda solution at 60°–70° C. for 2½ minutes and rinse; (2) immerse in cold 10 per cent. nitric acid, 10 per cent. sulphuric acid (vol.), for 1 minute, rinse, and dry.

The loss of metal resulting from this treatment was 0·00094 in., as observed by loss of weight.

In these and subsequent experiments treatment of specimens for fatigue tests was carried out immediately before commencement of the fatigue tests.

The results of the fatigue tests are plotted in Fig. 1.* The fatigue test results are somewhat irregular, even in the case of tests of material in the unpickled condition. Probable endurance curves have been drawn with reference to the lower values obtained in each series of tests. The fatigue limit of the untreated material at 10 million cycles was ± 10·2 tons/in.², and that of pickled material ± 7·0 tons/in.², the reduction in stress being 31 per cent. For material which had received pickling treatment A and subsequent immersion in boiling water for 15 minutes, the fatigue limit was 9·1 tons/in.², 10 per cent. lower than that of the original material. The maximum stress ranges for which an endurance of ten million cycles may be expected are collected in Table II.

TABLE II.

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Pickling Treatment.	Untreated.	Pickled.		Pickled and Boiled.		Pickled and Machined.		
						Fatigue Limit.		Decrease in Stress, Per Cent.
	Fatigue Limit, Tons/in.².	Fatigue Limit, Tons/in.².	Decrease in Stress, Per Cent.	Fatigue Limit, Tons/in.².	Decrease in Stress, Per Cent.	0·005 in. off Diameter.	0·010 in. off Diameter.	
A	±10·2	±7·0	31·4	± 9·1	10·0	±10·5	±10·5	Nil
B	±10·0	±8·5	15·0	...	...	...	...	...
C	±10·4	±9·8	5·8	±10·0	3·8	...	...	...

Samples 0·005 in. and 0·01 in. oversize in diameter, respectively, pickled and subsequently machined to normal size showed the same fatigue limit as the original material (Fig. 4).

Pickling Treatment B.

In view of the fact that etching in hydrofluoric–nitric acid solutions is frequently employed to develop the macrostructure of wrought light aluminium alloys, experiments were made with a pickling bath of that type. The treatment employed was to immerse in 10 per cent. hydro-

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* The letter at each point on the fatigue graphs indicates the bar from which the specimen was taken.

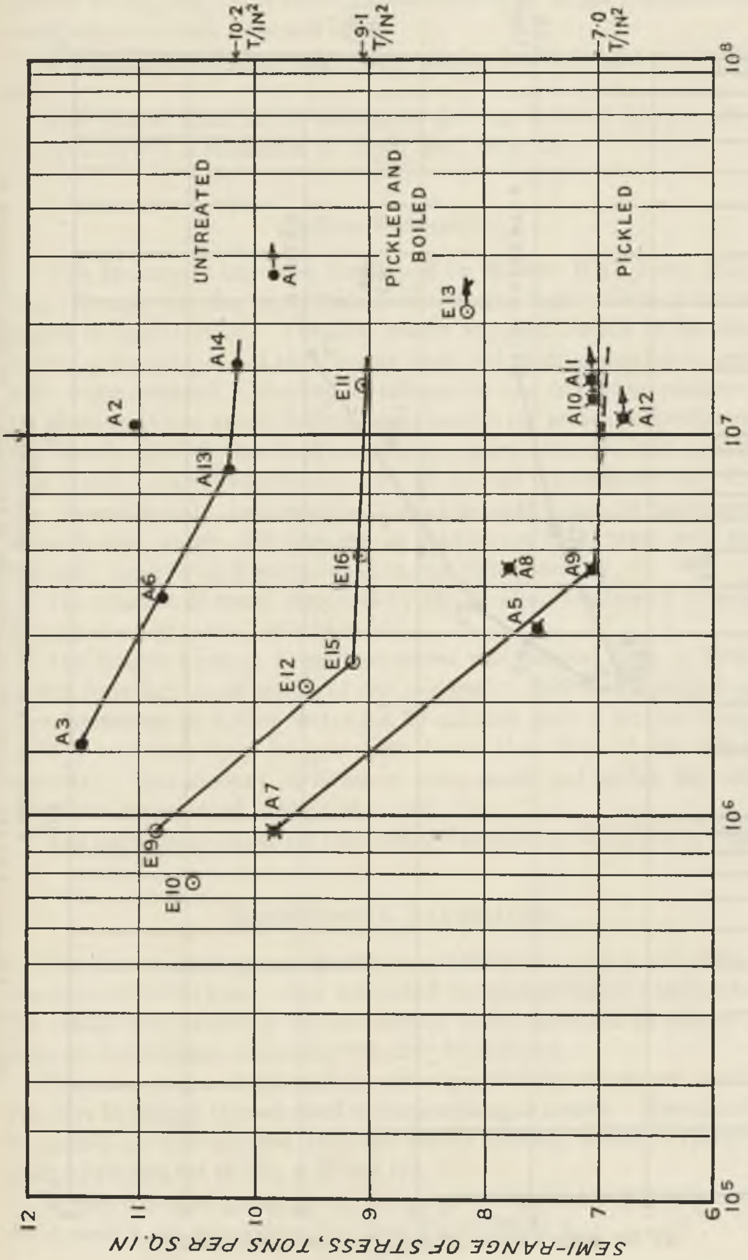

FIG. 1.—Influence of Pickling on the Fatigue-Strength of Duralumin. Pickling Treatment A.

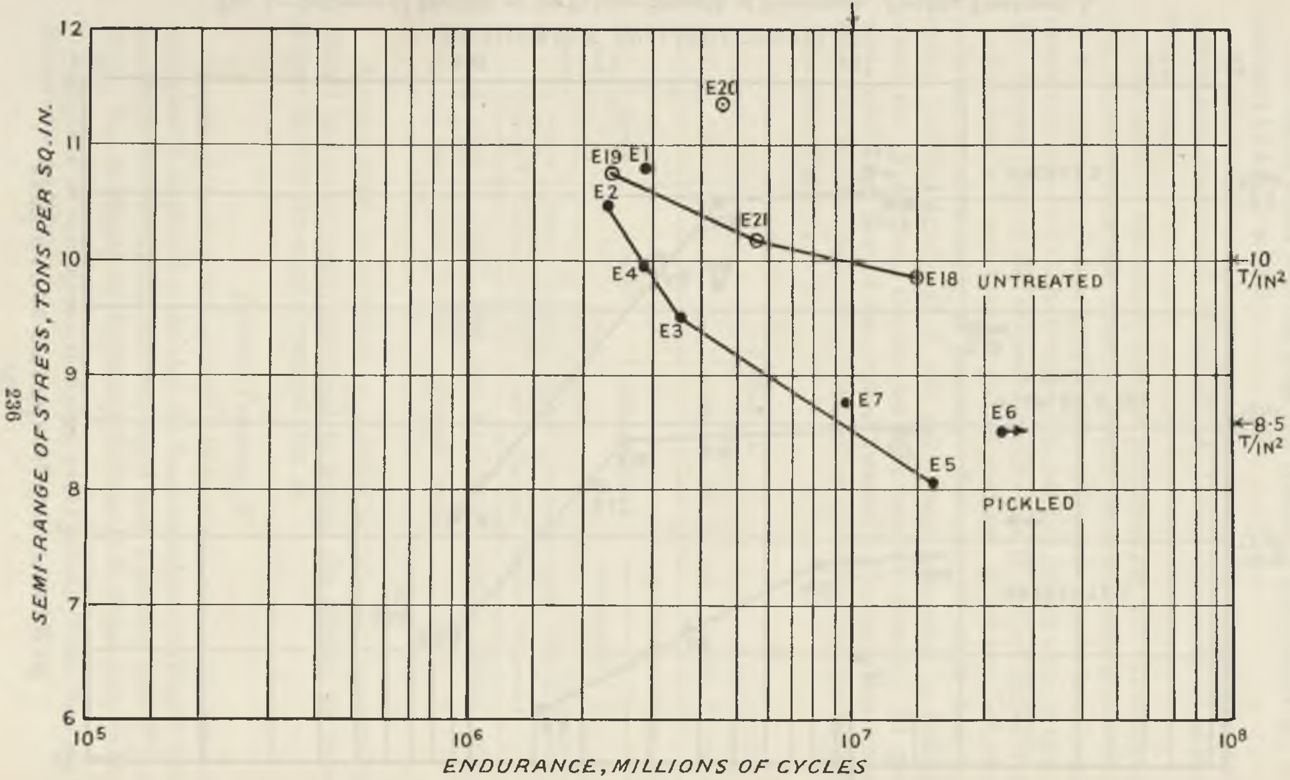

FIG. 2.—Influence of Pickling on the Fatigue-Strength of Duralumin. Pickling Treatment B.

fluoric, 10 per cent. nitric acid solution (vol.) at 20° C. for 2 minutes with constant movement, rinse and dry.

The loss of metal observed by determining loss in weight was 0·00031 in.

The fatigue limit at 10 million cycles was lowered from ± 10 to ± 8·5 tons/in.^{2}, a reduction of 15 per cent. (Fig. 2).

Pickling Treatment C.

This treatment has been developed by Messrs. High Duty Alloys, Ltd., Slough, for the examination of wrought light alloys at various stages of manufacture. The firm kindly supplied details of the treatment for the purpose of the present tests and their assistance is gratefully acknowledged. Pickling is effected in the following manner :—(1) immerse in hot water (boiling water used in the present experiments); (2) transfer directly to a bath containing 4 parts of 10 per cent. suphuric acid (vol.), 1 part hydrofluoric acid, at normal temperature (20° C. in the present tests) : immerse for 3 minutes with constant movement : rinse in cold water; (3) immerse in cold 50 per cent. nitric acid for 1 minute; rinse in cold water, wash in hot water and dry.

The amount of metal removed by the pickling treatment, observed by loss of weight, was 0·00033 in.

The fatigue limit at 10 million cycles was lowered from ± 10·4 to ± 9·8 tons/in.^{2}, a reduction of 5·8 per cent. Specimens pickled and then immersed in boiling water for 15 minutes gave a fatigue limit of ± 10·0 tons/in.^{2}, only 3·8 per cent. lower than that of the original material. This amount is, however, very small and within the range of scatter experienced in the tests.

The endurance curves for this series of specimens are given in Fig. 3.

MICROSCOPICAL EXAMINATION.

Samples pickled by treatment A, extended to give a reduction in diameter of 0·0015 in., were subjected to microscopical examination. No cracks were observed but the surface of the specimen as seen at the edge of the sections examined was sharply serrated.

Sections prepared from test-pieces pickled by treatment A after fracture in fatigue tests showed numerous fatigue cracks. Examination of etched sections showed that the cracks followed a trans-crystalline path as illustrated in Fig. 6 (Plate I).

Typical fatigue fractures of specimens which had received pickling treatment A are reproduced (× 2) in Fig. 7 (Plate I).

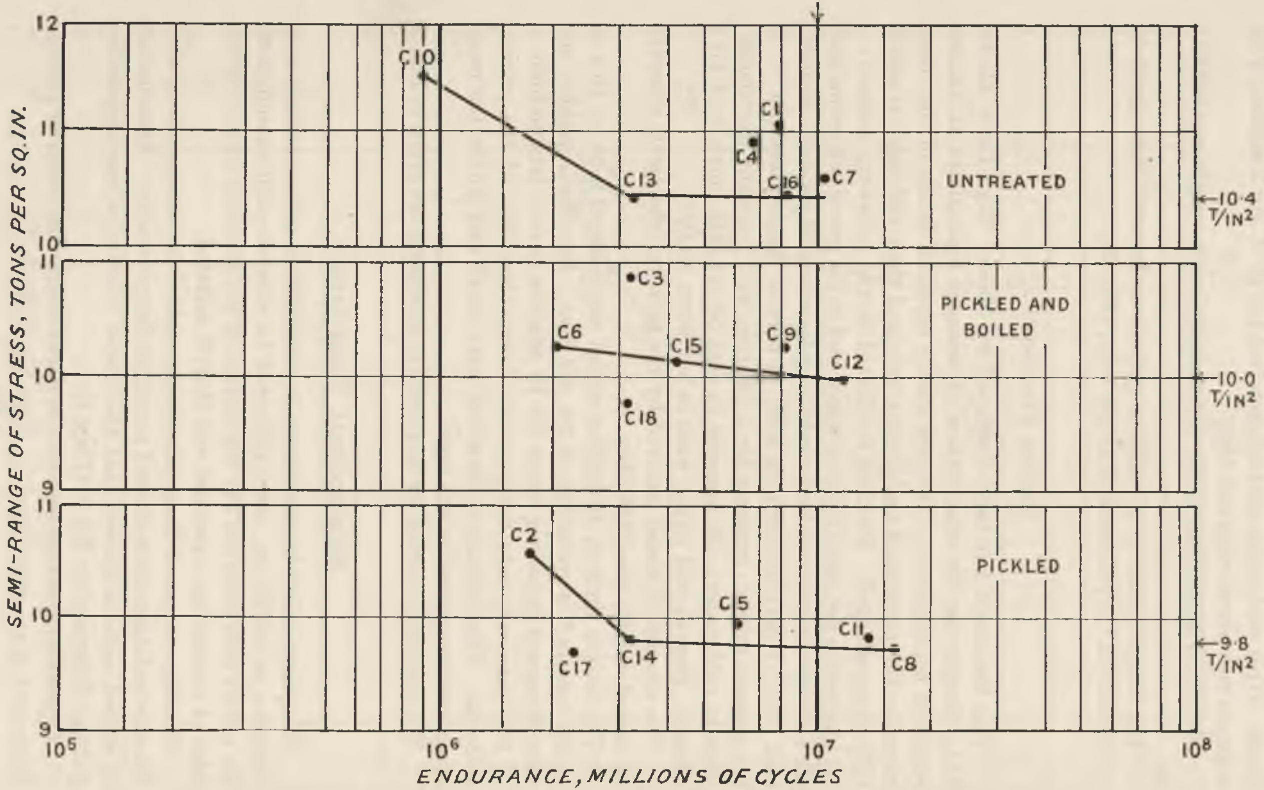

FIG. 3.—Influence of Pickling on the Fatigue-Strength of Duralumin. Pickling Treatment C.

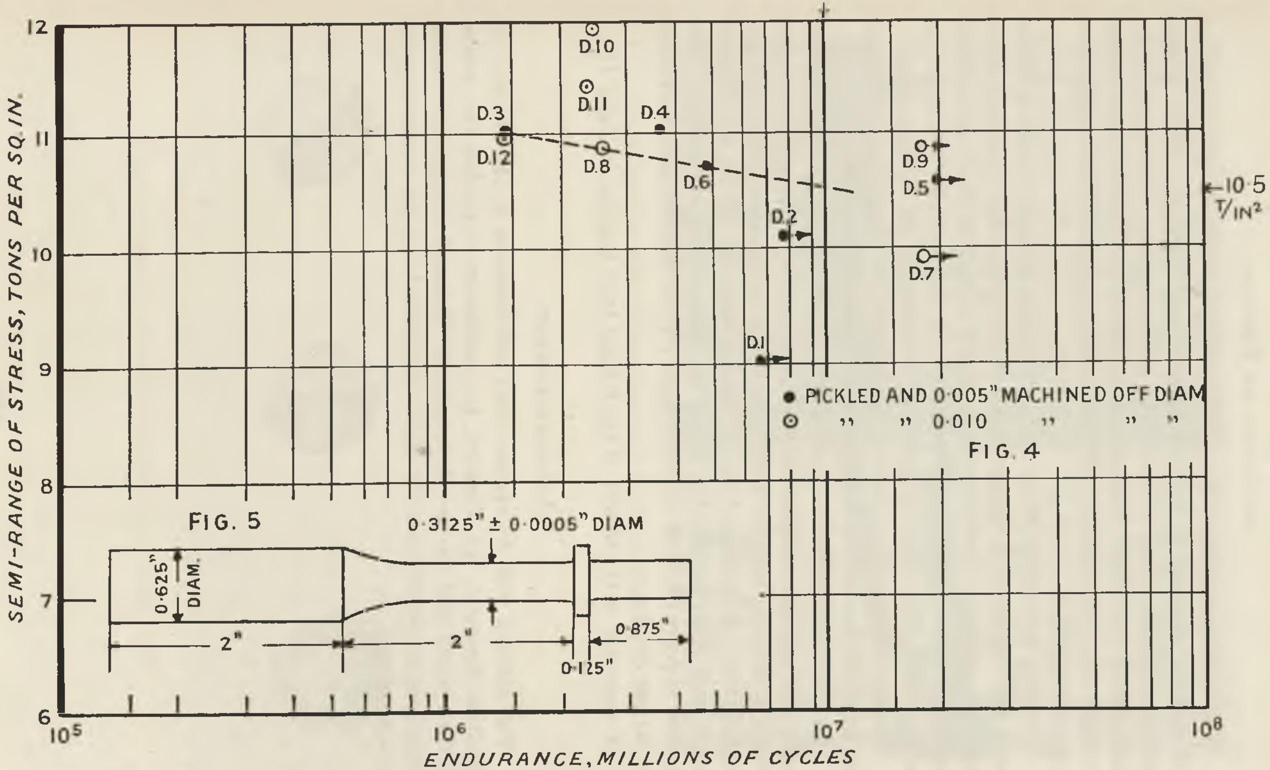

FIG. 4.—Influence of Pickling on the Fatigue-Strength of Duralumin. Effect of Machining after Pickling.
FIG. 5.—Standard Wöhler Test-Piece.

DISCUSSION OF RESULTS.

The investigation has shown that pickling in caustic soda solutions followed by cleaning in nitric–sulphuric acid solutions effects a substantial lowering of the Wöhler limit of Duralumin. The effect of the treatment is to produce a rough, serrated surface. When a layer 0·0025 in. thick has been machined off the surface, the pickled material shows normal properties.

Pickling treatment B in nitric–hydrofluoric acid solution effects much less reduction in fatigue range of Duralumin, and pickling treatment C in sulphuric–hydrofluoric solution followed by 50 per cent. nitric, only very slight reduction. Treatment C followed by immersion in boiling water gives only 3·8 per cent. reduction in the Wöhler range.

Immersion in boiling water appears to remove to a substantial degree the injury in the surface layer resulting from pickling.

Pickling by treatment C reveals the macrostructure of Duralumin parts and appears suitable for the examination of pieces at various stages of manufacture for defects such as forging cracks, laps, and discontinuities. It is also of service for examination of the structure of ingots and observation of " flow " in forgings and stampings. This method appears likely to prove suitable for the inspection of used parts for fatigue cracks.

A summary of the results of the fatigue tests is given in Table II.

ACKNOWLEDGMENTS.

The authors wish to express their indebtedness to the Director of Scientific Research, Air Ministry, for permission to publish the results of their work and to the Aeronautical Research Committee, under whose general supervision the work was carried out, for assistance and encouragement.

FIG. 6.—Section from Broken Fatigue Test-Piece, Etched. × 200

FIG. 7.—Typical Fractures of Fatigue Test-Pieces. × 2

PAPER No. 669. This paper is not to be reprinted, wholly or in part, until presented (and then only with due acknowledgment) at a meeting to be held on September 3–6, 1934, in Manchester. The Institute as a body is not responsible for the statements or opinions expressed in this paper, on which **written discussion** may be sent to the Secretary not later than October 1, 1934.

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

A REFLECTIVITY METHOD FOR MEASURING THE TARNISHING OF HIGHLY-POLISHED METALS.*

By L. KENWORTHY,† M.Sc., A.R.C.S., MEMBER, and
J. M. WALDRAM,‡ B.Sc. A.C.G.I.

SYNOPSIS.

This paper describes an apparatus and method for carrying out the quantitative assessment of tarnish on highly-polished metals, by reflectivity measurements. The method involves the separate determinations of the specular and diffuse components of reflection, and the use of an empirical formula combining these two properties. The application and validity of the method are illustrated by the results of periodical measurements, and observations made on specimens of pure tin and 2 tin alloys exposed to indoor and outdoor atmospheres.

In the course of research on the atmospheric corrosion and tarnishing of metals and alloys, it was found necessary to measure, by means of the change of reflectivity, the tarnishing and dulling of highly-polished metals when exposed to the atmosphere. The object of this paper is to describe the apparatus and method employed for this purpose.

In devising a method, the wide utilization of highly-polished metalwork was borne in mind, and a considerable amount of preliminary work was carried out to ensure that the quantitative assessment made should be a proper indication of the appearance; but although it is often desirable that materials used in decoration should possess and exhibit a high degree of polish, a high reflection factor, *per se*, is not a criterion. For instance, a clean silvered glass mirror represents the most suitable surface, having both a high polish and a high reflection factor; but a white blotting-paper surface, having a high reflection factor, but no polish, is less suitable than a surface of polished black slate as used for switchboards, which has a very low reflection factor, but a high polish. A glazed white porcelain surface, having a high

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* Manuscript received April 26, 1934.

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

‡ Research Laboratories of the General Electric Co., Ltd., Wembley.

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

reflection factor and some polish, is probably less suitable than the slate surface in that it does not exhibit its polish, which is masked by diffuse reflection. When a polished surface is used in decoration it forms images by specular reflection of objects in the vicinity, and if

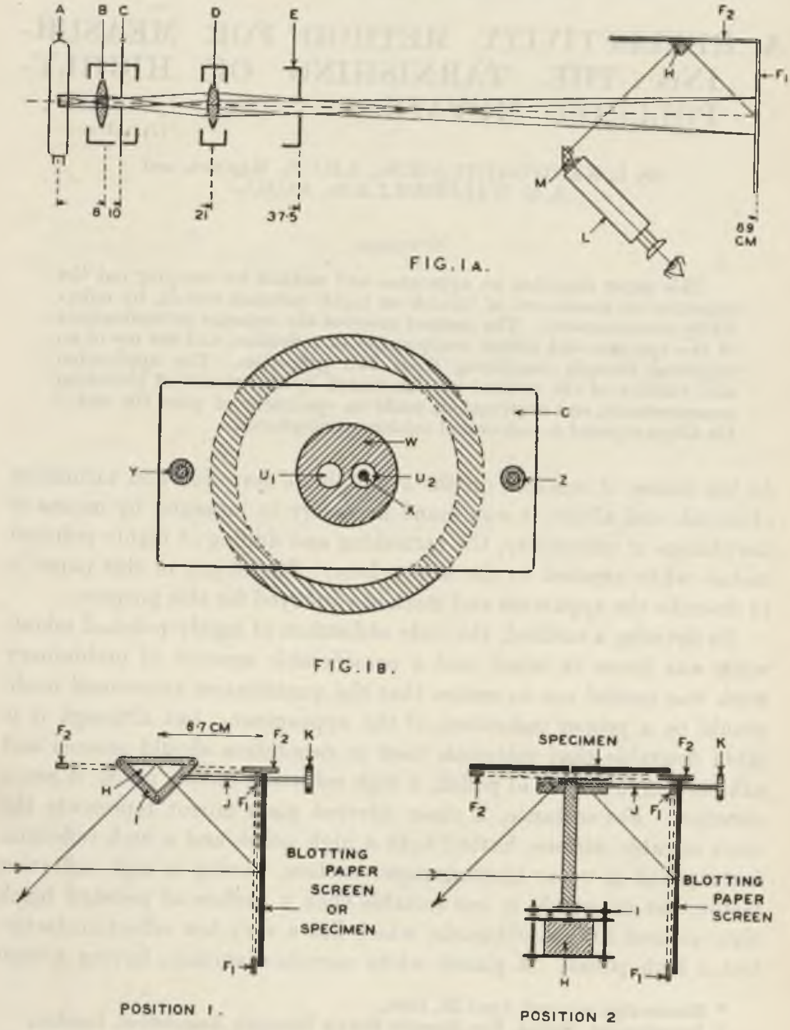

FIG. 1A.

FIG. 1B.

POSITION 1.

POSITION 2

FIG. 1C

FIG. 1 A–C.—Apparatus for Measurement of Reflectivity. (See key on page opposite.)

the appearance is to be satisfactory the image formed should be crisp, the proper degree of contrast being retained between the different parts. Dark parts of the image must appear really dark. In the case of a tarnished surface there is an appearance of fog all over the image. The marring of the appearance is due not so much to the fact

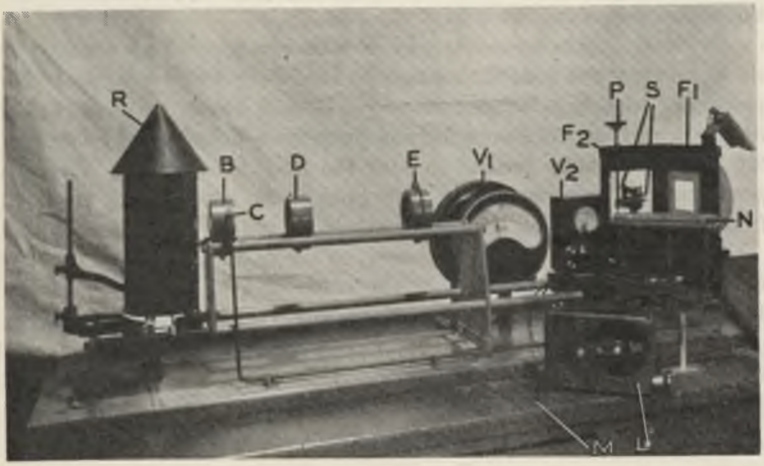

Fig. 2.—Photograph of Apparatus. The photometer is shown removed from its mounting, in order that essential parts of the apparatus shall not be obscured in the photograph.

KEY TO FIGS. 1 *and* 2.

A—Lamp; 110 volt, 100 watt coiled-coil Kodascope type.
B—Condenser lens, approximately 19 cm. focus.
C—Brass slide. See Fig. 1B.
D—Projection lens, approximately 9 cm. focus.
E—Screen.
F_1, F_2—Specimen guides.
H—Right-angled silvered prism.
I—Prism platform and adjustments.
J—Spindle.
K—Prism—moving knob.
L—Photometer.
M—Prism elbow.
N—Photometer mounting.
P—Knob operating prism screens.
R—Lamp-house.
S—Prism screens.
U_1, U_2—Apertures in slide.
V_1—Voltmeter across projection lamp.
V_2—Voltmeter across photometer lamp.
W—Cover glass.
X—Ball bearing, $\frac{3}{32}$ in. diameter, stuck to glass.
Y, *Z*—Limit stops for slide.

that the bright parts are not bright enough, but that the dark parts are not dark enough. If such a surface, or a dusty mirror, is partly cleaned, the general effect is that the clean parts appear darker than the uncleaned parts.

Evidently, therefore, a tarnished mirror reflects in two modes at the same time and its behaviour depends on (1) its specular reflection properties, defining the degree of polish and ability to form bright images, and (2) its diffuse reflection properties, defining the amount of fog which has been formed to mar the bright image. If these two properties are measured it is then possible to assess some arbitrary function which is a fair "figure of merit."

Vernon in his earlier work * was, so far as we are aware, the first to apply reflectivity methods to the study of atmospheric tarnishing. In this work, however, he was concerned only with the measurement of specular reflectivity, and a review of the literature showed that there was no published method or standard apparatus which would fulfil satisfactorily the requirements of the present investigation.

METHOD.

Preliminary experiments indicated that simple methods, such as those involving the use of an optical wedge or a disappearing-filament optical pyrometer, as alternatives to a photometer and optical bench, were insufficiently sensitive or accurate for the purpose. The use of the sphere reflectometer, which is another obvious method for measuring these properties, was tried and found to be unsuitable for several practical reasons; moreover, it was considered that a method involving direct observation of the specimen was to be preferred as more closely resembling practical conditions.

After several trials, the scheme indicated in Fig. 1A was adopted. The method is, briefly, as follows: the specular reflection factor is measured as the ratio of the observed brightness of an illuminated white object, after reflection at the surface under test, to its brightness after reflection at a prism whose reflection factor has been determined. A correction for brightness due to diffuse light is made. The diffuse reflection is measured as a specific reflectivity, *i.e.* the ratio of the brightness of the surface under test, to that of a matt white surface, under standard conditions of illumination and direction of view. In Fig. 1A, F_1 is a standard white surface, illuminated by an optical pro-

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* "First Report to the Atmospheric Corrosion Research Committee of the British Non-Ferrous Metals Research Association," *Trans. Faraday Soc.*, 1924, **19**, 851.

jection system and viewed by a photometer *L via* a prism *H*. For the determination of the specular reflection factor, *H* can be replaced by the specimen at F_2 (Fig. 1c, position 2) and a second determination of brightness made. A correction must be made for any diffuse reflection which will contribute to this brightness; a spot of light with a dark centre is therefore projected on to F_1 and the brightness of the dark centre measured. This gives the contribution due to diffuse reflection, which can be subtracted. For the determination of diffuse reflectivity, *H* is replaced and the white surface and the specimen viewed in turn when placed at F_1. It will be seen that the specimen is illuminated normally and viewed at 45°.

APPARATUS.

The apparatus used is illustrated in Figs. 1A, 1B, and 1C, and in the photograph Fig. 2. The source of light *A* (Fig. 1A) was a 110-v. 100-watt coiled-coil Kodascope projection lamp, run at 70 v., from the d.c. mains. Constant voltage was maintained by a barretter (1-amp. 40–100-v. type) and variable resistance in series. The optical system was that of a lantern projector, *B* being the condenser, *C* the slide, and *D* the projection lens. An image of the lamp filament was formed at *E*, and a screen was placed there with an aperture exactly fitting the image so as to cut off all stray light. *B*, *C*, *D*, and *E* were mounted in brass tubes and were carried on a parallel rod optical bench. The construction of the slide *C*, which permitted the projection of either a clear circular spot or a similar spot with a dark centre, will be clear from Fig. 1B, and the mounting of the prism *H*, and the means for taking it out of the optical system for the measurement of specular reflection factor, is shown in Fig. 1C. Two additional screens *S* shown only in the photograph, Fig. 2, operated by the knob *P*, were arranged over the two faces of the prism, having apertures only just large enough to fill the field of the photometer; they were replaced in position when the prism was removed. These screens are particularly important. The specimens and the white comparison surface were carried in brass slides running in guides in the vertical plates F_1 and F_2, in which windows 3½ in. square were cut, through which the specimen was observed. Mechanical stops were arranged to bring under observation either the centre of the specimen or a spot on the centre line midway between the centre and the edge. The photometer was a Holophane Lumeter, provided with a field lens of 5-in. focus and a right-angled prism, which enabled the photometer to be placed in a position far more convenient for taking observations. The field lens formed an image of the exit pupil of the photometer at F_1.

It was found necessary to have all parts rigidly fixed, and the design of the mounting will be sufficiently clear from the photograph.

MEASUREMENT OF SPECULAR REFLECTION FACTOR.

A white blotting-paper screen was placed at F_1. The lumeter was set up so as to view the centre of the projection spot at 45° from the normal by reflection at either the prism or a specimen placed at F_2. The reflection factor of the prism was found once for all by comparing a reading of the brightness of the spot seen through the prism with a reading with the lumeter moved to view the spot directly at 45°. The following readings were then taken :

(*a*) The clear spot was projected in the centre of the blotting-paper screen and a reading was taken *via* the prism;

(*b*) The reading (*a*) was then repeated on the black spot with the clear surround, in order to determine the amount of light due to diffuse reflection from the specimen, and this value was subtracted from the value of (*a*). The readings of (*a*) and (*b*) should theoretically be constant and (*b*) should be very small. Checks on these values were made periodically;

(*c*) and (*d*). These were readings similar to (*a*) and (*b*) taken *via* the specimen.

The specular reflection factor is then given by the following expression :

$$R_S = \frac{c-d}{a-b}\rho_1$$

where ρ_1 = reflection factor of the prism.

MEASUREMENT OF DIFFUSE REFLECTIVITY.

One more reading (*e*) was necessary for the determination of the diffuse reflectivity. For this, the blotting-paper screen was replaced by the specimen at F_1. The slide was moved so that the clear spot without the black centre was projected. A reading was then taken *via* the prism. The diffuse reflectivity is given by the expression :

$$R_D = \frac{e\rho_2}{a-b} \text{ where } \rho_2 = \text{the reflectivity of the blotting paper.}$$

The effect of buffing marks could be avoided, when determining this component, by measuring the specimens with the lengths of the marks horizontal, and thus in the plane of the normal to the specimen and the photometer.

The arrangement and procedure above described were adopted after trials with several other methods. A few of the difficulties encountered may be indicated briefly. It was necessary when measuring specular reflection to use the surface under test as a reflector between the photometer and the bright spot, not between the bright spot and the illuminating system, to avoid errors due to departure from flatness. Owing to the nature of the diffuse reflection, it was necessary to choose a direction of view well removed from the angle of specular reflection, otherwise small changes in direction of view considerably affected the result. All the lenses and glass surfaces had to be very carefully cleaned, in order to avoid diffusion of light by dust, which can cause a serious error. It is specially important to set the screens on the prism faces so as to prevent light from the bright surround from entering the photometer when viewing the dark spot. It was also found that, in making correction for diffused light, the dark spot must be in the centre of the bright spot. A measurement made adjacent to the bright spot gave a lower value. Finally, the projection system must be so set as to give a very even illumination of the spot. If the condenser is arranged to collect too much flux from the lamp, the illumination will be increased at the expense of evenness.

CALCULATION OF "FIGURE OF MERIT."

A figure of merit incorporating the specular and diffuse reflectivity was computed by the use of the following empirical expression :

$$M = \sqrt{\frac{R_S(R_S + R_D)}{R_D + 1}} \times 10$$

It will be seen that with this expression when the diffuse component is zero, the value of the " figure of merit " is simply the specular reflection factor, multiplied by 10.

In order to illustrate the application of the method, the results of exposure tests on samples of pure tin, commercial tin, and Britannia metal are given. These tests were designed not only with the object of determining the rate of tarnishing, but also to investigate the effect of cleaning on the subsequent rate of tarnishing. For this purpose, four plates of each material were exposed, two plates being untouched throughout the exposure and the other two cleaned at intervals. In addition, two extra plates of Britannia metal were exposed, and these were brushed at frequent intervals to determine the effect of dust.

The specimens, which were 4 in. square and of 12 S.W.G. thickness, were buffed by a firm of metal platers and polishers. Before being exposed, they were swabbed thoroughly in acetone to remove most of the grease, and were then given a final degreasing treatment with trichlorethylene vapour. The initial reflectivity measurements were then made and the plates exposed in a vertical position in an indoor atmosphere. Measurements on all the plates were made after 3, 6, 11, 16, 21, and 26 weeks' exposure, and after each of these, two specimens of each material were cleaned and measured again before being re-exposed. The extra two specimens of Britannia metal were given no cleaning treatment, but were lightly brushed daily with a camel-hair brush (except at week-ends) in order to remove dust.

Graphs connecting " figure of merit " and time of exposure for the three materials are shown in Figs. 3–5. In these graphs, the specimens which were subjected to continuous exposure are represented by smooth curves and those which were cleaned periodically by stepped curves, the vertical portions of which indicate cleaning.

The methods employed for cleaning, which were (1) swabbing with distilled water or (2) swabbing with soap and water, are indicated by the numbers shown above each vertical portion of the curves, and the treatments to which these refer are given below the graphs.

In discussing briefly the results obtained, attention is directed to the fact that the rapid initial drop in " figure of merit " shown by the continuously exposed specimens was caused to a large extent by deposition of dust. This is well illustrated in Fig. 5. The smooth dotted curve shows the relationship between " figure of merit " and time of exposure for the plates which were brushed, and therefore represents loss of " figure of merit " due entirely to tarnishing. As this tarnish was not detected visually until after about 9 weeks' exposure, the method is shown to be sufficiently sensitive to record slight changes which cannot be detected by direct visual observation.

In the case of the specimens which were periodically cleaned,* swabbing with distilled water for the first two cleanings, *i.e.* after 3 and 6 weeks' exposure, was sufficient for all the materials to restore a large proportion of the original " figure of merit." For the subsequent cleanings, however, soap and water were used, as water alone did not prove sufficiently effective. The small amount of tarnish that developed between these cleanings was apparently completely removed by this treatment, the only change in appearance at the end of 26 weeks being a slight scratching caused by cleaning, to which the small drop in " figure of merit " is largely, if not entirely, due.

In conclusion, it may be mentioned that the observations and

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* It should be noted that in the case of pure tin, the specimens used for the cleaning tests were not exposed with the same degree of polish as the specimens which were exposed continuously.

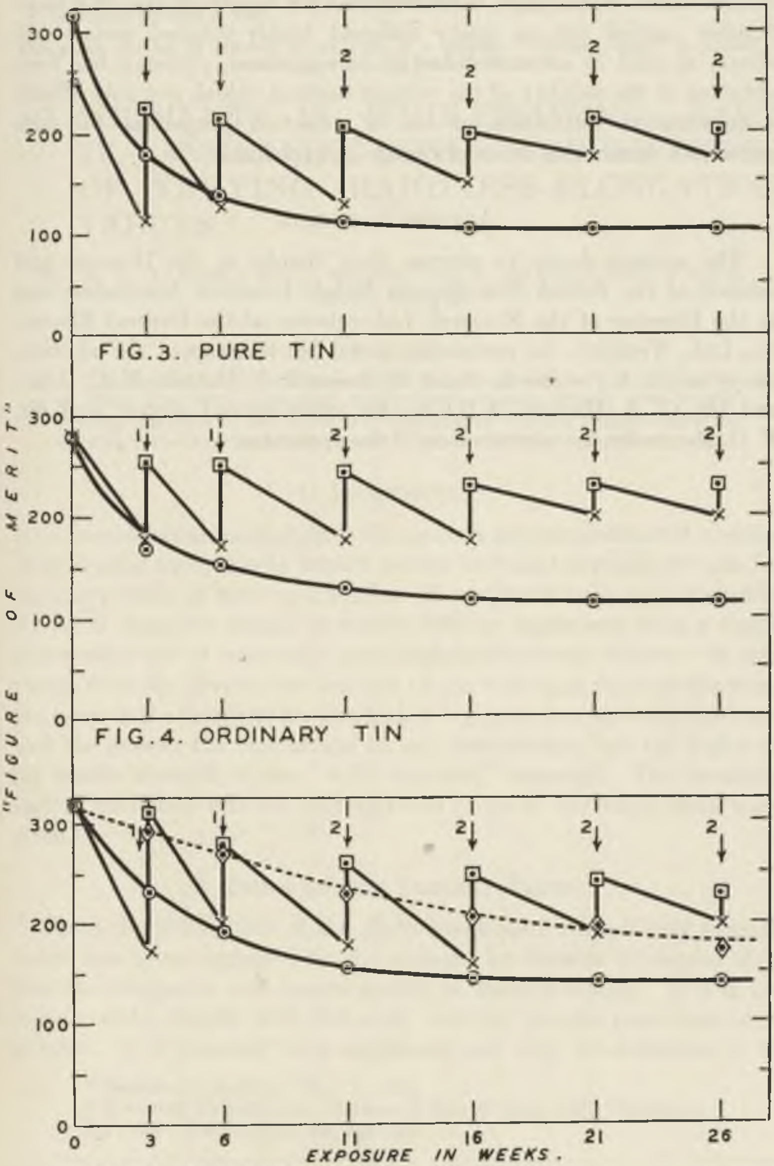

FIG. 5. BRITANNIA METAL.

Figs. 3–5.—Cleaning Treatments: 1, Wash with Water; 2, Wash with Soap and Water.

measurements which have been described are representative of a large number carried out on many different highly-polished metals and alloys, as used in art and industry. From these, evidence has been obtained of the validity of the present method, which not only affords a quantitative estimation of loss of reflection properties, but also provides a serviceable index of change in appearance.

ACKNOWLEDGMENTS.

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PAPER No. 670. This paper is not to be reprinted, wholly or in part, until presented (and then only with due acknowledgment) at a meeting to be held on September 3–6, 1934, in Manchester. The Institute as a body is not responsible for the statements or opinions expressed in this paper, on which **written discussion** may be sent to the Secretary not later than October 1, 1934.

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

EXPERIMENTS IN WIRE-DRAWING. PART IV.—ANNEALING OF H.-C. COPPER WIRES OF VARYING HARDNESS–ELONGATION VALUES.*

By W. E. ALKINS,† M.Sc., Member, and W. CARTWRIGHT,† O.B.E., M.Sc., Member.

Synopsis.

The results of determinations of the elongation values of a series of wires of a very pure high-conductivity copper, drawn with widely varying amounts of reduction and annealed at varying temperatures for varying periods of time, are recorded in full and briefly discussed.

1. Introduction.

In a previous communication ‡ the authors gave an account of a series of annealing experiments carried out at varying temperatures and for varying periods of time on a number of samples of wire, approximately 0·1 in. in diameter, drawn to widely different hardnesses from a single heavy wire-bar of unusually pure high-conductivity copper. It was shown that, the greater the amount of the cold-work done on the wire, the lower is the temperature at which it begins to lose its work-hardness and the greater the rate of loss at any temperature, but the higher is the tensile strength of the "fully annealed" material. The breaking load of the wires was the only physical property for which data were given.

2. Scope of the Present Paper.

Since the publication of the above-mentioned work, a very general desire has been expressed to the authors by drawers of copper wire that the elongation test results should be made available. It is in an endeavour to comply with this wish that the present paper has been written. It is confined to a statement and very brief discussion of

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† Research Department, Thomas Bolton & Sons, Ltd., Oakamoor.

‡ *J. Inst. Metals*, 1933, **52**, 221–239.

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

the elongation values corresponding with the breaking load data already published.

3. MATERIAL.

In view of the interest that has been shown in the chemical composition of the copper used, and of the obvious importance of the question, further attention has been given to the estimation of the impurities present. The authors wish to thank in this connection Mr. W. Sheppey, who has made a detailed chemical analysis, and Dr. F. J. Brislee, who has prepared and read spectrograms. Their work completely confirms the view that the material was in fact of an unusually high degree of purity; as such it was in entire agreement with the intentions of the authors, who wished to study first the annealing behaviour of the purest available—and not necessarily therefore of a typical commercial—high-conductivity copper. The composition can now be stated as follows :—

	Chemical.	Spectrographic.
Copper, per Cent.	99·953	...
Silver, ,, ...	0·0008	trace
Lead, ,, ...	less than 0·001	...
Iron, ,, ...	0·003	less than 0·005
Nickel, ,, ...	0·0005	...
Oxygen (by determination), per Cent. .	0·041	...
or		
Total, copper plus oxygen, . . .	99·994 per Cent.	
Total, impurities excluding oxygen .	0·006 ,,	

The preparation of the wires is fully described in the previous paper,* in which are also discussed the methods used for annealing and the range of annealing treatments given.† The percentage reductions given to wires Nos. 1–11 by cold-drawing (after intermediate annealing) to the uniform finished diameter of approximately No. 12 S.W.G. (0·104 in.) are repeated in Table IX of the present paper.

4. METHOD OF TESTING.

The elongation tests were made on a hand-operated Farrar machine of simple type, on a length of 10 in. between the grips. The wires were stretched as steadily as possible at an approximately constant speed and fractured, and the elongation value was read, at the instant of fracture, in terms of percentage elongation in 10 in. The results were read to the nearest 0·5 per cent.

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* *Loc. supra cit.*, p. 222, and Table I, p. 223.

† *Ibid.*, pp. 222–223.

In the case of wires having a considerable general elongation, this method of testing gives results which are rather lower than those obtained by stretching a test-piece more than 10 in. long between grips, on which a 10-in. gauge-length is marked off well clear of the grips. For wires possessing an elongation of 35 to 40 per cent., the difference is 1·5 to 2 per cent. With hard wires the difference is inappreciable.

5. RESULTS.

The mean elongation values of the whole of the eleven wires after the different annealing treatments are tabulated in Tables I–VIII,

TABLE I.—*Annealed at* 130° *C.*

No.	Mean Elongation per Cent. in 10 in.					
	Annealing Period, Hrs.					
	½.	1.	2.	6.	12.	24.
1	1	1	1	1·5	1	1
2	1	1	1	1	1	1
3	1	1	1	1	1	1
4	1	1	1	1	1	1
5	1	1	1	1	1	1
6	1	1	1	1	1	1
7	1	1	1	1	1·5	1
8	1	1	1	1	3	3
9	1	1	1·5	4	8	16·5
10	1	1	1	2·25	5·75	12·5
11	1	1	1·5	3·25	6·75	10·75

TABLE II.—*Annealed at* 155° *C.*

No.	Mean Elongation per Cent. in 10 in.					
	Annealing Period, Hrs.					
	½.	1.	2.	6.	12.	24.
1	1	1	1	1	1	1·5
2	1	1	1	1	1	1
3	1	1	1	1	1	2·25
4	1	1	1	1	1	2·75
5	1	1	1	1	1·75	6·25
6	1	1	1	1	6·25	7·25
7	1	1	3·5	8·5	18·5	17
8	1	2·5	3	13·5	22	27·75
9	1	6	13	25·25	30·5	34
10	1	2·25	10·5	20·75	28·5	33
11	1	6·5	11	21	26	28

of which all except the last relate to a single temperature; in Table VIII are collected the test results after ½-hr. annealings at temperatures of 330° C. and above. The present data can thus be readily and directly correlated with the data for breaking load given in Tables II–IX of the earlier paper.

TABLE III.—*Annealed at* 170° *C.*

No.	Mean Elongation per Cent. in 10 in.					
	Annealing Period, Hrs.					
	½.	1.	2.	6.	12.	24.
1	1	1	1	1	1	1
2	1	1	1	1	1	2
3	1	1	1	3·5	9	14
4	1	1	2	3·5	8	17·5
5	1	1	1	4	14·5	23·5
6	1·75	1	4	10·5	14	17·5
7	2	5·75	13	25	20·5	33
8	3	3	19·5	31	31	35
9	4	16	25·5	34	34·5	37
10	4·25	14·5	27	33·5	35	36·5
11	4·5	13·5	23	30·5	32	34

TABLE IV.—*Annealed at* 180° *C.*

No.	Mean Elongation per Cent. in 10 in.					
	Annealing Period, Hrs.					
	½.	1.	2.	6.	12.	24.
1	1	1	1	1	1	1·5
2	1	1	1	1·25	2·5	8
3	1	1·25	2	10	22	26
4	1	1·5	1·75	11·5	22·5	26
5	1	1·75	2·5	17·5	18·5	25
6	1	1·75	7·5	24·5	24·5	35
7	1	5·5	7	26	34·5	37·5
8	2·5	10·5	26	34	36·5	37
9	4·5	22·5	32	36	37	37
10	5·5	26	33·5	36	37	36·5
11	9·5	22	30	33·5	35	35

In the as-drawn condition all the wires had, within the limits of accuracy of the method of testing, the same elongation—1 per cent.—and the recurrence of this "hard-wire" elongation value makes it possible, by inspection of the Tables, easily to follow the commencement of annealing. At 130° C. (Table I), softening is apparent only in the case of the (four) most severely drawn wires after treatments of 6 hrs.'

duration and over—the value 1 per cent. persists throughout the Table except in the extreme right-hand lower corner. As the temperature of annealing increases, the area occupied by the figure 1 shrinks progressively towards the left-hand upper corner of the Table, *i.e.* the lightly drawn wires undergo annealing less readily than those which have been severely cold-worked. Whereas a significant increase of elongation is apparent with a number of the hardest drawn wires after 6 hrs. at 130°, after 1 hr. at 155°, and after ½ hr. at 170° C., the No. 1 wire (36 per cent. reduction) shows only the slightest softening after 24 hrs. at 205° C. and is by no means fully annealed even after 24 hrs. at 230° C.

TABLE V.—*Annealed at 205° C.*

No.	Mean Elongation per Cent. in 10 in.					
	Annealing Period, Hrs.					
	½.	1.	2.	6.	12.	24.
1	1	1	1	1·25	1·5	2
2	1	2	4	14·75	27·5	19·5
3	2	13	20·5	34·5	37	37·75
4	3	18	26	36	37·5	36·75
5	4	18	30	27·75	34·5	36
6	7·5	32	34·5	36·5	37·25	36·5
7	26	21	31	34	37	34·5
8	29	36·5	36·5	35	36	37
9	31	36	37	36	37	37
10	32·75	37·25	36·75	36·5	37	36
11	29	35	36	35·5	36·25	35

TABLE VI.—*Annealed at 230° C.*

No.	Mean Elongation per Cent. in 10 in.					
	Annealing Period, Hrs.					
	½.	1.	2.	6.	12.	24.
1	1·5	1·5	1·5	3·5	8	15
2	4	20·5	28	38	40·25	38
3	31	36·5	39	39	41·25	39·75
4	30·5	36·5	39·25	39	40·75	38·75
5	31	37	37	38	39·75	38·5
6	34·5	34	37·5	36·5	38·5	37·5
7	38	37·5	36·25	36	38	36·5
8	37·5	36·25	37·25	37·5	39·5	38
9	37·5	37·5	38·5	38	38	38
10	38·5	37	38	37·5	38·25	37·5
11	36·5	36	37	36·5	37	37

In marked contrast with the behaviour of the lightly worked wires, several of the most heavily drawn wires are annealed down to elongation values of the order of 30 per cent. after 24 hrs. at 155° C.; they are annealed to values of 35 per cent. and over after 1 hr. at 205° C. and after ½ hr. at 230° C.—treatments which are without appreciable effect on No. 1 wire.

TABLE VII.—*Annealed at 280° C.*

No.	. Mean Elongation per Cent. in 10 in.					
	Annealing Period, Hrs.					
	½.	1.	2.	6.	12.	24.
1	6·75	23	30·75	36·5	36·5	35·25
2	36·5	38·75	39	39·75	40·75	39·5
3	39	40·5	40·5	40·75	40·75	40·5
4	38·75	39·5	39·75	38·5	41	40
5	37	39	39·25	38	39	39·25
6	37·25	37·75	37·5	38·5	38	39·5
7	37	37·75	38·75	38	38·5	38·5
8	36·25	36·5	38·5	38·5	38·5	38·5
9	37·25	38·5	37·5	38·5	38·75	37·75
10	36·5	37·75	38	38	39	38
11	37	37·5	37	37·75	38·5	38

TABLE VIII.—*Annealed for ½ hour.*

No.	Mean Elongation per Cent. in 10 in.				
	Annealing Temperature, ° C.				
	330.	450.	650.	750.	850.
1	38·5	38	40	37·5	37·25
2	39	39·5	39·25	38·25	35·75
3	39	40	39·5	37·75	34·5
4	39	38	39·75	38	34·5
5	37·5	38	38·75	35	33·25
6	37·5	38·5	36·75	36·25	34
7	37	38	37·5	35·5	32·75
8	37·5	38	38·5	33	34·25
9	37	37·5	37	34	33·5
10	38	38	38·25	32·25	33·25
11	36·5	38·5	37·5	33	31·5

It is worthy of remark that, even at the low temperatures, wire No. 9 (94·8 per cent. reduction) appears to anneal to a greater extent, as judged in the light of elongation values, than wire No. 11 (96·7 per cent.); the behaviour of wire No. 10 (95·8 per cent.) is on the whole intermediate between that of No. 9 and that of No. 11.

The variation of percentage elongation with temperature is illustrated, in the case of ½-hr. annealings, in Fig. 1; in order to show all the wires in the same diagram, use has been made of the device of moving up the elongation zero through five units, from each wire to the next. The steeply-ascending left-hand portions of the curves bring out the much greater tendency shown by the hardest-drawn wires to become annealed at lower temperatures.

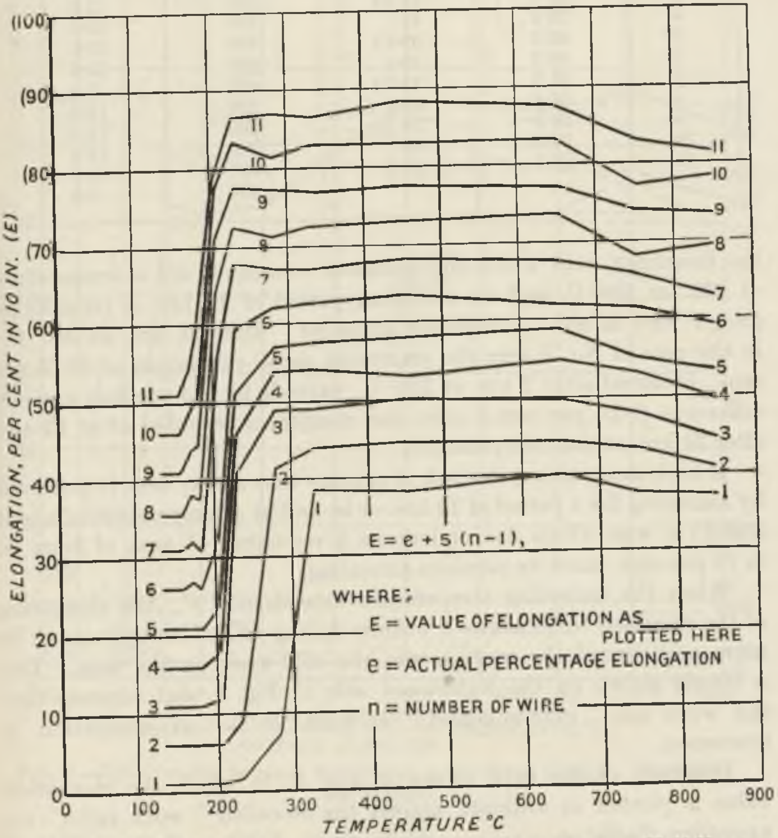

Fig. 1.—Relationship between Elongation and Temperature. Half-Hour Annealings.

It is, in general, true that in the case of each wire the greatest elongation is obtained by annealing at a moderate temperature for a fairly long time. In Table IX are collected particulars of the annealing treatments which resulted in the highest elongation for each wire, and

TABLE IX.—*Maximum Elongation Values.*

No.	Reduction of Area, per Cent.	Maximum Elongation, per Cent.	Temperature, ° C.	Time, Hrs.
1	35·9	40	650	0·5
2	59·0	40·75	280	12·0
3	69·6	41·25	230	12·0
4	76·6	41	280	12·0
5	83·5	39·75	230	12·0
6	88·3	39·5	280	24·0
7	91·3	38·75	280	2·0
8	93·4	39·5	230	12·0
9	94·8	38·75	280	12·0
10	95·8	39	280	12·0
11	96·7	38·5	280 450	12·0 0·5

the frequency with which the optimum conditions are a temperature of 230° or 280° C. and an annealing period of 12 hrs. is remarkable (No. 1 wire is not "completely annealed" after 24 hrs. at 280° C.; in the case of No. 7 wire the maximum mean elongation of 38·75 per cent., obtained after 2 hrs. at 280° C., exceeds by the smallest possible difference (0·25 per cent.) only, the elongation recorded after 12 and after 24 hrs. at that temperature).

If high elongation is desired, it appears that it may best be achieved by annealing for a period of 12 hrs. or so and at a temperature of about 250° C. a wire which has undergone a reduction of area of from 50 to 75 per cent. since its previous annealing.

When the annealing temperature exceeds 650° C., the elongation of the annealed wires shows a definite falling off, which appears to be more pronounced the more severe the cold-work on the wire. This is clearly shown on the right-hand side of Fig. 1, and suggests that the wires are "over-annealed," at least so far as elongation is concerned.

Diagrams of the type shown in Fig. 2, in which the elongation value is plotted as ordinate against the so-called "work ratio," *i.e.* $\frac{\text{annealing diameter}}{\text{finished diameter}}$, as abscissa, have again been found very useful in assisting towards a satisfactory conception of the whole of the annealing phenomena.

No attempt will be made here to correlate the elongation values set out in Tables I–VIII with the data for breaking load given in Tables II–IX of the previous paper. All the results are, however, now available for the purpose, and a number of interesting and significant features can be established if the data for the two properties are compared.

ACKNOWLEDGMENTS.

The authors wish once again to record their thanks to Messrs. Thomas Bolton & Sons, Ltd., and particularly to Mr. Thomas Bolton, for permission to publish these results. Similarly they desire to acknowledge again the assistance given by a number of colleagues at Oakamoor.

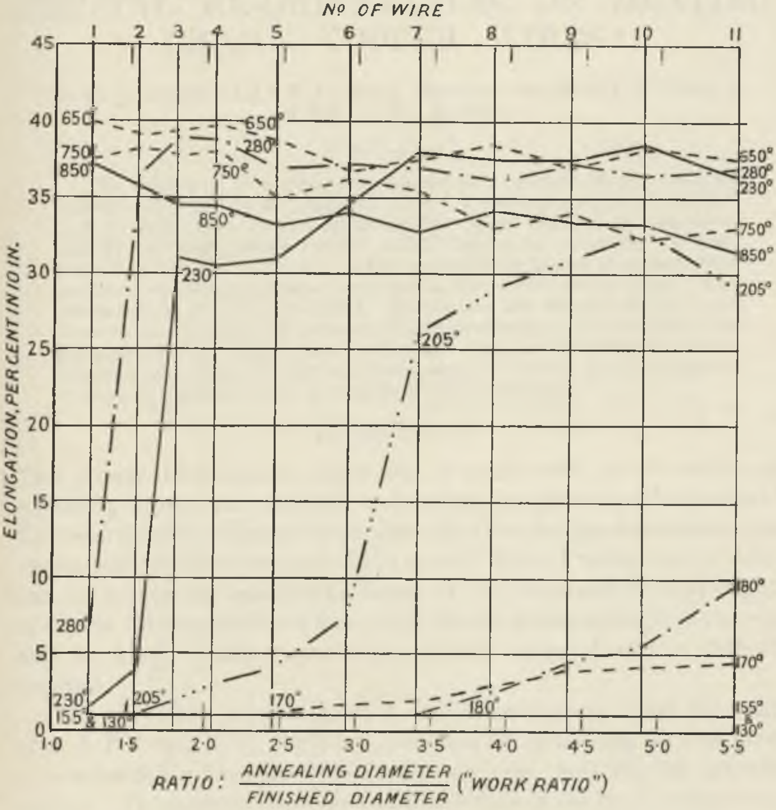

FIG. 2.—Relationship between Elongation and "Work Ratio." Half-Hour Annealings.

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CRYSTAL RE-ORIENTATION ON HEATING DRAWN COPPER WIRES.*

By G. S. FARNHAM,† B.A., M.Sc., MEMBER, and HUGH O'NEILL,‡ M.Met., D.Sc., MEMBER.

SYNOPSIS.

The behaviour of a silver-free copper wire reduced 59 per cent. by cold-drawing, has been compared after "low-temperature treatment" (L.T.T.) with that of two silver-bearing wires reduced 59 per cent. and 49 per cent., respectively. L.T.T. hardening occurs in the first, but not in the last of these. X-ray spectroscopy makes it evident that preferred orientation is less developed in the silver-bearing wires. The general effect of L.T.T. at 130° C. is to reduce the amount of [111] preferment, but to cause an increase of [100] preferment. This change-over probably causes "orientation hardening." In the silver-bearing wires, however, the change is only relatively small in extent, and this appears to explain the differences as regards L.T.T. hardening.

INTRODUCTORY.

THE present investigation arose out of some work on the effects of annealing copper wire recently undertaken by Alkins and Cartwright.[1] The behaviour of similarly drawn wires after low-temperature treatments varies with the silver content of the metal. Table I makes this evident, and the authors are indebted to Messrs. W. E. Alkins and W. Cartwright, of Messrs. Thomas Bolton & Sons, Ltd., for the information given therein, and for kindly placing specimens of their material at the authors' disposal.

The silver-free copper shows a tensile hardening of 2·6 per cent. after L.T.T. at 130° C. for 2 hrs., whereas silver-bearing wire 4S gives a corresponding increase of only 0·4 per cent. and No. 3S actually softens. The authors therefore examined these wires by X-ray spectroscopy to detect any observable differences in crystalline behaviour.

INDENTATION TESTS.

The existing evidence for L.T.T. hardening in wire No. 2 was an increase in tensile maximum load, but the authors have further con-

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

Table I.—*Drawn Copper Wires, Nominal Diameter* 0·104 *in.* (*Alkins and Cartwright.*)

Wire Number.	No. 2.*	No. 3S.	No. 4S.
Reduction of Area by Drawing, per Cent.	59	49	59
Maximum Tensile Load, lb.			
As drawn	457	450	473
Heated 130° C. for 1 hr.	469	446	474
,, ,, ,, 2 hrs.	469	445·5	475
,, ,, ,, 6 ,,	466	445	477
Composition, per Cent.			
Copper	99·95	99·855	
Silver	nil	0·093	
Lead	nil	0·018	
Iron	0·003	0·001	
Oxygen	0·047	0·031	

* Original values reported in paper ref. (1).

firmed the effect by indentation tests. These were made by mounting the specimens in plastic wood, carefully sectioning them parallel to the direction of drawing by rubbing on emery cloth, and then making 1-mm. ball tests at different indenting loads. Great accuracy was not obtained, presumably owing to the hardness gradients which are known to exist across the section of such drawn wires. The results given in Table II must not therefore be held to disprove the observation of Pfeil [2] that L.T.T. hardening is in reality nothing more than an effect due to an increase of the Meyer *n* value. As they stand, the present figures indicate a definite hardening in wire No. 2 of at least 5 per cent.

Table II.—*L.T.T. Hardening of Wire No.* 2.

	As Drawn (59 per Cent. Reduction of Area) and Aged for 2 Years.	Ditto and Heated 130° C. for 2 Hrs. Aged for 3 Months.
Brinell Hardness No. ($H_{1\cdot 10/30}$)	93 kg./mm.^{2}	101 kg./mm.^{2}
Meyer Index *n*	2·03 (approx.)	2·03 (approx.)
Ultimate Ball No., kg./mm.^{2} ($P_u = 1{\cdot}273a_1$)	99	104

X-Ray Tests on Unetched Wire.

Debye–Scherrer spectrograms using unfiltered Cu X radiation were obtained from the different specimens. Intensity measurements were made with a Cambridge (Dobson) microphotometer through three of the reflection lines on the films, in an equatorial direction. This direction passes through the centre of intensity maxima on the (200)

PLATE I.

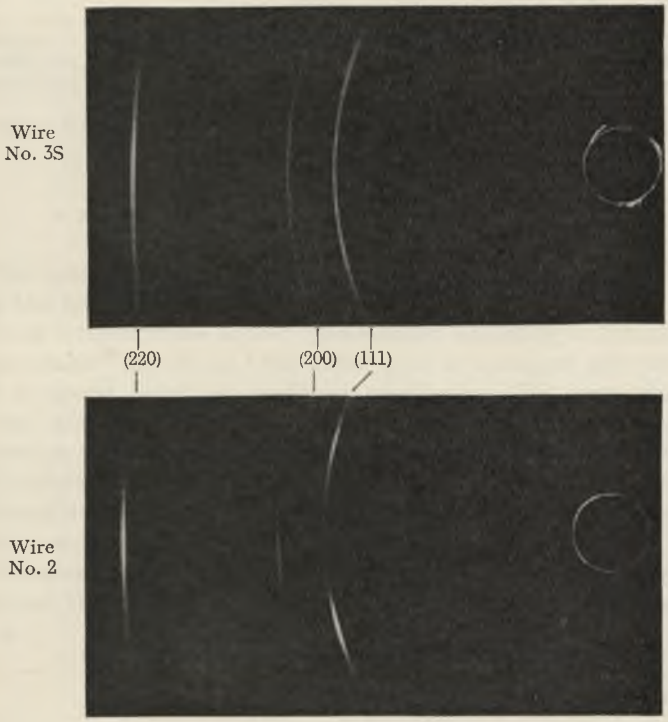

FIG. 1.—Spectrograms after L.T.T. at 130° C. for 2 Hrs. (0·047 in diam.).

and (220) lines (see Fig. 1, Plate I), and the results for the outside layer of wire No. 2 are given in Table III.

TABLE III.—*Photometric Survey of X-Ray Spectrograms of Unetched Wire No. 2.*

Photometric Curve.	As Drawn.			Annealed at 130° C. for 2 Hrs.		
	(111).	(200).	(220).	(111).	(200).	(220).
Height	1,626	1,564	1,644	1,268	1,280	1,408
Width, cm.	0·067	0·073	0·085	0·036	0·043	0·054
Blackening	21,680	22,840	30,590*	10,040	11,810	16,540
Relative height	1	0·961	1·011	1	1·010	1·110
,, width	1	1·090	1·266	1	1·194	1·500
,, blackening	1	1·054	1·411*	1	1·176	1·648

* Film rather over-exposed, and this value is probably low.

The bottom line of Table III is the most significant, and indicates that the (200) reflection becomes relatively more intense (by 12 per cent.) as a result of the L.T.T. Incidentally, according to Schmid and Wassermann [3] and Wood,[4] the outer layer of a copper wire such as this is almost devoid of preferred orientation. By comparing the figures obtained by the present authors with the theoretical relative intensities for unworked copper, however, it will be seen that the (200) reflection is much stronger than normal. This indicates that an abnormal number of crystals have a [100] direction parallel to the axis of the wire.

The normal theoretical relative intensities calculated from scattering data and the appropriate absorption and temperature factors are as follow :

Plane.	(111).	(200).	(220).
Cu wire : 0·104 in. diam.	1	0·601	0·979
0·047 ,,	1	0·583	0·949
0·024 ,,	1	0·556	0·913
Intensity measurements from powder spectrogram of unannealed copper filings (corrected to 0·047 in. diam.)	1	0·634	0·785

The blackening figures, corrected for difference in density and diameter, obtained from a casual powder spectrogram kindly loaned by Dr. A. J. Bradley, confirm the general order of the theoretical normal values given above for copper wire.

X-Ray Tests on Etched Wires.

As wires such as these are generally more "preferred" towards the core, we etched away the outer layer in 25 per cent. nitric acid, and obtained spectrograms from the new surface. Wire No. 2 was also given further successive heatings in paraffin until recrystallized. The results of intensity measurements for this specimen are reported in Table IV, the "blackening" column on the right being the one which best indicates the changes.

Table IV.—*Photometric Survey of X-Ray Spectrograms from Wire No. 2, Etched to* 0·047 *in. Diameter.*

Treatment.	Plane.	Photometric Curve.			Ratios.		
		Height.	Width.	Blackening.	Height.	Width.	Blackening.
(1) As drawn	(111) (200) (220)	0·264 0·456 1·236	0·049 0·055 0·064	2,700 5,015 16,970	1 1·730 4·675	1 1·120 1·304	1 1·858 6·285
(2) Annealed at 130° C. for 2 hrs. (L.T.T. hardening)	(111) (200) (220)	0·315 0·624 1·200	0·048 0·053 0·065	3,400 7,140 16,320	1 1·980 3·805	1 1·103 1·355	1 2·100 4·800
(3) Ditto, plus 170° C. for 2 hrs.	(111) (200) (220)	0·442 0·846 1·502	0·056 0·059 0·075	5,390 10,345 23,020	1 1·911 3·360	1 1·052 1·339	1 1·919 4·265
(4) Treatment (3), plus 205° C. for 2 hrs.	(111) (200) (220)	0·382 0·638 1·120	0·055 0·056 0·078	4,715 8,475 18,290	1 1·670 2·930	1 1·019 1·419	1 1·797 3·879
(5) Treatment (4), plus 280° C. for 2 hrs. (recrystallized)	(111) (200) (220)	0·620 0·666 0·958	0·062 0·070 0·080	8,555 9,515 15,220	1 1·172 1·543	1 1·128 1·290	1 1·112 1·779

L.T.T. at 130° C. has caused a relative increase in intensity of the (200) reflection by 13 per cent., whilst the (220) reflection has decreased by 24 per cent. The recrystallized wire still shows preferment.

Wires 3S and 4S (containing silver) yielded the results given in Table V after similar etching.

It is obvious that there is less preferred orientation in wire 4S than in No. 2 which is silver-free. Although No. 3S has been drawn to about the same tenacity as No. 2, it is only very slightly "preferred" in this present layer. Fig. 1 (Plate I) shows the difference after L.T.T. of the spectrograms of these two wires. Further etching of No. 3S gives

TABLE V.—*Wires 3S and 4S, Etched to* 0·047 *in. Diameter.*

	Photometric Curve.	As Drawn.			Annealed at 130° C. for 2 Hrs.		
		(111).	(200).	(220).	(111).	(200).	(220).
3S	Height . . .	720	480	912	842	564	980
	Width, cm. . .	0·050	0·053	0·063	0·050	0·055	0·063
	Blackening . .	7,565	5,420	1,142	8,910	6,655	13,280
	Relative height .	1	0·667	1·266	1	0·670	1·164
	,, width .	1	1·060	1·260	1	1·100	1·260
	,, blackening	1	0·716	1·509	1	0·747	1·491
4S	Height . . .	455	434	1,204	719	684	1,620
	Width, cm. . .	0·046	0·049	0·060	0·044	0·045	0·061
	Blackening . .	4,515	4,495	15,590	6,940	6,930	20,070
	Relative height .	1	0·954	2·646	1	0·951	2·253
	,, width .	1	1·065	1·364	1	1·023	1·386
	,, blackening	1	0·995	3·454	1	0·999	2·892

results in Table VI, indicating that the interior (and more severely displaced) metal is more highly preferred than the outside.

TABLE VI.—*Wire 3S, Etched to* 0·024 *in. Diameter.*

Photometric Curve.	As Drawn.			Annealed at 130° C. for 2 Hrs.		
	(111).	(200).	(220).	(111).	(200).	(220).
Height . . .	234	292	874	416	498	1,204
Width, cm. . .	0·078	0·078	0·080	0·063	0·070	0·080
Blackening . .	3,765	4,665	14,430	5,430	6,780	19,730
Relative height .	1	1·248	3,727	1	1·197	2·894
,, width .	1	1·000	1·026	1	1·111	1·270
,, blackening	1	1·239	3·833	1	1·248	3·634

The relative intensities for the various wires and layers are represented in Fig. 2. One difference between the silver-bearing and silver-free specimens is that as a result of L.T.T. the former show but a slight intensity increase for the (200) reflection. This is 0·4 per cent. for No. 4S, as compared with 13 per cent. for No. 2 (0·047 in. diameter).

CRYSTALLINE REORGANIZATION ON HEATING.

Using the normal theoretical relative intensities as a blank, and considering that the equatorial position of the (111) line has no intensity maximum (and may be said to represent unpreferred metal), a calculation can be made of the relative distribution of the crystals between the unpreferred and the *two* preferred positions which copper wire is known to assume.[3] One of these positions is responsible for the maximum on the (200) line, and both contribute to that on the (220). The results of such a calculation are represented in Fig. 3. The lengths of the lines with arrow-heads indicate the extent of the change-over in preferred orientation as a result of L.T.T. The percentage distribution of the crystals between the two preferred positions is given in Table VII.

As stated in the synopsis, this change-over in distribution appears to be associated with the L.T.T. hardening, and probably by giving a smaller number of crystals which are in a position for easy slip. Furthermore, the intensity rise of the (200) line due to L.T.T. is 4 per cent. for No. 3S (0·047 in. layer), but only 0·4 per cent. for No. 4S (0·047 in. layer), and 0·7 per cent. for No. 3S (0·024 in. layer). Within limits, therefore, heavier drawing or displacement gives less change-over to the [100] preferred position after L.T.T. This would be consistent

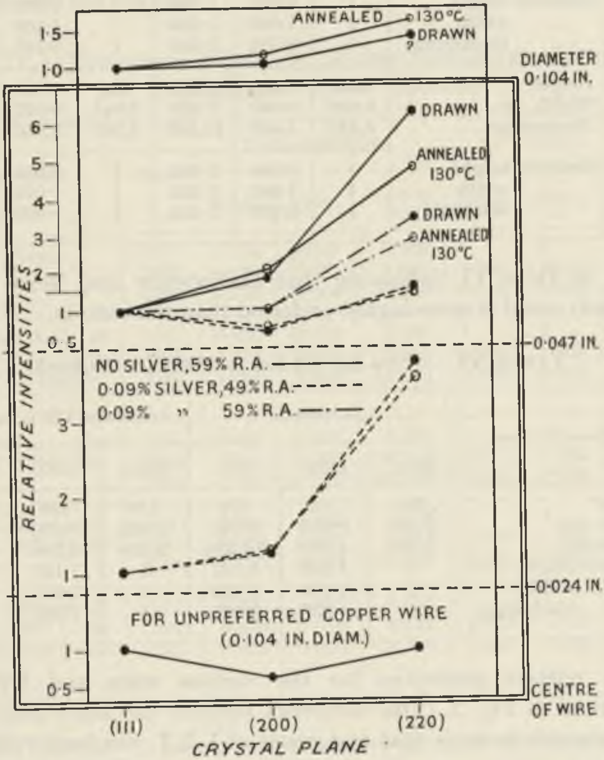

Fig. 2.—Diffraction Intensities for Copper Wire.

TABLE VII.—*Percentage Distribution of the "Preferred" Crystals Between the Two Positions.*

Specimen.			[100] Position.	[111] Position.
No. 2	(0·104 in.)	As drawn . .	100	0
		L.T.T. 130° C. .	100	0
	(0·047 in.)	As drawn . .	39	61
		L.T.T. 130° C. .	64	36
		,, 170° C. .	64	36
		,, 205° C. .	66	34
		,, 280° C. .	100	0
No. 3*S*	(0·047 in.)	As drawn . .	39	61
		L.T.T. 130° C. .	49	51
	(0·024 in.)	As drawn . .	38	62
		L.T.T. 130° C. .	42	58
No. 4*S*	(0·047 in.)	As drawn . .	27	73
		L.T.T. 130° C. .	35	65

with the finding of Alkins and Cartwright,[1] that heavily-drawn wires show practically no L.T.T. hardening.

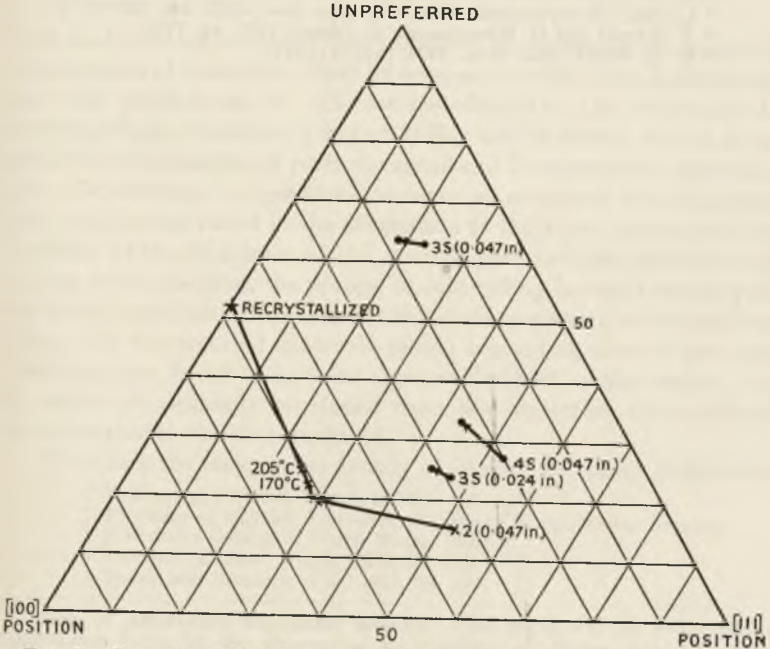

FIG. 3.—Percentage Distribution of Crystals. (The Arrow-Head shows the Condition reached after L.T.T. at 130° C.)

Removal of internal stress by heating should tend to cause a reduction in the width of a spectral line such as the (220). Conversely, the generation of colloidal-like new grains by heating should cause a broadening of the lines. The nett effect to be observed in our figures is a slight widening of the (220) line after heating the wires, the width values being measured at half the heights of the intensity peaks.

ACKNOWLEDGMENTS.

This work was carried out with the encouragement of Professor F. C. Thompson, D.Met., and with apparatus largely provided by financial grants from Messrs. Imperial Chemical Industries, Ltd. Professor W. L. Bragg, F.R.S., kindly gave the authors permission to use the microphotometer of his department, and they are indebted to Dr. A. J. Bradley and Dr. J. F. Keggin, for helpful discussions. One of the authors (G. S. F.) holds an Overseas Research Scholarship awarded by the Royal Commission for the Exhibition of 1851.

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CRYSTAL DENSITIES OF INDUSTRIAL BRASSES FROM X-RAY DATA.*

By PROFESSOR E. A. OWEN,† M.A., D.Sc., MEMBER, and LLEWELYN PICKUP,‡ M.Sc. (Lond.), Ph.D. (Wales).

SYNOPSIS.

Crystal density values have been obtained from X-ray data of copper–zinc alloys in thermal equilibrium, for compositions in the α-, $(\alpha + \beta)$, and β-regions. Whilst it is shown that the degree of porosity, cold-work, and grain-size have no effect on the results obtained, it is essential to take into account the heat-treatment given, when interpreting the values of alloys with duplex structures.

The relation between the composition of the pure α-phase and its density is not strictly linear, but both that of alloys in the pure β-region and that in the $(\alpha + \beta)$ region can be taken as linear to a high degree of accuracy. At the phase boundaries $(\alpha) - (\alpha + \beta)$ and $(\alpha + \beta) - (\beta)$ there are discontinuities in this relation.

Densities derived from X-ray data are considered to be nearer the true values than those obtained by any of the other methods hitherto employed, and hence, for copper–zinc alloys in true equilibrium the values obtained are the most reliable standards available for comparison purposes.

THE usefulness of a density determination to ascertain the degree of unsoundness of a sample of alloy by comparison with a standard sample, has been pointed out by different metallurgists. One object of the investigations of Bamford § and of Bailey and Genders ‖ was to determine the true densities of perfectly sound and homogeneous copper–zinc alloys of different compositions, to serve as standards of comparison. The main points raised in the discussions of these two papers were the question of the soundness of the samples used and the effect of cold-rolling on the density, the process of cold-rolling having been adopted by Bailey and Genders to close up any cavities present in the chill-cast alloy. It was reported that cold-rolling amounting to a 50 per cent. reduction was found to have no appreciable effect on the density, but it cannot be definitely concluded from this statement that perfectly sound material was thus produced.

To obtain the true crystal density of an alloy by means of the usual

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§ Bamford, *J. Inst. Metals*, 1921, **26**, 155.

‖ Bailey and Genders, *ibid.*, 1925, **33**, 191.

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

method of weighing in air and in water there appear four aspects of varying importance to consider, namely: (1) freedom from porosity and impurities; (2) true thermal equilibrium; (3) effect of cold-work; and (4) effect of grain-size. In addition, if comparisons are to be made for ascertaining porosity, the casting conditions of the standard adopted and the sample to be compared must be the same, as a perfectly sound chill-cast sample, because of its unstable constitution, will not give the true crystal density corresponding with its composition. For example, Bailey and Genders found traces of the β-phase in a chill-cast alloy containing 71 per cent. copper, whereas this composition is well within the pure α-region of the thermal equilibrium diagram.

Values of the true crystal density can be derived from X-ray data, and these are independent of the grain-size, the presence of porosity, and the amount of distorted (amorphous) metal in the sample photographed. Therefore, of the four aspects already mentioned, only the true thermal equilibrium need be considered. It has been shown by the good agreement of the authors' determinations of the phase boundaries of the copper–zinc system with those of other workers that the X-ray data which have been published elsewhere * can be taken as applying to these alloys in their condition of true thermal equilibrium, and hence these can be used to obtain true values of crystal density. In the present paper, crystal densities derived from these data are given, as it is possible that these results will be of interest for comparison with, and a supplement to, the density investigations of Bamford and of Bailey and Genders. By such a comparison, some indications of the order of change in density due to cold-work and to grain-size may be found, two features about which little definite knowledge seems available. Further, apart from these simplifications of the problem, a higher degree of accuracy is available with the X-ray method than with the usual density method.

METHOD OF CALCULATION.

Pure copper and the α-phase in the copper–zinc system have a face-centred cubic structure having four atoms to the unit cube; then, if a is the parameter value (in A.) of the lattice of an alloy containing N atomic per cent. copper, the crystal density is given by the expression; †

$$\rho_a = 0{\cdot}06596\{Nm_{\mathrm{Cu}} + (100 - N)m_{\mathrm{Zn}}\}/a^3 \text{ grm. per c.c.}$$

where m_{Cu} and m_{Zn} are the atomic weights of copper and zinc atoms, respectively (0 = 16).

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* Owen and Pickup, *Proc. Roy. Soc.*, 1932, [A], **137**, 397.

† For the purpose of calculation, the atomic weight of hydrogen is taken to be 1·0078, $m_{\mathrm{Cu}} = 63{\cdot}57$, $m_{\mathrm{Zn}} = 65{\cdot}38$, oxygen = 16, and the mass of the hydrogen atom = $1{\cdot}662 \times 10^{-24}$ grm.

The β-phase of this system has a body-centred cubic structure having two atoms to the unit cube, so with the same notation the crystal density of this phase is given by the expression :

$$\rho_\beta = 0{\cdot}03298\{Nm_{\mathrm{Cu}} + (100 - N)m_{\mathrm{Zn}}\}/a^3 \text{ grm. per c.c.}$$

Utilizing the values of N and a from the authors' previous work,* these formulæ have been used to obtain the crystal densities of the α- and the β-phases. In these pure phase regions, since the lattice is unsaturated, the temperature from which the sample is quenched has no effect on the parameter value provided that the composition remains unaltered and does not enter an adjacent mixed region at any temperature.

Table I contains the calculated densities of the α-phase at different compositions in the pure region and at its saturated compositions on the α-(α + β) boundary at different temperatures.

TABLE I.

	Parameter, A.	Copper, per Cent.		Calculated Density 18° C., grm./c.c.
		By Weight.	Atomic (N).	
Pure α-region . . .	$3{\cdot}607_8$	100	100	8·938
,, ,, . . .	$3{\cdot}629_1$	89·3	89·6	8·799
,, ,, . . .	$3{\cdot}657_6$	76·4	76·9	8·626
,, ,, . . .	$3{\cdot}673_2$	70·3	70·9	8·531
,, ,, . . .	$3{\cdot}692_9$	62·8	63·5	8·413
Boundary of α-region at 350° C.	$3{\cdot}694_2$	62·5	63·15	8·404
,, ,, ,, 400° C.	$3{\cdot}695_7$	61·9	62·55	8·396
,, ,, ,, 500° C.	$3{\cdot}696_0$	61·8	62·45	8·394
,, ,, ,, 600° C.	$3{\cdot}694_3$	62·5	63·15	8·404
,, ,, ,, 700° C.	$3{\cdot}690_5$	63·9	64·5	8·426
,, ,, ,, 800° C.	$3{\cdot}686_4$	65·4	66·0	8·443

These results are shown graphically in Fig. 1, where it is seen that the relation between crystal density and composition in weight per cent. copper is not strictly linear.

Table II gives the calculated crystal densities of alloys of different compositions in the pure β-phase region.

These results are plotted in Fig. 1, where the relation between density and composition can be taken as almost linear.

In the mixed regions, where both phases are saturated, the parameter value of each phase, and therefore the density, is a function of the temperature, and is independent of the composition within the region. This change of parameter value with temperature is brought about by the change in the saturated solubility of the phases with temperature;

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* *Loc. cit.*

so that an alloy with a fixed composition within this region has a crystal density depending on the temperature from which it has been quenched. For example, at a temperature $t°$ C., suppose the saturated compositions of the α- and the β-phases are at A and B per cent. copper, these are the α-$(\alpha + \beta)$ and $(\alpha + \beta)$-β boundaries at $t°$ C. Take an alloy containing p per cent. copper within this region, then the relative amounts of α- and β-phases present at the time of quenching are proportional to $(p - B)$ and $(A - p)$. If ρ_α and ρ_β are the crystal densities of the saturated α- and β-phases quenched from this temperature, then the density of an alloy of this composition quenched from $t°$ C. is given by the formula :

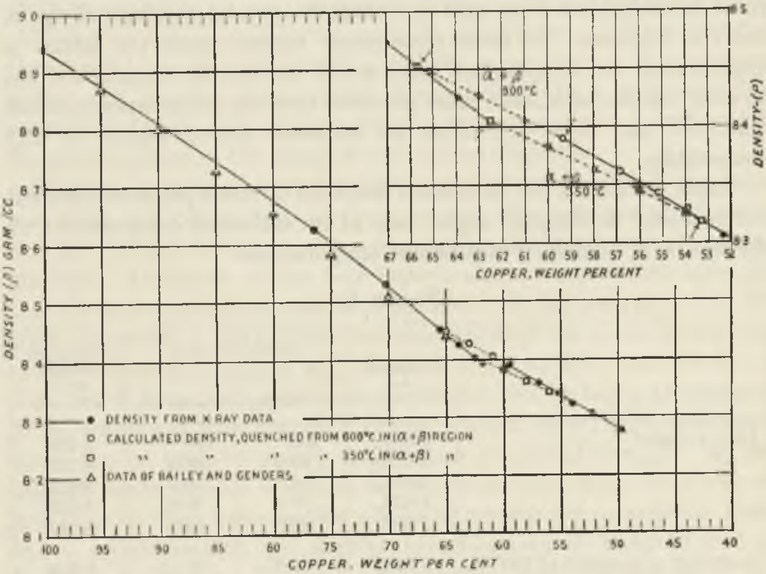

FIG. 1.

TABLE II.

Parameter (a), A.	Copper, per Cent.		Calculated Density 18° C., grm./c.c.
	By Weight.	Atomic (N).	
$2{\cdot}934_7$	59·4	60·1	8·389
$2{\cdot}938_8$	56·9	57·6	8·360
$2{\cdot}941_3$	55·2	55·9	8·343
$2{\cdot}943_8$	53·9	54·6	8·324
$2{\cdot}946_4$	52·3	53·0	8·306
$2{\cdot}950_5$	49·75	50·5	8·277

$$\rho_{\alpha\beta} = (A - B)/\left(\frac{p - B}{\rho_\alpha} + \frac{A - p}{\rho_\beta}\right) . \quad . \quad . \quad . \quad \text{(i)}$$

In Table III, values of A and B, with corresponding values of ρ_α and ρ_β from Fig 1, are collected for use with the above formula, which may be written for calculation purposes in the more convenient form,

TABLE III.

Temperature, t° C.	Boundary.*		$A - B$.	Density, grm./c.c.	
	$\alpha - (\alpha + \beta)$ (A).	$(\alpha + \beta) - \beta$ (B).		ρ_α (from Fig. 1).	ρ_β (from Fig. 1).
350	62·5	53·3	9·2	8·406	8·318
400	61·9	53·8	8·1	8·398	8·324
500	61·8	54·6	7·2	8·397	8·332
600	62·5	55·4	7·1	8·406	8·344
700	63·9	58·7	5·2	8·430	8·382
800	65·4	59·4	6·0	8·453	8·389

* See Owen and Pickup, *loc. cit.*

$$\frac{1}{\rho_{\alpha\beta}} = C - p \, . \, D \quad . \quad . \quad . \quad . \quad . \quad . \quad \text{(ii)}$$

where $C = \dfrac{A\rho_\alpha - B\rho_\beta}{\rho_\alpha\rho_\beta(A - B)}$ and $D = \dfrac{\rho_\alpha - \rho_\beta}{\rho_\alpha\rho_\beta(A - B)}$

The values of the constants C and D in formula (ii) for different values of t° C. are given in Table IV.

TABLE IV.

Temperature, t° C.	C.	D.
350	0·12750	0·00013680
400	0·12718	0·00013069
500	0·12705	0·00012904
600	0·12673	0·00012400
700	0·12699	0·00013064
800	0·12814	0·00015042

In order to ascertain the change in density produced in an $(\alpha + \beta)$ alloy of fixed composition when quenched from different temperatures, formula (ii) with Table IV have been used. The densities of alloys with compositions 60, 58, 56, and 54 per cent. copper, which remain in the mixed regions at the quenching temperature are contained in Table V.

The densities of the alloys containing 60, 58, and 56 per cent. copper have been plotted in Fig. 2 against the quenching temperature. The form of each curve is similar, showing a minimum density in the temperature range 400°–500° C. The last two alloys pass, at the higher temperatures, into the pure β-region, where the density is constant. Fig. 2

TABLE V.

Quenching Temperature, t° C.	Crystal Densities of Alloys in ($\alpha + \beta$) Region.			
	Copper, per Cent. by Weight.			
	60.	58.	56.	54.
350	8·382	8·363	$8{\cdot}344_5$	8·326
400	8·379	8·361	8·343	8·325
500	$8{\cdot}381_5$	8·363	8·346	...
600	8·385	8·368	8·350	...
700	8·393	...	...	...
800	8·396	...	...	...

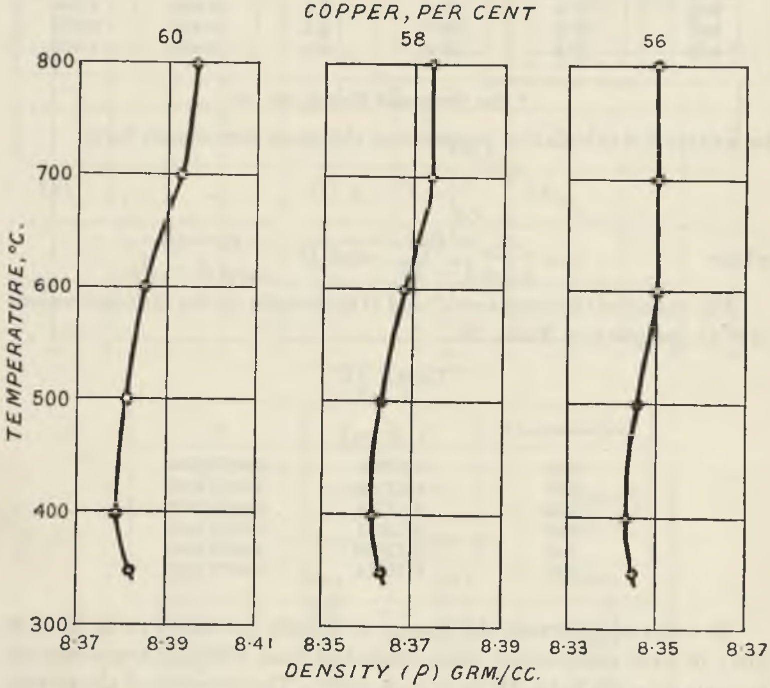

FIG. 2.

shows clearly that alloys with compositions in a mixed region can have density values which depend on the temperature from which they have been quenched. If an alloy is allowed to cool from an annealing temperature, the density value may vary considerably, depending on the rate of cooling. Such considerations as these lead the authors to emphasize that the precise heat-treatment of a sample with a composition in the mixed region should accompany the determined value of its density. As already mentioned, this precaution is not of such importance for alloys in the pure regions, provided that the heat-treatment is sufficient to bring about the true thermal equilibrium. As a consequence of these observations, since lump samples often require considerable periods of annealing to produce, throughout their entire mass, the state of true thermal equilibrium, density values on such samples obtained by the usual method must be interpreted with caution. In a paper * on copper–cadmium alloys, the authors have investigated the effects of different annealing heat-treatments in producing the true stable equilibrium, and have concluded that this state can be most expeditiously attained when the alloy is in the form of powder or fine filings; therefore, the values of the crystal densities of alloys in the $(\alpha + \beta)$ region, calculated by means of formula (ii) and Table IV, are probably nearer the true values than those obtained with lump samples by the direct method. In Fig. 1, the density of alloys in the $(\alpha + \beta)$ region and the neighbouring α- and β-pure regions, which have been quenched from 350° C. and from 800° C., are plotted against the composition in weight per cent. copper.

Fig. 1 shows the relation between the density and composition from 100 to 50 per cent. copper. In the range of composition between 67 and 55 per cent. copper, there is a variable range of densities depending on the heat-treatment. Similar phenomena are shown in the completed curve of Bailey and Genders, and their explanation is fundamentally that given in the present work.

According to Fig. 2, when an alloy consisting entirely of β-phase above a certain temperature, breaks up into α- and β-phases on cooling, there is a decrease in the density. This observation confirms that of Bailey and Genders. They also state that "a pure β alloy (52 per cent. copper) showed no appreciable change in density, whether quenched in water from 700° C. or slowly cooled to 300° C. at a rate of 10° C. per minute." From the authors' observations, no change in density is to be expected in any pure phase at whatever rate the sample is quenched or cooled, provided that the lattice structure remains unaltered.

The data given by Bailey and Genders, from which they deduce the production of porosity by a constitutional change $(\beta \longrightarrow \alpha)$ during the annealing treatment at 500° C. to produce equilibrium, are interesting. Referring, however, to their data on alloy 65·2 per cent. copper, the annealing at 500° C. after quenching and rolling gives a low density value, which can also be explained by the presence of cavities, which have only been diminished in volume, and not eliminated by the cold-

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* Owen and Pickup, *Proc. Roy. Soc.*, 1933, [A], **139**, 526.

working. There appears to be some support to this conclusion from a comparison of the densities at different compositions, obtained by these authors, and those calculated from the present X-ray data, the X-ray densities being slightly higher in alloys in which the constitutional change ($\beta \longrightarrow \alpha$) cannot take place (see Fig. 1).

The densities obtained from X-ray data for alloys in equilibrium in the pure α-region are shown in Table VI, and are the densities which the authors consider should be used for standards of comparison. In the case of alloys with compositions in the ($\alpha + \beta$) region the heat-treatment given must be carefully specified, as the densities of alloys in mixed regions are found to depend on the heat-treatment to which the alloys are subjected.

TABLE VI.

Copper, per Cent.	Density from X-Ray Data, grm./c.c. at 18°C.
100	8·938
95	8·876
90	8·812
85	8·747
80	8·677
75	8·604
70	8·528
65	8·448

After comparing the present authors' density values with those of Bailey and Genders, it is concluded that the effects of cold-work and of grain-size on the density must be small, in comparison with the effect due to unsoundness.

CONCLUSION.

To obtain accurate values of the density of perfectly sound alloys by the usual method of weighing in air and in water, involves considerable experimental difficulties, the greatest of which appears to be the elimination of any unsoundness or porosity which may be present.

The values obtained from X-ray data are the crystal densities, and are probably nearer to the true densities than those obtained by other methods, in which difficulties arise due to porosity, cold-work, grain-size, and also heat-treatment in the case of alloys with duplex structures.

The densities of alloys consisting of a single phase are not affected by heat-treatment when in true equilibrium, whilst alloys consisting of a duplex structure can give a range of values depending on the heat-treatment which they have received.

The effects of cold-work and of grain-size on the density are small, but at present few quantitative data are available.

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METALLURGICAL ABSTRACTS

(GENERAL AND NON-FERROUS)

Volume 1 JUNE 1934 Part 6

I.—PROPERTIES OF METALS

(Continued from pp. 225–230.)

***Change in Properties of Deformed Polycrystalline [Aluminium] During Recovery [Erholung].** M. O. Kornfeld (*Zhurnal eksperimentalnoy i teoreticheskoy Fiziki* (*Journal of Experimental and Theoretical Physics*), 1933, **3,** (6), 563–566).—[In Russian.] Annealing of deformed polycrystalline aluminium in the region of " pure recovery " does not restore the original properties. The processes which take place during recovery lead to a highly stable condition characterized by a yield-point higher than that of the original material due to the residual distortion of the lattice after recovery. Laue photograms indicate that during recovery there is no noticeable shift in the boundaries between grains. It may therefore be concluded that any change in properties during recovery is determined mainly by processes taking place within the grain.—N. A.

***On the Question of the Allotropic Transition of Bismuth at 75° C.** Shin 'Ichi Aoyama and Gohei Monna (*Sci. Rep. Tôhoku Imp. Univ.*, 1934, [i], **23,** 52–61 [in English]; and *Kinzoku no Kenkyu*, 1934, **11,** 203–209 [in Japanese]).—Investigations by means of thermal analysis, thermal expansion, thermoelectromotive force, and oil dilatometry, indicate that the alleged allotropic transition of bismuth at 75° C. does not exist.—E. S. H.

Preparation and Properties of Cadmium. Edmund T. Richards (*Metallbörse*, 1934, **24,** 242–243).—A review.—A. R. P.

***The Electrolytic Valve Action of Columbium and Tantalum on A.C. Circuits.** D. F. Calhane and A. J. Laliberte (*Electrochem. Soc. Preprint*, **1934,** (April), 287–293).—Oscillograph records are given showing the film behaviour of tantalum and columbium in dilute sulphuric acid on a.c. circuits. Tantalum gives fairly efficient rectification, but columbium is efficient only just after immersion in the acid; even at only 2·5 v. the efficiency rapidly falls almost to zero, but rises again to the original value after washing and re-immersion in the acid. Peculiarities in the oscillograph curves are discussed.—A. R. P.

†Copper and Oxygen. L. L. Wyman (*Gen. Elect. Rev.*, 1934, **37,** 120–129).—Following a brief description of the ordinary process for refining copper, the production of deoxidized and oxygen-free copper is discussed. Previously unpublished data by Skowronski on the effect of added metals on the conductivity of copper are given. The behaviour of various types of copper when heated in a reducing atmosphere is discussed. Deoxidized coppers react in different degrees to an oxidation–reduction cycle. Copper deoxidized with calcium boride and to which an excess of silicon has been added is not embrittled by an oxidation–reduction cycle. A number of commercial applications of the various forms of copper are discussed.—S. V. W.

***Volatilization of Silica and Copper in Steam.** J. Gillis (*Natuurwetensch. Tijds.*, 1933, **15,** 153–154; *Brit. Chem. Abs.*, **1933,** [A], 1245).—Copper cylinders weighing 20 grm. lost about 50 mg. in steam at 300 atm. after 3 days.—S. G.

***Change of the Resistance of Single Crystals of Gallium in a Magnetic Field.** W. J. de Haas and J. W. Blom (*Physica*, 1933, **1,** 134–144; *Brit. Chem. Abs.*, **1934,** [A], 135).—The resistance of a single gallium crystal at 10°–20° abs. and

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* Denotes a paper describing the results of original research.

† Denotes a first-class critical review.

in a magnetic field of 5000–22,000 gauss shows similar behaviour to that of a single bismuth crystal. The curve of relative change in resistance against inclination of the field to the axis of the crystal is almost sinoidal at low field strengths. The results are in agreement with the rhombic crystal structure of gallium.—S. G.

***Supplement to the Paper : " Atomic Heats, Heats of Fusion, and Heats of Transformation of Gallium, Indium, and Thallium."** W. A. Roth, Ingrid Meyer, and H. Zeumer (*Z. anorg. Chem.*, 1934, **216**, 303–304).—Cf. *J. Inst. Metals*, 1933, **53**, 690. The latent heats of fusion of gallium and thallium are now given as 19·16 ± 0·01 and $5{\cdot}04_0 \pm 0{\cdot}01_2$ grm.-cal./grm., respectively. The heat of transformation of thallium is 0·40 ± 0·01 grm.-cal./grm. —M. H.

The Vibration Strength of Lead. Wilhelm Stockmeyer (*Z. Metallkunde*, 1934, **26**, 93).—By bending backwards and forwards lead tubes connected with a water pipe until a leak occurred, it has been shown that the resistance to bending deformation of tubes of lead containing 1% antimony is nearly twice as great as that of soft lead tubes.—M. H.

***Thermoelectric Powers of Nickel and Nickel–Chromium Alloys Near the Curie Point.** A. W. Foster (*Proc. Leeds Phil. Soc.*, 1933, **2**, 401–405; *Brit. Chem. Abs.*, **1933**, [A], 559).—The thermoelectric powers of nickel (99·5%) and nickel–chromium alloys (nickel 98·5, chromium 1%, and nickel 97·5, chromium 2%) have been measured against copper. The change in the specific heat of electrons at the Curie point is lowered very rapidly by the addition of chromium. —S. G.

Change of the [Electrical] Resistance of Nickel Wire Under Tension at Various Temperatures. S. Arzybaschew and V. Jushakow (*Z. Physik*, 1933, **86**, 521–522).—Experiments with *pure* nickel under tension at various temperatures between − 190° and 350° C. confirm results previously obtained with comparatively *impure* nickel (*ibid.*, 1930, **64**, 405).—J. S. G. T.

***On the Sorption of Hydrogen by Reduced Nickel. I.—Determination of the Quantities of the Hydrogen Adsorbed by and Diffused in Pure and Spoiled Reduced Nickel, and Determination of the Isothermal Adsorption Lines and the Heat of Adsorption.** Shun-Ichiro Iijima (*Sci. Papers Inst. Phys. Chem. Res. Tokyo*, No. **468**, 1933, 285–300).—W. H.-R.

***On the Sorption of Hydrogen by Reduced Nickel. II.—Adsorption of Hydrogen by Reduced Nickel at Low Temperatures.** Shun-Ichiro Iijima (*Sci. Papers Inst. Phys. Chem. Res. Tokyo*, No. **474**, 1933, 34–43).—W. H.-R.

***On the Sorption of Hydrogen by Reduced Nickel. III.—Heat-Treatment of Reduced Nickel and Its Relation to the Sorption Velocity and to the Quantity of Hydrogen Sorbed.** Shun-Ichiro Iijima (*Sci. Papers Inst. Phys. Chem. Res. Tokyo*, No. **481**, 1934, 164–172).—W. H.-R.

Preparation of Metallic Praseodymium. G. Canneri and A. Rossi (*Gazz. chim. ital.*, 1932, **62**, 1160–1163; *Brit. Chem. Abs.*, **1933**, [A], 360).—A maximum yield of praseodymium was obtained by the electrolysis of a fused mixture (melting point 535° C.) of 55% $PrCl_3$, 27% NaCl, and 18% KCl, using a tungsten cathode and Acheson graphite anode. The temperature must be kept $<$ 600° C. to avoid polarization and formation of PrO_2. The praseodymium contains $<$ 0·2% of other rare-earth metals and only traces of silicon and carbon. Its density is 6·765 ± 0·008, and melting point 932° ± 2° C.—S. G.

The Magnetic Nuclear Moment of Rubidium Isotopes. D. A. Jackson (*Z. Physik*, 1933, **86**, 131).—J. confirms results obtained by Kopfermann (*ibid.*, 1933, **83**, 417), *viz.* that the nuclear spin moments of the rubidium isotopes are respectively Rb 85, 5/2,; Rb 87, 3/2.—J. S. G. T.

***Preparation of Ductile Tantalum by Thermal Dissociation of Tantalum Pentachloride.** W. G. Burgers and J. C. M. Basart (*Z. anorg. Chem.*, 1934, **216**, 223–227).—Ductile tantalum can be prepared by thermal dissociation of its chloride on a glowing nuclear wire if foreign gases are rigorously excluded. The lattice of tantalum has $a = 3{\cdot}296 \pm 0{\cdot}000_5$ A., the specific electrical resistance is $10^4\rho_0 = 0{\cdot}124\ \Omega$ cm., and the temperature coefficient of the electrical resistance : $10^5\,\alpha = 364$. Niobium prepared by thermal dissociation of the pentachloride has a lattice with $a = 3{\cdot}294 \pm 0{\cdot}001$ A.—M. H.

***Specific Heat of Thallium at Liquid Helium Temperatures.** W. H. Keesom and J. A. Kok (*Physica*, 1934, **1**, 175–181; *Brit. Chem. Abs.*, **1934**, [A], 246).—Measurements have been made from 1·3° to 4·2° abs. The atomic heat falls from 0·01325 to 0·01177 at the transition point. No latent heat was observed at this point.—S. G.

New Determination of the Half-Period Life of Thorium. Hans Fesefeldt (*Z. Physik*, 1933, **86**, 605–610).—The total number of α-particles emitted per second from 1 grm. of thorium is found to be $4{\cdot}7 \times 10^3$. This result agrees with that obtained by Geiger and Rutherford. The corresponding half-period life of thorium is $1{\cdot}3 \times 10^{10}$ years.—J. S. G. T.

***The Adsorption of Hydrogen on Tungsten.** J. K. Roberts (*Proc. Camb. Phil. Soc.*, 1934, **30**, 74–79).—Saturation occurs when the partial pressure of hydrogen is less than 4×10^{-4} mm.—E. S. H.

On the Cause of the " Hardness " of Electrolytic Zinc. A. A. Botchvar and A. J. Uljanow (*Zvetnye Metally* (*The Non-Ferrous Metals*), 1932, **7**, 33–36; *Chem. Zentr.*, 1934, **105**, I, 2343).—The hardness of zinc does not primarily depend on the thermal treatment, since the presence of iron has a profound effect on the recrystallization process, as little as 0·2% preventing it entirely. The hardness is unaffected by 0·2% lead, but 0·1–0·2% cadmium increases it appreciably. In making zinc sheets of uniform hardness strict control of the iron content is essential.—A. R. P.

***The Effect on the Density of Zinc of Deformation by Cold- and Hot-Rolling.** O. Bauer and P. Zunker (*Mitt. Material., Sonderheft* **24**, 1934, 93–98).—See *J. Inst. Metals*, 1933, **53**, 612–613.—J. W.

Composition of Zinc for Polygraphic Zinc Type Plates. M. D. Zudin (*Zvetnye Metally* (*The Non-Ferrous Metals*), **1933**, (1), 100–103; *C. Abs.*, 1934, **28**, 1966).—[In Russian.] Compositions of Russian and imported zinc for type plates are given. Hardness and fine grain are obtained by adding small amounts of cadmium (up to 0·5%). Melting in an induction furnace is recommended.—S. G.

***Superconductivity of Zinc.** W. H. Keesom (*Physica*, 1933, **1**, 123–127; *Brit. Chem. Abs.*, **1934**, [A], 135).—Zinc becomes superconducting at 0·79° abs. Cadmium and gold are not superconducting at 0·73° abs., or platinum at 0·77° abs. Phosphor–bronze is not superconducting at 0·75° abs., so copper is probably not superconductive at that temperature.—S. G.

***The Question of the [Possible] Radioactivity of Zinc.** Hans Fesefeldt (*Z. Physik*, 1933, **86**, 611–614).—F. finds that the α-radiation observed from pure zinc is of the order of $\frac{1}{10}$th of that obtained by Ziegert, using zinc residues. —J. S. G. T.

Production of Single Crystals with Prescribed Axial Orientation. P. A. Palibin and A. I. Froiman (*Z. Krist.*, 1933, **85**, 322–325; *Brit. Chem. Abs.*, **1933**, [A], 665).—A method for obtaining crystals of, for example, zinc or cadmium with the hexagonal axis parallel to their length is described.—S. G.

***The Condition Determining Flow of Crystals.** W. Boas and E. Schmid (*Z. Physik*, 1933, **86**, 828–830).—The question whether incidence of flow in strained crystals is conditioned by the attainment of a constant shear stress (*Schubspannung*) or a constant elastic slip (*Schiebung*) in the translation system is answered in favour of the former hypothesis.—J. S. G. T.

The Effect of Cold-Work on Metals. Gustav Tammann (*Forschungen u. Fortschritte*, 1934, **10**, 128–129).—A summary of T.'s work on the cold-working and recovery of metals from a theoretical point of view.—J. W.

***The Influence of Prior Stress on Fatigue Strength.** P. Ludwik and J. Krystof (*Anz. Akad. Wiss. Wien*, 1933, **70**, 51–52).—Using steel, high-grade cast iron, and non-ferrous test-pieces, the relations between initial stress, alternating stress, and fatigue above and before the plastic limit have been determined. For stresses below the torsion and tensile limits, the fatigue strength in torsion was $\tau_0 = \tau_w + x_t\tau_v$ and in bending $\sigma_0 = \sigma_w + x_b\sigma_v$ where τ_w and σ_w are respectively the strength under alternating loads in torsion and bending, and x_t and x_b are respectively coefficients independent of the magnitude of the prior stress. The effect of corroding influences has been studied. —W. A. C. N.

Nature of "Yield-Value." G. W. S. Blair (*Physics*, 1933, **4**, 113–118; *Sci. Abs.*, 1933, [B], **36**, 327).—The flow of materials at stresses far below their normal yield-values is discussed, and B. points out that the sharpness with which yield-values can be measured depends on the grouping of the relaxation times for the different strains set up within the material, an uneven distribution making for a sharper definition. Any sharp and drastic change in the relaxation time of the system as a whole may justifiably be said to constitute a yield-value, the question as to which of these points is actually taken as *the* yield-value depending on the conditions of the experiment. The results (to date) are discussed of certain experiments on flour doughs, which it is claimed are peculiarly suitable material for such investigations. A new rapid method, recently described, for studying flow in flour doughs is discussed. The dangers of classifying materials in hard-and-fast rheological divisions is emphasized; for practical purposes, however, and given adequate safeguards, such classifications may be extremely useful.—S. G.

***Studies on the Transformation of Metals by Secondary Electron Emission.** Kazuma Hayakawa (*Sci. Rep. Tôhoku Imp. Univ.*, 1934, [i], **22**, 934–958).—[In English.] Methods have been devised for studying phase transformations in metals by (*a*) measuring the secondary electron emission excited by the thermoionic current at various temperatures and (*b*) measuring the ionisation current at various temperatures. Changes have been observed in the range of magnetic transformation in the case of nickel, cobalt, and iron–nickel alloys.—E. S. H.

***Investigations Relating to Metallic Films.** H. Zahn and J. Kramer (*Z. Physik*, 1933, **86**, 413–420).—Electrolytically deposited antimony and platinum are shown to be transformed into the crystalline state by being heated above a definite transformation temperature—222° C. in the case of platinum, 160° C. in the case of antimony—which is characteristic of the metal irrespective of its mode of production. Very thin metal films are shown to be necessarily amorphous to some extent.—J. S. G. T.

***The Optical Properties of Metals.** N. F. Mott (*Proc. Camb. Phil. Soc.*, 1934, **30**, 249–270).—A discussion on theoretical lines.—E. S. H.

Electrical Properties of Metals and Wave Mechanics. L. Brillouin (*Rev. gén. Élect.*, 1933, **34**, 163–175, 202–208; *Sci. Abs.*, 1933, [B], **36**, 615).—A non-technical account is given of the modern theory of the conduction of electricity in metals, based on the conception that electrons are physically "waves" which are transmitted through the crystal lattice formed by the metal. Hartree's theory of "self-consistent" field for dealing with this problem is explained, as well as the use which is made of the Fermi–Dirac statistics. The subjects of thermoelectric emission of electrons from hot metals, of thermal agitation, of magnetism, and of superconductivity are dealt with in detail. —S. G.

***On the Theory of Liquid Metals.** S. Shubin (*Zhurnal eksperimentalnoy i teoreticheskoy Fiziki* (*Journal of Experimental and Theoretical Physics*), 1933, **3**, (6), 461–474).—[In Russian.] A number of points in connection with the theory of conductance electrons in liquid metals are examined. In particular, the question of the movement of electrons in the field of an almost uniform, non-periodic potential is considered in detail: it is shown that these electrons possess all the properties characteristic of the "almost free" electron. The behaviour of such an electron in constant and alternating fields was investigated. The relation between the conductance electrons and the thermal motion of ions was examined: if thermal motion of liquid ions be regarded as small oscillations round the point of stable equilibrium, then (in spite of the irregularity of the distribution of the centres of oscillation) we would have had the usual relation of the form $R = AT$ for the specific resistance at high temperatures. The resistance of liquid metals includes the rest part independent of temperature, which is explained by the large number of isoenergetic conditions of the liquid which render impossible the processes of direct distribution of the electrons among the ions.—N. A.

Change in the Electrical Conductivity of a Metal Foil Dependent on Its Electric Charge. G. Polvani (*Nuovo cimento*, 1932, **9**, 69–71).—S. G.

Some Measurements of Contact Resistances at Low Temperatures. R. Holm and W. Meissner (*Z. Physik*, 1933, **86**, 787–791).—Measurements of the contact-resistances between gold–gold, copper–copper, and nickel–nickel surfaces at room temperature and at 20° abs. indicate the presence at the contact of a transition layer having an electrical resistance of the order 10^{-9} ohm/cm.^{2} of contact surface in the cases of gold and copper, and 50×10^{-9} ohm/cm.^{2} in the case of nickel, these values being practically independent of the temperature. These transition resistances obey Ohm's law over a considerable range of e.m.f.—J. S. G. T.

A New Effect at the Commencement of Superconductivity. W. Meissner and R. Ochsenfeld (*Naturwiss.*, 1933, **21**, 787–788).—When a cylindrical lead or tin rod is brought into a homogeneous magnetic field perpendicular to its axis, the changes in distribution of the lines of force in the neighbourhood of the rod, on cooling below the spring point, follow those which would occur in the permeability o and the diamagnetic susceptibility $-1/4\pi$. In the inside of a long lead tube, in spite of this effect around the tube, the magnetic field remains practically unchanged when the spring point is passed. These results can probably be represented by the development of micro- or macroscopic currents in the superconductor on the assumption of a permeability of 1 in the current-free parts. These currents change or develop spontaneously when the metal becomes a superconductor.—J. W.

***Magnetic Permeability of Ferromagnetic Metals at Very High Frequencies.** G. Potapenko and R. Sanger (*Naturwiss.*, 1933, **21**, 818–819).—The permeability of iron, nickel, and cobalt decreases rapidly with increasing frequency, probably owing to some relationship between the surface layer of ferromagnetic conductors and a magnetic secondary structure.—J. W.

Magnetism of the Metals. E. Vogt (*Ergebn. exakt. Naturwiss.*, 1932, **11**, 323–351; *Brit. Chem. Abs.*, **1933**, [A], 342).—A discussion of the magnetic properties of metals in relation to the quantum states of the atoms in the crystal lattice.—S. G.

***The Change of Magnetic Susceptibility in Metals and Alloys Caused by Internal Stress.** Yosomatsu Shimizu (*Sci. Rep. Tôhoku Imp. Univ.*, 1933, [i], **22**, 915–933 [in English]; and *Kinzoku no Kenkyu*, 1934, **11**, 159–174 [in Japanese]).—Cf. *Met. Abs.*, this volume, p. 3. The paramagnetic susceptibility of metals and alloys decreases, whilst the diamagnetic susceptibility increases numerically with increasing degree of residual internal stress. The susceptibility of a homogeneous platinum–gold alloy, containing 30 atomic-% of platinum, is changed from paramagnetic to diamagnetic by cold-working. A theory is proposed in explanation of these results.—E. S. H.

***Electron Interference at Mechanically-Worked Surfaces.** H. Raether (*Z. Physik*, 1933, **86**, 82–104).—The effects of scratching, rubbing emery, polishing, pressing, and hammering on metallic and non-metallic surfaces are investigated in considerable detail by means of electron interference.—J. S. G. T.

The Positive Electron. Paul Langevin (*Bull. Soc. franç. Élect.*, 1934, [v], **4**, 335).—The experimental and theoretical considerations underlying modern conceptions of atomic structure are reviewed. L. emphasizes that in certain important instances, notably on the questions of magnetic spin, and of the existence of the positive electron, experimental verification has followed deductions made by Dirac and others on purely theoretical grounds. Certain problems of transmutation are considered in the light of recent work by Irène Curie and Joliot on the bombardment of aluminium, magnesium, and boron by α-rays, and some phenomena are predicted which await verification. —P. M. C. R.

***A Note on the Theory of the Photoelectric Current Across a Metal Semi-Conductor Contact.** R. H. Fowler (*Proc. Camb. Phil. Soc.*, 1934, **30**, 55–58).—Theoretical.—E. S. H.

Report of the Physikalisch-Technische Reichsanstalt for 1933. Anon. (*Physikal. Z.*, 1934, **35**, 217–248).—The annual report is briefly reviewed. Amongst matters which receive notice are the following: resistance and superconduction of various metals and alloys; chemical and physical properties of rhenium; purification of masurium; preparation of extremely pure samples of aluminium, iron, zinc, niobium, tantalum, platinum, iridium, and gold; change of length of Invar wires due to flaws; elastic constants of aluminium and magnesium single crystals; heats of transformation of cobalt and iron; magnetic transformations exhibited by nickel and alloys of this metal with copper, chromium, silicon, tungsten, aluminium, cobalt, iron, and of iron with chromium; use of iron–chromium alloys for the construction of resistances; magnetostriction; effect of composition and heat-treatment on the hysteresis of ferromagnetic metals and alloys; resistance thermometers of lead and gold; capillary constants of gold; adiabatic metallic calorimeter for high temperatures; thermal conductivity of metals.—J. S. G. T.

II.—PROPERTIES OF ALLOYS

(Continued from pp. 231–237.)

***Equilibrium Diagram of the System Aluminium–Copper–Manganese.** Hachie Sawamoto (*Suiyokwai-shi*, 1933, **8**, 239–244; *C. Abs.*, 1933, **28**, 2254).—[In Japanese.] The constitution of the aluminium-rich aluminium–copper–manganese alloys containing up to 40% copper and 30% manganese was investigated by means of differential thermal analysis and microscopic examination. A peritectic–eutectic reaction liquid + $Al_5Mn \rightleftharpoons Al_3Mn$ + (Al) occurred at 630° C. and at the composition copper 8·3, manganese 1·75, and aluminium 89·95%, and a ternary eutectic reaction liquid $\rightleftharpoons CuAl_2 + Al_3Mn$ + (Al) took place at 544° C., the composition being copper 30·5, manganese 0·65, and aluminium 68·85%.—S. G.

***Investigations of the Transformations in the Solid State in Magnesium–Silicon–Aluminium Alloys.** A. A. Botchvar, K. W. Gorew, and A. M. Korolkow (*Metallurg* (*The Metallurgist*), 1932, **8**, (1), 7–20; *Chem. Zentr.*, 1934, **105**, **I**, 1931).—[In Russian.] The equilibria in the ternary system up to 2% silicon and 3% magnesium have been determined. The solid solubility of silicon and Mg_2Si in aluminium is decreased by excess of either constituent, contrary to the statement of Hanson and Gayler (*J. Inst. Metals*, 1921, **26**, 321–359) that excess of silicon increases the solid solubility of Mg_2Si. B., G., and K. also find that excess of magnesium has a greater depressing effect on the solid solubility of Mg_2Si in aluminium than stated by H. and G. From the changes in hardness on heat-treatment of Aldrey with 0·2–0·4% iron it is shown that an excess of silicon increases the effect of heat-treatment, but has no effect in iron-free

Aldrey, except to retard somewhat the ageing; this difference is attributed to the formation of FeSi, so that an excess of silicon is necessary to get the full effect due to Mg_2Si.—A. R. P.

***The Transformations in Solid Alloys of Aluminium with up to 30% Zinc and 12% Magnesium.** A. A. Botchvar and M. O. Kuznetzov (*Metallurg* (*The Metallurgist*), 1933, **8**, (2), 7–14; *Chem. Zentr.*, 1934, **105**, I, 2345).—[In Russian.] The solubility isotherms of the ternary system magnesium–zinc–aluminium have been determined at 200°, 400°, and 450° C. by micro-analysis of specimens quenched in water after prolonged annealing. The solubility of $MgZn_2$ is a maximum of 16–17%, whereas Sander and Meissner found 25%. The phases in equilibrium with the ternary γ-solid solution could not be ascertained by the method employed.—A. R. P.

***The Influence of Heat-Treatment with Age-Hardening and Prolonged Storage on the Properties of an Aluminium Alloy.** W. Schwinning and E. Dorgerloh (*Z. Metallkunde*, 1934, **26**, 91–92).—The influence of the quenching temperature (460°, 490°, 530° C.) and ageing temperature (8 hrs. at 120°, 145°, 160°, 175° C.) on the tensile properties, endurance, vibration strength (rotating bending), and electrical conductivity of 3 mm. conductor wires of an aluminium alloy containing magnesium (composition not stated) has been investigated. Results are shown in tables and graphs. Quenching at 490° ± 10° C. proved to be best; with a lower quenching temperature the yield-point, tensile strength, and endurance strength decrease and the conductivity only slightly increases. Quenching at 530 ± 10° C. has practically no advantage in any respect. To obtain good mechanical properties the lowest ageing temperature should be selected consonant with the production of the desired electrical conductivity. In wires quenched at 490° C., tempered at 160° C. for 8 hrs. and stored at room-temperature the endurance strength increases from 10 to 11·5 kg./mm.^{2}, during 7 months, while the tensile properties remain unchanged, but after 2 years, the endurance strength decreases again to 10 kg./mm.^{2}, while the yield-point and tensile strength slightly decrease and the elongation and reduction of area slightly increase.—M. H.

Progress in Light Metal Castings for High Stresses. G. Sachs (*Z.V.d.I.*, 1933, **77**, 115–120; *Sci. Abs.*, 1933, [B], **36**, 327).—Cf. *J. Inst. Metals*, 1933, **53**, 294. A description of some improved alloys of the surface-hardened aluminium–silicon type which are likely to be of use in petrol and Diesel engines. Addition of copper to aluminium–silicon alloys increases the fatigue strength, while addition of magnesium coupled with suitable heat-treatment improves the mechanical properties generally.—S. G.

The Aluminium–Silicon Alloys. Maurice Déribéré (*Technique Automobile et Aérienne*, 1934, **25**, (164), 7–13).—A review of the constitution, microstructure, preparation, uses, and properties of these alloys. The mechanical properties of the 5% sand- and chill-cast alloy are tabulated. Apart from certain high-silicon alloys (18–20% silicon), Alpax is far the most important binary alloy, and its mechanical and physical properties are fully considered. Ternary and other derivatives of Alpax include Birmasil (nickel 2–3·5%), and Lo-Ex (silicon 13–14, nickel 2, copper 1, magnesium 1%). Commercial alloys of higher silicon content include the KS series, Supra-Kolben, Alusil, Supra-Alu S.S., and Alsia; properties and analyses are given in most cases. Duralumin is fully described, with a table of mechanical properties corresponding with 7 commercial treatments: other alloys especially noticed, with details of analysis and mechanical properties, are Almasilium (Anticorodal), the L.M. series, the "R.R." (Hiduminium) alloys, the KS anti-corrosion alloys, a copper–silicon die-casting alloy, Almelec, and Aldrey. Analyses only are given for Feralsit, Silical, silico–mangano–aluminium, Mansical, Alsimin. A *bibliography* is given.—P. M. C. R.

***The Influence of Alternating Stresses on the Tensile Properties and Damping Power of Aluminium Alloys.** H. Frankenberg (*Light Metals Research*, 1934, **2**, (47), 1–11).—Translated from *Metallwirtschaft*, 1934, **13**, 187–191. See *Met. Abs.*, this volume, p. 231.—J. C. C.

***The Influence of Addition Metals on the Electric Conductivity of Aluminium.** H. Bohner (*Light Metals Research*, 1934, **2**, (47), 12–17).—Translated from *Z. Metallkunde*, 1934, **26**, 45–47; see *Met. Abs.*, this volume, p. 168.—J. C. C.

Beryllium Alloys from the Electrical Point of View. A. Donat (*Machine moderne*, 1934, **28**, 104).—Cf. *ibid.*, 1933, **27**, 294, 574–575. Beryllium, when used as a deoxidant in the casting of copper and of certain of its alloys, greatly increases the electrical conductivity of the product. Conductivities for samples of sand-cast copper deoxidized with (*a*) 0·02% phosphorus, (*b*) 0·01% beryllium, and (*c*) 0·02–0·03% beryllium, are given, together with corresponding values for several ordinary copper alloys. The conductivities of 8 copper–beryllium alloys are tabulated for hard and soft conditions.—P. M. C. R.

***The Eutectoidal Decomposition of Solid Solutions of β-Copper–Aluminium Alloys.** N. W. Ageew and G. W. Kurdjumow (*Metallurg* (*The Metallurgist*), 1932, **7**, (9), 3–21; *Chem. Zentr.*, 1934, **105**, I, 2344).—[In Russian.] Cf. *J. Inst. Metals*, 1933, **53**, 237. X-ray and micrographic examination, and determinations of the hardness and coeff. of expansion show that the β-phase in copper–aluminium alloys decomposes on cooling into a eutectoidal mixture of (α + γ), both of which have face-centred cubic lattices, the γ lattice containing 52 atoms in the unit cell. No intermediate phase is formed during slow cooling through 540° C., all the properties conforming to a mixture of the α- and γ-phases. A stable intermediate stage is obtained only on very rapid cooling. —A. R. P.

***Researches on Copper Alloys Containing Cadmium.** P. I. Gradusov (*Metallurg* (*The Metallurgist*), 1932, **7**, (9), 79–83; *Chem. Zentr.*, 1934, **105**, I, 2033).—[In Russian.] The value of copper alloys with 0·5–2% cadmium for deoxidizing copper has been investigated. Under the same conditions as used when phosphor–copper is employed as deoxidant, the loss of cadmium does not exceed 2% of that added. The addition of small quantities of cadmium to copper increases the tensile strength, but reduces the conductivity; for hot-rolling the copper should be heated to 780°–800° C. With increasing cadmium content the intensity of recrystallization of hard-drawn copper is increased; 600° C. is the best annealing temperature for cadmium–copper, and 0·8% cadmium gives the best combination of mechanical and electrical properties. —A. R. P.

Investigations of the Phenomena of Diffusion of Copper in Iron with Reference to the Manufacture of Bimetals. M. I. Sacharowa (*Zvetnye Metally* (*The Non-Ferrous Metals*), 1932, **7**, 542–550; *Chem. Zentr.*, 1934, **105**, I, 2342).—[In Russian.] The rate of diffusion of copper into iron is very small, and appears to proceed along the crystal boundaries, especially in the case of soft iron containing silicon and manganese. At a magnification of 1000 a surface zone consisting of a solid solution of iron in copper can be observed on the copper. —A. R. P.

Copper–Lead Anti-Friction Alloys. M. P. Slavinski, A. E. Vol, I. V. Gutman, G. T. Fomin, and L. R. Edelson (*Metallurg* (*The Metallurgist*), 1933, **8**, (4/5), 91–109; (6), 3–21; *C. Abs.*, 1934, **28**, 1644).—[In Russian.] Copper–lead alloys with small additions of nickel, tin, zinc, and phosphorus are homogeneous above the melting point, but separate into 2 layers below the melting point of copper with pure copper freezing out separately. With larger additions, layers of copper containing lead and of lead containing copper are formed. If considerable amounts of nickel are present, lead is evenly distributed in the solid state. Additions of 1–15% of nickel and 1–18% of zinc to a 10% tin–bronze containing 10, 20, and 30% lead show that nickel raises the melting point and causes equal distribution and fineness of the lead particles and decreases the δ-constituent. Up to 10% of nickel increases the hardness but larger amounts decrease the hardness. Zinc causes unequal distribution, decreases hardness and increases plasticity. Phosphorus also causes unequal distribution of the lead. A list is given of 18 copper–tin–lead–nickel–zinc alloys which are probably suitable for bearings.—S. G.

Selenium [–Copper] Compound of High Thermoelectric Power. M. A. Levitiskaja and V. J. Dlugač (*Dokladii Akademii Nauk U.S.S.R.* (*Compt. rend. Acad. Sci. U.R.S.S.*), **1933**, 106–108 (in Russian), 109–110 (in German); *Brit. Chem. Abs.*, **1934**, [A], 19).—The properties of Cu_2Se are described.—S. G.

Nida Bronze. Anon. (*Metallwirtschaft*, 1934, **13**, (10), 175–176; and *Automobiltech. Z.*, 1934, **37**, (4), 115–117).—Nida bronze is a phosphor–bronze with 8–9% tin which has been hot-worked then cold-worked to the finishing state; it is particularly suitable for bearings capable of withstanding high loads at high speed. The tensile strength is 40 kg./mm.^{2} in the soft, and 80 kg./mm.^{2} in the hard state; the corresponding elongations are 70 and 7%, and Brinell hardness 95 and 200. The corrosion-resistance and other mechanical properties are also given.—v. G.

***Chemical Investigation of an Alleged Ancient Greek Statuette.** Earle R. Caley (*Tech. Studies Field Fine Arts*, 1934, **2**, 144–148; *C. Abs.*, 1934, **28**, 1971).—The alleged Greek statuette had the following composition: copper 83·25, tin 7·36, zinc 4·87, lead 4·40, iron 0·15%, no other elements were present in determinable amounts. The absence of semi-metallic or non-metallic impurities such as arsenic or sulphur and the presence of appreciable amounts of zinc indicate that the bronze was not of ancient Greek origin. Further, the analysis does not agree with those of ancient statuary bronzes from other localities, but corresponds closely with that of a favourite modern composition for making delicate bronze castings.—S. G.

White Metal [Nickel–Brasses]. J. Cournot and F. Hiltbold (*Rev. Nickel*, 1934, **5**, (1), 16–33).—A very complete summary of the constitution and physical and mechanical properties of various white metals and nickel–brasses. Specific features dealt with are casting conditions, heat-treatment, working, pickling, polishing, and pressure casting. Illustrated examples of white metal work are given. Of especial interest are the methods of testing particular to the work in hand, *viz.* the force necessary to bend a fork or spoon handle, or to bend a prong of a fork through a definite angle.—W. A. C. N.

***The Equilibrium Diagram Germanium–Copper.** Robert Schwarz and Gertrude Elstner (*Z. anorg. Chem.*, 1934, **217**, 289–297).—The constitution of the system was studied by thermal analysis and microscopic examination of unannealed alloys. The liquidus curve consists of 5 branches corresponding with the crystallization of α (solid solution of germanium in copper), β, γ, Cu_3Ge, and germanium. There are three peritectic reactions (concentrations in atomic-% germanium in parentheses): α (10) + melt (18) $\rightleftarrows$ β(14) at 828° C., β (16·5) + melt (24·5) $\rightleftarrows$ γ (23) at 744° C., γ (24·5) + melt (30) $\rightleftarrows$ Cu_3Ge at 700° C. Cu_3Ge and germanium form a eutectic at 35 atomic-% germanium and 650° C., γ has a transformation point at 558° C., and Cu_3Ge at 615° C.—M. H.

Some Causes of Variations in Hardness of Gold–Copper Castings. Harry H. Aster and John A. Comstock (*J. Dental Research*, 1933, **13**, 407–413).—In making dental castings of gold–copper alloys porosity always occurs at the sprue; the point of sprueing should therefore be made on the smaller surfaces of the castings, and on parts which are not to be subjected to strains or stresses. Hardness variations due to segregation and coring of the crystallites may be overcome by annealing at about 850° C.; precipitation-hardening effects do not occur in the simple binary alloys used in dentistry.—A. R. P.

On the Relations Between the Diffusion Coefficients and Concentration in the Gold–Platinum, Gold–Palladium, and Gold–Nickel Systems. Chujiro Matano (*Proc. Phys. Math. Soc. Japan* (*Nippon Sûgaku Buturi-gakkwai Kizi*), 1933, **15**, 405–406; *Chem. Zentr.*, 1934, **105**, I, 1931).—[In English.] The diffusion coeff. in these systems have been calculated, taking into account the dependence of the coeff. on the composition, from data published by Jedele (*J. Inst. Metals*, 1933, **53**, 697). The results obtained differ from those of J. by an amount which increases with the gold content of the alloys.—A. R. P.

***Alloys of Iron Research. XI.—The Constitution of the Alloys of Iron and Manganese.** Marie L. V. Gayler. **Appendix.—X-Ray Analysis of Manganese-Rich Alloys Heat-Treated and Quenched from Different Temperatures.** C. Wainwright (*J. Iron Steel Inst.*, 1933, **128**, 293–340; discussion, 341–353).—For abstract of the paper and appendix see *J. Inst. Metals*, 1933, **53**, 624. In the discussion *W. Rosenhain* emphasized the important effect which small quantities of impurities could have on the equilibria in certain metallic systems. *E. Öhman* stated that the 66% manganese alloy annealed at 1200° C. and cooled in the furnace showed the lines only of β-manganese, $a = 6{\cdot}255$ A., and suggested that this surprising result is due to the slowness of the $\beta \longrightarrow \alpha$ transformation in iron–manganese alloys. In quenching powdered specimens of these alloys from just above the transformation point, it is difficult to suppress the transformation, whereas suppression is easy with coarse-grained alloys. Quenching experiments with filings of alloys containing about 55% manganese showed that the two-phase γ-iron/α-manganese region was incorrectly drawn in Gayler's diagram, and indicated that α-manganese is precipitated from the γ-phase during cooling. *Cyril Wells* and *F. M. Walters, Jr.*, gave a summary of the results of their work on alloys in the range 0–30% manganese. They also had found evidence of a eutectoid at 67·7% manganese and 707° C., and that the solubility limit of manganese in γ-iron at 650° C. was about 55%, *i.e.* about midway between that given by Ö. and that given by G. Alloys with 74–94% manganese showed a tetragonal structure when quenched from the γ-field, but a cubic structure when more slowly cooled, and they suggested that the γ-iron and γ-manganese phases were identical. In reply, G. put forward evidence which indicated that the eutectoid found by W. and W. at 67·7% manganese was really due to the presence of nitrogen in the alloys, but agreed that much more work was necessary to clear up various points which had emerged in the discussion.—A. R. P.

***The System Manganese–Nitrogen.** Rudolf Schenck and August Kortengräber (*Z. anorg. Chem.*, 1933, **210**, 273–285).—The system up to 10% nitrogen has been studied by determination of the equilibrium isotherms (pressure–concentration) between 540° and 800° C.; these have a horizontal portion which shortens with rise in temperature and vanishes at about 800° C. The end-points of these horizontals correspond with the compositions of the two solid phases which co-exist in a nitrogen atmosphere; (*a*) contains 6–6·3% nitrogen at 540°–800° C., and (*b*) 8·8% at 540° C. and 6·3% at 800° C., *i.e.* it loses nitrogen with rise in temperature until at 800° C. it merges into the first phase. X-ray analysis has shown that (*a*) is Hägg's cubic face-centred ε-phase and (*b*) his close-packed hexagonal ζ-phase (cf. *J. Inst. Metals*, 1930, **43**, 530). —M. H.

***The Binary System $MnO–SiO_2$.** J. White, D. D. Howat, and R. Hay (*J. Roy. Tech. Coll.* (*Glasgow*), 1934, **3**, 231–240).—The diagram for the system $MnO–SiO_2$ is developed from thermal data and the phase changes in many cases are confirmed by observations with a high-temperature microscope. A description of the apparatus for this including furnace, crucible, and thermocouple arrangements is given, and it is stated that the highest temperature attained in this apparatus was 1650° C. A differential method is employed to obtain the thermal curves, and molybdenum crucibles, made by drilling holes in molybdenum rods, are used with success for melting the various mixtures.

The preparation of the various melts and the checking of their purity by chemical and spectrographic methods are discussed. The solid phases of the system are confirmed by examination of their optical properties.—J. W. D.

***The Equilibrium Diagram Manganese–Silicon.** Rudolf Vogel and Herbert Bedarff (*Arch. Eisenhüttenwesen*, 1933–1934, **7**, 423–425).—The equilibrium diagram of the system from 0 to 34% silicon (MnSi) has been redetermined by thermal and micrographic methods. The existence of Mn_2Si could not be confirmed, but two new compounds have been discovered, Mn_5Si_3 and Mn_3Si; the latter melts incongruently, and can dissolve up to 1% manganese in the solid state. The two transformations of manganese occur at higher temperatures with increasing silicon content of the alloys.—J. W.

***High-Grade Chromium–Nickel Alloys and Life Tests Thereon.** W. Hessenbruch and W. Rohn (*Elektrowärme*, 1933, **3**, 245–249, 294–297, 317–322).—See *J. Inst. Metals*, 1933, **53**, 624–625, 697.—S. G.

Engineering Properties of Monel Metal. Anon. (*Henry Wiggin and Co., Ltd.*, **1934**, (MB 7), 1–10).—The mechanical properties of Monel metal in various states are tabulated, the composition, physical properties, and technical data are given, and the resistance of the alloy to the corrosion of a number of different agents at various temperatures and the working properties are described.—J. H. W.

***Large Barkhausen Discontinuities and Their Propagation in Nickel–Iron Alloys.** Raymond E. Reinhart (*Phys. Rev.*, 1934, [ii], **45**, 420–424).—Cf. *Met. Abs.*, this volume, p. 236. The propagation of large Barkhausen discontinuities in 10% nickel–iron alloy wire, 0·0334 cm. in diam., has been studied as a function of circular field, longitudinal field, torsion, and tension. Many results confirming those of Sixtus and Tonks (*J. Inst. Metals*, 1931, **47**, 371; 1932, **50**, 345) were obtained, and also new data. The velocity of propagation is determined by the component of the resultant field, impressed on the wire, in the direction of the principal strain axis of elongation; the component perpendicular to this direction has no appreciable effect on the velocity. A combination of heat-treatment and straining is described by means of which a nickel–iron alloy with 70% of nickel was obtained in a condition in which the effects could be studied over much wider ranges of field and velocity than with untreated wire.—W. H.-R.

New Materials for Cores of Induction Coils. Materials with High Magnetic Stability: "Isoperm." O. Dahl, J. Pfaffenberger, and H. Sprung (*Elekt. Nachr. Tech.*, 1933, **10**, 317–332; *Sci. Abs.*, 1933, [B], **36**, 650).—In telegraphic work and technology the importance of the core of the coils used is well known. The present work has as its object the production of a working material for the manufacture of coil and armature cores the internal granular structure of which will render it particularly suitable for the purposes in view. The mechanical and thermal characteristics of such materials are first considered in relation to the magnetic behaviour required, the influence of cold formation is particularly reviewed. Whilst sufficiently small instability can be attained with many materials, yet at the same time the range is comparatively small when small hysteresis is required also. These "Isoperm" groups, namely, aluminium–nickel–iron, and in particular copper–nickel–iron alloys, are reviewed in regard to the point at issue, where it is shown that not only the mechanical, but the thermal behaviour of the material is of great importance. Comparison with other materials used illustrates the particularly valuable character of the "Isoperm" evolved by the present authors. For aluminium–nickel–iron "Isoperm" the value of μ_0 is 65 and of $\mu_{\text{max.}}$ is 87, giving a ratio of 1·3, whilst for copper–nickel–iron "Isoperm" the values are 66 and 73, respectively, giving a ratio of 1 : 1. For tungsten steel the values are $\mu_0 = 47$ and $\mu_{\text{max.}} = 188$, with a ratio of 4·0.—S. G.

Manganese–Nickel: Its Properties and Technology. P. I. Gradusov (*Metallurg* (*The Metallurgist*), 1933, **8**, (6), 46–49; *C. Abs.*, 1934, **28**, 1645).—[In

Russian.] The addition of 2·5% manganese to nickel increases the tensile strength, decreases the ductility, and gives a finer microstructure. The alloy shows no noticeable grain-growth when heated to 1100° C. for 5 hrs.—S. G.

***On the Nature of the Solid Solution of Aluminium in Silver.** Sadajirô Kokubo (*Sci. Rep. Tôhoku Imp. Univ.*, 1934, [i], **23**, 45–51 [in English]; and *Kinzoku no Kenkyu*, 1934, **11**, (3), 128–133 [in Japanese]).—The silver–aluminium alloy containing 4·5% of aluminium was studied by measuring its density. The experimental value for the density of the solid solution of aluminium in silver is somewhat lower than that calculated from X-ray data, on the basis of a simple substitution of aluminium for silver atoms in the silver lattice. It is shown that the ionized solid solution theory proposed by R. T. Phelps and W. P. Davey cannot possibly account for this discrepancy. The principal cause of the decrease in density of the alloy is attributed to minute gas holes produced during the solidification of the alloy.—S. G.

***The Freezing Points, Melting Points, and Solid Solubility Limits of the Alloys of Silver and Copper with the Elements of the B Sub-Groups.** William Hume-Rothery, Gilbert W. Mabbott, and K. M. Channel Evans (*Phil. Trans. Roy. Soc.*, 1934, [A], **233**, 1–97).—(1) The factors affecting the formation of primary α substitutional solid solutions in silver and copper by the elements of the B sub-groups have been investigated. Complete determinations of the solidus curves and solid solubility limits are given for the systems silver–cadmium,* silver–indium,* silver–gallium*, silver–aluminium, copper–gallium,* and copper–germanium,* liquidus determinations being made in the systems marked *. The solidus curves for the systems silver–zinc and copper–zinc, and the solubility curves for the systems copper–arsenic and copper–antimony, were also investigated. Partial or confirmatory determinations were made for the liquidus and solidus of ternary alloys of copper with zinc, gallium, and germanium, for the solidus and solubility curves of the system silver–tin, and for the solidus of the system copper–aluminium. These experimental data, and those of other investigators for further B group alloys are collected in tables showing the liquidus and solidus points for 1, 2, 3 . . . atomic-% of the different solutes, and the solubility limits at intervals of 100° C. (2) If the atomic diameters of solvent and solute differ by more than about 14% of that of the solvent, the solid solution is restricted to a few atomic-%, but where the "size factor" is favourable a solid solution may be formed, and the solubility limits generally obey clear valency laws, the solubility becoming less as the valency increases. (3) Where solvent and solute are in the same period (*e.g.*, silver, cadmium, indium . . .) alloys of a given freezing point have atomic compositions which vary inversely as the valency of the solute as far as Group V, whilst the compositions of alloys of a given melting (solidus) point are approximately inversely proportional to the square of the valency as far as Group IV. These principles permit the calculation of the solidus and liquidus points of ternary alloys. (4) Where solvent and solute are in different periods, the initial depression of freezing point is usually greater than to be expected from the normal valency effect, but in many cases the solute atoms act as though they possessed a fictitious valency which is a whole number, and to which the name "liquidus factor" is given. The same liquidus factors are shown to apply to ternary alloys, and methods are given for the calculation of liquidus points in ternary and quaternary alloys where the binary curves are known. (5) When the size factor is favourable, the maximum solid solubility is determined mainly by the concentration of valency electrons, and this principle permits the approximate calculation of solubility limits in certain ternary alloys. (6) The data are discussed theoretically, and explained on the assumption of an equilibrium involving both atoms and electrons, the electronic factor being predominant when the size factors are favourable, and the atomic factor predominant when the atomic diameters differ widely.—W. H.-R.

[Stability of] Liquid Sodium Amalgams. G. R. Paranjpe and R. M. Joshi (*J. Univ. Bombay*, 1932, **1**, 17–24; *Brit. Chem. Abs.*, **1933**, [A], 118).—Sodium amalgams are said to represent colloidal suspensions of sodium in mercury.
—S. G.

***The Brinell Hardness of Bearing Metals.** A. Vath (*Z. Metallkunde*, 1934, **26**, 83–86).—The investigation was carried out to ascertain the effect of the experimental conditions on the Brinell hardness of bearing metals with a tin or lead base. The diameter of the ball, the load, and the time of loading were varied within wide limits. The Brinell hardness of the bearing metals depends chiefly on the last two factors, the hardness being greater the shorter the time of loading, and increasing with the load to a maximum, then decreasing again. A hardness diagram has been constructed from which the hardness for different ball diameters, loads, and times of loading can be read off, so that hardness values determined under different conditions can be quickly compared.—M. H.

***On the Formation of High-Melting Metal Carbides on Heating a Carbon Filament in the Vapour of a Volatile Halogen Compound of the Metal.** W. G. Burgers and J. C. M. Basart (*Z. anorg. Chem.*, 1934, **216**, 209–222).—The reactions between a glowing carbon filament and the vapour of titanium chloride (in the presence of hydrogen), zirconium chloride, and tantalum chloride have been studied (*a*) by measuring the change in the electrical resistance of the filament, (*b*) by X-ray examination of the resulting products. In all cases the carbon is converted into the carbide of the metal (TiC, ZrC, or a mixture of TaC and Ta_2C, with, under certain conditions, metallic tantalum). At about 2500° C. with a regulated amount of tantalum chloride, however, the formation of Ta_2C and tantalum can be avoided. X-ray and chemical analysis shows that TiC, ZrC, and TaC can retain a certain amount of the respective metal in solid solution. The pure carbides are obtained if the reaction products are annealed either in vacuum or in an atmosphere of hydrocarbon. TiC, ZrC, and TaC have cubic face-centred lattices with $a = 4{\cdot}320 \pm 0{\cdot}001$ A., $4{\cdot}687 \pm 0{\cdot}002$ A., and $4{\cdot}445 \pm 0{\cdot}001$ A., respectively. The lattice of Ta_2C is hexagonal close-packed with $a = 3{\cdot}091 \pm 0{\cdot}001$ A., $c = 4{\cdot}93 \pm 0{\cdot}007$ A., $c/a = 1{\cdot}595$.
—M. H.

The Superconductivity of Alloys. G. Tammann (*Z. Metallkunde*, 1934, **26**, 61).—The relation between superconducting temperature and the composition and structure of various binary alloys in which either one or both constituents are superconductors is discussed.—M. H.

Some Conclusions from Rules on the Concentration of Valency Electrons in Binary Intermetallic Compounds. Harald Perlitz (*J. Chem. Physics*, 1933, **1**, 335–336; *Brit. Chem. Abs.*, **1934**, [A], 22).—The empirical rules governing the formation of intermetallic phases of the types of β-, γ-, and ε-brass are expressed algebraically. These phases are not to be expected when the metals have the same number of valency electrons, but may be expected if the concentration of valency electrons of one component is $>$, and of the other $<$, 3/2, 21/13, or 7/4 electrons per atom. Since the same conditions govern the appearance of β-, γ-, and ε-phases, all these may be expected when any one is found.—S. G.

***Quaternary Intermetallic Compounds.** A. S. Russell (*Nature*, 1934, **133**, 217).—The following quaternary intermetallic compounds have been formed by reaction of zinc with the ternary compound $SnCu_2Hg_7$ in mercury: $Sn_4Cu_{12}Zn_4Hg_3$, $Sn_5Cu_{15}Zn_5Hg_9$, $SnCu_3ZnHg_6$, $SnCu_3ZnHg_9$, $Sn_4Cu_{12}Zn_4Hg_{45}$, $Sn_4Cu_{12}Zn_7Hg_{21}$, and $Sn_4Cu_{12}Zn_7Hg_{33}$. The following compounds have been formed by the reaction of tin with ZnCu in mercury: $Zn_8Cu_8SnHg_7$, $Zn_6Cu_8SnHg_9$, $Zn_{40}Cu_{40}Sn_5Hg_{14}$, $Zn_{40}Cu_{40}Sn_{12}Hg_{21}$. The total number of valency electrons appears to be even more characteristic of an intermetallic compound than the ratio of electrons to atoms.—E. S. H.

***An Equilibrium Diagram for Ternary Alloys.** V. Fischer (*Z. Metallkunde*, 1934, **26**, 80–82).—A method is given for representing the constitution of ternary systems on a rectangular, plane co-ordinate system. The new diagram is applied to the liquid–solid equilibria in the systems nickel–copper–manganese, silver–gold–copper, and silver–lead–tin.—M. H.

†**Study of the Constitution [of Metals and Alloys] by Means of Magnetic Methods. II.—Ferromagnetic Measurements.** A. Kussmann (*Z. Metallkunde*, 1934, **26**, 25–33).—Cf. *Met. Abs.*, this volume, p. 197. A comprehensive review under the following headings: fundamental conceptions; relation between ferromagnetic properties and constitution; methods of measurement; examples of application (*a*) by determination of the saturation magnetization and Curie point (determination of phase limits in equilibrium diagrams, detection of the quantity of structural constituents, detection of transformations), (*b*) by measurement of the hysteresis properties (analysis of internal stresses produced by deformation, detection of precipitations and transformations, and study of age-hardening phenomena); 60 references are appended.—M. H.

III.—STRUCTURE

(Metallography; Macrography; Crystal Structure.)

(Continued from pp. 237–240.)

Distinction Between Double and Plated Gold. E. Raub (*Metallwaren-Ind. u. Galvano-Tech.*, 1934, **32**, 115–118).—Reprinted from *Mitt. Forschungsinst. Edelmetalle*, 1932, **6**, 57–63. See *J. Inst. Metals*, 1933, **53**, 188.—A. R. P.

***Metallographic Investigation of Tungsten Wire with Addition of Thoria.** N. M. Zarubin and A. N. Koptzik (*Zvetnye Metally* (*The Non-Ferrous Metals*), **1932**, (5/6), 59–66; *C. Abs.*, 1934, **28**, 2308).—[In Russian.] A discussion of the microstructure of tungsten wire with addition of ThO_2, SiO_2, and K_2O. More pores were observed in wires prepared from cheaper grades of tungsten contaminated with aluminium, molybdenum, iron, &c. The number of pores was found to be greater the finer the grain.—S. G.

Some Statistical Properties of an Annealed Alpha-Grain Aggregate.—I. R. G. Johnston and W. G. Askew (*Met. Ind.* (*Lond.*), 1934, **44**, 363–365).—The orientation of grains with respect to an arbitrary line drawn across a photomicrograph of a field of annealed α-crystals has been measured by taking in every grain in the field and plotting in such a way that the lengths of radii in given directions represent the number of grains found to be orientated in those directions. This method was also applied to the measurement of the directions of maximum diameters and of twins. The degree of "directionality" is expressed by the eccentricity of the ellipse which will best cover the ends of the radii. It is claimed that it has been conclusively established that quite strong "directionality" persists in the visible structure of α-brass and similar alloys, even after strong over-annealing. It is also stated that the preferred directions generally lie across the direction of last rolling, but never along it.—J. H. W.

***Petrographic Methods in Slag Examination.** R. Graham and R. Hay (*J. Roy. Tech. Coll.* (*Glasgow*), 1934, **3**, 241–243).—Petrographic methods for the examination of slags are discussed, and it is shown that examination of thin sections by transmitted light is very difficult, due to the friable nature of the material, and examination by reflected light is also unsatisfactory as changes in the composition of phases cannot be detected with sufficient accuracy. Utilization of the optical properties of the various phases offers a method of successful identification, and such properties as refractive index, pleochroism, isotropic or anisotropic state, and angle of extinction if anisotropic can be determined by various methods described. It is stated that the methods used have been very helpful in the elucidation of the constitution of the $MnO–SiO_2$ system, and have been applied with equal success to the systems FeO–MnO and $FeO–MnO–SiO_2$. A table of results for the system $MnO–SiO_2$ is given.
—J. W. D.

Photomicrographic Investigations in the Resolving Power of Microscopic Objectives with the Violet Mercury Monochromat (Wratten Filter No. 50). A. P. H. Trivelli (*J. Amer. Microscop. Soc.*, 1930, **49,** 258–263).—The Wratten Filter No. 50 with the mercury vapour lamp gives higher resolving power than any other filter for the visible spectrum, but only if apochromatic objectives and compensating occulars are used. Filters for the visible spectrum give better results with apochromats than with achromats, and the mercury lamp with monochromatic filters gives somewhat higher resolving power with achromats than a ribbon filament lamp with the same filters.—P. M. C. R.

***X-Ray Examination of Electrolytic Chromium.** G. R. Levi and M. Tabet (*Atti R. Accad. Lincei* (*Roma*), 1933, [vi], **17,** 647–653; *Brit. Chem. Abs.*, **1933,** [A], 1003).—From X-ray measurements data are obtained regarding the size of particles in chromium deposits prepared by the electrolysis of solutions of $Cr_2(SO_4)_3$, CrO_3, and NH_4 chromioxalate, respectively, and also of chromium obtained by thermal reduction.—S. G.

***The Crystal Structure of the Heusler Alloys.** A. J. Bradley and J. W. Rodgers (*Proc. Roy. Soc.*, 1934, [A], **144,** 340–359).—In an investigation of the ferromagnetic alloys of copper, manganese, and aluminium an alloy was found which showed an almost complete change of crystal structure due to heat-treatment. Drillings of this alloy, annealed for several hrs. at 500° C. and cooled slowly to room temperature, were found to have the δ copper–aluminium (Cu_9Al_4) type of structure. The formula of the alloy can be written $(CuMn)_9Al_4$. The annealed and slowly cooled alloy is non-magnetic, but on quenching from 800° C. it becomes strongly ferromagnetic. The structure is now entirely body-centred cubic, with a face-centred superlattice. A method of X-ray analysis capable of distinguishing manganese atoms from copper atoms depending on the comparison of X-ray powder photographs of the alloy using radiations from iron, copper, and zinc anticathodes was developed and the results indicated that the actual structure differed slightly from the ideal structure of the ferromagnetic alloy. In the actual specimen examined there was a deficit of manganese atoms. The alloy was nevertheless homogeneous, some copper taking the place of the missing manganese atoms. The aluminium atoms in excess were distributed equally in the positions normally occupied by copper and manganese.—J. S. G. T.

***Crystal Structure of the Compound $LaAl_4$.** A. Rossi (*Atti R. Accad. Lincei* (*Roma*), 1933, [vi], **17,** 182–185; *Brit. Chem. Abs.*, **1933,** [A], 558).—Cleavage takes place along the (001) pinacoid faces, and the lattice distance between the cleavage planes is 5·1 A. or an integral multiple thereof. The unit cell has $a = 13{\cdot}2$ A., $c/a = 0{\cdot}77$; $d_{calc.}$ 3·69, $d_{obs.}$ 3·86.—S. G.

***Crystal Structure of $LaSn_3$ and $LaPb_3$.** A. Rossi (*Atti R. Accad. Lincei* (*Roma*), 1933, [vi], **17,** 839–846; *Brit. Chem. Abs.*, **1933,** [A], 1003).—The following data are obtained by the powder method: $LaSn_3$, $a = 4{\cdot}77$ A., $d = 7{\cdot}15$–$7{\cdot}20$, $d_{calc.} = 7{\cdot}516$; $LaPb_3$, $a = 4{\cdot}893$, $d = 10{\cdot}50$, $d_{calc.} = 10{\cdot}71$.—S. G.

***X-Ray Investigation of the Compounds MgZn and $MgZn_5$.** L. Tarschisch (*Z. Krist.*, 1933, **86,** 423-438; *C. Abs.*, 1933, **28,** 2238).—The existence of MgZn is proved by X-ray data. The structure resembles that of $MgZn_2$. The latter has a hexagonal unit containing 4 mols. (4 Mg + 8 Zn). A similar unit for MgZn, with $a = 5{\cdot}33$ and $c = 8{\cdot}58$ A. contains 6 mols. (6 Mg and 6 Zn), but certain weak reflections indicate that the true unit cell should be doubled. For $MgZn_5$ $a = 9{\cdot}92$, $c = 16{\cdot}48$ A., with 16 mols.; D_6^6, calculated density $= 6{\cdot}60$. Both structures consist of alternate layers of magnesium and zinc atoms.—S. G.

The [Crystal] Structure and Gas Content of Nickel Films, Produced by Cathodic Sputtering. Wilhelm Büssem and Friedrich Gross (*Z. Physik*, 1933, **86,** 135–136).—Nickel films produced by cathodic sputtering in hydrogen or in neon + helium are either hexagonal I or cubic (A) in structure; produced in nitrogen, the films are tetragonal, hexagonal II, or cubic (B). The phases of

(A) are transformable one into the other; the same holds for the phases (B). Films (A) contain hydrogen, whilst films (B) contain nitrogen and hydrogen. The ratio between the amount of dissolved gas and the amount of metal is briefly discussed.—J. S. G. T.

***The Crystalline Structure of PrMg.** A. Rossi and A. Iandelli (*Atti R. Accad. Lincei* (*Roma*), 1933, [vi], **18**, 156–161; *C. Abs.*, 1933, **28**, 2238).—The structure of PrMg was determined by the powder method. On the basis of the structure determined, the density is calculated as 4·65 (4·67 determined). The structure should be cubic with 2 atoms each of magnesium and praseodymium at the diagonally opposite corners. The side *a* would then be 10·8 A., whereas the value found for $n = 2$ is 7·77 A.; hence this supposed structure cannot be correct.—S. G.

***X-Ray Study of the Binary Alloys of Silicon with Silver, Gold, Lead, Tin, Zinc, Cadmium, Antimony, and Bismuth.** Eric R. Jette and Emery B. Gebert (*J. Chem. Physics*, 1933, **1**, 753–755).—The lattice constants of these alloys have been measured. It is shown that the lattice constants of the elements in these alloys are practically identical with those of the pure elements. This fact leads to the interpretation that mutual solubility of the elements in these alloys occurs to only a very slight extent. It is further observed that silicon forms no compounds with any of these elements.—S. G.

Surface [Crystal] Lattice Interference Exhibited by Electron Radiation Incident on Thin Silver Films. H. Lassen (*Physikal. Z.*, 1934, **35**, 172–175).—Silver films, deposited on rock salt in high vacuum, are found frequently to possess a single-crystal structure, the face of the cubic crystal structure lying parallel to the plane of the film.—J. S. G. T.

***Crystal Structure of Phase *A* of the System Ag–Li.** H. Perlitz (*Z. Krist.*, 1933, **86**, 155–158; *Brit. Chem. Abs.*, **1933**, [A], 1007).—Phase *A*, with 76·3–80·2 atomic-% lithium, has a cubic unit cell containing 52 atoms, with $a =$ 9·94 A.—S. G.

***The Structure of Silver Amalgam.** A. Weryha (*Z. Krist.*, 1933, **86**, 335–339; *C. Abs.*, 1934, **28**, 2238).—By adding drops of mercury to a dilute solution of $AgNO_3$, prismatic crystals of Ag_3Hg_4 [*Note*: In accordance with the Hume-Rothery rule, this γ-phase would be expected to have the formula Ag_5Hg_8, and this was found by Preston] were obtained. These were six-sided and proved to be cubic. Powder photographs of these crystals, and also of silver wire dipped in mercury, indicate a unit cube with $a = 1{\cdot}09$ A., containing 4 mols., space group O_h^9. Atomic positions are suggested.—S. G.

***X-Ray Proof of [the Existence of] ZrW_2.** A. Claasen and W. G. Burgers (*Z. Krist.*, 1933, **86**, 100–105; *Brit. Chem. Abs.*, **1933**, [A], 1003).—X-ray examination of a tungsten wire on which, when incandescent, zirconium had been deposited from its vapour showed the presence of a face-centred cubic compound, ZrW_2, with $a = 7{\cdot}61$ A., 8 molecules in the unit cell, Zr–W = 3·15 A., $d_{\text{calc.}}$ 13·78. The structure resembles that of $MgCu_2$. ZrW_2 was prepared by volatilizing zirconium on to tungsten and heating for 20 hrs. at 1800° C.; it contained a slight excess of zirconium, and had a density of 12–13·5, and melting point $>$ 2200° C.—S. G.

***The Electrolytic Growth of Metal Crystals.** T. Erdey-Grúz (*Naturwiss.*, 1933, **21**, 799–800).—A short preliminary note on the development of growth planes on the surface of spherical silver crystals immersed in solutions of complex salts.—J. W.

†**The Effect of X-Ray Investigations on the Development of Metallography.** Ulrich Dehlinger (*Arch. Eisenhuttenwesen*, 1933–1934, **2**, 523–526).—A review of the scope and most important results of the X-ray investigation of the structure of metals and alloys.—J. W.

***Binding Energies in the Growth of Crystal Nuclei from Metallic Atoms.** Hugh S. Taylor, Henry Eyring, and Albert Sherman (*J. Chem. Physics*, 1933, **1**, 68–76;

Brit. Chem. Abs., **1933**, [A], 213).—Binding energies for various geometrical configurations of 3–8 atoms of sodium, 4–5 atoms of copper, and 4 and 6 atoms of hydrogen have been calculated. The data obtained indicate the manner in which a unit cell would grow from the vapour phase in the absence of surfaces. The unit cell is shown to be unstable.—S. G.

***Characteristic X-Rays from Metals in the Extreme Ultra-Violet [Electron Theory of Metals].** H. M. O'Bryan and H. W. B. Skinner (*Phys. Rev.*, 1934, [ii], **45**, 370–378).—Soft X-ray bands in the region 50–500 A. from lithium, beryllium, carbon, sodium, magnesium, aluminium, silicon, and barium have been investigated experimentally. The bands correspond with transitions of outer or conduction electrons into a vacant *K* or *L* shell, and the energy spread of the bands may be calculated approximately from the Sommerfeld theory of metals, which thus provides a method for determining the number of conduction electrons per atom. The characteristic properties of metals, semi-conductors (silicon), and insulators (carbon) are reflected in the sharpness of the X-ray band heads. For the true metals the calculated numbers of conduction electrons per atom agree with the normal valencies, except for aluminium, where the discrepancy is outside the limits of error.—W. H.-R.

***A Theory of the Form of the X-Ray Emission Bands of Metals. [Electron States in Metals.]** H. Jones, N. F. Mott, and H. W. B. Skinner (*Phys. Rev.*, 1934, [ii], **45**, 379–384).—Theoretical. The results of O'Bryan and Skinner (preceding abstract) are investigated theoretically by an extension of the theory of Bloch (*Z. Physik*, 1928, **52**, 555). The difference between the exact form of the bands in the different metals is explained.—W. H.-R.

Quantitative Crystal Analysis by X-Rays. M. E. Nahmias (*Z. Krist.*, 1932, **83**, 329–339; *Brit. Chem. Abs.*, **1933**, [A], 44).—Sources of error in previous methods are discussed and improvements are suggested. The essential difference in the new method is that the intensities of the lines of the substance to be determined are not compared directly with those of that pure substance, but both are compared with the lines of a third substance, *e.g.* aluminium. The powdered materials are stuck on fine (0·03 cm. diameter) aluminium wire which is moved helicoidally, thus averaging the composition of the material examined and diminishing errors due to heterogeneity. With quartz and kaolin and quartz and mullite results accurate to 10%, or with practice to 5%, are readily obtained. Cf. following abstract.—S. G.

Quantitative Crystal Analysis by X-Rays. M. E. Nahmias (*Z. Krist.*, 1933, **85**, 319–321).—Cf. preceding abstract. Further details of the method are given.—S. G.

IV.—CORROSION

(Continued from pp. 240–245.)

Influence of Aluminium on Wine. Josef Schindler (*Vinařský Obzor*, 1932, **26**, 86–88; *C. Abs.*, 1934, **28**, 2461).—Aluminium, especially in combination with other metals, is corroded by contact with alcoholic beverages; beer and wine cause discoloration of aluminium and are made turbid by it. Fruit juices containing more sugar and acids have no effect.—S. G.

***Corrosion Experiments with Screws in Aluminium Alloys. Behaviour with the Application of Different Materials in Sea-Water and Sea-Air.** H. Bauermeister (*Z. Metallkunde*, 1934, **26**, 34–37).—Cast KS–Seewasser alloy and Silumin containing screws of brass, iron, or phosphor–bronze were exposed to sea-water and sea-air, both separately and alternately for 47–169 days, and tests made to ascertain whether the screws could then be loosened. The results showed that brass screws were by far the best, that phosphor–bronze screws were quite unsuitable, that greasing greatly assisted loosening, and that exposure to the wet and dry test caused more difficulty in removal than did permanent immersion in sea-water, especially if the samples had dried before testing. KS–Seewasser has a greater resistance than Silumin to corrosion by sea-water.—M. H.

A Recommended Test for Determining the Reactivity of Aluminium and Aluminium Alloys. H. Röhrig (*Korrosion u. Metallschutz*, 1934, **10**, 38–39).—The following test provides a much more satisfactory method than the Mylius test for comparing the reactivities of aluminium after various heat and mechanical treatments: the specimen is pickled for 1 minute in 30% caustic soda solution at 90° C., rinsed, and dipped in concentrated nitric acid for 1 minute, then washed, dried, and weighed; it is then immersed for 1 hr. at 20° C. in a mixture of nitric acid 4, hydrochloric acid 1, and water 4 parts, again rinsed, dried, and weighed, the loss in weight in grm./m.^{2} being a measure of the reactivity. The values obtained in this test for aluminium wire containing 0·16% silicon and 0·21% iron were (*a*) hard-drawn 348, (*b*) annealed for 30 minutes at 500° C. and quenched 19·6, (*c*) as (*b*) but slowly cooled 23·1, (*d*) as (*b*) but 300° C. 64·4, (*e*) as (*c*) but 300° C. 91·2.—A. R. P.

Condenser Tube Corrosion Research. R. May and F. A. Champion (*Trans. Inst. Marine Eng.*, 1933, **45**, xi–xii).—The Annual Report of this Institute contains a summary of recent progress in the investigations of condenser tube corrosion carried out under the auspices of the British Non-Ferrous Metals Research Association, and deals with the influence of the nickel content on the various types of corrosion that may attack cupro–nickel tubes. Resistance to impingement attack increases gradually with increase in nickel content, becoming practically complete between 50 and 70% nickel, and the constituents have a somewhat similar influence on deposit attack. Intercrystalline attack and/or intercrystalline pitting is characteristic of the alloy with a nickel content of 50% or more, and has not been observed with 40% nickel or less. Evidence regarding the effect of the various constituents on oxide pitting is not yet conclusive. Reference is also made to work in progress on aluminium–brasses, the use of potential measurements in corrosion tests, and oxide pitting.—J. W. D.

Anodic Dissolution of Copper–Tin Alloys. J. W. Baimakow and P. B. Popow (*Zvetnye Metally* (*The Non-Ferrous Metals*), 1932, **7**, 513–536; *Chem. Zentr.*, 1934, **105**, I, 2344).—[In Russian.] Contrary to statements in the literature, tin can be dissolved practically completely from copper–tin alloys by anodic dissolution if the following conditions are observed: the anode should contain at least 10–15% tin, the electrolyte should contain 150–175 grm./litre of sulphuric acid with 37 grm./litre of copper, and the temperature should not exceed 20° C. The electrolyte should be protected from the air by a layer of machine oil, and it should be adequately circulated; the current density at the anode should be 120–150 amp./dm.^{2} and at the cathode 70–80 amp./dm.^{2} Addition of 0·6 c.c. of hydrochloric acid per litre assists in the production of smooth cathode deposits of copper; electrolysis can be continued until the copper content of the electrolyte falls to 10 grm./litre and the tin content rises to 50 grm./litre as stannous sulphate. The anodes should be well annealed and should be practically free from lead and zinc.—A. R. P.

Researches on the Corrosion of Various Leads of Different Chemical Composition in Sulphuric Acid Manufacture. Adolf Schünemann (*Korrosion u. Metallschutz*, 1933, **9**, 325–331).—Tests on lead prepared by various processes and on alloys of lead with small quantities of other metals have shown that, for general use in sulphuric acid manufacture, the purest lead gives the best results. Addition of small quantities of copper, nickel, or bismuth may, under certain conditions and in certain parts of the plant, confer a higher corrosion resistance on the lead, but this is due to the formation of a protective film which later is broken down by local element action, and corrosion then proceeds more rapidly than with pure lead. For parts which are subject to vibrational stresses such as would cause intercrystalline fatigue of pure lead, the use of lead containing a small quantity of copper is recommended.—A. R. P.

***An Investigation of the Corrosion of Magnesium Alloys. III.—The Effects of Heat-Treatments on the Corrosion of Magnesium–Zinc and Magnesium-Aluminium Alloys.** Takejirô Murakami and Susumu Morioka (*Kinzoku no Kenkyu*, 1934, **11**, (3), 99–116).—[In Japanese.] By dipping specimens of magnesium–zinc and magnesium–aluminium alloys in dilute sodium chloride solutions, the corrodibility of the alloys was determined in the cast, annealed, quenched, and tempered conditions, and the effects of heat-treatment on the corrosion of the alloys were studied. The effect of tempering on the corrosion of magnesium–aluminium alloys is quite different from that of magnesium–zinc alloys. In the latter the corrodibility is a maximum when the precipitation of fine particles due to tempering of quenched specimens is a maximum, whereas in the former the corrodibility of the alloys treated under the same conditions is a minimum when the precipitation is maximum. In general, the cast specimens corrode less than the annealed and quenched ones; this fact leads to the conclusion that the heat-treatment of magnesium alloys has harmful results on their corrosion-resistance.—S. G.

***Concerning the Topochemistry of Magnesium. A Contribution to Our Knowledge of Metallic Corrosion.** A. Vyskočil (*Coll. trav. chim. Tchécoslov.*, 1934, **6**, 1–16).—In aqueous solutions of ammonium salts or of salts of the alkalis or alkaline earths magnesium decomposes water, the hydroxide formed dissolving in the presence of ammonium salts. In acid solutions of ammonium salts the rate of dissolution of magnesium slowly decreases until neutrality is reached, then increases for a certain period, since slight alkalinity promotes the reaction in the presence of ammonium salts. Strongly alkaline solutions retard the reaction, the magnesium surface becoming resistant and retaining its metallic lustre. The catalytic effect of salts on the decomposition of water by magnesium is due solely to the anions, but oxidizing anions, *e.g.* chromate, passivate the metal; the anions are first adsorbed on discontinuities in the metal surface, and the free atoms of magnesium in the vicinity of the complexes formed then become activated for the reaction with water liberated from the hydrated anion adsorbed. The rate of formation of corrosion products on the magnesium surface depends on the adsorbability of the ions present, on the nature of the catalyzing ions (chloride ions being the most active), and on the nature of the metallic surface (whether made inhomogeneous by chemical action or originally so). The activity of the more active anions can be disturbed by the presence of less active ions which are more readily adsorbed, so that the magnesium surface may become more or less passivated for the action of the more active anions.—A. R. P.

Behaviour of Nickel and Alloys to Caustic Alkalis. H. E. Searle and R. Worthington (*Internat. Nickel Co. Bull.* No. **T–6**, 1933, 11 pp.; and (abstract) *Chem. and Met. Eng.*, 1933, **40**, 528–529; *Bull. B.N.F.M.R.A.*, 1933, **(58)**, 11). —Gives test data on the corrosion-resistance of nickel and its alloys to caustic alkalis of various concentrations and fused caustic soda, and a comparison with other metals, together with a *bibliography*.—S. G.

Attack of Metal Containers by So-Called Canned Fish in White Wine. Daniel Florentin (*Ann. Falsif.*, 1933, **26**, 594–597; *C. Abs.*, 1934, **28**, 2073).—Investigation of complaints regarding digestive disturbances alleged to have been caused by fish in so-called white wine (which are really fish in vinegar) showed that tin-coated cans were considerably attacked by the high acidity (even when they were not swollen or blown), most of the dissolved tin being fixed by the fish instead of remaining in solution in the liquid. With well-varnished containers the amount of tin dissolved was negligible.—S. G.

***The Corrosion of Zinc in Various Waters.** E. A. Anderson, C. E. Reinhard, and W. D. Hammel (*J. Amer. Waterworks Assoc.*, 1934, **26**, 49–60).—Samples of galvanized iron (hand-dipped after cutting to shape), 25·8 cm.^{2} in area, were immersed for 1 day and 7 days in 140 c.c. of chlorinated water from Franklin, N.J., U.S.A., in distilled water, and in water to which 1, 3, and 5 p.p.m. of chlorine were added. Tests were done in quadruplicate with bottles loosely corked and sealed and the weights of zinc in solution, in suspension, and as adhering salts, together with loss of weight of the specimens, were determined. Distilled water dissolved sufficient zinc in 7 days to render it unfit for drinking, but the addition of 1–5 p.p.m. of chlorine greatly reduced the rate of attack. The available data concerning the maximum safe amount of zinc that can be contained in drinking water are reviewed, and it is tentatively suggested that 40 milligrams per litre might be a safe upper limit.—J. C. C.

Roofing Paper and Zinc Sheeting. H. Mallinson (*Teer u. Bitumen*, 1933, **31**, 345–348; *C. Abs.*, 1934, **28**, 2493).—Weathering action on zinc surfaces protected by asphalt and tar papers has been studied. Corrosion is caused by the action of condensed moisture and occurs with both types of paper. Provision for evaporation of condensed water prevents corrosion.—S. G.

Aluminized Roofing Paper. E. Tauber (*Teer u. Bitumen*, 1933, **31**, 387). —S. G.

Accelerated Tests of Electroplated Metal Coatings on Steel. P. W. C. Strausser (*Monthly Rev. Amer. Electroplaters' Soc.*, 1934, **20**, (5), 6–10; discussion, 11–16).—The ferroxyl test is shown to yield in a short time results for nickel and chromium-plated finishes which correspond exactly with their behaviour under ordinary atmospheric exposure.—A. R. P.

***Some Comparative Corrosion-Fatigue Tests Employing Two Types of Stressing Action.** H. J. Gough and D. G. Sopwith (*J. Iron Steel Inst.*, 1933, **127**, 301–332; discussion, 333–335).—For abstract of the paper see *J. Inst. Metals*, 1933, **53**, 309. In the discussion *F. Bacon* suggested that the fatigue limit in air : flexural value ratio might be modified by the creation of a concentric condition of self-stress as the Wöhler test proceeded, and this stress would rise to a sharp peak at the surface of the specimen. He expressed the opinion that the above ratio must be bound up in some way with the notch sensitivity under alternating stresses and with the capacity to raise the fatigue limit by preliminary understressing.—A. R. P.

The Corrosion of Metals by Gases at High Temperatures. A. Portevin, E. Pretet, and H. Jolivet (*Congrès du Chauffage Industriel* (Preprint), *Group* 1, *Sect.* 3, **1933**, 33 pp.; *Bull. B.N.F.M.R.A.*, 1933, (**60**), 15).—Following a discussion of previous work, the authors describe their own results for the oxidation of electrolytic iron and binary alloys of iron with aluminium, chromium, and silicon. A full *bibliography* is appended.—S. G.

The Theories of Corrosion. O. A. Knight (*Mineral Ind., Pennsylvania State Coll.*, 1933, **3**, (2), 2, 4; 1934, **3**, (4), 3–4; *C. Abs.*, 1934, **28**, 1647).—K. reviews the following theories of corrosion: the acid, film, peroxide, direct oxygen attack, colloidal, biological, and electrochemical. Soil corrosion and methods for combating atmospheric corrosion are discussed.—S. G.

V.—PROTECTION

(Other than Electrodeposition.)

(Continued from pp. 245–248.)

Electric Oxidation of Aluminium. The Eloxal Method. J. Loewenthal (*Teknisk Ukeblad*, 1933, **80**, 561–564; *C. Abs.*, 1934, **28**, 2275).—An electrolytic method is described for the coating of articles of aluminium or aluminium alloys with a 0·02–4 mm. film of γ-oxide. As a rule a.c. is employed, and no counter-electrodes are necessary. Articles of limited size are treated in rubber-lined sheet-iron vats at a temperature of 15°–30° C. In most cases 3·5–4·5 kw.-hrs. per m.^{2} surface will be sufficient, the treatment being completed in

15–20 minutes. Wire or ribbon is drawn continuously through the bath. Tube spirals and similar articles that cannot be treated in the bath are treated by means of a special spraying apparatus, the article being grounded and serving as one electrode, the electric current playing between the sprayed surface and a counter-electrode on the spraying apparatus through the jet of an electrolyte. The latter is an acid solution containing oxidative substances, no further details being stated. The oxide film can be coloured by treatment with solutions of organic or mineral dyestuffs. The oxide film obtained by the Eloxal process is claimed to be far better than any other oxide coatings with respect to electrical resistance, non-porosity, and chemical resistivity.—S. G.

Anodic Oxidation of Aluminium. C. L. Mantell (*Metal Cleaning and Finishing*, 1934, **6**, 11–16, 29; *C. Abs.*, 1934, **28**, 2625).—The production of oxide films on aluminium for protective and decorative purposes by the use of chromic acid and the sulphuric acid anodic oxidation processes is described in detail. The composition of such films and their electrical, chemical, and mechanical properties are discussed. Paint, varnish, and other coating materials adhere much better to aluminium thus treated. The colour of the oxide films may be varied, depending on the purity of the aluminium, the electrolyte, and the operating conditions.—S. G.

Anodic Treatment and Dyeing of Aluminium Castings. N. D. Pullen (*Proc. Inst. Brit. Found.*, 1932–1933, **26**, 335–345; discussion, 346–347).—See *J. Inst. Metals*, 1933, **53**, 444.—S. G.

Copper-Coating of Aluminium Parts in the Cold. Anon. (*Metallwaren-Ind. u. Galvano-Tech.*, 1934, **32**, 118–119).—The articles are polished brightly on linen wheels, then immersed in a mixture of 10 vol. of hydrochloric acid and 60 vol. of water, to which are added 2 parts of sulphuric acid and 2 parts of copper sulphate. After well rinsing, the copper deposit is burnished, and the article is then hung in a bath containing 38 grm. of copper sulphate and 0·8 grm. of potassium chloride in 135 c.c. of water until the desired thickness of copper is obtained. The deposit adheres well, and the coated article may be mechanically worked without flaking occurring.—A. R. P.

Protection from Deterioration of Lead Sheaths of Cables. A. Noirclerc and L. Lussaud (*Rev. gén. Élect.*, 1933, **34**, 19–28; *Sci. Abs.*, 1933, [B], **36**, 555).—Various causes of the deterioration of the lead sheaths of cables, telephone, telegraph, or power, are described. The causes dealt with are: (1) mechanical, such as tension or crushing when the cables are being handled; (2) intercrystallization due to vibration; (3) chemical action due to the reagents in the soil or atmosphere; and (4) electrochemical action due to stray currents. It is pointed out that the mechanical strength can be increased by alloying the lead with tin, antimony, or cadmium. Protection against chemical and electrochemical corrosion may be obtained by coating the lead with a layer of a composition of sulphur and mercury, and tables are given showing the results of tests of samples of lead that have been treated with this composition. Care should be exercised in the selection of the routes along which to run the cables. —S. G.

***Tin–Iron Alloy in Tinplate, with Notes on Some Imperfections.** W. E. Hoare (*Iron Steel Inst. Advance Copy*, **1934**, (May), 1–12).—The structure of the compound layer occurring in commercial tinplates has been investigated. The compound is $FeSn_2$, no other compound or iron–tin phase of any kind has been observed. Certain defects which occur are classified as "normal pores" and "potential pores," the former being true pores immediately after the tinning of the plate and the latter tending to become true pores during forming. Microscopic examination shows that both the "hot-water" and the "modified ferricyanide paper" tests register an exposure of the steel base, but give no reaction with $FeSn_2$ crystallites. The low results given with the latter tests can be obviated by correct dampness of the paper and careful exclusion of minute air bubbles. The hot-water test is considered as the standard test, although the ferricyanide paper test is the more convenient. The following defects were noted, their nature investigated, and suggestions made as to their causes: normal pores, blisters, mottle, dry patches, grease lines, and isolated $FeSn_2$ crystallites.—J. H. W.

Hot-Galvanizing and Lead-Coating [of Metals]. Anon. (*Metallwaren-Ind. u. Galvano-Tech.*, 1934, **32**, 91–93).—An account of modern technique in these processes.—A. R. P.

Galvanization, a Means of Protecting Ferrous Metals Against Atmospheric Corrosion. Marcel Lepingle (*Science et Industrie*, 1934, **18**, 110–114).—(See also *J. Inst. Metals*, 1933, **53**, 638; and *Met. Abs.*, this volume, p. 182.) Results of service tests on galvanized material are discussed and summarized, notably those carried out by the American Society for Testing Materials. A *bibliography* is given.—P. M. C. R.

Paints for Aluminium and Its Alloys. H. Rabaté (*Peintures, Pigments, Vernis*, 1933, **10**, 64–65, 67–69; *C. Abs.*, 1934, **28**, 2201).—A general account is given of the suitability of coatings made from oils, asphalt, tar, nitrocellulose, and synthetic resins, and of the preparation of the metal surfaces.—S. G.

Review of Rustproofing Processes with Reference to the Use of Town's Gas. O. W. Roskill (*Metallurgia*, 1934, **9**, 185–188).—Rustproofing processes, both by actual physical deposition of the protective coating on the surface of the metal, and by transforming the surface of the metal itself chemically into a protective coating, are dealt with. Spraying with tin, lead, zinc, aluminium, or nickel; Sherardizing, the Parker process, Coslettizing, and anodic oxidation are among the processes which are discussed in brief detail, not only with regard to the general technique involved, but also with special reference to the use of town's gas in the various furnaces required. Reference is also made to the types of deposit obtained, to the applications of the various processes, and to recent developments which have taken place in their technique and applications.—J. W. D.

A New Metal Spraying Process for Coating Iron and Steel. Anon. (*Illust. Z. Blechindustrie*, 1934, **63**, 355).—A recent development of the Schoop spraying process includes subsequent heat-treatment after the application of an aluminium coating. It is claimed that interaction between the basis metal and the aluminium produces a perfect bond, the coating being stable at working temperatures up to 1000° C., at which temperature the life of the coated material is estimated at 8 times that of the original; values for lower service temperatures are given. Graphite and sulphur present in grey iron may weaken the coating by combination with the aluminium.—P. M. C. R.

Paints for Aluminium and Its Alloys. H. Rabaté (*Synthetic and Applied Finishes*, 1933, **4**, 219–220, 222).—See *Met. Abs.*, this volume, p. 19.—S. G.

Painting Elektron. Fr. Kolke (*Farben-Zeit.*, 1933, **38**, 1756; *C. Abs.*, 1934, **28**, 1875).—A Bakelite primer containing 30% TiO_2, baked on, was the best of several for the magnesium alloys A2M and AM 503. Chromatizing pretreatment also favourably affected the durability of the paints.—S. G.

Study of Rust-Preventing Power of Paints on Tinned-Iron Food Containers. A. Vila (*Recherches et Inventions*, **1933**, (228), 308–318).—S. G.

The Use of Metallic Zinc Paint for the Protection of Metal [Zinc and Zinc-Coated| Surfaces. H. P. Fritsch (*Agric. Eng.*, 1933, **14**, 337–338; *C. Abs.*, 1934, **28**, 2549).—Owing in part to its chemical composition and in part to its unusual distensibility, metallic zinc paint affords much better adherence to zinc and zinc-coated surfaces than many other paints commonly used for this purpose.—S. G.

The Function of Paint as a Metal Preservative. L. A. Jordan *et al.* (*J. Oil Colour Chem. Assoc.*, 1933, **16**, 398–421).—A discussion.—S. G.

VI.—ELECTRODEPOSITION

(Continued from p. 248.)

Cadmium Plating on Full Automatic Machines. F. L. Greenwald (*Monthly Rev. Amer. Electroplaters' Soc.*, 1933, **20**, (3), 19–25; discussion, 25–26).—The work is degreased anodically in an electric cleaner, then pickled in 20% hydrochloric acid for 1 minute at 50° C., rinsed in a water-spray, and cleaned cathodically for 1 minute with 20 amp./ft.^{2} in a bath containing 5 oz./gall. of sodium cyanide; it is then transferred without washing to the plating bath, which contains cadmium 2, free cyanide 6, and sodium carbonate 5 oz./gall. and is operated at 25–30 amp./ft.^{2} for 6 minutes, after which the plated articles pass through a series of cold- and hot-water washes and sprays, then into a drying oven at 175° C.—A. R. P.

Analytical Control of Cadmium Electro-Plating Solutions. E. E. Halls (*Metallurgia*, 1934, **9**, 183–184).—The necessity of analytical control to ensure the maximum utility of the cadmium plate is discussed. The determinations which it is necessary to make are total cadmium content, free cyanide content, and alkalinity, present as hydroxide and carbonate. The procedure necessary before making the determinations is first considered, then different methods for the determination of cadmium, volumetric and electrolytic, are given, as well as methods for the determination of the free cyanide content, and the alkali present as carbonate and hydroxide.—J. W. D.

Iron in Chromium[-Plating] Baths. Oskar Krämer (*Metallwaren-Ind. u. Galvano-Tech.*, 1934, **32**, 90, 118).—The sources of contamination of the bath with iron, the deleterious effect thereof on the plating process, and means for removing iron from contaminated baths are briefly discussed.—A. R. P.

Chromium Plating in the Cold. O. Macchia and D. Raffaelli (*Indust. meccanica*, 1933, **15**, 793–795; *C. Abs.*, 1934, **28**, 1606).—A discussion of the problem of plating chromium at 30°–50° C. as contrasted with that at 16°–20° C. It is concluded that plating in the cold is entirely practicable and possesses the following advantages over the heated-bath method: the heating apparatus and the expense of its operation are eliminated; a smaller current density may be used, in consequence of which a smaller investment in the generating plant and its operation is required; the apparatus required for ventilation on account of harmful vapours is reduced to a minimum.—S. G.

†**Protection of Workers Exposed to Chromium and Its Compounds.** Anon. (*Monthly Rev. Amer. Electroplaters' Soc.*, 1934, **20**, (7), 39–47).—Symptoms, cure, and methods of preventing diseases caused by spray from chromium plating tanks are described.—A. R. P.

On the Effect of Chromium in Nickel Plating Baths. F. Pietrafesa (*Atti Congr. naz. Chim. pura appl.*, 1933, **4**, 776–785; *Chem. Zentr.*, 1934, **105**, I, 1384).—Even very small quantities of chromic acid in nickel-plating baths, impart a leady appearance to the deposits due to the formation of colloids which are deposited on the cathode by cataphoresis and cause the formation of gas bubbles. Prolonged electrolysis regenerates the baths.—A. R. P.

Chromium Plating. A. Guillerot and J. Pierson (*Bull. Soc. franç. Élect.*, 1933, **3**, 859–866; *Sci. Abs.*, 1933, [B], **36**, 603).—Low-temperature methods (15° C., current density 3–5 amp./dm.^{2}, with additions to the chromic acid electrolyte have been examined. The authors do not anticipate much development, but consider that eventual improvement may lie in the adoption of trivalent chromium salts in the electrolyte instead of chromic acid.—S. G.

***On the Question of the Chromium Plating of Nickel Films.** Joachim Korpiun, Ernst Vogel, and Karl Schneider (*Naturwiss.*, 1934, **22**, 135).—The peeling of nickel plate during or after chromium plating is attributed to the diffusion of hydrogen through the nickel layer with the development of a hydrogen pressure. The diffusion of hydrogen through nickel films which have a tendency to peel is particularly strong and the grain size correspondingly small.—J. W.

Production of Thick Brass Coatings on Iron and Steel. Anon. (*Metallwaren-Ind. u. Galvano-Tech.*, 1934, **32**, 94).—A cheaper way than electroplating with brass direct from a cyanide bath is to plate alternately with copper and zinc from separate acid baths, then to heat the article to cause diffusion of the two metals to produce brass. Flaking of the first zinc coating from the steel is prevented by first applying a thin nickel coat.—A. R. P.

The Use of Acids in the Preparation of Steel for Plating [with Copper and Nickel]. Walter S. Barrows (*Monthly Rev. Amer. Electroplaters' Soc.*, 1933, **20**, (3), 12–18; discussion, 18).—Practical hints on acid cleaning before plating. —A. R. P.

***The Electrodeposition of Copper, Nickel, and Zinc Alloys from Cyanide Solutions.—I.** Charles L. Faust and G. H. Montillon (*Electrochem. Soc. Preprint*, **1934**, (April), 267–281).—Copper–nickel–zinc alloys can be deposited from cyanide solutions, the colour of the deposit varying from golden-yellow to platinum-white, according to the conditions of deposition. Zinc deposits more readily than copper, and copper more readily than nickel; the copper content of the alloy is relatively greater than the proportion of copper in the bath, that of zinc about the same as the zinc content of the bath, and that of the nickel much less than the % of nickel in the bath. Increase in current density increases the zinc and nickel contents of the deposit, and increase in temperature the copper content. Curves are given showing the composition of alloys deposited under various conditions of temperature and current density.—A. R. P.

Deposition of Pink Gold. Alfred K. Pritchard, Jr. (*Met. Ind.* (*N.Y.*), 1933, **31**, 408).—The bath contains sodium phosphate crystals 60, sodium cyanide 3, nickel cyanide 3, palladium (as chloride) 3, gold (as aurous cyanide) 0·25, and copper cyanide 0·5 grm./litre, it is operated at 55°–65° C. with 4–6 v., using nickel or hard carbon anodes. High temperatures favour deposition of nickel and palladium, low temperatures deposition of gold and copper; by careful regulation a pink gold alloy is deposited.—A. R. P.

***The Electrodeposition of Indium from Cyanide Solutions.** Daniel Gray (*Electrochem. Soc. Preprint*, **1934**, (April), 283–286).—The bath is prepared by dissolving indium in hydrochloric acid, expelling the excess of acid, precipitating the indium as hydroxide with ammonia, dissolving the precipitate in saturated sodium cyanide solution containing 0·5 grm. of dextrose per 1 grm. of indium, and diluting until the indium concentration is 60 grm./litre. The bath remains stable for at least 2 years, and can be boiled without deposition of hydroxide. Operating at 1–16 amp./dm.^{2} soft silver-white deposits are obtained at 100% current efficiency when the bath is new, but at only 50% efficiency with old baths. Indium anodes cannot be used, but good results are obtained with platinum or other insoluble anodes.—A. R. P.

***Ductility and Adhesion of Nickel Deposits.** F. P. Romanoff (*Electrochem. Soc. Preprint*, **1934**, (April), 251–256).—The ductility of nickel deposits depends on the crystal structure, amount of adsorbed gas, and the presence or absence of entrapped basic salts. Hard nickel deposits have an acicular or columnar structure or contain adsorbed gas or basic compounds, whereas ductile deposits are free from inclusions, and consist of conical or pyramidal crystals. Ductile deposits up to 0·01 in. thick have practically no effect on the ductility of the base metal, but fibrous non-ductile deposits cause an apparent hardening of the base metal probably due to notch-propagation by transmission from fractures produced in the nickel deposit by the deformation applied. The inherent ductility of copper remains unaffected by plating with fibrous nickel, since when the latter is removed the copper is just as ductile as it was before plating. A ductile nickel deposit on copper can be embrittled by cathodic treatment in an alkaline solution, but chromium may be deposited on a ductile deposit without causing embrittlement. The most reliable method for determining the adhesion and ductility of nickel and other coatings on sheet metal consists in stamping out a flanged cap. Examples of stampings made from copper and brass plated with ductile nickel are shown.—A. R. P.

Some Problems in Technical Control of Nickel-Plating Production. F. A. Maurer (*Monthly Rev. Amer. Electroplaters' Soc.*, 1934, **20**, (8), 42–48).—A brief account of the methods used in the nickel-plating of flat-irons.—A. R. P.

Rhodium Plating. Osvaldo Macchia (*Indust. meccanica*, 1933, **15**, 621–622; *C. Abs.*, 1934, **28**, 1606).—A review of rhodium in electroplating, covering the published researches and the proposed baths.—S. G.

Production of Electrolytic Cadmium–Silver Plate. Ralph W. Harbison (*Deut. Goldschmiede-Zeit.*, 1933, **36**, 525–526; *Chem. Zentr.*, 1934, **105**, I, 759).—Silver–cadmium deposits from cyanide baths have good mechanical properties, but poor resistance to sulphide tarnishing when the cadmium content is less than 25%; with more than 70% cadmium they are hard and fairly resistant to tarnishing, but with 25–70% cadmium brittle and useless. Suitable baths for obtaining good deposits contain cadmium 80–90, silver 10–25, and sodium cyanide 17–18 grm./litre.—A. R. P.

Throwing Power of Zinc-Plating Solutions. I.—Relation Between Current Density and Current Efficiency of Zinc Sulphate Solutions. Masami Nakajima (*J. Electrochem. Assoc.* (*Japan*), 1934, **2**, 19–25; *C. Abs.*, 1934, **28**, 1931).—[In Japanese.] The p_H values of 0·5, 1·5, and 2·5*N* zinc sulphate solutions have been determined and compared with each other. On the basis of quality of deposit and current efficiency, 1·5–2·5*N* zinc sulphate solution at 3·4 p_H and 1–3·5 amp./dm.^{2} is recommended.—S. G.

Discussion of the Applications of Electrodeposition to Printing. H. E. Boughay (*Met. Ind.* (*Lond.*), 1934, **44**, 377–379).—Abstract of the discussion of a paper read before the Electrodepositors' Technical Society. See *Met. Abs.*, this volume, p. 137.—J. H. W.

Filtration of Plating Solutions. Louis Weisberg and Willard F. Greenwald (*Met. Ind.* (*N.Y.*), 1934, **32**, 15–18).—The operation of the following types of filters is discussed: presses, leaf filters, and asbestos disc filters. Means for circulating plating solutions and the cost of filtration are also considered. —A. R. P.

Methods of Stripping Plated Coatings [from Steel]. A. Brenner (*Monthly Rev. Amer. Electroplaters' Soc.*, 1933, **20**, (3), 7–10; discussion, 11–12).—See *Met. Abs.*, this volume, p. 248.—A. R. P.

VII.—ELECTROMETALLURGY AND ELECTROCHEMISTRY

(Other than Electrodeposition and Electro-Refining.)

(Continued from pp. 248–249.)

Investigations on the Influence of Aluminium Salts on the Electrolysis of Zinc Sulphate Solutions. L. Wasilewski and A. Weber (*Przemysl Chem.*, 1933, **17**, 259–267; *Chem. Zentr.*, 1934, **105**, I, 1551).—In the production of electrolytic zinc from solutions containing 90 grm./litre of zinc as sulphate and 3·3 grm./litre of free acid using lead anodes and aluminium cathodes, addition of 0·9 grm./litre of aluminium sulphate results in the production of smooth adherent deposits, which show no tendency to "tree" even at the edges, and increases the current yield; if hydrogen bubbles are allowed to accumulate on the cathode, however, the beneficial effect of the aluminium salt is nullified. With larger additions of aluminium sulphate the current yield at 1–4·3 amp./dm.^{2} is further increased up to a maximum with 3·6 grm./litre of sulphate, and then falls rapidly until with 9 grm./litre an effect is obtained similar to that produced by cobalt.—A. R. P.

***The Electrolysis of Metals Studied with Scraped Electrodes.** J. Hoekstra (*Coll. trav. chim. Tchécoslov.*, 1934, **6**, 17–36).—Irregular current-voltage curves are obtained with unscraped silver electrodes in *M*-silver nitrate solution, whereas straight lines are obtained with scraped electrodes. Copper electrodes behave similarly to silver, but mercury always gives a straight-line relation. Scraping eliminates slight irregularities in the curves for lead electrodes, but has a profound effect on the curves for zinc electrodes. With nickel electrodes scraping prevents polarization. Photomicrographs are given of growing deposits of silver, copper, lead, tin, and thallium. A theoretical explanation of the effects observed is given based on activation and adsorption phenomena. —A. R. P.

Electrochemistry and Electrometallurgy—1932–1933. —— (*Elect. Eng.*, 1933, **52**, 706–707).—Excerpts from the annual report of the A.I.E.E. committee on the subject. It is stated that the commercial production of lithium has been established in America. It is being extensively used as a hardener for aluminium and lead alloys and the degassing of copper, where it is of particular importance in connection with the manufacture of H.-C. copper.—S. V. W.

IX.—ANALYSIS

(Continued from pp. 250–252.)

***Spectrographic Investigations of Technical and Very Pure Metals. III.—Aluminium.** Walther Gerlach and Else Riedl (*Sitzber. math. naturw. Abt. bayer. Akad. Wiss. München*, 1933, (**2**), 227–236; *C. Abs.*, 1934, **28**, 1625).—Cf. *Met. Abs.*, this volume, p. 25. Spectrograms in the region 3900–4300 A. are given for Al from several sources. All the impurities can be detected. Chemical analyses for Fe and Si in the purer sorts agree well with the spectral determination but not for the impure samples. Ga was found in considerable quantities in nearly all samples. Sc but no Ga was found in Al from the Aluminum Company of America. The relative amounts of Ag, Cr, Cu, Fe, Ga, Mn, Ni, Pb, Sc, Si, Sn, Ti, V, and Zn are estimated in each sample.—S. G.

Kinematographic Process of Quantitative Spectrum Analysis. A. Betim (*Boletim do Museu Nacional* (*Rio de Janeiro*), 1933, **9**, (3), 52 pp.; *Bull. B.N.F.M.R.A.*, 1934, (**65**), 11).—[In French.] The principle of the method rests on the measurement of the mass of the elements present in a (mineral) sample by means of variation of one of the lines. A photographic plate is displaced in the direction of the spectrum lines, thus giving a record both of intensity and duration of emission. Integration of intensity and time factor gives mass.—S. G.

Analysis of Babbitt Metal. Frank W. Scott (*Chemist-Analyst*, 1934, **23**, (2), 10–11, 14–15).—Details are given for the determination of Pb as $PbSO_4$, Fe as Fe_2O_3, Cu by electrolysis, Sb by titration with $KMnO_4$, and Sn by titration with I_2.—A. R. P.

Electroanalysis of Molybdenum. Chujiro Nemoto and Yoshio Tanabe (*J. Electrochem. Soc.* (*Japan*), 1934, **2**, 53–56; *C. Abs.*, 1934, **28**, 2296).—[In Japanese.] Add 0·5 grm. CH_3COONH_4 to the aqueous solution containing 0·1 grm. MoO_3 as $(NH_4)_2MoO_4$, dilute to 150 c.c., heat to about 70° C. and electrolyze with a current of 0·2 amp. for 5 hrs. and with a cathode of Pt gauze plated with Cu. Add 1 c.c. of 50% CH_3COOH at the middle of the electrolysis. After complete precipitation, wash the deposit with hot water without breaking the circuit, rinse with alcohol, dry and weigh.—S. G.

***The Analysis of High-Grade Ferrosilicon.** Paul Klinger (*Arch. Eisenhüttenwesen*, 1933–1934, **7**, 551–556).—Methods are given for the determination of C, Mn, P, S, Al, Ti, Ca, Mg, Cu, Fe, Si, and SiO_2.—J. W.

Methods of Detecting Arsenic. Roberto Intonti (*Atti Congr. naz. Chim. pura appl.*, 1933, **4**, 732–737; *Chem. Zentr.*, 1934, **105**, I, 1527).—Modifications of the Reinsch test are described.—A. R. P.

***On the Reaction of Bismuth with Thiourea.** J. V. Dubský, A. Okáč, and B. Okáč (*Z. anorg. Chem.*, 1934, **216**, 386–390).—HNO_3 solutions of Bi salts yield an intense yellow colour with thiourea.—M. H.

***The Detection of Copper by Means of *p*-Phenylenediamine.** R. J. McIlroy (*Analyst*, 1934, **59**, 103).—Addition of 5 c.c. of saturated KCNS solution and 2–3 drops of *p*-phenylenediamine to a feebly ammoniacal solution containing Cu yields a black precipitate; Co, Mn, Ni, and Mg give no precipitate, Cd, Zn, and Ag white precipitates, and Hg a grey precipitate.—A. R. P.

Notes on the Determination of Aluminium in Nickel Alloys. R. C. Chirnside (*Analyst*, 1934, **59**, 278).—The cold, feebly acid solution is treated with KCN until all the Ni and Cu are converted into complex cyanides, and the mixture is then poured slowly with constant stirring into excess of dilute NH_4OH. The precipitate of $Al(OH)_3$, $Cr(OH)_3$, and $Fe(OH)_3$ is allowed to settle, collected, washed with 2% NH_4NO_3 solution, and analyzed as usual.—A. R. P.

Determination of the Lead Content of Tinned Containers. E. Wohnlich (*Z. Untersuch. Lebensm.*, 1933, **66**, 453–460; *C. Abs.*, 1934, **28**, 1626).—A discussion of methods.—S. G.

***On the Quantitative Determination of Some Metals with Anthranilic Acid. III.—A Simple Method for the Quantitative Determination of Manganese.** H. Funk and M. Demmel (*Z. anal. Chem.*, 1934, **96**, 355–358).—The neutral solution (80 c.c. for every 0·1 grm. Mn) is treated with 60 c.c. of cold 3% Na anthranilate solution. The precipitate of Mn $(C_7H_6O_2N)_2$ is collected in a porous crucible washed with a 0·5% solution of the reagent, then with C_2H_5OH, dried at 105°–110° C., and weighed; it contains 16·795% Mn.—A. R. P.

Nephelometry. III.—Determination of Phosphorus in Steels and Arsenic in Arsenical Copper. Luigi Belladen, Ugo Scazzola, and Renato Scazzola (*Annali chim. applicata*, 1933, **23**, 517–521; *C. Abs.*, 1934, **28**, 1953).—Determine As in alloys by the method of Kleiman and Pangritz but use the strychnine–molybdic acid reagent instead of the cocaine derivative.—S. G.

Chemical Researches on Galvanizing and Rapid Methods for the Determination of Zinc on Galvanized Iron. E. Azzarello, A. Accardo, and A. Scalzi (*Atti Congr. naz. Chim. pura appl.*, 1933, **4**, 629–656; *Chem. Zentr.*, 1934, **105**, I, 1554).—Cf. *Met. Abs.*, this volume, p. 27. The properties of galvanized Fe prepared by various processes are described and methods of determining the Zn are critically discussed. The most rapid method consists in dissolving off the Zn in dilute H_2SO_4 containing $MgSO_4$, measuring the H_2 evolved, and determining the $Fe^{\cdot\cdot}$ in solution by titration with 0·05*N*-$KMnO_4$; the H_2 equivalent to the Fe is deducted from the total, and the remainder calculated to Zn. Another procedure consists in dissolving the greater part of the Zn in 100 c.c. of 2% H_2SO_4, treating the solution with 2 grm. of tartaric acid and 6 grm. of NaOH, and electrolyzing, using the partly stripped Fe as anode and a Cu gauze cathode; the Fe and Pb in the deposit must be determined by the usual methods and deducted from the weight.—A. R. P.

X.—LABORATORY APPARATUS, INSTRUMENTS, &c.

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

(Continued from pp. 252-253.)

***A New Optical Dilatometer.—II.** Fr. Bollenrath (*Z. Metallkunde*, 1934, **26**, 62–65).—Cf. *J. Inst. Metals*, 1933, **53**, 650. Determinations with a highly sensitive dilatometer have been made of the thermal expansion curves of aluminium (99·87%), magnesium (99·96%), extruded Elektron V1w (containing aluminium 10·0, and manganese 0·4%), cast Silumin, and cast 90 : 10 aluminium–copper alloy. The coeff. of thermal expansion of these materials are given.—M. H.

***The Expansion Characteristics of Some Common Glasses and Metals.** E. E. Berger (*Gen. Elect. Rev.*, 1934, **37**, 93–96).—A description of an apparatus for measuring expansion. The expansion of the sample is compared with that of a sample of known expansion, the difference being measured by means of the rotation of a small mirror mounted on a roller between extensions to the two samples. The furnace, which is mounted vertically, and method of mounting the specimens are described. Samples up to 12 in. long can be used. Some typical results are given.—S. V. W.

†Magneto-Caloric Production of Extremely Low Temperatures. W. Meissner (*Physikal. Z.*, 1934, **35**, 303–310).—The literature relating to the production of extremely low temperatures by utilizing the magneto-caloric properties of bodies is reviewed. Briefly, the method is as follows: a paramagnetic body is magnetized isothermally at a high temperature; the heat evolved is transferred to a cooling medium; the body is then demagnetized adiabatically out of contact with the cooling medium; in the case of some paramagnetic bodies further cooling is thus produced. Temperatures very close to absolute zero have been attained in this manner.—J. S. G. T.

***Apparatus for the Preparation of [Rods of] High Melting Alloys.** F. Beck (*Z. tech. Physik*, 1933, **14**, 544–556).—A vacuum sintering apparatus with optical and electrical control of the temperature is described for the manufacture of sinter rods of high melting point metals and alloys.—J. W.

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

(Continued from pp. 254–256.)

Some Tests of Intermetallic Abrasion. H. W. Swift (*Engineering*, 1931, **131**, 783–785; and (abstract) *Organ Fortschritte Eisenbahnwesen*, 1932, **87**, 183–184).—The testing machine consists essentially of a cylindrical drum, the flat annular end of which rubs against 3 evenly spaced specimens of the material to be tested. Either the whole drum or the annular portion is made of some selected abrading medium. Lubrication is not applied, and only sliding abrasion is considered. The loss of weight of the 3 specimens together is found after every 20,000 revolutions, the test normally covering 250,000–500,000 revolutions. Friction readings are taken periodically. Results are tabulated for 3 steels, cast iron, phosphor–bronze, and " Halo," a synthetic brake-lining. Certain induced surface effects are noted as requiring further investigation. —P. M. C. R.

Suitability of the Torsion Test for Following the Course of Corrosion. B. Garre and H. Brose (*Korrosion u. Metallschutz*, 1933, **9**, 334–336).—Tests on copper and aluminium wire have shown that the torsion test provides an accurate indication of the nature and degree of corrosion which the wire has undergone.—A. R. P.

Applications of Some Machines for the Testing of Metals. Gérard de Smet (*Machine moderne*, 1934, **38**, (296), 7–11).—Testing methods in general use are classified, and the advantage to the constructor of systematic testing is emphasized. The working of the following types of machine is discussed: tensile; impact; repeated shock; fatigue; Brinell, Shore, Herbert, and Rockwell hardness and wear-testing machines.—P. M. C. R.

A Method for Non-Destructive Testing of Weld Seams. S. Kiesskalt (*Autogene metallbearbeitung*, 1934, **27**, 65–68).—A description of the I.G. electro-acoustic weld tests in which magnetic lines of force, induced in the material to be tested, are " tracked " by a portable instrument connected to a pair of headphones. The characteristic sound produced is varied by the presence of flaws or inclusions. Although primarily intended for ferrous materials, the tester is said to be applicable to nickel welds.—H. W. G. H.

Characteristics of Strength of Metals at High Temperatures. M. Roš and A. Eichinger (*Congrès du Chauffage Industriel* (Preprint), *Group* 1, *Sect.* 3, **1933**, 11 pp.; *Bull. B.N.F.M.R.A.*, 1933, (**60**), 15).—Discusses mathematical aspects, typical curves, &c., for static and alternating tests, with notes on Amsler testing machines in use at the Swiss Federal Testing Laboratory, Zürich.—S. G.

RADIOLOGY.

Future of Technical Radiology. C. N. Kemp. (*Brit. J. Radiology*, 1933, **6**, 166–172; discussion, 172–174; *Sci. Abs.*, 1933, [B], **36**, 328).—Possibilities of using X-ray examinations in directions other than medical are reviewed. Where more simple methods of investigation are available, at less cost, the method is not applicable, but there are many problems in industry where the X-ray method can be applied to otherwise insoluble problems. For this purpose the apparatus should be specifically designed for the investigations in question and be as simple as possible. Whereas in France and Germany industrial radiology is widely used, in Great Britain manufacturers of X-ray apparatus report that, apart from medicine, the volume of business in respect of the applications of X-rays is practically nil. Education in this respect is greatly needed and K. offers various suggestions. A discussion followed. —S. G.

Recent Results of the Radiometallographic Examination of Castings. René Leonhardt (*Machine moderne*, 1934, **38**, (296), 19–21).—See *Met. Abs.*, this volume, p. 199.—P. M. C. R.

†**Application of X-Ray Fine Structure Research to Technical Problems.** Franz Wever (*Arch. Eisenhüttenwesen*, 1933–1934, **7**, 527–530).—Important results of röntgenography, especially in the solution of technical problems, are described. The use of X-rays in technical practice is difficult, but yields valuable information.—J. W.

Possible Uses of X-Rays in the Determination of Internal Stresses in Materials and Constructional Parts. R. Berthold (*Z. tech. Physik*, 1934, **15**, 42–48).—A review of recent work.—J. W.

Radiometallography Applied to Welding. Anon. (*Machine moderne*, 1934, **38**, (297), 66–67).—An account of an improved radium-tube apparatus for the examination of metals; the effects of variations of thickness in the material examined are obviated by immersion in a liquid of similar permeability to X-rays.—P. M. C. R.

X-Ray Testing Apparatus. W. E. Schmid (*Arch. tech. Messen*, 1934, **3**, (33), T41–T42).—A review of X-ray testing plant for investigating either macro- or micro-structures. Some details of suitable current strengths are given for various metals of stated thickness. For microstructures, a table gives wavelength, filter, and voltage for anodes of chromium, iron, cobalt, copper, molybdenum, and tungsten.—P. M. C. R.

XII.—TEMPERATURE MEASUREMENT AND CONTROL

(Continued from p. 256.)

***A Circuit Doubler for Use with a Dotting Recorder [for Thermocouples].** H. E. Beckett and H. Sheard (*J. Sci. Instruments*, 1934, **11**, 111–113).—In recording electrical quantities (*e.g.*, thermocouple readings) by galvanometers with dotting and circuit changing mechanisms, the frequency of dotting is often greater than is necessitated by the rate of change of the quantity measured. A circuit doubler is described for use on thermocouple circuits with a six-point thread recorder made by the Cambridge Instrument Co., Ltd., which enables

12 records to be obtained simultaneously. It can be modified for use with any standard type of dotting recorder.—W. H.-R.

A Thermostat for Higher Temperatures. Břetislav G. Šimek and Jevgenij Zamrzla (*Mitt. Kohlenforschungsinst. Prag*, **1933**, 485–489; *C. Abs.*, 1934, **28**, 1578).—The thermostat is based on the principle that if the pressure on a boiling liquid is held const. to within 1 mm. mercury, the temperature of the thermostat, which is heated by saturated vapour, can be held const. to within $\frac{1}{16}^{\circ}$. A vacuum regulator is used to regulate the pressure. A diagram shows the saturation pressures of several liquids suitable for thermostat material. By using a suitable construction material, liquid and condensation temperature this principle can be applied to the regulation of very low or relatively high temperatures.—S. G.

Expansion-Rod Thermostatic Regulators. L. Nolte (*Elektrotech. Z.*, 1933, **54**, 798–799; *Sci. Abs.*, 1933, [B], **36**, 627).—Alternative methods of securing automatic control of temperature in electric furnaces are noted briefly. An expansion-bar regulator comprises the actual regulating bar and switch-gear controlling the heating circuit. The operative device generally consists of a rod of material of low coeff. of expansion enclosed in a tube having a higher coeff. of expansion. The effect of conductivity is reduced by dividing this device into active and indifferent lengths. Curves are given showing the range of temperature between switching on and off, as a function of the depth of immersion of the expansion device. The calculation of the controlling force developed under stated conditions is explained, and notes are included on the desirable degree of mechanical magnification of movement, the behaviour of various contact materials, and the suppression of sparking.—S. G.

Temperature Control of Electric Furnaces. M. Lang (*Elektrotech. Z.*, 1933, **54**, 789–791; *Sci. Abs.*, 1933, [B], **36**, 627).—Cf. *J. Inst. Metals*, 1933, **53**, 515. L. describes the developments in the temperature control of industrial furnaces, contrasting the features of aperiodic control and other systems which aim at closeness of control, speed of operation, and protection from overheating should the regulator fail.—S. G.

Constant-Temperature Apparatus.—VI., VII. S. Kambara and M. Matsui (*Kōgyō Kwagaku Zasshi* (*J. Soc. Chem. Ind., Japan*), 1933, **36**, (4); *Brit. Chem. Abs.*, **1933**, [A], 800).—[In Japanese, with English abstract in supplemental binding, pp. 134–137B.] (VI.—) A low-temperature thermostat electrically controlled for the range 0° to − 60° C. is described. (VII.—) An air-bulb thermoregulator and a thermocouple control for an electric furnace are described.—S. G.

Pyrometric Economies. W. Bowen (*Ice and Cold Storage*, 1933, **36**, 168).—See *Met. Abs.*, this volume, p. 200.—S. G.

XIII.—FOUNDRY PRACTICE AND APPLIANCES

(Continued from pp. 257–259.)

***Periodic Structures in Metals and Alloys.** L. Northcott (*Iron Steel Inst. Advance Copy*, **1934**, (May), 1–9).—The banding effect which occurs in many steel ingots and castings is considered to be due to periodic crystallization. Similar structures have been prepared in a number of non-ferrous alloys, in which the periodicity was controlled by the casting conditions. It appears that the melt adjacent to the first batch of crystals undergoes both temperature and composition changes: an increase in temperature by virtue of the latent heat of solidification from the crystals, and an increase in the proportion of the lower melting-point constituents resulting in the lowering of the solidification temperature. Meanwhile the liquid further away from the solid eventually starts to crystallize spontaneously and the effect is repeated. Supercooling is an essential factor without which crystal growth would be continuous, and the metal must probably reach the labile state for periodicity to occur, since growth from the metastable state is also continuous.—J. H. W.

Indications for the Melting of Aluminium Casting Alloys. —— Irmann (*Aluminium Broadcast*, 1934, **4**, (26), 2–6).—Translated from *Tech. Rundschau*, **1934**, March 2. See *Met. Abs.*, this volume, p. 258.—J. C. C.

New Methods of Producing O.F.H.C. Copper. Anon. (*Indust. Bull. Arthur D. Little, Inc.*, 1934, (**85**), 2–3; *Bull. B.N.F.M.R.A.*, 1934, (**62**), 6).—O.F.H.C. copper has hitherto been prepared by melting cathode copper in the electric furnace under reducing conditions, and casting into vertical moulds in an oxygen-free atmosphere. Three other types of O.F.H.C. copper are now reported, produced (1) by deoxidation with phosphorus, so that the amount of phosphorus remaining is too small to be deleterious; (2) by careful deoxidation with lithium; (3) by forming solid homogeneous copper without melting, *e.g.* by sintering solid particles of cathode copper in a reducing atmosphere, followed by extrusion. No details are given.—S. G.

Cause and Effect in Bronze Founding. F. W. Rowe (*Proc. Inst. Brit. Found.*, 1932–1933, **26**, 380–391).—See *J. Inst. Metals*, 1933, **53**, 147.—S. G.

Some Factors Affecting the Soundness of Bronze Castings. E. J. L. Howard (*Proc. Inst. Brit. Found.*, 1932–1933, **26**, 430–454).—See *J. Inst. Metals*, 1933, **53**, 378.—S. G.

New Demands on the Brass Foundry. J. Arnott (*Proc. Inst. Brit. Found.*, 1932–1933, **26**, 653–661; discussion, 661–666).—See *J. Inst. Metals*, 1933, **53**, 378.—S. G.

Developments of Typefounding Since 1720. H. Daniel Caslon (*J. Roy. Soc. Arts*, 1934, **82**, 490–505).—A lecture.—E. S. H.

Advances in Die-Casting Technique. Ernst Praetorius (*Forschungen u. Fortschritte*, 1934, **10**, 134–135).—A short review.—J. W.

Plaster Patterns in General Foundry Practice. R. Ballantine (*Proc. Inst. Brit. Found.*, 1932–1933, **26**, 543–559; discussion, 560–565).—S. G.

Notes on Foundry Sands and Facings. F. A. W. Livermore (*Met. Ind.* (*Lond.*), 1934, **44**, 387–390).—Consideration is given to: composition, permeability and porosity, refractoriness, cohesiveness, and durability of moulding sand, the composition of core sand and the types of bonding materials used, the composition and treatment of parting sand and facing sand, and other materials used for facing.—J. H. W.

Routine Methods of Testing Green Sands. Sands and Refractories Sub-Committee of the Technical Committee (*Proc. Inst. Brit. Found.*, 1932–1933, **26**, 61–90; discussion, 90–103).—S. G.

Mechanized Foundries. F. J. Cook (*Proc. Inst. Brit. Found.*, 1932–1933, **26**, 246–259; discussion, 260–268).—S. G.

Time Studies in Foundry Work. V. Bernard (*Proc. Inst. Brit. Found.*, 1932–1933, **26**, 292–334).—French exchange paper.—S. G.

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

(Continued from p. 260.)

Separation of Copper from Complex Copper–Lead–Tin–Antimony Alloys. N. N. Muratch (*Zvetnye Metally* (*The Non-Ferrous Metals*), **1933**, (1), 99–100; *C. Abs.*, 1934, **28**, 1636).—[In Russian.] Laboratory experiments showed that copper can be removed almost completely from complex copper–lead–antimony–tin alloys by melting with large amounts of lead oxide.—S. G.

XV.—FURNACES AND FUELS

(Continued from pp. 260–262.)

Heating by Producer Gas in the Structural Materials Industry. Joseph Deforge (*Rev. mat. constr. trav. publ.*, **1934**, 19–20, 46–49, 79–83).—An explanation of the principle of the gas-producer is followed by an account of its development, with descriptions of certain modifications required by special types of practice. Causes of faulty performance are analyzed. A numerical instance illustrates the economy effected by utilizing pulverized fuels of poor quality. The working of the two-chamber type of transformer is described in some detail. The advantages of installing purifiers are emphasized; an example is shown in diagram, with an explanation of the theory of its working. A summarized account of modern industrial producers includes 3 main types, the special adaptations of which are described.—P. M. C. R.

The Problem of the Heat Recuperator. Arnold N. Lowan (*Phil. Mag.*, 1934, [vii], **17**, 914–933).—A mathematical theory of the heat recuperator is developed, employing partial differential equations. The treatment is entirely mathematical.—J. S. G. T.

Automatic Regulation of Large Industrial Gas Furnaces. G. Wunsch (*Congrès du Chauffage Industriel* (Preprint), *Group* 4, *Sect.* 1, **1933**, 6 pp.; *Bull. B.N.F.M.R.A.*, 1933, (**60**), 14).—Various methods for regulation of temperature and combustion are discussed.—S. G.

The Annealing of Wire. O. S. Haskell (*Heat-Treat. and Forging*, 1934, **20**, 94–96).—The development of furnace equipment, the type of furnace and its operation, and the essentials for the good annealing of copper wire are discussed.
—J. H. W.

The Fundamental Formula for the Design of Electric Furnaces. Gorō Harada (*Kōgyō Kwagaku Zasshi* (*J. Soc. Chem. Ind. Japan*), 1933, **37**, (1); *C. Abs.*, 1934, **28**, 1929).—[In Japanese, with English abstract in supplemental binding, pp. 9–10.] A formula for the most favourable electrode diameter is developed on the assumption that CV = constant, where C is the current density in amp./cm.², and V is the actual voltage between electrode tip and top. This constant depends on the kind of material processed and the reaction temperature in the furnace; it is 355 for grey pig iron (1500°–1550° C.). The assumption does not hold for extreme cases. The formula is $r = \sqrt{KW\,1000/355 \times 3\pi}$, where r is the electrode radius in cm. and KW is the furnace capacity in kw.—S. G.

†**Rocking Indirect Arc Electric Furnaces.** E. L. Crosby (*Elect. Engineering*, 1934, **53**, 132–138).—An illustrated paper dealing with this type of furnace which is extensively used in brass and bronze foundries. It is claimed that the rocking action coupled with a non-oxidizing atmosphere and accurate temperature control results in the production of dense and homogeneous castings.—S. V. W.

Development of Metallurgical H.-F. Furnaces. M. Tama (*Z.V.d.I.*, 1933, **77**, 199–202; *Sci. Abs.*, 1933, [B], **36**, 354).—In general, the larger the furnace the lower is the frequency employed. For frequencies above 500∼ the current generator is a homopolar machine, while for frequencies below 600∼ a single-phase heteropolar construction is employed: typical machines of these types are described. The construction of the furnaces is described with particular reference to the water cooling of the coils and to the copper screening. The H.-F. condensers are constructed of paper and aluminium foil and are water-cooled. Finally, the coreless type of L.-F. furnace is discussed.—S. G.

Heating of Metals and Alloys by H.-F. Induction. E. F. Northrup (*Elect. World*, 1933, **101**, 252–254; *Sci. Abs.*, 1933, [B], **36**, 434).—For extremely fast heating the induction process is unexcelled as the heat is generated inside the material itself instead of being imparted to it from without. To secure the best results the metal pieces should have a certain symmetry of form. Large diameters are better than small ones. Magnetic material is cheaper to heat than non-magnetic. The tonnage to be handled must be sufficient to justify the installation of a motor-driven generator to supply current at a frequency of 500 to 1000~, or, in special cases, 5000~.—S. G.

High-Frequency Induction Furnaces. C. A. Adams, J. C. Hodge, and N. H. Mackusick (*Elect. Engineering*, 1934, **53**, 194–205).—Gives a brief outline of the theory of induction furnaces and the application of the theory to the operating characteristics and limitations of such furnaces. From a metallurgical point of view the important features are freedom from contamination of the melt, high temperature obtainable, and circulation of the molten charge. There is a very extensive *bibliography*.—S. V. W.

***A Coreless Induction Furnace for Alternating Current of Ordinary Frequency.** Werner Hessenbruch and Wilhelm Rohn (*Stahl u. Eisen*, 1934, **54**, 77–82).—The construction and method of operating a coreless induction furnace with a capacity of 1·75 tons are described. The furnace is lined with powdered, fused magnesia, which sinters into a shell during the first melt. The cost of lining and the action of the current in promoting stirring of the charge are discussed. The furnace has been used for melting pure iron and for the refining of chromium–nickel steel.—J. W.

†Electrical Equipment for Induction Furnaces. C. C. Levy (*Elect. Engineering*, 1934, **53**, 43–48).—Frequency converters, switchgear, and condensers used in conjunction with induction furnaces are discussed and described. Particular reference is made to the advantages and possibilities of water-cooled equipment.—S. V. W.

Furnaces for High Temperatures, Especially for Ceramic Purposes, Melting, and Forging. H. Masukowitz (*Elektrowärme*, 1934, **4**, 15–18; *C. Abs.*, 1934, **28**, 1603).—Details of construction and operating data are given for furnaces which are equipped with a new design of heating unit as described by Junker (*Z. Metallkunde*, 1933, **25**, 38–42). This unit is like a ribbon with a reinforcing rib in the middle and permits an almost uniform surface heating of the walls and roof. A brass-melting furnace for a 100-kg. crucible, with 8–9 castings every 8 hrs., consumed only 300 kw.-hrs. per ton of brass when in continuous operation.—S. G.

Recent Developments in Electric Bright-Annealing Furnaces. —— Tamele (*Elektrowärme*, 1934, **4**, 3–8; *C. Abs.*, 1934, **28**, 1605).—Box-type and continuous furnaces with and without protective atmosphere for the material are described, and details of construction are illustrated.—S. G.

The Electric Melting and Heat-Treatment of Iron and Steel. A. G. Robiette (*J. West Scotland Iron Steel Inst.*, 1933, **41**, 41–49, discussion, 49–52; and (abridged) *World Power*, 1934, **21**, 138–142).—The paper concludes with a brief reference to advances in non-ferrous practice.—S. V. W.

Industrial Electric Heating XX.—Forced Convection in Gases. N. R. Stansel (*Gen. Elect. Rev.*, 1933, **36**, 549–555).—The effect of velocity and the flexibility of its control, together with the penetrating property of gases, make forced convection in gases an effective method of heat transfer in many cases. The main limitation on this method of heating is the upper limit of about 650° C. at which fans can be operated although there are ways of overcoming this to a certain extent. The theoretical aspect of the subject is considered and then a number of forced convection resistance furnaces are described.
—S. V. W.

The Pyroptic Inspection Window. Anon. (*Glass*, 1933, **10**, 368).—A brief description of the " Mahon " inspection window for furnaces.—S. V. W.

XVI.—REFRACTORIES AND FURNACE MATERIALS

(Continued from pp. 262–263.)

†**Recent Research in Special Refractories.** E. Preston (*Glass Rev.*, 1933, **9**, 101–105).—Reviews recent advances in the manufacture of highly refractory articles from pure alumina and magnesia and mixtures of the two oxides. A new refractory Siemensit with the composition 20–40% Cr_2O_3, 18–30% MgO, 25–40% Al_2O_3, and 8–14% residual matter, is also referred to. The fusion point of this refractory is stated to be greater than 2000° (C. ?).—S. V. W.

A Method for Decreasing the Porosity of Crucibles Made of Alumina. Tomo-o Satô (*Kinzoku no Kenkyu*, 1934, **11**, 69–76).—[In Japanese, with English summary.] The porosity of alumina tubes and crucibles may be decreased by soaking them with saturated aqueous solutions of magnesium or aluminium chlorides or nitrates, drying and heating above 600° C. to produce magnesia or alumina in the pores. Crucibles treated in this way can be used in a Tammann furnace without fear of contaminating molten metal with carbon; they are also fairly resistant to the slagging action of cupric and ferrous oxides.—A. R. P.

Making High-Speed Calrod. C. H. Hannon (*Gen. Elect. Rev.*, 1933, **36**, 409–410).—Briefly describes the production of fused magnesia used in "Calrod" heating units which consist of a Nichrome resistor, concentric with an outer metallic tube, with the magnesia insulation between them. Electrically fused magnesia, from specially selected calcined magnesia, has an insulation resistance, at 1000° C., six times that of the old grade. The specific resistance of the material is given as $11{\cdot}4 \times 10^6$ ohms/in.^{3} at 1800° F. (982° C.). The power consumption is about 1·25 kw.hr per lb. of fused magnesia. The construction and application of the Calrod heater units is described in *Gen. Elect. Rev.*, 1933, **36**, 354–360, 411–415 (following abstract).—S. V. W.

The Construction and Application of Calrod Heating Units. I.—The Calrod Unit. II.—Cartridge Units and Strip Heaters. R. M. Cherry and F. E. Finlayson (*Gen. Elect. Rev.*, 1933, **36**, 354–360, 411–415).—(I.—) The Calrod type of heating element consists of a coiled nickel–chromium resistor insulated from the case by a dense mass of magnesium oxide. Of the numerous applications, the melting of soft metal such as tin, solder, and lead is one of the most important. Various forms are described. For the cast-in type cast-iron, aluminium, or copper may be used for the outer casting. Some actual furnaces using these units are illustrated, and certain particulars regarding this method of heating are given. (II.—) Describes a variation of the Calrod unit in which the coil of resistor is wound on a suitable former.—S. V. W.

Olivine as a Refractory. R. A. Heindl and W. L. Pendergast (*U.S. Bur. Stand. J. Research*, 1934, **12**, 215–222; *Research Paper* No. **645**).—Olivines representing 3 different deposits in North Carolina and 1 each in California, British Columbia, and Russia were tested to determine the possibilities of the material as a refractory. The chemical analyses were made on raw materials, and linear thermal expansion, sp. gr., P.C.E., and petrographic analyses determinations were carried out on both raw and heated materials. The results show that olivine from North Carolina apparently has the necessary properties demanded of a high-grade special refractory and that it might be used in industrial processes where possible contamination by iron is of no consideration.—S. G.

***The Thermal Expansion of Silica Bricks.** Fritz Fromm (*Arch. Eisenhüttenwesen*, 1933–1934, **7**, 381–384).—Five silica bricks of the same manufacture with d between 2·38 and 2·44 were tested for thermal expansion up to 1600° C. The expansion up to 1400° C. and the growth at 1400°–1600° C. due to the quartz transformation were greater the higher the d; after heating at 1600° C. all the samples had $d = 2{\cdot}32$. Specimens heated under pressure showed a higher *d* owing to shrinkage of the pores. Conclusions on the behaviour of silica bricks in practical use are reached.—J. W.

***A Note on the Permeability of Refractory Materials to Gases.** A. Eric J. Vickers (*J. Soc. Glass Tech.*, 1933, **17**, 93–101).—From measurements of the permeabilities and porosities of refractories, it is shown that the porosity measurements offer no guide to permeability except in such circumstances as are not likely to occur in commercial usage. An apparatus for measuring permeability at high temperatures is described, and the influence of temperatures has been measured in the case of some experimental refractories.—S. V. W.

***The Permeability of Refractory Materials to Gases. I.—Experiments with Fireclay and Silica Products at Ordinary Temperatures. II.—Experiments with Fireclay and Silica Products at Temperatures up to 500° C. III.—Experiments at Temperatures up to 850° C.** F. H. Clews and A. T. Green (*Trans. Ceram. Soc.*, 1933, **32**, 295–318, 319–331; 1934, **33**, 21–32).—(I.—) The literature on the subject is reviewed and the results are summarized. An apparatus is described for measuring the permeability of test-pieces 6 cm. in diameter. The rate of flow of air through a specimen is found to be directly proportional to the pressure difference up to 8 cm. of water, and probably beyond, and inversely proportional to the thickness, providing the pore spaces are uniformly distributed. The results of the permeability measurements for sixteen representative products in relation to their textures are considered and the uniformity of pore distribution in relation to a number of factors, is emphasized. (II.—) The permeability to nitrogen of eleven refractory materials has been directly measured at temperatures up to 500° C. As the temperature increases the permeability decreases in a manner almost independent of the nature of the material and the value of the permeability coeff. at ordinary temperatures. The decrease is accounted for, almost quantitatively, by the increase in the viscosity of the gas with increase in temperature. (III.—) The permeability to nitrogen of thirteen refractories between 500° and 850° C. has been measured. The results have followed the same general rules as those observed for temperatures up to 500° C. The reduction in permeability produced at 1000°–1350° C. has been calculated.—S. V. W.

†**Refractory Materials, Their Permeability to Gases.** E. Preston (*Glass Rev.*, 1934, **10**, 10–13).—A brief consideration of the subject with particular reference to the work of Clews and Green, *Trans. Ceram. Soc.*, 1933, **32**, 295–318, 319–331 (preceding abstract).—S. V. W.

***The Significance of Permeability to Gases in Relation to the Texture and Industrial Usage of Refractory Materials.** F. H. Clews and A. T. Green (*Trans. Ceram. Soc.*, 1934, **33**, 56–72).—An attempt is made to illustrate the additional useful information that measurements of the permeability to gases can yield, in regard to the structure and texture of refractory materials. In particular, attention has been paid to the relation of the permeability of gases to the mechanism of corrosion in different types of industrial service.—S. V. W.

***The Action of Carbon Monoxide on Refractory Materials. I.—Experiments on the Disintegration of Fireclay Products by Carbon Monoxide. II.—Further Experiments on the Disintegration of Fireclay Products by Carbon Monoxide.** W. Hugill, H. Ellerton, and A. T. Green (*Trans. Ceram. Soc.*, 1933, **32**, 533–542, 543–550).—(I.—) The literature is reviewed and an apparatus for studying the effect of carbon monoxide at 420° C. is described. There does not seem to be any direct relationship between the tendency to disintegrate and the amount of "iron" in the brick as determined by chemical analysis, although the amount of ferruginous matter which can be separated by bromoform appears to have some effect. (II.—) Tests for 200 hrs. at 420° C. on eleven fireclay products have been carried out. Only three resisted disintegration. The character of the iron compounds present is the most important factor influencing disintegration.—S. V. W.

†**The Strength of Refractories at High Temperatures.** E. Preston (*Glass Rev.*, 1933, **9**, 129–134).—A brief review of existing information on the subject.
—S. V. W.

†**Further Notes on the Strength of Refractory Materials at High Temperatures.** E. Preston (*Glass Rev.*, 1933, **9**, 152–155).—A review of some fairly recent papers on the subject.—S. V. W.

***The Chemical Examination of Refractory Materials. IV.—Zirconiferous Bricks and Cements.** H. J. van Royen and H. Grewe (*Arch. Eisenhüttenwesen*, 1933–1934, **7**, 505–512).—The determination of zirconia is improved and simplified, and a new procedure for the complete analysis of zirconiferous refractories is given.—J. W.

***The Chemical Examination of Refractory Materials.—VI. The Determination of Alumina in Clays and Grog.** H. J. van Royen and H. Grewe (*Arch. Eisenhüttenwesen*, 1933–1934, **7**, 517–521).—A new rapid method for the determination of alumina and titania in clay and grog is described.—J. W.

***The Chemical Examination of Refractory Materials. V.—Carborundum and Carbon Bricks [and Graphite].** H. J. van Royen and H. Grewe (*Arch. Eisenhüttenwesen*, 1933–1934, **7**, 513–516).—Standard procedures are recommended for the determination of carbon and of the water-absorptive power of graphite, and for the complete analysis of silicon carbide bricks, carbon bricks, and graphite. Examples are given.—J. W.

***The Calculation, From Their Physical Constants, of the Resistance of Refractories to Temperature Changes.** K. Endell (*Glastech. Ber.*, 1933, **11**, 178–182).—The resistance of refractories to temperature changes has been calculated by Norton's modified formula from the physical and mechanical constants. The results are in relatively close agreement with those obtained experimentally by determining the number of quenches from 950° C. in cold water which produce the first signs of cracking.—J. W.

Some Uses of Refractory Materials in the Foundry. J. G. A. Skerl (*Proc. Inst. Brit. Found.*, 1932–1933, **26**, 566–592; discussion, 592–596).—See *J. Inst. Metals*, 1933, **53**, 384.—S. G.

XVII.—HEAT-TREATMENT

(Continued from pp. 263–265.)

The Annealing of Duralumin Wire. S. D. Zypurdejew (*Metallurg* (*The Metallurgist*), 1933, **8**, (6), 50–52; *C. Abs.*, 1934, **28**, 1640).—[In Russian.] The best results are obtained by heating to 370°–400° C. for 2–3 hrs., cooling in the furnace to 250°–70° C. and then cooling in air. This gives a tensile strength of 22–23 kg./cm.^{2} and an elongation of 17–18%.—S. G.

***Influence of Thermal Treatment and Hardening on the Magnetic Properties of Copper–Nickel–Iron Alloys.** I. Antik and B. G. Lifschitz (*Fisitscheski Zhurnal*, B, *Zhurnal tehnicheskoi Fiziki*, 1933, **3**, 765–770; *Chem. Zentr.*, 1934, **105**, I, 2033).—By annealing at 1200° C. instead of at 800° C. before tempering or hardening the homogeneity and grain size are increased, and thereby the permeability is improved and the coercivity reduced. Rapid cooling after hardening has the opposite effect, probably owing to the development of internal stresses.—A. R. P.

XVIII.—WORKING

(Continued from pp. 265–266.)

On Some Precautions for Avoiding Local Elements in the Working of Aluminium. H. Röhrig (*Korrosion u. Metallschutz*, 1933, **9**, 332–334).—To prevent inclusions of small particles of foreign metals during rolling and drawing of aluminium, it is recommended to pickle the sheet or wire in dilute caustic soda, rinse in water, dip in nitric acid, and again rinse; these operations should be done at one or more intermediate stages of the working. Removal of casting skins is also advisable, since most deleterious impurities tend to segregate towards the surface, there forming inclusions which encourage pitting under corrosive conditions.—A. R. P.

The Influence of Antimony and Bismuth on the Workability of Copper Bolts. S. D. Zypurdejew (*Metallurg* (*The Metallurgist*), **1931**, (6), 875–882; *Chem. Zentr.*, 1934, **105**, I, 2343–2344).—[In Russian.] Copper containing less than 0·1% antimony and 0·006% bismuth can be rolled hot to 7 mm., but with 0·01% of each of these metals fracture occurs. For hot-rolling to 53 mm. the upper limits of these impurities are 0·24% antimony (with less than 0·005% bismuth) and 0·01% bismuth (with less than 0·01% antimony). Similar limits hold for cold-rolling. Normal properties of 2 mm. wire are obtained only when both impurities are less than 0·005%.—A. R. P.

***Studies of the Wire-Drawing Process. IV.—Angle and Contour of the Die.** E. L. Francis and F. C. Thompson (*Carnegie Schol. Mem., Iron Steel Inst.*, 1933, **22**, 1–13).—With straight tapered dies, the best angle for most work is 6°; deviations from this angle in either direction sets up a greater frictional loss. Where the reduction is small, a smaller angle is necessary, especially with harder materials, in order to obtain the necessary length of bearing; but even in this case, the angle should be as near 6° as possible. With a rough, hot-rolled rod, where efficient lubrication is difficult, the angle may be 10°–11°, or, alternatively, a radial taper die, giving the necessary high angle of die when the metal first enters and decreasing to about 6° at the point of exit, may be used. It is probable that the parallel portion of the die at the exit end will entail the use of a higher tension, against which must be set off the increased life of the die before resetting. This work refers only to tungsten carbide dies, but the optimum conditions for steel dies are probably about the same. It appears that the die angle is not affected by the speed of drawing, the nature of the lubricant, or the carbon content of the steel, so long as the steel is not of the austenitic type. For the latter, a plain cone of 5°–5½° angle appears to be the best. The reduction of area has a small effect, 5¼° being the best angle for a 35% reduction, and 6° for 20%. The work recorded was carried out on material of essentially one size; it does not follow that the ideal angle of die will be the same for all values of the original area. Cf. *J. Inst. Metals*, 1933, **53**, 163.
—J. H. W.

***Studies of the Wire-Drawing Process. V.—Experiments with a Rotating Die (with Appendix: The Mechanical Properties of Wire Drawn Through Stationary and Rotating Dies).** E. L. Francis, H. Greenwood, and F. C. Thompson (*Carnegie Schol. Mem., Iron Steel Inst.*, 1933, **22**, 15–30).—Linicus and Sachs (*Mitt. Material., Sonderheft* **16**, 1931, 38) suggest that with rotating dies the drawing loads are lower than with still dies, owing to the smaller frictional loss. This was found to be the case only at low drawing speeds. At higher speeds, the loads become greater with the rotating dies, and L. and S.'s hypothesis must be abandoned. An alternative explanation is not put forward, but it is tentatively suggested that Lonsdale's work (*Phil. Mag.*, 1929, **8**, 703; 1931, **11**, 1169) on the elongation of wires under combined tension and torsion may have some bearing on the problem. In an appendix, the mechanical properties and recrystallization of wire drawn through stationary and rotating dies are compared, and it is concluded that there is very little, if any, difference in the mechanical properties, structure, recrystallization temperature, and rate of subsequent grain growth of wires drawn by the two methods, but the surface of wire drawn through rotating dies was in all cases more highly polished, and remained perfectly straight without any cast. Cf. preceding abstract.
—J. H. W.

***Studies of the Wire-Drawing Process. VIa.—Some Experiments Bearing on the " Casting " of Wire.** A. S. Kenneford and F. C. Thompson (*Carnegie Schol. Mem., Iron Steel Inst.*, 1933, **22**, 31–49).—" Casting " is overcome in the wire industry by tilting the die up to 5°, usually in two planes at right angles, by metal packing. This procedure, is, however, unreliable, and various data bearing on both the " casting " of wire and the effect of the internal stress which is always present are recorded. No constructive theory is put forward, but an examination of the effects of actual drawing on the curvature of the wire is submitted as a first step in elucidating the problem. Cf. preceding abstracts.—J. H. W.

A Note on the Effect of a Backward Pull Upon the Tension Required to Draw Wire. F. C. Thompson (*J. Iron and Steel Inst.*, 1933, **128**, 369–373; discussion, 374–382).—For abstract of the paper see *J. Inst. Metals*, 1933, **53**, 667. In the discussion in which *J. Dick* and *K. B. Lewis* took part, and to which F. C. T. replied, attempts have been made to analyze mathematically the forces involved in wire-drawing and to advance a theoretical explanation of the observed phenomena.—A. R. P.

The Drawing of Zinc Sheet. Anon. (*Illust. Z. Blechindustrie*, 1934, **63**, 408–409).—Suitable compositions are indicated for zinc intended for deep-drawing. The cadmium content should not exceed 0·5%. According to the treatment of the material subsequent to drawing, optimum diameter ratios are given for drawing rings and blanks. Appropriate materials are suggested for rings, the preparation of which is described, with precautions intended to obviate certain defects in the finished pieces.—P. M. C. R.

Research on Machining Expedites Work. W. Leyensetter (*Maschinenbau*, 1932, **11**, 221–223).—Modern machining practice demands, on economic grounds, an increasing use of light rather than heavy cutting, and investigation on machinability, wear, waste, and surface finish becomes necessary, the results obtained using heavy cuts being inapplicable to light-cutting practice. The significance and derivation of the " cutting coefficient " are discussed. The application of the pendulum process to investigations of wear and machinability is described.—P. M. C. R.

***Diamond-Impregnated Carboloy.** George F. Taylor (*Gen. Elect. Rev.*, 1934, **37**, 97–99).—Describes an interesting development in the manufacture of hard cutting tools in which diamond is embedded in Carboloy. Even in tools, such as wire-drawing dies, it is advisable to set the single stone in Carboloy because the coeff. of expansion of the two are very close together, and the good thermal contact obtained results in a greater dissipation of the heat generated when the tools are in use. At present diamond-impregnated Carboloy is used principally for dressing emery wheels. The method of manufacture and certain other applications are briefly described. [*Note :* Carboloy is the American counterpart of Widia.]—S. V. W.

XIX.—CLEANING AND FINISHING

(Continued from p. 266.)

Metal Finishes Used in Modern Architecture. S. Wernick (*Metallurgia*, 1934, **9**, 191–192).—The basic principles underlying metal finishing and the value of various finishes as regards durability and general efficiency of a structure are discussed. The processes discussed in considering these principles are Sherardizing, Calorizing, chromizing, spraying, and anodic oxidation, and it is stated that in the future anodizing will be one of the most useful adjuncts to the architect and builder who wishes to make use of aluminium for constructional purposes.—J. W. D.

Baked Finishes on Die-Castings. C. F. Scribner (*Indust. Finishing*, 1934, **10**, (4), 39–40; *C. Abs.*, 1934, **28**, 2550).—Practical suggestions for obtaining better finished products are given.—S. G.

XX.—JOINING

(Continued from pp. 266–269.)

Light Metal Rivets.—II.–III. K. Guler (*Z. Metallkunde*, 1934, **26**, 65–67, 90–91).—Cf. *J. Inst. Metals*, 1933, **53**, 669. (II.—) Tolerances for the dimensions of the riveting wire, rivet, and boring for various types of rivets are tabulated and some practical hints are given. (III.—) Directions are given for the determination of the shear strength, tensile properties, hardness, and compressibility of riveting wire of age-hardenable aluminium alloys, *e.g.* Avional. —M. H.

†**High-Strength Light Alloy Rivets.** Anon. (*Metallurgist* (Suppt. to *Engineer*), 1934, **10**, 108–110).—A summary and critical discussion of papers by G. W. Akimov, *Korrosion u. Metallschutz*, 1932, **8**, 309–313 (see *J. Inst. Metals*, 1933, **53**, 355), and by M. Abraham, *Z. Metallkunde*, 1933, **25**, 203–206 (see *J. Inst. Metals*, 1933, **53**, 695).—R. G.

***Soldering, Brazing, and Autogenous Soldering.** C. V. Boys (*J. Sci. Instruments*, 1934, **11**, 105–111).—A general article, describing practical methods of soldering, brazing, and welding (lead burning) developed by the author for different purposes, chiefly connected with the construction of instruments. Soft soldering, fluxes, sweating, brazing, silver-soldering, and lead burning are dealt with, and also the design of instruments where soldered joints are required.—W. H.-R.

On the Proper Use of Certain Soft-Soldering Alloys. Anon. (*Illust. Z. Blechindustrie*, 1934, **63**, 409–410).—The selection of a solder is influenced not only by its setting properties, but also by its tendency to form compounds with the basis metal, by its strength, and in some cases by its electrical conductivity. Suitable compositions are recommended for general purposes, for high tensile strength, and for electrical work: in each case variations are indicated for different basis materials. The importance of proper cleaning and of selecting a suitable flux is emphasized.—P. M. C. R.

Cadmium–Zinc Solder. —— ((*British*) *Air Min. Specification* No. **D.T.D. 221,** 1933, 1 p.).—S. G.

Recent Experience in Welding Duralumin. Anon. (*Illust. Z. Blechindustrie*, 1934, **63**, 408).—Gas welding is preferred to electrical welding on account of the high working temperature involved in using the latter: intense local heating without burning can be effected by proper adjustment of the flame. Details as to flux and flame control are given for the oxy-acetylene welding of thick Duralumin sheet.—P. M. C. R.

Five Per Cent. Magnesium-Alloy Welding Rods and Wire. —— ((*British*) *Air Min. Provisional General Specification* No. **D.T.D. 202,** 1932, 1 p.).—Covers the material generally known as " MG 5 " alloy, which is suitable for welding " MG 7 " alloy. The sp. gr. of this alloy is between 2·63 and 2·7.—S. G.

Welding of Lead. Ch. Schlingmann (*Maschinenbau*, 1933, **12**, 299–300; and (abstract) *Z. Metallkunde*, 1934, **26**, 93).—The rate of production of butt-welded and welded spigotted joints in lead tubes of different diameters is tabulated as a base for the calculation of welding costs.—M. H.

The Welding of Monel Metal and Nickel. Anon. (*Welding Ind.*, 1934, **1**, 369–371; **2**, 84–86).—For oxy-acetylene welding, the great importance of accurate flame control is emphasized. A slightly reducing flame is recommended. The best flux is considered to be powdered boric acid, which may be sprinkled on the part to be welded or made into a saturated solution in alcohol. Sheets thinner than 18 G. are butt-welded without filler rod by flanging the edges. The edges of thicker sheets should be chamfered at 45° C. and welded with a filler rod of diameter equal to the thickness. For metallic arc welding, covered electrodes of diameter slightly greater than the thickness of the sheet, are recommended. These should be connected to the positive pole of the generator. Tacking at not more than 6 in. pitch is essential. Spot and seam welding present no difficulties. Welds in Monel metal and pure nickel are said to have almost as great corrosion-resistance as the parent metal.—H. W. G. H.

Concerning the Strength of Welded Joints, Especially the Dependence of Strength on the Form [of Joint]. Otto Graf (*Autogene Metallbearbeitung*, 1934, **27**, 1–12; discussion, 17–22).—The use of the tensile test, the information it gives, and the characteristics of a typical load–extension diagram are discussed. The importance of the plasticity of a material is explained; it is pointed out that stress concentration in a drilled tensile test-piece causes it, when made of brittle material, to fail at a lower stress, calculated on the reduced area, than does a solid test-piece of the same area. Moreover, a ductile material fractures in a " brittle " manner under repeated stressing so that drilled test-pieces have lower fatigue strength than solid specimens of equivalent area. In the investigation of welded joints, fatigue tests give more useful information than the tensile test. For example, " undercut " in arc welds produces stress concentration which lowers the fatigue strength, although little effect can be noticed on the tensile strength. Incomplete penetration and flaws have similar effect. The more even distribution of stress, produced by inclining the weld to the direction of stressing, is found to be an advantage. The possibility of imperfections even in welds produced under the best conditions led to the use of straps welded across butt-joints. Although these reduce the deformation and static stress which may occur in the butt-weld, it is found that stress concentration occurs at the ends of the straps, with little effect on the tensile, but serious effect on the fatigue strength. The use of these straps is therefore considered unnecessary except as a support for poor butt-welds. Various designs are reviewed, their object being to reduce the stress concentration. In the discussion, *Hoeffgen* described tests on joints between steel plates made by two straps on opposite sides, sandwich fashion, secured by fillet welds parallel to the straining axis of the test-piece, the stress thus being transmitted through four fillet welds on each side of the joint It was found that higher tensile strengths were obtained with short than with long fillet welds. H. considers that the latter impede plastic flow of the parent material and consequently cause uneven stress distribution. *G. Bierett* discussed the effect of raising the mean stress in fatigue testing welded joints (in steel) of various designs.
—H. W. G. H.

Stress Distribution in, and Strength of, Fillet-Welded Joints. G. Bierett and G. Gruning (*Elektroschweissung*, 1934, **5**, 33–34).—The stress distribution in a butt-cross joint and two strapped joints, one having 45° fillets and the other 30° fillets, was investigated by elongation measurements in test-pieces cut out of solid sheet to the shape of the welded joints. In this way, the effects of heterogeneity of the material were eliminated. Fatigue tests were also made on similar " solid " specimens, and these confirmed the conclusions reached from the stress-distribution experiments. It was found that the fatigue-strength of one of these specimens was no greater than that of the corresponding welded joint.—H. W. G. H.

The Control of Autogenous Welding. Anon. (*Machine moderne*, 1934, **38**, 115).—Cf. *Met. Abs.*, this volume, p. 210. The findings of the Committee on Welding Technique appointed by the Verein Deutscher Ingenieure are considered and criticized.—P. M. C. R.

Physical Side of Electric Arc Welding. E. Westman (*A.S.E.A. Journal* (*Allmanna Svenska Elektriska A.B.*), 1932, **9**, 158–160; *Sci. Abs.*, 1933, [B], **36**, 146).—The inter-electrode gaseous conditions which exist during the formation of an arc are discussed and the behaviour of the arc when the anodes and cathode are relatively displaced is illustrated. Oscillograms show the advantage of the inductive welding circuit over the non-inductive method with regard to the stability of the arc produced.—S. G.

Atomic-Physical Bases for the Phenomena of the Welding Arc. H. v. Conrady (*Elektroschweissung*, 1934, **5**, 21–25).—The electronic structure of the atom is briefly described with particular reference to its behaviour in the electric arc. The zones existing in a d.c. arc are explained and a theory is suggested to account for the transfer of metal in the welding arc, especially in the case of overhead welding, for which the " pinch effect " theory is considered inadequate.—H. W. G. H.

Atomic Arc Welding and Its Applications. J. A. Dorrat (*Metropolitan-Vickers Gazzette*, 1933, **14**, 100–110).—Cf. *Met. Abs.*, this volume, p. 43.—S. G.

The Performance Diagram of Acetylene Apparatus. Gottfried Lottner (*Autogene Metallbearbeitung*, 1934, **27**, 49–54).—An apparatus is described for testing the load-capacity of acetylene generators. These are classified into various types, according to the method of gasification and the kind of gasholder; an example of each type is illustrated diagrammatically and its performance under load is shown by curves giving the pressure in the gasification chamber, the gasholder, and the burner tube, during the gasification of a charge and under a constant load.—H. W. G. H.

[Contribution to] the Question of Testing Injector Blowpipes. E. Streb and H. Kemper (*Autogene Metallbearbeitung*, 1934, **27**, 54–58).—It is pointed out that heating of the nozzle during welding causes an alteration in the proportion of oxygen to acetylene flowing through an injector blowpipe. The maximum variation which can be permitted without detrimental effect on the quality or economy of welding is considered to be from 1 : 1 to 1·2 : 1. Previous researches on the subject are criticized. A testing apparatus is described by which the effect of increase of pressure at the burner nozzle and the acetylene pipe-line pressure can be observed. It is found that the influence of nozzle temperature on gas ratio is reduced by increase in pressure of acetylene.
—H. W. G. H.

Gas Ratio and Shape of Flame of an Injector Blowpipe with Varying Acetylene Pressure in the Supply Pipe. Eduard Sauerbrei (*Autogene Metallbearbeitung*, 1934, **27**, 59–62).—The supply from an acetylene generator is rarely at constant pressure. An apparatus is described for determining the effect of variations on the proportion of oxygen to acetylene in the flame and the resultant form of the latter. It is found that pressure variations in the acetylene supply have less effect as the average acetylene pressure is increased. Pressures in the injector chamber and at the nozzle are found to be independent of the acetylene supply pressure, and are always the same for a given gas ratio and flame form. The acetylene supply pressure is measured before the control valve of the blowpipe.—H. W. G. H.

XXI.—INDUSTRIAL USES AND APPLICATIONS

(Continued from pp. 269–274.)

Aluminium Castings for Tramcar Bodies. E. R. L. FitzPayne (*Modern Transport*, 1934, **31**, (785), 12).—The specification is quoted for the material of light-alloy body castings used in a tramcar which has been in satisfactory service in Edinburgh for 2 years. A table gives the variation in properties of the sand-cast, and in 2 cases, the chill-cast alloy as supplied by 6 tendering firms, together with the cost per lb. The chemical analysis of the alloy chosen was: silicon 11·5–12·3, manganese 0·3–0·5, magnesium 0·4–0·6, iron less than 0·5, other metals less than 0·1%, remainder aluminium.—P. M. C. R.

Development of Modern Passenger Coaches on the German State Railway. —— Stroebe and —— Wiens (*Organ Fortsch. Eisenbahnwesens*, 1932, **87**, (2/3), 4–40).—Coaches for use on urban lines utilize Lautal, Skleron, and Silumin wherever possible, steel being employed only for the most heavily stressed members. The concomitant variations in design are discussed, and the mechanical problems involved in the adoption of light alloy construction are summarized.—P. M. C. R.

Ten Years' Use of Aluminium Light Alloys in American Railroad and Tramway Construction. —— Theobald (*Glasers Ann.*, 1934, **114**, 21–22).—J. W.

Heavy Bridge Floor Replaced with Aluminium. J. P. Growdon, Ross M. Riegel, and R. L. Templin (*Civil Eng.*, 1934, **4**, 113–117).—The steel and wood floor of Smithfield Street Bridge, a 50-year-old bridge in Pittsburgh, Pa., U.S.A., was replaced with 340 tons of aluminium alloy, reducing the dead load by more than 1 ton per lineal foot, and extending the estimated useful life of the bridge by 25 years. A battle-deck floor was designed on the basis of measurements on test-panels under H-20 loading, checked by service tests. Heat-treated " 17 ST " alloy was used for the floor, " 4 SH " alloy for the top rail and balusters, and " 53 ST " alloy for the bottom rail and posts. Painting is not necessary.—J. C. C.

The Grid at Work [Aluminium Conductors]. J. D. Peattie (*Electrician*, 1933, **110**, 546–547; *Sci. Abs.*, 1933, [B], **36**, 514).—Outlines experience in operation and maintenance over a period of 4 years since the first 132 kv. line was put into service. Tests on steel-covered aluminium conductors removed from lines show that no appreciable mechanical or electrical deterioration has taken place. Even in industrial atmospheres the dark deposit which quickly forms over the strands provides a good protective coating. Conductor joints both of Continental and British design have proved thoroughly reliable, except for a small number made of an aluminium–zinc alloy which became unstable. The latter have been replaced by others of aluminium–magnesium alloy or of pure aluminium.—S. G.

Some Experiences in the Use of Aldrey for Overhead Conductors. Maurice Thomas (*Conférence internat. des Grands Réseaux électriques à haute tension*, (Preprint), **1933**, (June), 15 pp.).—See *Met. Abs.*, this volume, p. 215.—S. G.

Aluminium Round Seamless Tubing. —— (*U.S. Federal Specifications Board, Federal Specification* No. **WW–T–783**, 1933, 10 pp.).—S. G.

Half-Hard Aluminium Alloy Sheets and Strips. —— ((*British*) *Air Min. Specification* No. **D.T.D. 209**, 1933, 3 pp.).—Covers the aluminium alloys containing in each case not more than magnesium 3·0, manganese 1·5, iron 0·75, and silicon 0·75%, and having a sp. gr. of 2·70.—S. G.

Aluminium Alloy (Aluminium–Copper–Magnesium–Manganese) Bars, Rods, Shapes, and Wire. —— (*U.S. Federal Specifications Board, Federal Specification* No. **QQ–A–351**, 1933, 10 pp.).—S. G.

Aluminium Alloy (Aluminium–Copper–Magnesium–Manganese) Plates and Sheets. —— (*U.S. Federal Specifications Board, Federal Specification* No. **QQ–A–353**, 1933, 9 pp.).—S. G.

Aluminium–Manganese Alloy Sheets and Strips. —— ((*British*) *Air Min. Specification* No. **D.T.D. 213**, 1933, 3 pp.).—Deals with the aluminium alloy containing not more than manganese 1·5, iron 0·75, silicon 0·6, and copper 0·15%, and having a sp. gr. of 2·70.—S. G.

Aluminium Alloy (Aluminium–Manganese) Bars, Rods, Shapes, and Wire. —— (*U.S. Federal Specifications Board, Federal Specification* No. **QQ–A–356**, 1933, 10 pp.).—S. G.

Aluminium–Magnesium Alloy Castings [Birmabright]. —— ((*British*) *Air Min. Specification* No. **D.T.D. 165**, 1933, 3 pp.).—Covers the alloy generally known as Birmabright, sp. gr. 2·68.—S. G.

10% Silicon–Aluminium Alloy Castings. —— ((*British*) *Air Min. Specification* No. **D.T.D. 231**, 1934, 3 pp.).—Covers the material generally known as " M.V.C." alloy.—S. G.

Aluminium Foil for Insulating Purposes. G. P. Crowden (*Lancet*, **1934**, Jan. 6; *Bull. B.N.F.M.R.A.*, 1934, (65), 3).—Reinforced aluminium foil (asbestos, &c., covered on both sides by aluminium foil) fixed so as to divide the air space across which transference of heat tends to take place, has been found to have good insulating properties. This is illustrated by laboratory experiments and by service tests in Egypt in huts, tents, trains, and ambulances, and with food-containers and tropical helmets, as well as on board ship.—S. G.

Aluminium Powders and Aluminium Paints. Franz Friedrich (*Metallbörse*, 1934, **24**, 162–163, 194–195).—A survey of the methods of production, properties, and uses of these products.—A. R. P.

Beryllium Alloys in Watchmaking. André Donat (*Machine moderne*, 1933, **27**, 574–575).—The alloys of copper with up to 3% beryllium possess high tensile strength and elasticity, considerable hardness and incorrodibility, and are non-magnetic. Their possible applications as watch and clock parts are enumerated. The hardening of Elinvar by the addition of beryllium produces a non-magnetic alloy (Nivarox) possessing superior mechanical and thermal properties to those of Elinvar, and hence a valuable material for springs. —P. M. C. R.

Tentative Standards for Copper in Semi-Finished Products. Outline 1 for DIN E 1787. German Committee for the Standardization of Non-Ferrous Metals (*Z. Metallkunde*, 1934, **26**, 94).—Copper for sheets, tubes, &c.: copper at least 99·4%, oxygen, not more than 0·1%. Copper for firebox plates, stays, &c.: copper at least 99·0%, arsenic, arsenic + nickel, and oxygen, not more than 0·50%, 1·0%, and 0·1%, respectively. In both cases the content of antimony, selenium + tellurium, bismuth, sulphur, and aluminium should not be more than 0·08%, 0·01%, 0·01%, 0·05%, and 0·01%, respectively.—M. H.

Aluminium–Bronze Die-Castings. —— ((*British*) *Air Min. Specification* No. **D.T.D. 174,** 1933, 2 pp.).—S. G.

Aluminium–Nickel–Iron Bronze Bars, Stampings, and Forgings. —— ((*British*) *Provisional Air Min. Specification* No. **D.T.D. 197,** 1932, 3 pp.).—Covers the alloy generally known as "Superston L. 189 bronze."—S. G.

Cadmium–Copper Alloy Wires and Strips. —— ((*British*) *Air Min. Specification* No. **D.T.D. 208,** 1933, 3 pp.).—S. G.

Lead–Bronze Ingots and Bars (Suitable for Bearings). —— ((*British*) *Air Min. Specification* No. **D.T.D. 229,** 1934, 1 p.).—S. G.

Hard-Drawn Phosphor–Bronze Bars. —— ((*British*) *Air Min. Specification* No. **D.T.D. 78A,** 1933, 3 pp.).—Supersedes specification No. D.T.D. 78.—S. G.

Hard-Drawn Phosphor–Bronze Tubes. —— ((*British*) *Air Min. Specification* No. **79A,** 1933, 2 pp.).—Supersedes specification No. D.T.D. 79.—S. G.

Design and Manufacture of Telephone Cables. F. H. Buckland and R. H. Franklin (*Inst. Post Office Elect. Eng. Paper* No. **144,** 1933, 1–52; *Sci. Abs.*, 1933, [B], **36,** 526).—The paper is divided into two parts, design, and manufacture. The second part deals among other matters with wire-drawing, materials, and lead-covering.—S. G.

Cadmium Alloy Ingots (Suitable for Bearings). —— ((*British*) *Air Min. Specification* No. **D.T.D. 217,** 1933, 1 p.).—S. G.

Marking of Gold-Filled and Rolled-Gold Plate Articles other than Watchcases. (*U.S. Dept. Commerce, Bur. Stand., Commercial Standard* CS **47–34,** 1934, 1–10).—The standard of rolled-gold or gold-filled demands that the gold coating of the article shall be at least 10-carat, and that the proportion by weight of this coating shall be marked on the article, thus 1/10–12 k. gold-filled implies that the base metal is covered on one or more surfaces with a gold alloy of 12-carat fineness, and that the coating comprises one-tenth of the total weight of the article.—A. R. P.

Manufacture and Technique of E.H.T. Cables. M. Ding (*Bull. Soc. belge Élect.*, 1933, **49,** 105–127; *Sci. Abs.*, 1933, [B], **36,** 332).—Progress made during the past 20 years is summarized. Consideration is given to materials of construction—sheath, armouring, and dielectric. The characteristics of the 3-core Hochstädter, and 1-core cable are discussed, and losses in sheaths and armouring of 1-core cables are tabulated. Methods of bonding sheaths to reduce sheath losses are described.—S. G.

White Metal Ingots (Suitable for Bearings). —— ((*British*) *Air Min. Specification* No. **D.T.D. 214,** 1933, 1 p.).—S. G.

Magnesium Alloy Sheets (not Suitable for Welding). —— ((*British*) *Air Min. Specification* No. **D.T.D. 120,** 1933, 2 pp.).—S. G.

Magnesium Alloy Bars. —— ((*British*) *Air Min. Specification* No. **D.T.D. 127,** 1932, 2 pp.).—S. G.

Heat-Resisting Alloys [Kanthal]. J. H. Russell (*Elect. Times*, 1933, **84,** 183–184; *Sci. Abs.*, 1933, [B], **36,** 627).—Refers particularly to the use of the new aluminium–chromium–cobalt–iron alloys, known as Kanthal, in the manufacture of heating elements for electric fires. These alloys, it is stated, possess decided advantages over the old 80 : 20 nickel–chromium alloys. There are 3 types of Kanthal—A1, A, and D. Of these Kanthal D is the best for electric fires.—S. G.

High Nickel–Copper Alloy Sheets [Monel Metal]. —— ((*British*) *Air Min. Specification* No. **D.T.D. 10B,** 1933, 2 pp.).—Supersedes specification No. D.T.D. 10A.—S. G.

High Nickel–Copper Alloy Hot-Rolled or Forged Bars, Stampings and Forgings [Monel Metal]. —— ((*British*) *Provisional Air Min. Specification* No. **D.T.D. 192,** 1932, 3 pp.).—S. G.

Cold-Rolled or Cold-Drawn and Annealed High Nickel–Copper Alloy Bars (Suitable for Cold-Bending) [Monel Metal]. —— ((*British*) *Provisional Air Min. Specification* No. **D.T.D. 196,** 1932, 3 pp.).—S. G.

Hard-Drawn High Nickel–Copper Alloy Bars [Monel Metal]. —— ((*British*) *Provisional Air Min. Specification* No. **D.T.D. 200,** 1932, 3 pp.).—S. G.

High Nickel–Copper Alloy Rods, Wire and Rivets [Monel Metal]. —— ((*British*) *Air Min. Provisional Specification* No. **D.T.D. 204,** 1932, 2 pp.).—S. G.

Application of Nickel–Iron Alloys to Modern Current Transformers. B. Hague (*Elektrotech. u. Masch.*, 1933, **51,** 208–211; *Sci. Abs.*, 1933, [B], **36,** 510).—Although silicon steel has low losses and a high permeability at low inductions, its exciting ampère-turns are sufficiently large to cause considerable ratio and phase-angle errors. With a corresponding size of nickel–iron core transformers, however, the necessary lines of force can be obtained with only $\frac{1}{6}$ to $\frac{1}{10}$ of the ampère-turns, with a corresponding reduction of these errors. The 50% nickel–iron alloy developed for current transformers is known as Hipernik and has a maximum permeability of 70,000 and an initial permeability of 3000: the hysteresis loss at 10,000 gauss is 220 ergs/cm.^{3}/cycle and the resistance is 46 microhms/cm.^{3} at 20° C. Alloys with about 78% nickel are known as Permalloys, the most important of which is Mumetal, which is an alloy of nickel 76, iron 17, copper 5, and chromium or manganese 2%. The highest permeability is from 45,000 to 100,000 and initial permeability from 12,000 to 30,000; the total iron loss at 5000 gauss and 50 ~ is 0·1 watt/kg. and the resistance is 43 microhms/cm.^{3}.—S. G.

Silvering of Mirror Surfaces by Cathode Sputtering. M. Romanova, A. Rubcov, and G. Pokrovskii (*Dokladi Akademii Nauk U.S.S.R.* (*Compt. rend. Acad. sci. U.S.S.R.*), 1934, **1,** 15–16 (in Russian); 17–18 (in German); *C. Abs.*, 1934, **28,** 2277).—Silvering was carried out in a hydrogen atmosphere of 0·05 mm. with a current of 15–20 ma., and a potential of 1400 v. Mirrors obtained had a reflectivity of 98% (normal–93%) only very slowly decreasing. Partly transparent mirrors absorbed less than 1% of incident light.—S. G.

The Féry–Carbone Dry Tin Accumulator. C. J. V. Féry (*Tech. Publ. Internat. Tin Research and Development Council*, 1934, [C], (**1**), 1–5).—The accumulator described uses electrodes of tin and lead peroxide, respectively, in sulphuric acid as electrolyte, which is rendered immobile by packing with acid-resistant, finely-divided ceramic material. The cell is capable of giving an e.m.f. of 1·9 v.; during discharge the horizontal occurs at 1·75 v. and the final drop at 1·60 v. The tin electrode has the advantage that no gas is evolved during discharge or storage. The cell is also lighter than a lead accumulator of similar capacity, has a low internal resistance, and can be kept in an inverted or other position.—E. S. H.

The Hard Metals. W. Guertler (*Glasers Ann.*, 1933, **113**, 105–106).—A short review.—J. W.

Metallization of Surfaces Other than Glass and Metal. —— (*Sci. Library (Lond.) Biblio. Series* No. **123**, 1934, 3 pp.).—A list of references to the literature and patents published since 1915.—S. G.

Selection of Service Pipe Material Under Present Prices. Walter A. Peirce (*J. Amer. Waterworks Assoc.*, 1933, **25**, 1653–1656).—Returns made in 1933 from 65 municipal and 14 private American and Canadian water supply plants giving the materials used for service pipes are tabulated, together with prices of copper tubing from 1929 to 1933. Changes in cost have had little effect on the choice of materials.—J. C. C.

XXII.—MISCELLANEOUS

(Continued from pp. 274–275.)

Aluminium in Great Britain. Method of Production and Uses. George Boex (*Times Trade and Eng. Suppt.*, 1934, **33**, (813), 451).—A useful summary giving facts and figures relating to the various stages in the production of aluminium from bauxite. The world's production of this metal has increased from 5000 tons (estimated) in 1900 to approx. 260,000 tons in 1930.—S. V. W.

***Cementation Tests with Various Metal Carbides.** Jwan Gaeff (*Arch. Eisenhüttenwesen*, 1933–1934, **7**, 587–588).—Cementation tests with the carbides of iron, manganese, tungsten, and chromium have shown that diffusion of these into mild steel starts only above their dissociation temperatures.—J. W.

Technique of a Thousand Years Ago. A Glance Through the *Diversarum Artium Schedula* of Theophilus Presbyter. W. Theobald (*Glasers Ann.*, 1933, **113**, 81–86, 99–105).—A selection from T.'s book ("Technik des Kunsthandwerks im zehnten Jahrhundert," Berlin, 1933). Of especial interest is the section on the recovery of metals and the technique of moulding and casting a thousand years ago.—J. W.

Some Aspects of the Selection of Engineering Materials. L. B. Hunt (*Proc. Inst. Brit. Found.*, 1932–1933, **26**, 479–500).—See *J. Inst. Metals*, 1933, **53**, 475.
—S. G.

Industrial Economy Suggestions. Glyn Powis (*Metallurgia*, 1934, **9**, 181–182).—Gives typical examples of industrial circumstances where careful consideration, coupled with wise expenditure, can result in appreciable savings. Among the points dealt with are furnace insulation; the use of improved steels for dies and tools, and of special heat-resisting non-corroding steels for hardening and annealing plant, pyrometer sheaths, and high-temperature furnace metal work; the question of machinery and outlay of plant; production costs, and laboratory control.—J. W. D.

The Control of Industrial Research. Metropolitan Life Insurance Co. (U.S.A.) (*Metropolitan Life Insurance Co. (U.S.A.) Policyholders Service Bureau, Pamphlet* No. **B–271**, 1934, 30 pp.; *Bull B.N.F.M.R.A.*, 1934, (**65**), 20).—A report based on a study of methods used by 45 American industrial organizations in controlling the activities of research and development departments. The data are set out under the following headings: organization of research department; origin and authorization of research projects; preparation of cost estimates; the research budget; standardized research procedure; cost keeping and control; review and reconsideration of research projects.
—S. G.

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(Continued from pp. 275–280.)

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XXIV.—BOOK REVIEWS

(Continued from pp. 281–284.)

La Cristallisation des Métaux. Par N. T. Belaiew. Conférences de Métallurgie faites à l'École Royale des Mines, Collège Imperial, sour les auspices de l'Université de Londres. Traduit de l'anglais par G. R. Delbart. Revu et mis à jour par N. T. Belaiew avec la collaboration de Mlle. L. Bloch-Sée. Preface de Henry Le Chatelier. Demy 8vo. Pp. 128, with 75 illustrations. 1934. Paris: Institut de Soudure Autogène, 32 Boulevard de la Chapelle. (20 francs.)

This is a translation into French of a book first published in English, and based on a series of lectures delivered in 1922 (see *J. Inst. Metals*, 1923, **29**, 839). Whilst the matter remains in general identical with the original edition, the bibliographical references have been brought more nearly up to date. The book has been reproduced in excellent fashion, both as regards text, illustrations, and diagrams.—W. A. C. NEWMAN.

Ausschuss in der Metallgiesserei. Ursachen und Beseitungen. Von Max Schied. Med. 8vo. Pp. 91, with 41 illustrations. 1933. Berlin: Otto Elssner Verlagsgesellschaft m.b.H. (Geb., R.M. 4.50.)

This small volume deals with the causes for, and prevention of, waste and scrap in foundries. It is divided into four sections dealing respectively with common errors that are made in: (1) casting in green-sand moulds; (2) casting in dry-sand moulds; (3) cover manufacture; and (4) general foundry melting. The arrangement is unusual. In each division mistakes that are frequently the cause of inferior work are dealt with individually. Their evidences, their causes, and finally the remedies are given in turn. It cannot be said, of course, that every contingency has been provided for, but the essentially practical details that are given should prove extremely useful to the foundryman in identifying faults and curing them.—W. A. C. NEWMAN.

The Casting of Brass Ingots. By R. Genders and G. L. Bailey. With an Introduction by H. Moore. (British Non-Ferrous Metals Research Association, Research Monograph No. 3.) Roy. 8vo. Pp. xv + 191, with 123 illustrations. 1934. London: British Non-Ferrous Metals Research Association, Regnart Buildings, Regnart St., N.W.1. (15*s.*; 15*s.* 6*d.* post free.)

This volume is a comprehensive summary of the work undertaken by the British Non-Ferrous Metals Research Association on casting methods and of the conclusions reached by those who were entrusted with the task. Much of the detail which is here omitted has been published in earlier reports. The work done has centred mainly round the casting of 70 : 30 brass, as this is the material most commonly used for strip. Thus the actual field of investigation has been rather circumscribed. The principles under examination, however, and the general deductions, are relevant to other industries using different alloys.

At the outset a brief historical digest of brass ingot casting, and of the conditions that existed when the major research was started is given. Collaterally with the progress of this research, other striking developments have occurred, *e.g.* in electric furnace melting, water-cooled moulds, vacuum melting, &c., which are also considered.

The correct relationships between the mould and the molten metal constitute the first portion of the preliminary investigation, and embrace mould size, surface perfection, structure, and composition, contraction, sub-surface and other minute cavities, density determinations for detecting unsoundness, and non-metallic inclusions. The second part of the preliminary examination is concerned with common surface defects in strip and the correlation of ingot properties with those of the strip. In each case a close study of typical instances and their probable history has been made. The subsequent portions of the book group themselves naturally as follows: (1) stages of transference from the crucible to the mould, (*a*) liquid, (*b*) molten stream, (*c*) solidification in the ingot; (2) analysis of the casting process; (3) materials of mould construction, (4) modified and improved casting methods.

In the liquid stage the influence of slag, fluxes, and deoxidizers is examined, and also that of varying surface tension and viscosity. Considerable discussion centres round the prevention of zinc oxide formation.

In examining the processes operative during the pouring of the metal into the mould, the authors describe their own method of casting successively two alloys, similar in density and freezing point, but different as regards colour. It has thus been possible to reconstruct the physical movements within the metal during chilling. The actual solidification of the metal is considered from the point of view of the general processes involved—contraction, feeding of liquid to fill contraction cavities, influence of pouring conditions on contraction, ingot structure, and crystal formation. There is also a section on the relationship between macrostructure and working properties.

The analysis of the casting process occupies four chapters which deal mainly with casting temperature, speed of pouring, feeding, shape of ingot, position of cooling surfaces, thickness of ingot, mould temperature and thickness, mould coating, mould position during casting, and the gas content of the metal. The significance and relative importance of each of these factors are assessed as far as possible by investigations in which the other determinants remained constant. Careful attention has been given to the study of mould materials. Greater knowledge is now available on the subject of cast-iron moulds and the various factors which affect their efficient use. The modern developments in the use of water-cooled copper-faced moulds of various types, and their influence on general industrial practice are fully discussed.

The next chapter is devoted to modified and improved casting methods and embraces a survey of the conditions that are essential for the elimination of sub-surface and surface defects. Special casting methods, *e.g.* the Durville, Erical, and bottom casting processes, are described, and the advantages of each, and the precautions to be taken to ensure success, are pointed out.

A number of appendices have been added in order to complete the story down to the final production of the strip. They deal, respectively, with: (1) the rolling mill, including the modern four-high, cluster, Lauth three-high and Steckel mills, and the relevant annealing processes for the production of bright or dull finish; (2) the constitution and density of the brasses, embodying sections on crystal structure and equilibrium diagrams; (3) aluminium-brasses, and the influence of aluminium in decreasing the evolution of zinc vapour; (4) brasses containing phosphorus, their mechanical properties and structure; and (5) a list of papers and pamphlets on brass ingot casting which have been issued previously by the Association.

The book is one of the best publications on the subject which have appeared in recent years, and should be in the hands of all those interested in foundry work. It is concise yet comprehensive; it is presented in a most acceptable form, for which credit must be given to the publishers. Finality in foundry work has not yet been achieved, but the present volume is a creditable contribution, and is a tribute to the necessity for the re-examination of fundamentals and to the care and discrimination which the authors have exercised.—W. A. C. Newman.

Recommended Methods for Testing and Control of Foundry Moulding Sands. (B.C.I.R.A. Special Publication No. 2.) Pp. 44, with 17 illustrations. 1933. Birmingham: British Cast-Iron Research Association, 21–23 St. Paul's Sq. (10*s.* 6*d.* net.)

This is the second edition of a report issued in 1930, as No. 73, and advantage has been taken of this opportunity to make several additions and modifications. Of these the most important are the following: (1) the strength test is now carried out only under compression; (2) strength and permeability tests are carried out on the same test-piece; (3) the permeability test has been modified to permit the use of air instead of gas; (4) the use of the standard test-piece of the American Foundrymen's Association for strength and permeability tests in the standard British apparatus. The recommended methods of testing include those for sampling, milling, moisture content, ramming, mechanical analysis (including sieving, sedimentation, elutriation), tests of strength, permeability, expansion and contraction, refractoriness, chemical analysis. At the end of each section a list of the requisite apparatus is given, and illustrations of special pieces of apparatus are included. Appendices are devoted to: (1) the size and method of preparation of sand test-pieces; (2) representative results; (3) a comparison of results between various test methods, and (4) recommended apparatus. A short bibliography is given at the end.

This publication is one of the most authoritative on the testing of moulding sands.
—W. A. C. Newman.

Dilatation et Retrait en Soudure Autogène. Par Marcel Piette. Demy 8vo. Édition Generale. Pp. 91, with 113 illustrations. Paris: Office Centrale de l'Acétylène et de la Soudure Autogène, 32 Boulevard de la Chapelle. (12 francs.)

This is a slightly revised version of the paper which was awarded the prize by the Société des Ingénieurs Soudures in its competition of 1932. It reviews, in a completely practical way, a subject of vital importance to the welding industry. By simple examples, clearly illustrated, the author explains the causes of distortion and residual stress produced by welding. Practical methods for minimizing residual stress, avoiding distortion, and preventing the formation of cracks, are described, and some popular remedies are shown to be ineffective in many cases. The pure metallurgist will find little of interest in this modest little work, but it will be valuable to welders, welding designers, and supervisors, to whom it will make clear the basic causes of many difficulties.—H. W. G. Hignett.

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