

P.100/34

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1935, Vol. LVI.

Vol. 1.

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Part 11.

The Monthly Journal of the
**INSTITUTE OF
METALS**



and

METALLURGICAL ABSTRACTS

NOVEMBER, 1934

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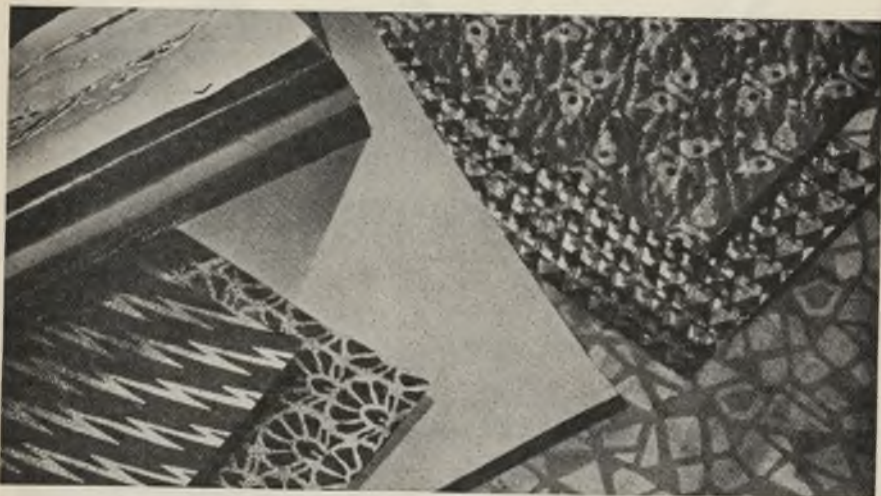
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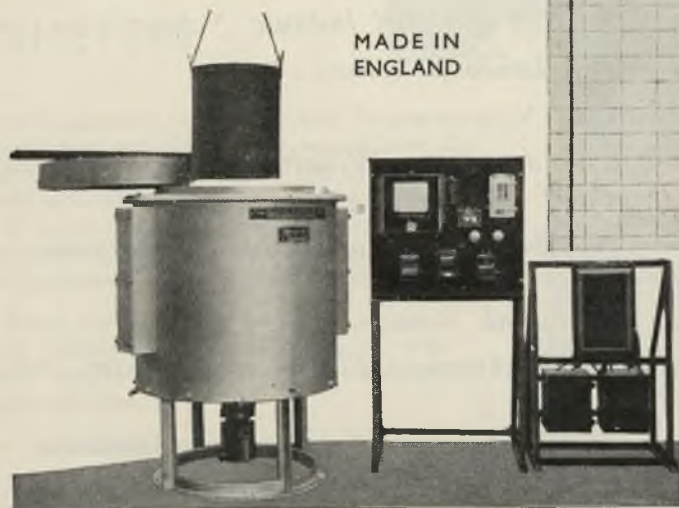
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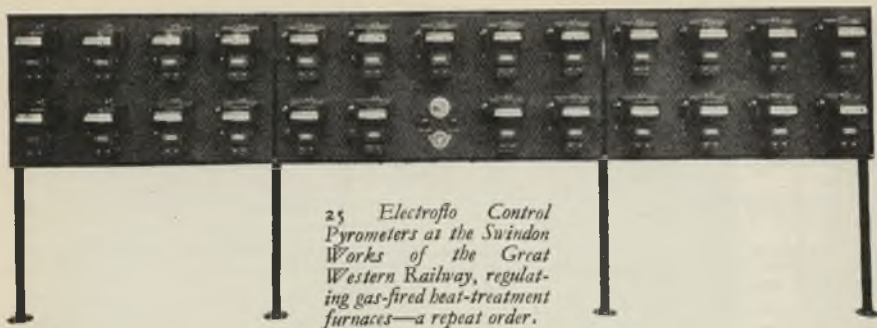


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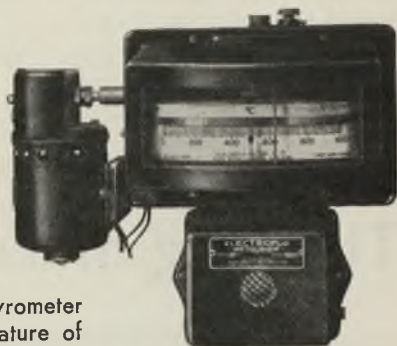


FIG. 1

Fig. 1 shows the Electroflo Indicating Control Pyrometer for the automatic regulation of the temperature of electric furnaces, and the temperature and atmosphere of fuel-fired furnaces, etc. It employs a "knife-edge" method of temperature detection, ensuring control within extremely fine limits, a high resistance, shock-proof moving element and an integral signal system.

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INSTITUTE NEWS AND ANNOUNCEMENTS

Supper-Dance.

As previously announced, the Council is arranging, in co-operation with the London Local Section of the Institute, for a Supper-Dance to be held on Friday, November 30, 1934, at Thames House, Millbank, S.W.1. Dancing will begin at 7.30 p.m. and will conclude at midnight. Tickets, price 6s. each, are now available, and can be obtained from the Honorary Secretary of any Local Section, or from the Secretary of the Institute of Metals.

It is hoped that members of Local Sections throughout the country will support the London Local Section by their attendance at what promises to be a pleasant and interesting new function.

Educational Tour.

The Council is arranging for the benefit of Student Members, an Educational Tour to the Rhineland of Germany in April, 1935. The party is expected to leave London on April 6, and to be back on April 15. The cost of the tour will not exceed £12. In response to a circular on the subject many Student Members have already indicated their intention to take part in the tour; others who have not replied to the circular and are interested in the tour are asked to return without delay the reply form attached to the circular.

Membership Additions.

The following were duly elected on November 1, 1934.

As Members.

- BOWKER, Tom Beaumont, Sheffield.
- CAPPONI, Commander Count Ferrante, London.
- FAIRCHILD, Sherman M., New York, U.S.A.
- GATHMANN, Emil, Baltimore, Mo., U.S.A.
- HARRINGTON, Richards Harry, Sc.D., New York, U.S.A.
- ISTOMIN, Professor Peter Stephano-wich, Moscow, U.S.S.R.
- MARTIN, Harold, Doncaster.

DOS REMEDIOS, Ernest Joseph Francis, Shanghai, China.

TIGERSCHÖLD, Kjell Magnus, Stockholm, Sweden.

As Student Members.

CASSON, James Henry, Belfast.
HAYES, Bernard Joseph Neville, Birmingham.

PELL-WALPOLE, William Thomas, B.Sc., Tipton.

PERSONAL NOTES

ENGINEER VICE-ADMIRAL SIR ROBERT DIXON, K.C.B., D.Eng., Member of Council, is now making a tour in the Far East. In his absence his duty as Chairman of the Finance and General Purposes Committee is being performed by Mr. E. L. Morcom, M.A.

DR. G. LÜTTKE, Director of the Zentralverband der deutschen Metall-Walzwerks- und Hütten-Industrie E.V., has been appointed Controller of Base Metals in Germany.

Birth.

HUME-ROTHERY.—On October 17, 1934, to Betty (*née* Fea), wife of William Hume-Rothery, of 54 Sandfield Road, Headington, Oxford, a daughter.

The Oldest Member ?

An endeavour is being made to ascertain who is the Institute's oldest member.

One member is known to be in his 84th year. If any member was born prior to August 28, 1851, will he kindly advise the Secretary of the date of his birth ?

OBITUARY.

GEH. REGIERUNGSRAT PROFESSOR DR.-ING.E.H. ROBERT OTZEN, Präsident des Staatlichen Materialprüfungs-amtes, Berlin-Dahlem, died on October 3 after a short illness. He was in his sixty-second year, and had been a member of the Institute since 1932.

LETTER TO THE EDITOR

Translations of Papers.

Could the Institute of Metals be a depository for translated papers of foreign research workers?

A person interested in a particular research and who has translated a

paper thereon, might send his translation to the Institute. Members (only) might then be allowed to borrow these translations for a small fee, which fee, after deducting clerical expenses, might be handed to the translator.

ROOSEVELT GRIFFITHS.
University College,
Swansea.

LOCAL SECTIONS NEWS

Registration for Membership.

A copy of the programme giving a list of papers to be read before each of the six Local Sections of the Institute was despatched last month to every member of the Institute resident in the British Isles. The programme took the form of the usual green folder, which was accompanied by a "registration" post-card. The latter is intended to be returned to the Secretary by all members who desire to be included on the roll of membership (free) of any Local Section. *Monthly notices of the Sections' Meetings are sent only to those members who return the post-card.* It is important for members resident in Local Section areas to receive from the appropriate Local Secretary these monthly notices, as occasionally the details differ from those given in the green-folder programme owing to unexpected changes having to be made either in the lecturer, title of lecture, or place of meeting. Members returning the post-card are asked not merely to state the name of the Local Section that they wish to join, but to complete the last two lines on the post-card—a service that is of real value to the Institute.

SYNOPSIS OF PAPERS TO BE READ IN DECEMBER.*

Birmingham Section.

Fatigue in Metals. By H. J. Gough, M.B.E., D.Sc., F.R.S. (Nov. 20.)

The lecture aims to discuss some of the more recent developments of interest. Attention is first given to recently-developed fatigue-testing machines, together with an account of some of the test results obtained: (1) the high-frequency wire-testing machine of Dowling, Dixon, and Hogan; (2) the Haigh-Robertson fatigue-testing machine for wire; (3) the high-frequency machine of Krouse; (4) the N.P.L. combined stress-fatigue testing machine; (5) the combined stress-fatigue testing machine of Lehr, Hohenemser, and Prager; (6) the N.P.L. machine for testing riveted and welded joints under boiler conditions.

An account is given of some recent work on corrosion-fatigue: Gough and Sopwith on comparative tests using reversed bending and reversed direct stresses; Gould's tests using potassium chloride solution; investigation by Gough and Sopwith into the optimum environment for fatigue-resistance.

A marked recent trend is towards the fatigue testing, where possible, of full-sized service components; some interesting examples are described: (1) tests on drill pipe and pipe joints by Spang Chalfont; (2) tests on rails at Illinois; (3) tests on metal airscrews at Bureau of Standards; (4) tests on lifting gear at N.P.L.; (5) tests on welded and riveted drums of Babcock and Wilcox.

New ground has been broken by the investigations of Russell and Welcher into the fatigue of metals at low temperatures. An accelerated method of

* For place and time of meetings the green-folder programmes already issued should be consulted.

Local Sections News

determining the endurance limit has been devised and explored by Moore and Wishart. Attention is directed to the extremely lengthy fatigue tests on light metals and alloys made by Templin. Fatigue is discussed as a fundamental problem; the position of present theory is examined. The respective fields open to the nuclear physicist and the engineer and metallurgist are suggested. Brief reference is made to the light thrown on the problem by various methods of examination, including X-rays.

Directionality in Some Annealed Non-Ferrous Alloys. By R. G. Johnston. (Nov. 29.)

Although cases arise sporadically of directional properties manifesting themselves in annealed alloys, as, for example, in the well-known four-cornered cup, yet it is fairly generally supposed that to the eye of the microscope no such anisotropy is visible.

The application of statistical methods to aggregates in other fields led to the hope that they would be fruitful here also. The method employed was to select some character of the grains in a photomicrograph of an alpha-brass, bronze, or other alloy, such that it had direction (*e.g.* the maximum diameter or the bands of twinning) and to measure this direction with reference to a fixed base-line. All the grains in the field are measured, and each measure is recorded. After suitable classification, the frequencies of the classes are plotted, using polar co-ordinates. This results in a diagram which consists of a "wheel of spokes," the length of the spoke being the frequency and its direction the orientation in which that frequency occurs. The results show that definite directionality persists even after quite strong annealing. The classes of *minimum* frequency persist more definitely than the maxima. The minima, or avoided directions, lie along the direction of rolling, the maxima across it.

A short discussion of the diagrams obtained and some speculation on the reasons for these results in relation to the phenomena of recrystallization and grain-growth conclude the paper.

London Section.

Manganese-Bronze. By Wesley Lambert, C.B.E., Member of Council. (Dec. 5.)

From information imparted to the author by Mr. Bernard Parsons of the Manganese Bronze and Brass Co., Ltd., he recalls that the non-ferrous alloy now commonly known as "manganese-bronze," and which in reality is a complex *brass*, takes its name from an earlier alloy of the true bronze type to which a small addition of iron and manganese had been made.

Manganese-bronzes, in common with the straight copper-zinc brasses, are conveniently grouped into distinct categories according to the microstructure of the alloy. The industrial alloys are of three types: (1) exhibiting a microstructure of the alpha copper-zinc constituent; (2) wholly of the beta constituent; (3) of duplex structure, alpha + beta constituents.

Alloys of all three categories are in use for rolled and extruded rods and sections, and also for plates; alloys falling within the first category are rarely, if ever, used for castings to shape. The physical and mechanical properties of the three types of alloys are given, together with practical hints to the foundryman on the preparation of moulds and on the casting of manganese-bronze.

North-East Coast Section.

Problems in Non-Ferrous Foundry Practice. By F. W. Rowe, B.Sc. (Dec. 15.)

The paper will deal with various problems in non-ferrous foundry practice, and particularly with those for which a satisfactory solution has not yet been found. It will attempt to suggest lines on which research, experimentation, and progress might usefully be directed, and suggest possible causes for various difficulties which are daily encountered in non-ferrous founding practice. In

Local Sections News

particular, it will deal with the various deficiencies and difficulties of the present methods of melting in non-ferrous foundries; with troubles in moulding practice due to limitations of the methods and materials now employed; and with frequent or universal defects in various types of alloys and castings, which might possibly be overcome by suitable research and improvement of existing practice.

The author hopes to exhibit samples of castings illustrating various defects and shortcomings, and trusts that the paper will form a basis for a round-table discussion and exhibition of various problems in connection with non-ferrous foundry practice.

Scottish Section.

Improvements in Surface Condenser Tubes. By A. Spittle. (Dec. 10.)

The paper will review the improvements made in surface condenser tubes as the result of the post-War demand for non-corrosive tubes to meet the more exacting conditions prevailing in modern condenser practice.

It will portray the inception and commercial development of various alloys newly applied to the manufacture of condenser tubes, describing their principal physical characteristics and the evolution of new plant and machinery necessary to overcome the difficulties attaching to their manufacture.

Reference will be made to the part played by academic research in assisting the quest for better alloys, and a brief description will be given of various forms of testing apparatus used for making accelerated corrosion tests and otherwise studying the phenomena of the corrosion of condenser tubes and the prevention thereof.

The paper will be illustrated by specimens and lantern slides.

Sheffield Section.

Rhodium Plating and Its Applications. By A. W. Scott. (Dec. 14.)

The paper deals chiefly with the merits and demerits of rhodium plating as an untarnishable and hard-wearing finish for silver ware. The nature, origin, and physical properties of rhodium are discussed, and an outline is given of the electrolytic plating baths which have found use.

Allusion is made to the principal peculiarities and pitfalls of plating operations, and to the available data regarding current efficiencies, current density, temperature, throwing power, &c.

Colour, scratch hardness, resistance to wear, and the general advantages and disadvantages of rhodium plate applied to domestic silver ware are discussed.

Swansea Section.

Refractory Materials of South Wales. By Professor W. R. D. Jones, D.Sc. (Dec. 11.)

Modern developments in the majority of industrial operations tend to the use of higher temperatures, with a consequent greater demand on the refractory material. In order to utilize the large resources of the commoner refractory materials in South Wales to meet the more severe service demanded from refractories, it is necessary not only to examine carefully the raw materials, but also to improve manufacturing processes, so that the right type of material is used in the correct way.

Refractoriness, although of great importance, is no criterion of the value of furnace linings. Many causes of failure may be attributed to attaching undue importance to the highest temperatures which a material will withstand without softening.

The paper reviews the refractory materials of South Wales: distribution and essential characteristics of the raw material; changes which take place during manufacture; properties of the refractory materials; their behaviour in use; comparison of silica bricks with fireclay bricks; precautions to be taken to obtain longest service possible; efficient kiln practice, correct shape and size of bricks, laying, spalling, repairs, and patching.

PAPER No. 687. This paper is not to be reprinted, wholly or in part, until presented (and then only with due acknowledgment) at a meeting to be held on March 6-7, 1935, in the Hall of the Institution of Mechanical Engineers, Storey's Gate, Westminster, London, S.W.1. The Institute as a body is not responsible for the statements or opinions expressed in this paper, on which written discussion may be sent to the Secretary not later than April 1, 1935.

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

SOME FURTHER EXPERIMENTS ON ATMOSPHERIC ACTION IN FATIGUE *

By H. J. GOUGH,† M.B.E., D.Sc., F.R.S., MEMBER, and D. G. SOPWITH,‡ B.Sc.Tech.

SYNOPSIS.

The paper describes experiments carried out to investigate further the effect of atmospheric environment on the fatigue-resistance of metals. Previous experiments § had shown that the substitution of a partial vacuum for the atmosphere led in some metals to a considerable improvement in the values of the fatigue limit determined using cycles of reversed direct stress. Three suggestions have been offered as to the cause of this improvement, namely: (1) that oxygen is the primary factor, the presence of water—as a catalytic agent—also being necessary; (2) that atmospheric impurities, acid and alkaline, are responsible, and (3) that impurities, mainly gaseous, dissolved in the metal under test, react with the metal during fatigue.

To examine possibilities (1) and (2), fatigue tests have been made using copper and brass in four environments, namely, air, partial vacuum, also purified air (freed from acid and alkaline impurities) both in the dry and damp conditions. To examine possibility (3) fatigue tests both in air and in a partial vacuum have been made on a copper containing cuprous oxide, on oxygen-free copper, and also on copper deoxidized with phosphorus. As a matter of general interest fatigue tests conducted both in the atmosphere and in a partial vacuum have been made on pure lead, also on Armco iron tested in two forms of heat-treatment.

The results of the tests on copper and brass suggest strongly that the acid and alkaline impurities present in the atmosphere can have little, if any, influence on atmospheric corrosion-fatigue, but that oxygen in the presence of water is probably primarily responsible. The results of the tests on the oxide-bearing and deoxidized coppers show that the comparative behaviour of these materials when tested in air and in a partial vacuum is unaffected by the different compositions of the dissolved gases present in the two materials.

INTRODUCTION.

A careful study of the literature dealing with the phenomena associated with what have become termed "fatigue" and "corrosion-

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§ *J. Inst. Metals*, 1932, 49, 93-112.

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

fatigue" reveals* that the optimum values of the fatigue-resistance of metals are not always obtained in an atmospheric environment. This fact suggests that the fatigue *limits* of metals, as ordinarily determined under atmospheric conditions, are sometimes lower than those obtained under conditions of environment approaching those of a complete vacuum, and that the values obtained in this way might be regarded as a measure of the real fatigue-resisting properties, as distinct from those obtained in circumstances where stress and corrosion effects were operating simultaneously. The first direct proof that the substitution of a vacuum for an atmospheric environment did, in fact, effect distinct improvement in the limiting range of stress of certain metals was afforded by some tests † made by the present authors. The results of principal interest, in the present connection, are included in a summary (Table XII) given at the end of this paper. The increases already recorded varied from zero value in one material up to as much as 26 per cent. in the case of 70 : 30 brass, whilst the value of 13 per cent. obtained with copper was also remarkably high. Although the practical value of these results is not yet apparent, they possess considerable theoretical interest, and evoked a very useful discussion at the reading of the paper † (hereinafter referred to as the "previous" paper) and subsequent interesting foreign correspondence. The curiosity aroused related mainly, of course, to the cause ‡ of the effect of which, at the time, the authors had no explanation to offer beyond suggesting (a) that, as some oxygen was still present in the partial vacuum tests, that element could not be safely regarded as the sole responsible factor, and (b) that as owing to the low value of the pressure (10^{-3} mm. of mercury) existing in the "vacuum" chamber, water vapour was, presumably, completely absent, water—either as a direct or a catalytic agent—might possibly play an important part: the authors proposed to carry out additional tests in a *dry* oxidizing atmosphere, and also in atmospheres of inert gas. Some valuable suggestions regarding further experiments were offered during the discussion of the previous paper.

W. H. J. Vernon, commenting on the relation that might possibly exist between atmospheric corrosion-fatigue and the well-known phenomenon of season-cracking, remarked that the latter could be brought about by atmospheric impurities, especially ammonia and sulphur dioxide. He suggested that it would be worth while to carry out further tests, in addition to the proposed tests in highly purified oxygen,

* For complete discussion, see H. J. Gough, "Corrosion-Fatigue of Metals," Eleventh Autumn Lecture, *J. Inst. Metals*, 1932, 49, 17-92.

† H. J. Gough and D. G. Sopwith, "Atmospheric Action as a Factor in Fatigue of Metals," *J. Inst. Metals*, 1932, 49, 93-112.

‡ It had been shown that "temperature effects" were *not* responsible.

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conducted in ordinary laboratory air and in the same air after passing through an efficient purifying train, as well as in an inert gas both dry and saturated with water vapour; such tests would afford information regarding the influence of atmospheric impurities and water vapour.

H. W. Brownsdon, in discussing particularly the results on copper and brass, directed attention to the aeronautical interest attaching to the fatigue properties of these materials (petrol and oil pipes, &c.), and said that it would be of considerable interest to determine to what extent the fatigue limit of copper is influenced by the impurities and gaseous constituents commonly present in that metal, recalling that these included—in addition to numerous small amounts of metallic impurities, cuprous and other metallic oxides—condensed water vapour, carbon monoxide, carbon dioxide, hydrogen, and, possibly, other gases. He suggested that it would be interesting to carry out fatigue tests, both in air and in a partial vacuum, on a series of coppers specially prepared so as to eliminate one or more of the constituent impurities, both solid and gaseous.

In view, also, of the very valuable work on the fatigue of lead which has been carried out* by and on behalf of the Research Department at Woolwich Arsenal, and of the general interest attaching to the fatigue properties of “soft” metals, it seemed desirable for the authors to avail themselves of their existing apparatus to make comparative fatigue tests on lead tested in air and in partial vacuum.

The present report relates to the further work, carried out since that described in the previous paper, and describes the results of the following experiments.

1. *Annealed Copper and Annealed 70 : 30 Brass*,† tested (under reversed direct stresses) in air, in a partial vacuum, in dry purified air, also in purified air containing water vapour; the object was to discover the influence of atmospheric impurities and of water vapour on the fatigue properties.

2. *Normal Copper, also Two Types of Deoxidized Copper*, tested in air and in a partial vacuum, to investigate the effect of occluded gases.

3. *Lead* tested in air and in a partial vacuum.

4. *Armco Iron* (normalized, also annealed), tested in air and in a partial vacuum: these tests were made merely to extend the range of the ordinary materials previously investigated and reported on in the previous paper.

* Beckinsale and Waterhouse, *J. Inst. Metals*, 1928, **39**, 375; Haigh and Jones, *J. Inst. Metals*, 1930, **43**, 271.

† These materials were chosen for this series as in previous tests (see previous paper) they had exhibited the greatest increase in fatigue limit, when tested in partial vacuum, of the materials investigated.

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TEST APPARATUS AND TECHNIQUE.

As in the previous paper, the tests were all made in a 30-cwt. model of the Haigh alternating stress testing machine operating at a test frequency of about 2200 stress cycles per minute. In the partial vacuum tests the specimen was enclosed in a special vacuum chamber* connected to a Cenco Hyvac pump: the degree of vacuum obtained was, as in the previous tests, from 0.5×10^{-3} to 1.0×10^{-3} mm. of mercury.

On account of the extremely soft nature of the pure lead used, it was considered necessary to develop a special technique for tests on this material, to avoid accidental strains being imposed on the specimens while they were being placed in the testing machine. The arrangement adopted (which in use has proved entirely satisfactory) is shown in Fig. 1. In place of the normal locknuts, the specimen is held in position in the adaptors of the Haigh machine by locking screws inserted from the back ends of the adaptors, and having square heads for tightening purposes. Hence, instead of securing the specimen by locknuts, which would

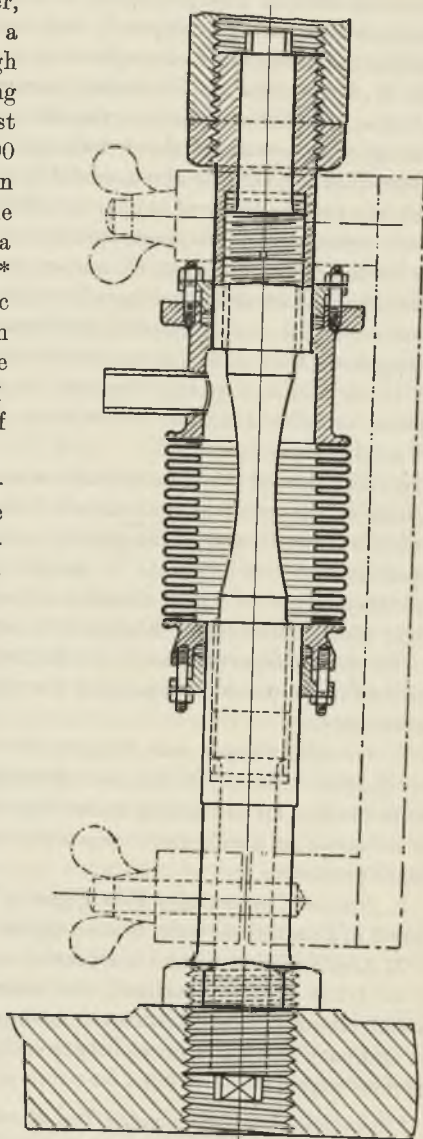


FIG. 1.

* For detailed description see previous paper.

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have necessitated constant tightening during test, the material was compressed into the screw threads in the adaptors. The adaptors with the specimen in position were inserted in the Haigh machine as a single unit in the same way as is a normal specimen. In order to reduce the possibility of bending the specimen during assembly or in tightening the locking screws, or of subjecting it to torsional strain during the operation of tightening up the locknuts on the adaptors, the latter were held in a special jig, shown in dotted lines in Fig. 1. This jig consisted of a base plate having two split bearings which could be clamped to the adaptors by means of the wing nuts shown. The jig was removed after the assembly had been inserted in the machine and the locknuts on the adaptors had been adjusted.

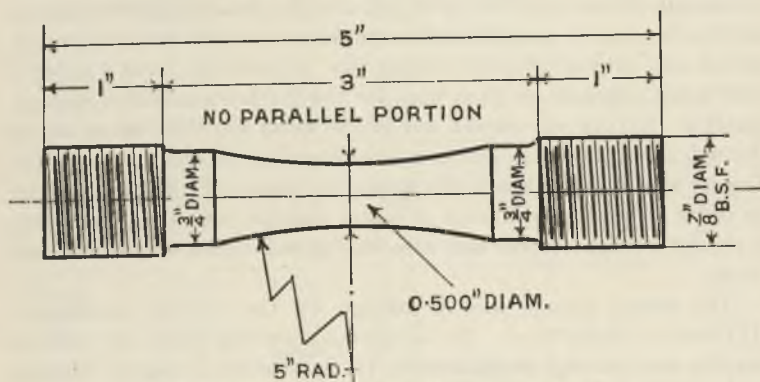


FIG. 2.—Fatigue Test-Piece (for Tests on Lead).

The lead specimens were made of the largest convenient size, on account of their low fatigue resistance. The form of specimen employed is shown in Fig. 2; the test portion of the specimen is machined with a single large radius (5 in.). This was adopted as the work of previous investigators had shown that, in spite of the extreme softness of material of this type, stress concentration effects may be considerable.

The test-specimens of the other materials were of the form as illustrated in Fig. 1 (c) of the previous paper, and were 0.25 in. diameter in the test portion.

The arrangements adopted for purifying and drying the atmospheric gases will be described in connection with the corresponding tests.

I. FATIGUE TESTS MADE IN PURIFIED AIR.

Full particulars of the materials used—annealed 70 : 30 brass and annealed copper—have been given in the previous report. In both

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cases the actual bars used for the previous tests had been exhausted; although a further supply of the same materials remained, it was considered advisable to carry out further reference tests both in air and *in vacuo* in order to avoid any error due to possible variations existing in the material from bar to bar.

The air was purified by being drawn through a purification train before obtaining access to the fatigue specimen, which was enclosed in a chamber similar to that used for the tests conducted in a partial vacuum. The purification train consisted of a tower containing cotton wool and an air filter (Institute of Metals Corrosion Committee pattern) for the removal of solid particles; a tower containing paraffin wax shavings on glass wool for the condensation of organic vapours; two Babo towers containing normal sulphuric acid and alkaline potassium permanganate solution for the removal of alkaline (mainly ammonia) and acid (mainly carbon and sulphur dioxides) impurities, respectively; and a tower of solid caustic potash on glass wool for the further removal of acid impurities. Drying was carried out in the usual way by passing the air through concentrated sulphuric acid followed by phosphorus pentoxide. The air was drawn through the system by means of a water jet pump. In order to prevent diffusion of water vapour back from the pump, a similar drying system was also interposed between specimen and pump.

The actual circuit passed through by the air was as follows: (1) tower of cotton wool; (2) Corrosion Committee filter; (3) tower of paraffin wax shavings on glass wool; (4) Babo tower of normal sulphuric acid; (5) Babo tower of conductivity water (to isolate (4) and (6)); (6) Babo tower of alkaline potassium permanganate; (7) tower of solid caustic potash on glass wool; (8) Babo tower of concentrated sulphuric acid; (9) and (10) two towers of phosphorus pentoxide; (11) Jena glass filter (to prevent phosphorus pentoxide powder being drawn through to specimen); (12) chamber enclosing specimen in Haigh machine; (13) tower of phosphorus pentoxide; (14) wash-bottle of concentrated sulphuric acid, and (15) water jet pump.

All joints in the system were, as nearly as possible, glass to glass, and each rubber connection was sealed with sealing-wax varnish. The rate of flow was of the order of 30 c.c./minute.

For the tests in pure damp air, the phosphorus pentoxide towers—items (9), (10), and (13)—were removed from the circuit, and dilute sulphuric acid was substituted for concentrated acid in items (8) and (14); the strength of sulphuric acid used was 40 per cent., corresponding to a relative humidity of approximately 55 per cent., which is an average value for the laboratory atmosphere.

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(a) *Results of Fatigue Tests on Copper (Reference Mark :—BIF 4).*

The results of the fatigue tests on annealed copper * are as stated in Table I; the corresponding *S/N* curves, plotted semi-logarithmically, are given in Fig. 3.

TABLE I.

Test Environment.	Specimen Test Mark.	Applied Range of Stress, tons/in. ² .	Endurance to Fracture, millions of cycles.	Estimated Endurance Limit on 3×10^7 Reversals Basis.	
				Tons/in. ² .	Ratio.
Atmosphere	BIF 4B	± 5.0	4.62	± 4.4 ₅	1.00
	BIF 4E	± 4.7	6.31		
	BIF 4A	± 4.5	23.25 (unbroken)		
	BIF 4C	± 4.5	30.11		
	BIF 4H	± 4.2	20.03 (unbroken)		
Partial vacuum	BIF 4EE	± 5.5	3.96	± 4.9 ₅	1.11
	BIF 4DD	± 5.3	10.53		
	BIF 4J	± 5.0	25.76		
Dry purified air.	BIF 4V	± 5.3	3.23	± 4.8 ₅	1.09
	BIF 4W	± 5.1	5.88		
	BIF 4Y	± 5.0	8.45		
	BIF 4X	± 4.9	28.16		
	BIF 4U	± 4.7	31.38 (unbroken)		
Damp purified air.	BIF 4FF	± 5.0	5.64	± 4.5	1.01
	BIF 4GG	± 4.8	6.08		
	BIF 4CC	± 4.6	22.16		
	BIF 4Z	± 4.55	18.17		
	BIF 4AA	± 4.45	37.94 (unbroken)		
	BIF 4BB	± 4.45	38.61 (unbroken)		

The shapes of the *S/N* curves (Fig. 3) do not indicate that the material possesses clearly defined fatigue limits within the endurances investigated, and, for this reason, the deduced values are stated as *endurance limits* on a 30 million reversals basis.

(b) *Results of Fatigue Tests on 70 : 30 Brass (Reference Mark :—BIF 2).*

The results of these tests are as stated in Table II; the corresponding *S/N* curves, plotted semi-logarithmically, are given in Fig. 4.

The shapes of the *S/N* curves (Fig. 4) are such that the existence of fatigue limits are definitely indicated, and the deduced results are expressed in these terms.

In general, the results plot regularly, with the sole exception of that of specimen BIF 2W, which caused some concern at the time. This was the third specimen tested, having been preceded by specimens BIF 2U

* For other fatigue tests on this material, see Table IV of the previous paper.

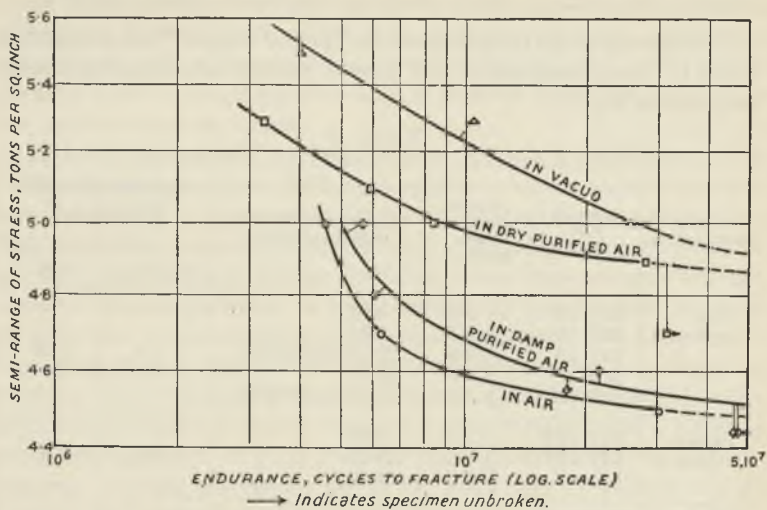


FIG. 3.—Fatigue Tests on Annealed Copper (Ref. Mark, BIF4).

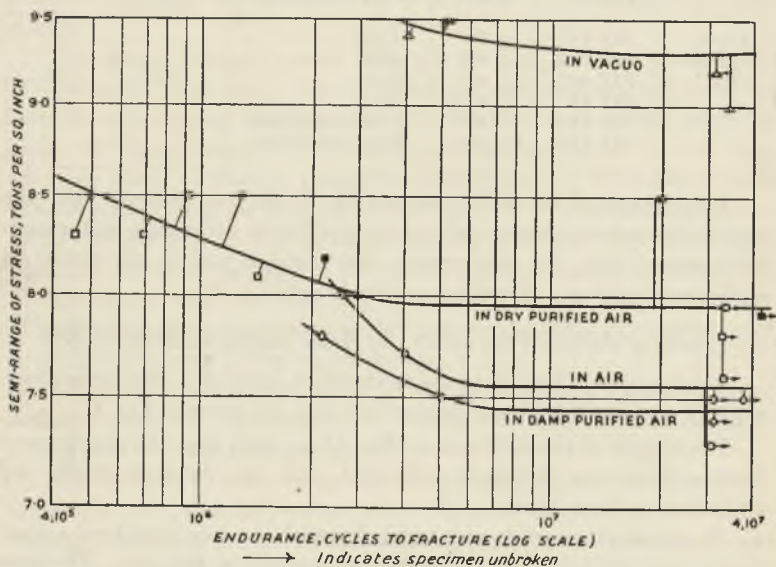


FIG. 4.—Fatigue Tests on Annealed 70 : 30 Brass (Ref. Mark, BIF2).

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and X. After the test on BIF 2W, the next specimen (BIF 2Y) broke much sooner at a lower stress. As this might have been due to the reagents in the purification train having become used up after the lengthy tests on BIF 2Y and W (although there was no obvious sign of this), the reagents were all renewed and all joints re-waxed. The next specimen (BIF 2M) gave a very similar result to that on BIF 2Y, actually

TABLE II.

Test Environment.	Specimen Test Mark.	Applied Range of Stress, tons/in. ² .	Endurance to Fracture, millions of cycles.	Estimated Fatigue Limits.				
				Tons/in. ² .	Ratio.			
Atmosphere	BIF 2GG	± 8.0	2.65	± 7.5 ₅	1.00			
	BIF 2HH	± 7.7	4.02					
	BIF 2LL	± 7.5	31.78 (unbroken)					
	BIF 2FF	± 7.5	37.79 (unbroken)					
	BIF 2EE	± 7.3	31.49 (unbroken)					
Partial vacuum	BIF 2JJ	± 9.5	5.23	± 9.3	1.23			
	BIF 2J	± 9.4	4.14					
	BIF 2MM	± 9.2	32.67 (unbroken)					
	BIF 2P	± 9.0	35.16 (unbroken)					
Dry purified air	First Series *	BIF 2U	± 8.5	0.93	± 8.0 ₅	± 7.9 ₅	1.05	
		BIF 2W	± 8.5	20.48				
		BIF 2M	± 8.3	0.46				
		BIF 2Y	± 8.3	0.70				
		BIF 2R	± 8.1	1.43				
		BIF 2Q	± 8.0	34.15 (unbroken)				
		BIF 2S	± 7.8	33.86 (unbroken)				
		BIF 2X	± 7.6	33.90 (unbroken)				
	Second Series *	BIF 2BB	± 8.5	1.31				
		BIF 2AA	± 8.2	2.27				
		BIF 2CC	± 8.0	3.01				
		BIF 2DD	± 7.9	42.68 (unbroken)				
	Damp purified air	BIF 2H	± 7.8	2.26	± 7.4 ₅			0.99
		BIF 2K	± 7.5	5.08				
BIF 2NN		± 7.4	31.68 (unbroken)					

* See note in text.

breaking at a somewhat lower endurance. In all this work, as also in the preceding tests, every means was taken to ensure that the general results were reproducible: in accordance with this general plan, a further series of tests, referred to in Table II as the second series, was carried out some 3½ months later, the testing machine having been used for other purposes in the meantime. As seen from Table II, really excellent agreement was obtained between the two sets of results, which enables confidence to be reposed in the deduced value of the fatigue limit.

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(c) Discussion of Results of Fatigue Tests on Copper and Brass.

Considering the tests made in the atmosphere and in a partial vacuum as the *reference* tests for discussion purposes, reference may first be made to the results obtained in the previous and present tests carried out under these two conditions, remembering that different *bars* of the materials were used. The summarized results * are as follows:

Material.	Fatigue Limit in Air.		Increase in Fatigue Limit obtained in Partial Vacuum.	
	Previous Tests.	Present Tests.	Previous Tests.	Present Tests.
	Tons/in. ² .		Per cent.	
Copper	± 4·3 ₅	± 4·4 ₅	13	11
Brass	± 7·2 ₅	± 7·5 ₅	26	23

The actual value of the fatigue limit obtained in the present tests, for each material, is slightly lower than in the previous tests, but the difference is quite compatible with the differences commonly existing between bars of the same material, and may be disregarded. Similar remarks apply to the percentage improvements effected by testing in a partial vacuum, and, in fact, the degree of agreement recorded was regarded as being extremely satisfactory, as showing that the "vacuum effect" was real and reproducible in spite of time intervals, and the fact that the

TABLE III.

Material.	Ambient Conditions of Tests.			
	Air.	Damp Purified Air.	Dry Purified Air.	Partial Vacuum.
	Fatigue Limits (Ratios).			
Copper	100	101	109	111
Brass	100	99	105	123

testing apparatus had been completely dismantled and the machine used for other types of test.

Having cleared up the above point, attention can be devoted to the principal object of the present tests, the results of which can be most concisely summarized as in Table III.

* For discussion purposes, the *endurance limit* of the copper will be referred to as a *fatigue limit*.

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The fatigue limits of the materials as determined in the atmosphere and in damp purified air are shown to have the same values, within the (very close) limits of accuracy of the test. This important result certainly indicates that the acid and alkaline impurities existing in the (laboratory) atmosphere play no part in the action which results in a reduced fatigue limit obtained under ordinary atmospheric conditions: the authors suggest that this conclusion can be regarded as established. This places the responsibility on the gaseous constituents, oxygen, nitrogen, inert gases, or water vapour, or some combination of these; the influence of carbon monoxide, carbon dioxide, sulphur dioxide, ammonia, suspended solid particles, &c., can reasonably be excluded from further consideration.

Turning to the results obtained in dry purified air, it is seen that the attempts made to remove all traces of water vapour have produced an approach towards the results obtained in a partial vacuum, but of unequal amount in the two materials: whereas 82 per cent. of the maximum value was obtained with copper, a value of only 22 per cent. is recorded in the tests on brass. In considering these values, one recalls the extremely small traces of water vapour which are required to convert oxygen from an inert gas into an active oxidizing agent. It is very unlikely, of course, that the drying apparatus used in the present experiments would be completely successful in removing every trace of water vapour, and, therefore, the *full* effect of drying could not reasonably be expected. Viewing the near approach to the optimum value obtained in the test on copper, and remembering that oxygen was present, although in small quantities, in the optimum conditions (partial vacuum) where the existing pressure ($< 1 \times 10^{-3}$ mm. mercury) was *less* than the vapour pressure of water, it might reasonably be concluded that the experiments have shown that *the effect of atmospheric corrosion is due to the catalytic agency of water in the presence of oxygen*. The results of the test on brass are not equally reassuring in this respect, in view of the much smaller degree of improvement obtained, although there is no reason to expect that equal traces of water vapour would produce similar effects with these two metals. A further possibility exists in that, under fatigue conditions, occluded hydrogen may react with the oxygen in the dry purified air to form water vapour in intimate contact with the material, thus providing a catalytic agent. In any case, if this interesting matter is to be elucidated, further experiments are required, and fatigue tests made on specimens in ambient atmospheres of dry and damp inert gases should be informative: it is proposed to carry out such tests, using nitrogen.

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II. FATIGUE TESTS ON SPECIAL SAMPLES OF COPPER.

The special materials used for these tests were kindly supplied by Messrs. Imperial Chemical Industries, Ltd. Three bars were supplied, each about $\frac{3}{4}$ in. in diameter by 11 ft. in length, described respectively as "oxygen-free copper," "copper deoxidized with phosphorus," and "copper containing cuprous oxide." The test reference marks of these materials, and also the chemical analyses as kindly supplied by Messrs. Imperial Chemical Industries, Ltd., are as follow :

N.P.L. Eng. Dept. Test Mark.	Copper, %.	Oxygen, %.	Phosphorus, %.	Traces * (only) of :
GSZ 1 . . .	99.96	nil	nil	Fe, Ni, Ag, Si, Bi, As
,, 2 . . .	99.96	nil	0.018	" "
,, 3 . . .	99.92	0.037	nil	" "

* By spectrographic examination.

All three bars were extruded, and, on account of the temperature gradient inseparable from the extrusion process, their mechanical properties varied somewhat from end to end of the bar. The results of tensile tests on the material, as made at the National Physical Laboratory (N.P.L.) and by the makers, are as stated in Table IV. The symbols F and B refer to the makers' tests on materials taken from the front and back ends, respectively, of the bars and F₁ to N.P.L. tests on material taken from the front ends; the latter tests were made using a Dalby autographic recorder. For convenient comparison, similar figures are given for the copper (BIF 3) used in the tests recorded in the previous paper.

TABLE IV.

Bar.	End.	Limit of Proportionality, Tons/in. ² .	Ultimate Tensile Stress, Tons/in. ² .	Elongation on $\sqrt{\text{Area}}$, %.	Reduction of Area, %.
GSZ 1	B	1.4	15.2	60	77
	F	1.4	14.5	56.5	79
	F ₁	...	13.4	54	76
GSZ 2	B	1.6	15.5	58	79
	F	1.4	14.3	51	80
	F ₁	...	14.4	56	82
GSZ 3	B	1.6	14.6	52.5	64.5
	F	1.8	13.7	53	76
	F ₁	...	13.6	52	73
BIF 3	...	0.8	14.4	59	74

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Because of the recorded variation in tensile strength, amounting to about 8 per cent., between opposite ends of the bars, it was important that the fatigue results in air and *in vacuo* should be obtained as far as possible from adjacent specimens. All specimens were therefore taken from the front ends of the bars and numbered in order from that end, e.g., GSZ 1A, B, C, &c. Alternate specimens were used for tests in air and *in vacuo*, e.g., specimens, A, C, E, &c., were tested in air and B, D, F, etc., *in vacuo*.

The fatigue tests were carried out in exactly the same manner as previously described.

The results of the tests are as stated in Tables V to VII; the corresponding *S/N* curves appear as Figs. 5, 6, and 7.

The shapes of the *S/N* curves of Figs. 5, 6, and 7 show that the existence of definite fatigue limits has not been established on the endurance

TABLE V.—Results of Fatigue Tests on Oxygen-Free Copper—GSZ 1.

Test Environment.	Specimen Test Mark.	Applied Range of Stress, Tons/in. ² .	Endurance to Fracture, Millions of cycles.	Estimated Endurance Limit on 3×10^7 Reversals Basis, Tons/in. ² .
Atmosphere	GSZ 1A	± 5.2	2.09	} $\pm 4.3_5$
	GSZ 1C	± 4.7	19.62	
	GSZ 1E	± 4.5	21.69	
	GSZ 1G	± 4.4	26.84	
Partial vacuum	GSZ 1B	± 5.2	6.36	} ± 4.6
	GSZ 1D	± 5.0	4.90 (possible flaw)	
	GSZ 1F	± 4.8	15.56	
	GSZ 1H	± 4.7	21.69	
	GSZ 1K	± 4.6	35.27	

TABLE VI.—Results of Fatigue Tests on Copper Deoxidized with Phosphorus—GSZ 2.

Test Environment.	Specimen Test Mark.	Applied Range of Stress, Tons/in. ² .	Endurance to Fracture, Millions of cycles.	Estimated Endurance Limit on 3×10^7 Reversals Basis, Tons/in. ² .
Atmosphere	GSZ 2A	± 5.2	1.69	} ± 4.4
	GSZ 2C	± 4.7	8.07	
	GSZ 2E	± 4.5	20.68	
	GSZ 2G	± 4.4	39.86	
Partial vacuum	GSZ 2B	± 5.2	0.79	} ± 4.5
	GSZ 2D	± 4.7	8.23	
	GSZ 2F	± 4.6	8.92	
	GSZ 2H	± 4.5	31.53 (unbroken)	



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TABLE VII.—*Results of Fatigue Tests on Copper Containing Cuprous Oxide—GSZ 3.*

Test Environment.	Specimen Test Mark.	Applied Range of Stress, Tons/in. ² .	Endurance to Fracture, Millions of cycles.	Estimated Endurance Limit on 3×10^7 Reversals Basis, Tons/in. ² .
Atmosphere	GSZ 3A	± 5.2	3.10	} ± 4.5
	GSZ 3C	± 4.7	12.48	
	GSZ 3E	± 4.6	9.01	
	GSZ 3G	± 4.6	(possible flaw) 14.58	
	GSZ 3J	± 4.4	30.44	
			(unbroken)	
Partial vacuum	GSZ 3B	± 5.2	6.08	} $\pm 4.7_5$
	GSZ 3F	± 5.0	10.06	
	GSZ 3D	± 4.8	30.25	

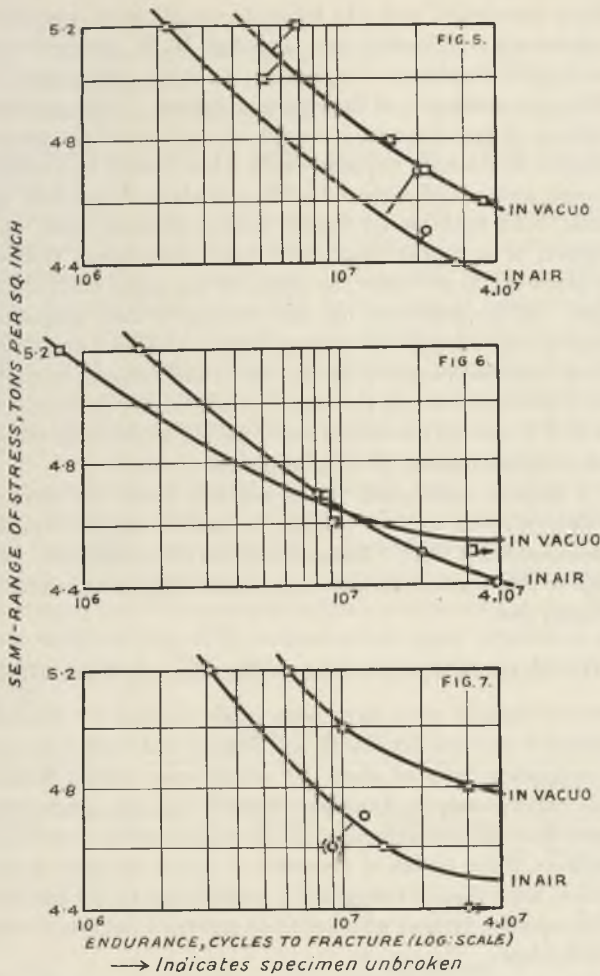
investigated, and the results can be reported only as endurance limits. These results are summarized in Table VIII, in which the values obtained from the two bars (BIF 3 and 4) of copper previously tested have been included for purposes of comparison.

TABLE VIII.

Ref. Mark of Material.	Description of Material.	Endurance Limits (3×10^7 Reversals).		Increase in Partial Vacuum, %.
		In Air, Tons/in. ² .	In Partial Vacuum, Tons/in. ² .	
GSZ 1	Oxygen-free copper.	$\pm 4.3_5$	± 4.6	6
GSZ 2	Copper deoxidized with phosphorus.	± 4.4	± 4.5	2
GSZ 3	Copper containing cuprous oxide	± 4.5	$\pm 4.7_5$	6
BIF 3	Annealed copper	$\pm 4.3_5$	± 4.9	13
BIF 4	Annealed copper	$\pm 4.4_5$	$\pm 4.9_5$	11

The increased value obtained in partial vacuum with the sample, GSZ 3, is seen to be considerably less than with the annealed coppers, BIF 3 and 4, previously tested; as the amounts of oxygen present in the materials are very similar (0.04 per cent. and 0.037 per cent. in BIF 3 and GSZ 3, respectively), this difference is presumably due to other causes. The ratio of endurance limit to ultimate strength is lower for the oxygen-free copper GSZ 1 than for sample GSZ 3, which contains cuprous oxide, but the percentage increase in fatigue limit due to testing in a partial vacuum has the same value in both cases. The presence of phosphorus appears to lead to a reduction in endurance limit when tested in a partial vacuum.

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FIGS. 5-7.—Fatigue Tests on Plain and Deoxidized Coppers.

Fig. 5.—Oxygen-Free Copper (Ref. Mark, GSZ1).

Fig. 6.—Copper Deoxidized with Phosphorus (Ref. Mark, GSZ2).

Fig. 7.—Copper (Ref. Mark, GSZ3).

Discussion of Results.

The exact significance of the results obtained would, no doubt, be much clearer if the amounts of dissolved gases existing in the three coppers—GSZ 1, GSZ 2, and GSZ 3—were known, but the very great

difficulties associated with the accurate quantitative determination of gas contents are well known, and, although H. W. Brownsdon has gone to considerable trouble in this matter, he is not yet satisfied with the reliability or consistency of the results obtained. From a consideration of a number of experiments, it would appear that of the gases evolved from copper containing cuprous oxide when heated in vacuum, about 80 per cent. consists of carbon dioxide and about 10 per cent. of carbon monoxide, with little or no free hydrogen, whereas when an oxygen-free copper, or a copper deoxidized with phosphorus, is heated in a similar manner, 50 per cent., or more, of the gases evolved consists of hydrogen. If this difference had any bearing on their fatigue behaviour when tested under a partial vacuum, then both GSZ 1 and GSZ 2 might have been expected to give a similar result and different from that given by GSZ 3, but this was not the case, and the smaller increase obtained in sample GSZ 2 can only be attributed, for the present, to the influence, of some unknown nature, of the phosphorus present.

As a general conclusion to be reached from the tests on these materials in relation to their origin, the authors suggest that the results have demonstrated that "atmospheric corrosion-fatigue" is unlikely to be due to the constituent impurities, solid or gaseous, contained in the metal under test.

III. FATIGUE TESTS ON LEAD (REFERENCE MARK GPK).

Previous fatigue tests have been made on lead by Beckinsale and Waterhouse,* and also by Haigh and Jones,* but these were carried out on an endurance basis of about 10^7 cycles only, whilst Wöhler tests † on lead, carried out in America, showed that no fatigue range was developed during tests extending to 26 million stress reversals. In the present tests, using cycles of reversals of direct stresses, more lengthy endurance tests have been investigated—particularly in the partial vacuum tests—to examine further whether there existed a definite limiting range of stress for lead.

The material used in the present tests was extruded "Broken Hill" lead, ‡ of 99.99 per cent. purity. Tensile tests to fracture gave the following results:

* The experiments of Beckinsale and Waterhouse, and of Haigh and Jones showed that, by surrounding the lead specimens by an oil bath or a coating of grease, the progress of fatigue fracture was considerably delayed, whilst an environment of acetic acid appeared definitely to increase the fatigue-resisting properties of lead: these results were ascribed to the exclusion, partial or complete, of oxygen from the specimens.

† Townsend and Greenall, *Proc. Amer. Soc. Test. Mat.*, 1930, 30, (II), 395.

‡ We are indebted to Mr. Waterhouse, of the Research Department, Woolwich, for assistance in obtaining this material.

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Rate of strain, in./minute	0.2	2.9
Ultimate tensile strength, tons/in. ²	1.48	1.16
Elongation on 2 in., per cent.	70	50
Reduction of area, per cent.	100*	100*

The material did not exhibit a tensile yield-point: its Brinell hardness number was 4.1.

Endurance tests were conducted in air, and in partial vacuum; it soon emerged that lead was subject to atmospheric corrosion-fatigue to a remarkable extent. In addition to the usual tests, it appeared of interest to vary the usual procedure, in the case of two specimens, to examine a point of general interest. It is now well known that a characteristic feature of corrosion-fatigue phenomena lies in the fact that the damage due to simultaneous corrosion and fatigue usually greatly exceeds the separate damages due to either corrosion or fatigue, and special tests were made to find out if the beneficial effects of a partial vacuum resulted only when fatigue stresses were, simultaneously, in operation; in other words, whether the effect of the atmosphere on *unstressed* specimens was negligible. Accordingly, two of the tests conducted in partial vacuum were interrupted at certain stages, the machine stopped and full atmospheric pressure restored in the chamber. After some time had elapsed the chamber was again exhausted and the fatigue test continued. The results of these special tests were as stated in Table IX.

TABLE IX.

Environment during Fatigue Test.	Specimen Test Mark.	Applied Range of Stress, Ton/in. ² .	Cycles Endured during Fatigue Tests, Millions.	Period of Exposure to Atmosphere between Stages of the Fatigue Test, Hours.
Partial vacuum	GPK 2H	± 0.50	0.24 0.14 0.38 (fractured) 0.76 Total	} 1.67 } 15.75
	GPK 2K	± 0.40	5.67 2.97 5.51 3.32 (fractured) 17.47 Total	} 7.50 } 15.92 } 7.75

Also, to make quite certain that the presence of the vacuum chamber, as such, had no effect on the results obtained, in one test, conducted in

* Specimens drew down to points.

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air, the vacuum chamber was left in place and merely connected up to the vacuum pump, the latter not being in operation.

The whole of the results of the fatigue tests on lead are recorded in Table X, and the corresponding S/N curves are plotted to logarithmic scales in Fig. 8.

TABLE X.

Test Environment.	Specimen Test Mark.	Applied Range of Stress, Ton/in. ² .	Endurance to Fracture, Millions of Cycles.	Endurance Limits, Ton/in. ² .
Atmo- sphere	GPK 2D	± 0.50	0.01	± 0.28 at 10 ⁶ cycles
	GPK 2C	± 0.40	0.12	
	GPK 1E	± 0.30	0.89	
	GPK 2F*	± 0.30	0.79	± 0.20 at 10 ⁷ cycles
	GPK 1B	± 0.25	1.58	
	GPK 1F	± 0.22	4.94	
	GPK 1C	± 0.20	17.40	± 0.17 at 3 × 10 ⁷ cycles
	GPK 1G	± 0.19	18.32	
	GPK 1D	± 0.18	30.61	
Partial vacuum	GPK 1J	± 0.50	0.60	± 0.48 at 10 ⁶ cycles
	GPK 2H†	± 0.50	0.76	
	GPK 1K	± 0.45	3.42	
	GPK 1N	± 0.40	20.44	± 0.41 at 10 ⁷ cycles
	GPK 2K†	± 0.40	17.47	
	GPK 1L	± 0.38	35.01 (unbroken)	
	GPK 2E	± 0.36	119.46	± 0.38 at 3 × 10 ⁷ cycles
	GPK 1H	± 0.31	35.28 (unbroken)	

* Test in vacuum chamber at atmospheric pressure.

† Tests with intermittent exposure to atmosphere.

These results are very interesting. Neither in air nor *in vacuo* is there any definite indication of the existence of a fatigue limit. Fig. 8 shows that an exponential relationship exists between stress and endurance, up to at least 35 millions of cycles for lead tested in air and up to 120 millions when tested in a partial vacuum. The uniformity of the results is also very marked. The failure to exhibit a fatigue limit may simply be a characteristic of the material as, for example, in Duralumin or Monel metal in some heat-treatments. It may also be recalled that the results ‡ of corrosion-fatigue tests made in salt spray showed in all cases a similar exponential relationship between stress and endurance, after a certain endurance was passed; this might be regarded as some kind of evidence that a process, akin to that of corrosion-fatigue, is also operative in fatigue tests on lead conducted in the atmosphere. The self-annealing

‡ Gough and Sopwith, "Some Comparative Corrosion-Fatigue Tests Employing Two Types of Stressing Action," *J. Iron Steel Inst.*, 1933, 127, 301-332.

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properties of lead at air temperature are likely, however, to play an important part in the fatigue properties of this metal.

The ratios of the endurance limits in a partial vacuum and in air increase very rapidly with increasing endurance, having the following values :—

- 1.7 at 10^6 cycles
- 2.0 at 10^7 cycles
- 2.2 at 3×10^7 cycles.

The special tests, previously described, show clearly that “stressless exposure” to the atmosphere, for periods long enough to cause con-

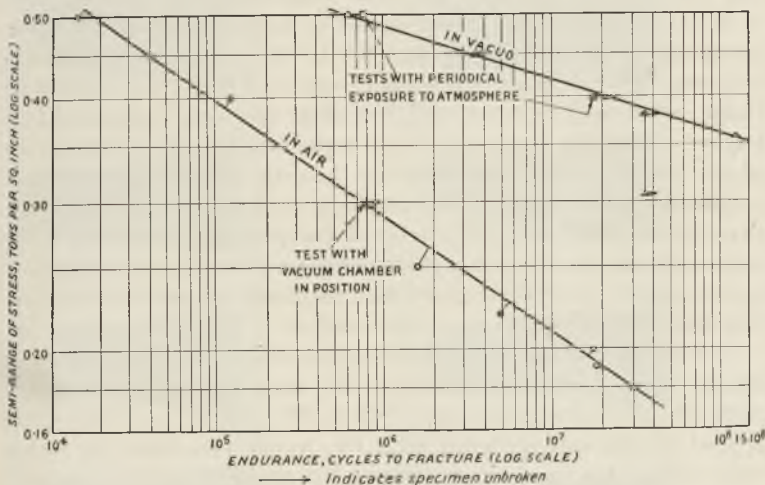


FIG. 8.—Fatigue Tests on Lead (Ref. Mark, GPK).

siderable damage when fatigue stresses are in operation, has no effect on the subsequent fatigue resistance *in vacuo*; and also that the presence of the enclosing chamber has no influence, as such, on the increased fatigue resistance exhibited when the tests are conducted in a partial vacuum. Although this latter result was expected, it is useful to have experimental data on the point concerned, which is of importance in relation to the technique employed, and on the accuracy of the whole of the result obtained, in the investigation.

In tests carried out using other metals, no differences were observed between the type and appearance of the fractured specimens when tested either in air or in a partial vacuum, but in the present tests on lead considerable differences were remarked in the visual appearance of the fractures. There is no doubt that where the same range of stress was

applied to a specimen tested in air and to a specimen tested in a partial vacuum, the amount of distortion involved differed appreciably, being greater in the specimen tested in air.* This will be seen in Fig. 9 (Plate I) which shows representative fractured specimens. Visual examination revealed irregular cracks present in several of the specimens tested in air, but none was observed on the surfaces of the specimens tested in partial vacuum. This suggested that failure in air might be due to intercrystalline fracture which was prevented or reduced by the substitution of a partial vacuum as environment; careful microscopical examination is necessary to decide a point of this kind, and some of the fractured specimens were, therefore, sent to Dr. C. H. Desch, who kindly agreed to have them examined in the Metallurgical Department of the N.P.L. In several of the fatigue fractures occurring in air, discoloured portions of the type referred to by Haigh and Jones † were observed, but these were *not* accompanied by a bright "shear" lip—occurring between the discoloured portion and the edge of the specimen—as described by the authors mentioned, who have expressed the view that the "atmospheric fatigue effect" in lead is due to oxygen diffusing into the interior of the specimen: it appears to the present authors, however, that the experiments on lead now described are quite consistent with their own tests on other metals and the conclusion that the atmospheric effect is a *surface* effect.

For the purposes of microscopical examination, two specimens were chosen which had, approximately, the same endurance; specimen GPK 1G, which fractured after 18.32×10^6 cycles of ± 0.19 ton/in.² applied in air, and specimen GPK 1N, which was tested in partial vacuum and fractured after 20.44×10^6 cycles of ± 0.40 ton/in.²: the appearance of the fractured surfaces is shown in Fig. 10 (Plate II).

Specimen 1G showed slight discoloration over a portion of the fractured surface at one side: this portion was roughly normal to the axis of the specimen, was "coarsely granular" in appearance, and was readily distinguishable from the remainder of the fractured surface, which was bright and silky in appearance and was inclined to the axis; this "darkened" portion suggested intercrystalline failure. The other specimen, 1N, presented a bright fibrous or silky appearance over the whole fracture, no darkened coarsely granular zone being visible; in the neighbourhood of the fracture, the sides of the specimen had a "roughened" appearance, which feature was absent from specimen 1G.

* One most interesting observation may be recorded; a specimen subjected in air, to a range of ± 0.18 ton/in.², extended or "crept" continuously at a rate of about 0.002 in. per day, whilst no measurable creep was observed in tests conducted *in vacuo* even at a stress range of ± 0.50 ton/in.².

† *Loc. cit.*

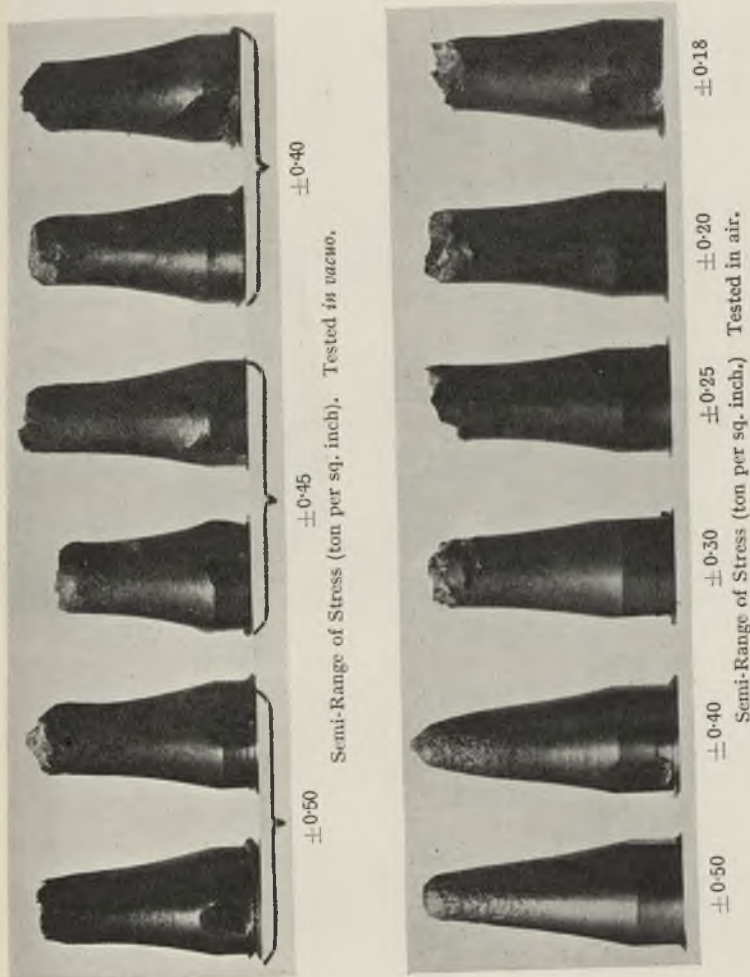


FIG. 9.—Fractures on Lead Fatigue Specimens.





Specimen
GPK 1G.

Specimen
GPK 1N.

Tested in Atmosphere.

Fractured after 18.32×10^6 stress
cycles of ± 0.19 ton/in.².

Tested in Partial Vacuum.

Fractured after 20.44×10^6 stress
cycles of ± 0.40 ton/in.².

FIG. 10.—Fatigue Tests on Lead. Typical Fractures.

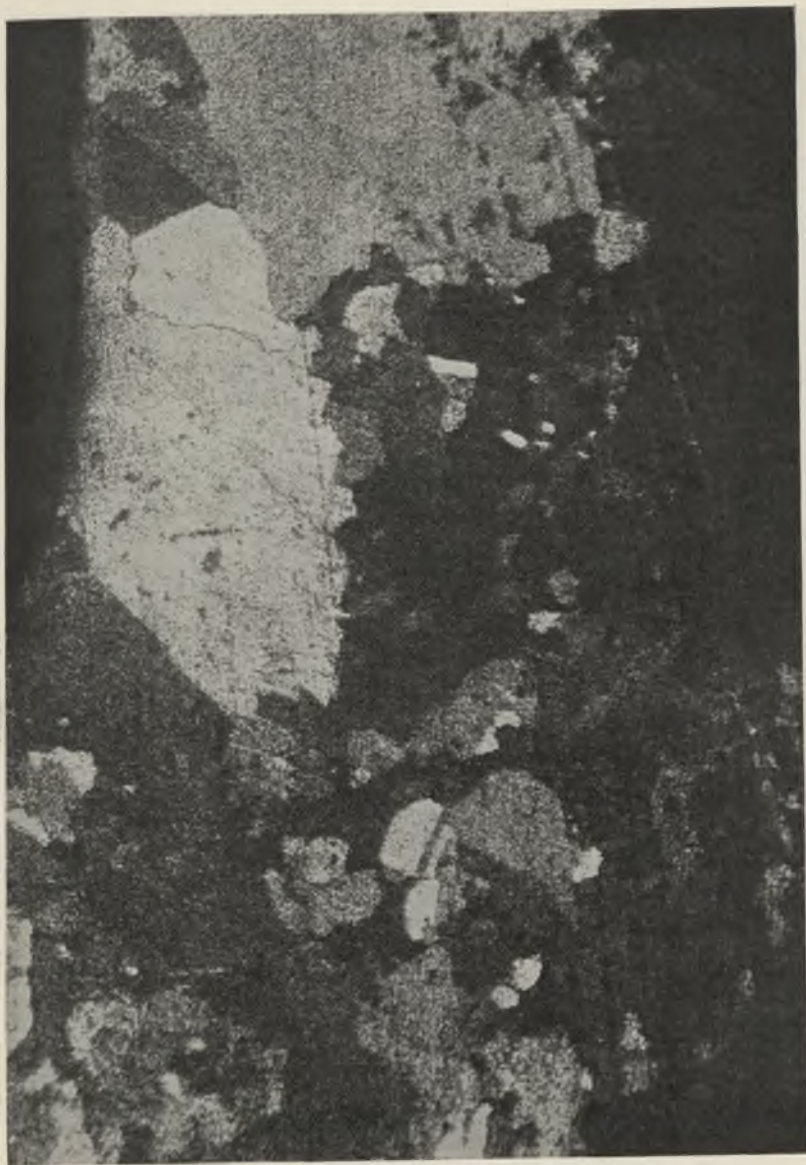


FIG. 11.—Fatigue Tests on Lead. Specimen GPK 1N: Tested in Partial Vacuum: fractured after 20.44×10^6 stress cycles of ± 0.40 ton/in.². $\times 150$.

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The fractured surfaces of each specimen had been slightly damaged by "hammering" during the final stage of the test before the testing machine had come to rest: it is very difficult to avoid this when a cycle of alternating stresses is applied.

For microscopic examination, the specimens were slit longitudinally, the resulting specimens being mounted in suitable sections of lead alloy tube by surrounding them with a resinous compound which melted at about 70° C. The sections were rubbed down on emery papers, soaked with paraffin oil, and were polished on a well-worn pad. The specimens were etched frequently during polishing to remove the work-hardened and recrystallized surface. Finally, polishing was carried out by hand on velvet without the use of any polishing powder.

Various etching reagents were tried, and reasonably satisfactory results were obtained with a strong solution of nitric acid in water (about 50 per cent. concentrated nitric acid).

The material exhibited a larger grain structure away from the fractures than in their immediate vicinity. It is thus apparent that recrystallization has occurred during the test or immediately after it, particularly in specimen GPK 1G (tested in air). This recrystallization has prevented, to some extent, any definite conclusions being reached as to whether failure has occurred by intercrystalline or by transcrystalline rupture. In specimen GPK 1G (tested in air) there is an absence of branching cracks which frequently form a guide to the nature of fracture. Two such cracks were, however, observed in GPK 1N (tested *in vacuo*), and these are illustrated in Figs. 11 and 12 (Plates III and IV) at a magnification of 150 diameters under approximately vertical illumination; the position of these branch cracks suggests that rupture in this specimen was partly intercrystalline and partly transcrystalline in character.

The difficulties involved in the micrographical examination of lead are well known, and it is only possible to express the conclusion of the examination in general terms, as follows: In test-piece GPK 1G (tested in air) microscopic examination provides no definite evidence as to whether rupture has taken place as a result of intercrystalline, transcrystalline, or duplex cracking, although the general appearance of one portion of the fracture is suggestive of intercrystalline failure. In GPK 1N (tested *in vacuo*) the evidence, so far as it goes, suggests that the fracture is duplex in character. Recrystallization has occurred during the tests particularly in GPK 1G (tested in air), and it is probable that this has to some extent obliterated the evidence as to the nature of the fractures.

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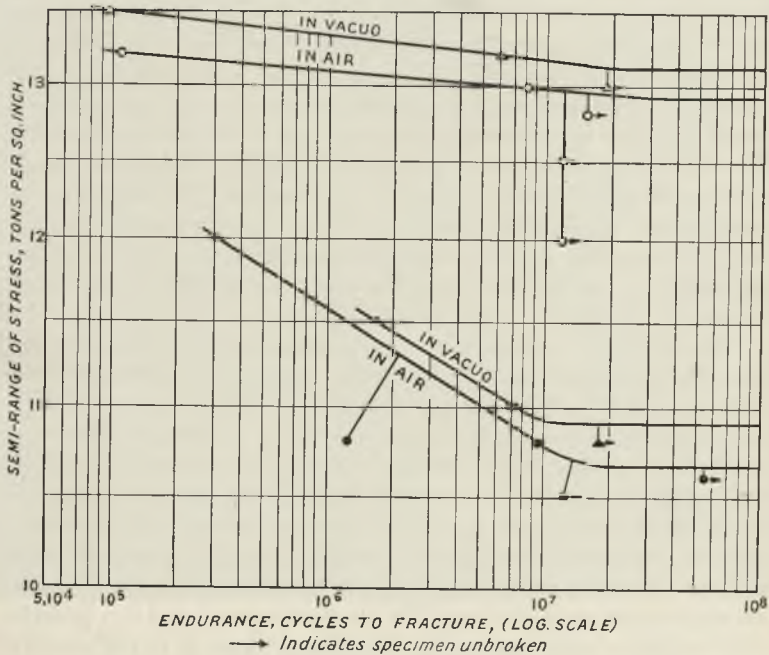
IV. FATIGUE TESTS ON ARMCO IRON (REFERENCE MARK : BMH).

As previously mentioned, fatigue tests conducted in air and in a partial vacuum have been made on this material merely to extend the scope of data already obtained on various commercial metals.

The material as received was stated to have been normalized : tests have been made in this condition, also after annealing at 1000° C. for $\frac{1}{2}$ hr. The composition of the iron has been determined with the following results : carbon 0.02, manganese 0.03, sulphur 0.034, phosphorus 0.017 per cent. ; traces of silicon and nickel.

A static tensile test made on the material in the condition as received at the laboratory gave the following results :

Limit of proportionality, tons/in. ²	9.6
Yield-point, tons/in. ²	11.8
Ultimate tensile strength, tons/in. ²	22.1
Young's modulus (E), lb./in. ²	29.8×10^6
Elongation on 2 in., per cent.	45
Reduction of area, per cent.	69



○ ▲ - IRON AS RECEIVED

● ▲ - IRON ANNEALED

FIG. 13.—Fatigue Tests on Armco Iron (Ref. Mark, BMH).

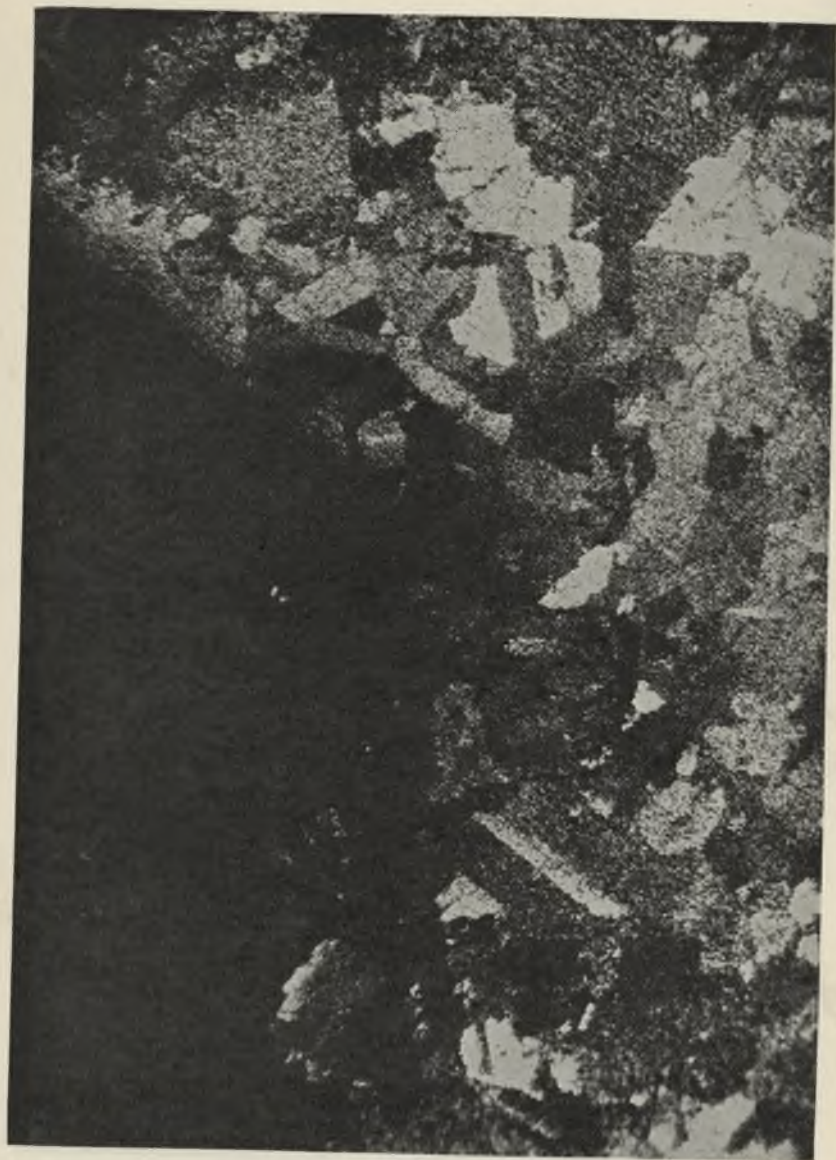


FIG. 12.—Fatigue Tests on Lead. Specimen GPK IN: Tested in Partial Vacuum: fractured after 20.44×10^6 stress cycles of ± 0.40 ton/in.². $\times 150$.

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The Brinell hardness numbers of the material in the "as received" and annealed conditions were, respectively, 102 and 93.

The results of the fatigue tests are as stated in Table XI and plotted, as *S/N* curves, in Fig. 13.

TABLE XI.

Condition of Material.	Test Environment.	Specimen Test Mark.	Applied Range of Stress, Tons/in. ² .	Endurance to Fracture, Millions of Cycles.	Fatigue Limit	
					Tons/in. ² .	Ratio.
Normalized (as received)	Atmosphere	BMH 11B	± 13.5	0.21*	} ± 12.9	1.00
		BMH 11C	± 13.2	0.11		
		BMH 11E	± 13.0	8.25		
		BMH 11A	± 13.0	8.89*		
		BMH 11D	± 12.8	(unbroken) 15.41		
		BMH 11B	± 12.5	(unbroken) 11.91*		
	BMH 11A	± 12.0	(unbroken) 12.00*			
	Partial vacuum	BMH 11F	± 13.5	0.09	} ± 13.1	1.02
		BMH 11P	± 13.2	6.12		
		BMH 11N	± 13.0	18.66 (unbroken)		
Annealed	Atmosphere	BMH 11G	± 12.0	0.31	} ± 10.7	1.00
		BMH 11H	± 11.0	7.00		
		BMH 11J	± 10.8	1.26		
		BMH 11S	± 10.8	9.67		
		BMH 11T	± 10.6	54.93 (unbroken)		
	BMH 11K	± 10.5	12.78 (unbroken)			
	Partial vacuum	BMH 11L	± 11.5	1.64	} ± 10.9	1.02
		BMH 11M	± 11.0	7.36		
BMH 11R		± 10.8	17.46 (unbroken)			

* Two specimens tested at 2 stress ranges.

The results show that only a slight, but definite, increase in fatigue limit results from the substitution of a partial vacuum for an atmospheric environment. This is comparable with the results of previous tests made on steels: apparently, steels are subject to atmospheric corrosion-fatigue, but only to a very small degree.

SUMMARY OF DATA OBTAINED REGARDING ATMOSPHERIC CORROSION-FATIGUE.

The total principal data now available from the present research are summarized in Table XII: this may be convenient for reference purposes.

TABLE XII.

Description.	Material.				Ultimate Tensile Strength, Tons/in. ²	Test Environment.	Fatigue Limit* (reversed Direct Stresses).	
	Approximate Chemical Analysis.	Conditions as Tested.	Test Mark of Bar.	Tons/in. ²			Ratio.	
Armco iron	0-02% C.	Normalized	BMH 11	22.1	Atmosphere Partial vacuum	± 12.9	1.00	
						± 15.1	1.02	
Mild steel †	0-03% Mn.	Annealed	BMH 11	—	Atmosphere Partial vacuum	± 10.7	1.00	
						± 10.9	1.02	
Medium steel †	0-13% C.	Hot-rolled	FQI	28.0	Atmosphere Partial vacuum	± 13.0	1.00	
						± 13.7	1.05	
Non-corroding steels †	0.5% C.	Cold-rolled	EOY	63.2	Atmosphere Partial vacuum	± 20 $\frac{1}{2}$ to 22 $\frac{1}{2}$	1.03 (average)	
						± 22 $\frac{1}{2}$ to 22 $\frac{1}{2}$		
Nickel-chromium steel †	15% Cr. 0-12% C.	Hardened and tempered	FAO	43.3	Atmosphere Partial vacuum	± 21 $\frac{1}{2}$ to 22 $\frac{1}{2}$	1.00 1.01 (average)	
						± 22 $\frac{1}{2}$		
Duralumin †	17% Cr. 1.2% Ni. 0.25% C.	Hardened and tempered	FAP	54.5	Atmosphere Partial vacuum	± 28 $\frac{1}{2}$	1.00 1.00	
						± 28 $\frac{1}{2}$		
Nickel-chromium steel †	18% Cr. 8% Ni. 0-1% C.	Cold-rolled	EWZ	66.3	Atmosphere Partial vacuum	± 24 $\frac{1}{2}$ to 25 $\frac{1}{2}$	1.00 0.98 (average)	
						± 24 $\frac{1}{2}$		
Duralumin †	3-4% Ni. 0-6% Cr. 0-36% C.	Hardened and tempered	S7B	90 †	Atmosphere Partial vacuum	± 35 $\frac{1}{2}$	1.00 1.03	
						± 36 $\frac{1}{2}$		
Duralumin †	4.25% Cu. 0.64% Mg. 0.82% Fe.	Rolled	FXA	28	Atmosphere Partial vacuum	± 6 $\frac{1}{2}$ to 9	1.00 1.05 (average)	
						± 8 $\frac{1}{2}$		

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Magnesium alloy †	2-46% Al.	Rolled	EXB	16-4	Atmosphere Partial vacuum	±5½ to 6 ±5½ to 6	1-00 1-00
Copper §	99-96% Cu. 0-04% O ₂	Annealed	BIF 3†	14-4	Atmosphere Partial vacuum	±4-3 ₅ (30) ±4-9 (30)	1-00 1-13
			BIF 4	14-4	Atmosphere Partial vacuum Dry purified air Damp purified air	±4-4 ₅ (30) ±4-9 ₅ (30) ±4-8 ₅ (30) ±4-5 (30)	1-00 1-11 1-09 1-01
		Extruded	GSZ 1	13-4 to 15-2	Atmosphere Partial vacuum	±4-3 ₅ (30) ±4-6 (30)	1-00 1-06
		Extruded	GSZ 2	14-3 to 15-5	Atmosphere Partial vacuum	±4-4 (30) ±4-5 (30)	1-00 1-02
		Extruded	GSZ 3	13-6 to 14-6	Atmosphere Partial vacuum	±4-5 (30) ±4-7 ₅ (30)	1-00 1-06
		Annealed	BIF 1†	19-8	Atmosphere Partial vacuum	±7-2 ₅ ±9-1 ₅	1-00 1-26
			BIF 2	19-8 (probably)	Atmosphere Partial vacuum Dry purified air Damp purified air	±7-5 ₅ ±9-3 ±7-9 ₅ ±7-4 ₅	1-00 1-23 1-05 0-99
		Annealed	BIX 2	22-5	Atmosphere Partial vacuum	±8-1 ±8-1	1-00 1-00
Cupro-nickel †	78-92% Cu. 20-61% Ni.	Extruded	GPK	1-2	Atmosphere Partial vacuum	±0-17 (30) ±0-38 (30)	1-00 2-24
Lead	99-99% Pb.						

* Where the *S/N* curve had *not* become definitely asymptotic to a stress value, an *endurance limit* is quoted; in such cases, the figure given in brackets refers to the corresponding reversals basis, in millions of cycles.

† Estimated.

‡ From previous paper.

§ N.P.L. stock.

|| Supplied by Messrs. Imperial Chemical Industries, Ltd.

ACKNOWLEDGMENTS.

The work described above has been carried out as part of a fundamental research into elasticity and fatigue, financed by the Advisory Council of the Department of Scientific and Industrial Research and supervised by the Executive Committee of the National Physical Laboratory. The authors desire to record their thanks to these bodies for the research facilities afforded. Also to Dr. W. H. J. Vernon, of the D.S.I.R. Chemical Research Laboratory, and to Dr. H. W. Brownsdon, of Messrs. I.C.I. Metals, Ltd., for their helpful suggestions, and to Messrs. Imperial Chemical Industries, Ltd., for the supply of materials; to Mr. P. L. Thorpe, of the Engineering Department of the National Physical Laboratory, for very considerable assistance in the experimental work; and also to Dr. C. H. Desch, Superintendent of the Metallurgical Department, National Physical Laboratory, who kindly agreed to undertake the metallurgical examination of the fractured samples of lead.

PAPER No. 688. This paper is not to be reprinted, wholly or in part, until presented (and then only with due acknowledgment) at a meeting to be held on March 6-7, 1935, in the Hall of the Institution of Mechanical Engineers, Storey's Gate, Westminster, London, S.W.1. The Institute as a body is not responsible for the statements or opinions expressed in this paper, on which written discussion may be sent to the Secretary not later than April 1, 1935.

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

CORROSION-FATIGUE PROPERTIES OF DURALUMIN WITH AND WITHOUT PROTECTIVE COATINGS.* §

By I. J. GERARD,† M.Sc., and H. SUTTON,‡ M.Sc., MEMBER.

SYNOPSIS.

Rotating cantilever endurance tests on Duralumin 3LI (copper 4·1-4·4, manganese 0·64, magnesium 0·62-0·67, iron 0·84-0·81, silicon 0·22 per cent.) have been made in air and in a salt-spray after protecting the surface in various ways. In air the untreated material gave a fatigue limit of stress of $\pm 9\cdot1$ tons/in.² at 10^7 cycles and the anodized material $\pm 11\cdot1$ tons/in.². In a salt-spray lanolin-coating and cadmium-plating afforded little protection, but zinc plating gave a substantial improvement in the corrosion-fatigue range. Spraying with aluminium was not so good as zinc-plating at long endurance. Coatings of organic resins and enamels afforded a very high degree of protection, especially when the metal had previously been anodized; the best results were obtained with a coating of synthetic resin varnish and stoving for 2 hrs. at 150°C ., metal so treated giving a fatigue limit stress of $\pm 12\cdot2$ tons/in.² at 10^7 cycles.

INTRODUCTION.

THE work described in this paper forms part of a programme of research on corrosion-fatigue now being carried out as a joint investigation at the National Physical Laboratory, and at the Royal Aircraft Establishment, under the general supervision of the Aeronautical Research Committee. The present paper deals with corrosion-fatigue tests of specimens of Duralumin bar both unprotected, and protected by surface treatments and coatings of various kinds. It was considered desirable at this preliminary stage of the investigation to test a fairly comprehensive range of protective coatings, but practical consideration necessitated the use of only a moderate number of test-specimens for each stress-endurance curve.

* Manuscript received August 15, 1934.

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

§ Air Ministry Official Report: Crown Copyright Reserved.

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

PREVIOUS WORK.

D. J. McAdam¹ found that for heat-treated Duralumin the results of ordinary rotating cantilever type fatigue tests in air were unusually erratic, considerable scatter of the points being observed in the stress-endurance (S/N) graphs. The erratic results were not considered by McAdam to be due to variation in surface finish, nor to atmospheric corrosion. The specimens were covered with a film of mineral oil during the normal endurance tests in air. Anodic oxidation caused no diminution in scatter, and did not appear to affect the fatigue tests in air.

McAdam's corrosion-fatigue tests gave consistent results, much below the normal. Anodic oxidation (Bengough process) did not appear to give appreciable protection against corrosion-fatigue. Anodic oxidation followed by lanolin treatment raised the fresh-water corrosion-fatigue limit well above that of uncoated Duralumin, except in the case of a single specimen, on which McAdam makes the following comment: "Lack of improvement in one specimen probably due to an accidental scratch."

K. Matthaes² gives the results of rotating cantilever fatigue tests in air and of corrosion-fatigue tests on Duralumin bar. The alloy used was that known as Duralumin 681ZB, which usually differs slightly in composition from material supplied to British Standard Specifications in containing rather more magnesium and considerably less iron. The alloy used in Matthaes's experiments contained 0.72 per cent. of magnesium, and that used in the R.A.E. experiments 0.65 per cent. Matthaes's material contained only 0.29 per cent. of iron, whilst that used at the R.A.E. contained 0.85 per cent. It is not known at present to what extent these differences would affect the fatigue and corrosion-fatigue properties. Matthaes found much scatter in the results of ordinary fatigue tests of the material in the "as received" condition, the fatigue range at 10 million cycles being about ± 9 tons/in.² (14.2 kg./mm.²). In corrosion-fatigue tests in which ordinary tap-water was the corroding agent, the corresponding range was very much lower, about ± 5.2 tons/in.² (8.2 kg./mm.²). Samples which had been treated by the Bengough anodic oxidation process and coated with lanolin gave scatter similar to that of the unprotected specimens when tested in air. Similar specimens tested under corrosion-fatigue conditions (tap-water) showed much improvement compared with unprotected material, the stress range being about ± 7.0 tons/in.² at 10 million cycles. Matthaes remarks that in corrosion-fatigue tests of unprotected material the curve falls progressively with increasing number of stress

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cycles, but that in corrosion-fatigue tests on anodized-lanolin material the curve falls at first in the normal manner, but changes direction later and proceeds onwards parallel to the horizontal axis.

Tests by Gough and Sopwith^{3, 4} on Duralumin bar from the same consignment as that used in the R.A.E. experiments gave about the same fatigue limit as that given by the tests described in this paper for rotating beam tests in air. A lanolin coating gave no improvement. Tests *in vacuo* indicated some improvement in fatigue strength. Further work by the same authors⁴ showed that the rotating beam corrosion-fatigue limit of the same material was about ± 4.5 tons/in.² at 10 million cycles, and about ± 3.0 tons/in.² at 100 million cycles. The endurance limits under direct stresses as given by Haigh tests also showed substantial reductions when the tests were of the corrosion-fatigue type. The salt water and general conditions of the tests were the same as those employed in the authors' tests.

MATERIAL.

The material used in the investigation was $\frac{3}{4}$ -in. diameter Duralumin bar to British Standard Specification 3L1. By special arrangement with the manufacturers, Messrs. James Booth and Co., Ltd., the entire consignment was from the same cast. The material was delivered in straight lengths, in the finally heat-treated and aged condition, and all tests were made on material in that condition. The results of the acceptance tests made by the manufacturer and check tensile tests made by the authors are given in Table I.

TABLE I.

	Acceptance Test.	Check Tests at R.A.E.		British Standard Specification 3L1 Requirements.
Limit of proportionality, lb./in. ²	...	13.4	16.8	...
0.1% Proof stress, tons/in. ²	15	17.1	18.7	<15
0.5% " " "	...	17.9	19.5	...
Ultimate stress, tons/in. ²	25.72	24.3	26.6	<25
Elongation, per cent.	18.5	9.7 *	19.7	<15
Reduction of area, per cent.	33.6	...	...	<20
Young's modulus $E \times 10^{-6}$, lb./in. ²	...	11.0 (bar L)	10.8 (bar S)	...

* Slight defect at fracture.

The chemical composition of two of the bars was determined by analysis, the results obtained being as shown in Table II.

TABLE II.

	Bar L.	Bar S.	British Standard Specification 3L1 Requirement.
Copper, per cent.	4.10	4.40	3.5 to 4.5
Manganese, per cent.	0.64	0.64	0.40 to 0.70
Magnesium, per cent.	0.62	0.67	0.40 to 0.70
Iron, per cent.	0.84	0.81	≥ 0.75
Silicon, per cent.	0.22	0.22	...
Aluminium	remainder	remainder	...

Several bars, including bars L and S, were subjected to nicked fracture test, and the fracture surfaces were considered to be satisfactorily free from defects.

DESCRIPTION OF TEST APPARATUS AND SPECIMENS.

Type of Fatigue Test.

The type of fatigue test employed in all cases was that in which the test specimen is mounted horizontally as a rotating cantilever with a single externally applied load.

Particulars of Fatigue Specimens.

A dimensioned drawing of the test-specimen used for both the ordinary fatigue and the corrosion-fatigue tests is given in Fig. 1. The test-specimens, after being turned, were polished, first using part-

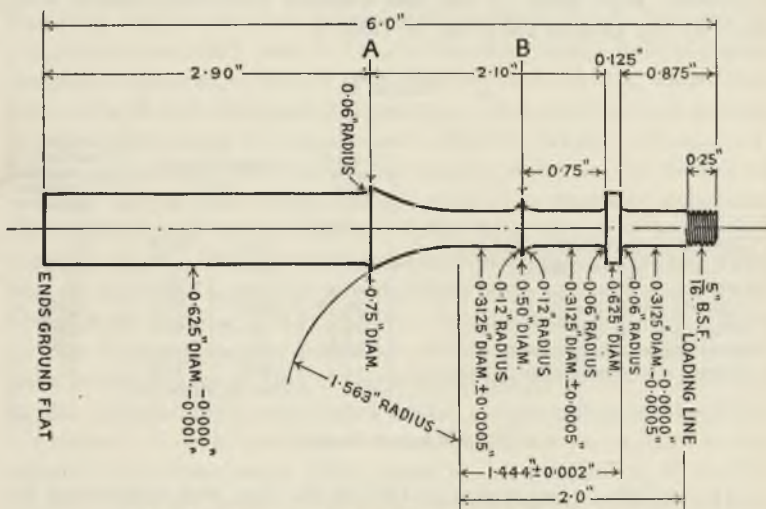


FIG. 1.—Corrosion-Fatigue Test-Piece (Wöhler Type.)

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worn "FF" emery cloth, and finishing with "1F" (Hubert's French) emery paper. The sharp-edged annular projections *A* and *B* assisted in confining the action of the salt-spray, in the corrosion-fatigue tests, to the acting portion of the test-piece.

All specimens were coated with lanolin grease directly after being machined, the coating being cleaned off with acetone just prior to the commencement of the fatigue-test, or the application of one of the protective treatments under investigation.

General Arrangement of Fatigue-Test Apparatus.

The general arrangement of the test apparatus is shown in Fig. 2. The specimen *C* was mounted horizontally in a six-radial-screw chuck rotating at 2000 r.p.m. It was loaded near its outer extremity by a single dead-weight load *D*. The load was applied through a very light ball bearing and housing, with shock absorbing suspension of the dead-weight to minimize the effect of any accidental eccentricity of the loaded end of the specimen relative to the axis of rotation.

For the corrosion-fatigue tests the acting portion of the test-piece was enclosed in an ebonite chamber *E* fitted with a spray injector *F*, through which salt solution was sprayed on the most highly stressed portion of the test-specimen. The spray chamber was provided with an inspection window at the top and a friction-held slide *G*, which permitted fracture of the test-specimen without damage to the chamber. The projecting sharp-edged rings *A* and *B* on the specimen served to throw off any accumulation of salt solution and to prevent it travelling along the test specimen to the bearings of the test apparatus. A drain pipe fitted at the bottom of each spray chamber was connected to a closed pipe line *H*, provided with an air exhausting fan in order to prevent escape of the salt-spray to other specimens under fatigue test, or to other parts of the test apparatus.

The general construction of the spray injector is shown in the diagram, the solution passing through a central glass tube of 0.02-in. bore, and the air passing through a surrounding annular orifice which was constructed to act as a Venturi tube.

The rate of flow of the solution was controlled by a needle valve, and the relative positions of the solution and air orifices were adjustable so as to ensure entry of the solution at the point of minimum pressure in the Venturi tube. The spray issued from the injector through a circular orifice of 0.05 in. diameter.

The salt solution used in the present research was a 3 per cent. solution of common salt in distilled water. In order to maintain a continuous supply of new salt solution to each spray a large constant

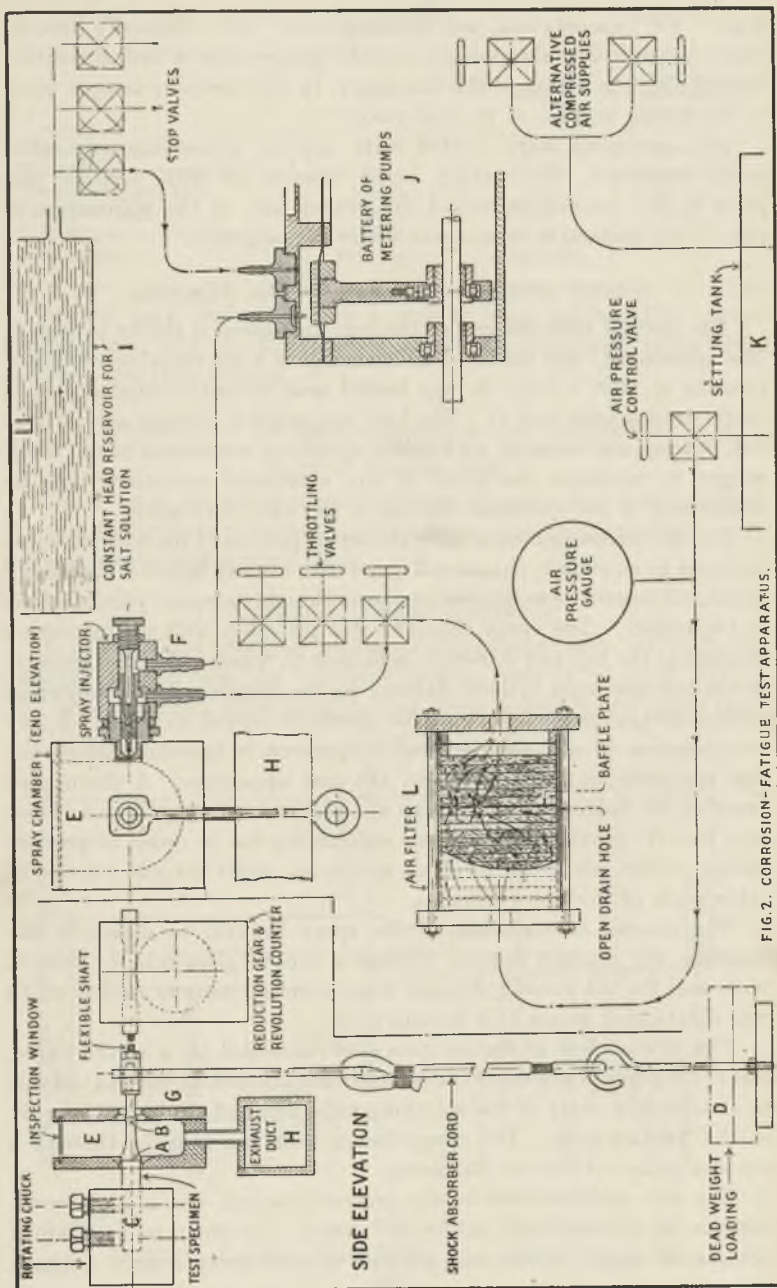


FIG. 2. CORROSION-FATIGUE TEST APPARATUS.

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head reservoir *I* was used. The solution was delivered with a small positive head through separate pipe-lines to each of the corrosion-fatigue machines. Each pipe-line included one of a battery of diaphragm metering pumps *J* which served the dual purpose of controlling the supply of solution (in this case 1 c.c. per minute for each spray), and of clearing away by built-up pressure any obstruction in the sprays due to sediment in the solution. This obviated the use of filters which had been found to silt up very quickly. The whole of the piping, pumps, sprays, &c., were so constructed that there was no contact of the solution with metal until the specimen was reached.

The compressed air for the sprays was maintained at a pressure of from 7 to 9 lb./in.², and was supplied during the day from the compressed air mains, and at night from an independent small Reavell rotary air compressor. It was found necessary to provide for the extraction of oil and water from both these air supplies, and in both cases the air was first passed through a settling tank *K* and then through a cylindrical filter *L* (of 4 in. diameter and 5 $\frac{3}{4}$ in. length), fitted with baffle plates and packed with discs of cotton wool.

The whole of the apparatus was installed in a small room, the temperature of which was controlled automatically between 20° and 28° C. The temperature measured by a thermometer in the spray chambers was lower than that of the room, and varied between 12° and 26° C.

SCOPE OF TESTS AND DESCRIPTION OF PROTECTIVE TREATMENTS APPLIED TO SPECIMENS

Fatigue Tests in Air.

The first series of fatigue tests in air was made on unprotected samples, and the next on anodically treated samples (not greased). The anodic treatment applied to these and other samples used in the present research was the Bengough-Stuart treatment. In this process the samples are made the anode in a 3 per cent. solution of chromic acid used at 40° C. The voltage is increased from 0 to 40 in 15 minutes, held at 40 v. for 35 minutes, increased to 50 v. in 5 minutes, and held at 50 v. for 5 minutes, after which the samples are removed from the bath, washed, and dried.

Corrosion-Fatigue Tests in Salt Spray.

In the case of specimens treated with lanolin the latter was applied in the form of a 50 per cent. solution of lanolin in a mixture of equal parts of white spirit and solvent naphtha.*

* Temporary Rust Preventive, *Air Ministry Specification D.T.D. 121 B.*

Cadmium-plated specimens N1-N6 and M9-M14 were prepared for plating by dipping in 10 per cent. caustic soda, then in nitric-sulphuric acid, and finally in 10 per cent. sodium zincate solution. They were plated in a bath containing 58 gm. cadmium sulphate and 65 gm. sodium cyanide per litre for 40 minutes at 8 amp./ft.².

Cadmium-plated specimens D13-D18 were prepared by being dipped in caustic soda solution, then in concentrated nitric acid, afterwards being lightly sand-blasted and plated for 40 minutes at 8 amp./ft.² in a bath containing 62 gm. cadmium potassium cyanide and 15 c.c. of ammonia (0.880) per litre.

Zinc-plated specimens D7-D12 were prepared by being lightly sand-blasted and plated for 14 minutes at 30 amp./ft.² in a bath containing 144 gm. zinc sulphate, 34 gm. sodium acetate, and 1 gm. gum arabic per litre; and specimens M1-M6 were prepared by dipping successively in 10 per cent. caustic soda, nitric-sulphuric acid, and 10 per cent. sodium zincate solution, followed by plating 1 hr. 50 minutes at 4 amp./ft.² in a bath containing 59 gm. zinc cyanide, 37 gm. sodium cyanide, and 30 c.c. ammonia (0.880) per litre. The electro-deposits applied were intended to be 0.0005 in. thick, and probably did not differ very much from that amount.

The coating of aluminium on specimens P1, 3, 9, 14, 16, and 20 was applied by the Schoop metal-spraying pistol, and was about 0.003 in. thick.

Specimens J1-J13 were given two coats of Air Ministry pigmented oil varnish,* and specimens N13-N18 were anodically treated, and then given two coats of the same varnish.

Specimens F14-F23, J16, and J17 were given two coats of Air Ministry grey cellulose enamel †; specimens K8-K14 were anodically treated and then given two coats of the same enamel.

Specimens N7-N12 were given two coats of transparent synthetic resin varnish and specimens K1-K7 were anodically treated and then given two coats of transparent synthetic resin varnish and all were stoved at 100° C. for 2 hrs.

Control Tensile Tests.

Tensile tests were made on the various bars used in the work, and the results are given in Table III. The results of tensile tests made on test-pieces machined from the chuck portions of broken Wöhler test-pieces indicated reasonable uniformity of material.

* *Air Ministry Specification D.T.D. 62.*

† *Air Ministry Specification D.T.D. 63.*

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TABLE III.—*Mechanical Properties of Duralumin Bars.*

Bar Ref. Mark.	Maximum Tensile Strength, tons/in. ² .	Limit of Proportionality, tons/in. ² .	0.1% Proof Stress, tons/in. ² .	0.5% Proof Stress, tons/in. ² .	Young's Modulus, lb./in. ² × 10 ⁻⁸ .	Elongation on 4√Area, Per Cent.
D	26.0	9.9	14.0	16.3	10.4	26.3
F	25.8	8.9	13.9	15.8	10.2	29.1
J	25.4	10.3	13.8	15.8	10.2	26.9
K	27.5	14.1	18.1	18.8	10.2	14.0
M	27.4	15.0	18.7	19.4	10.0	18.5
N	28.3	17.5	19.1	20.5	10.3	17.7
P	27.7	16.4	18.4	19.2	10.8	16.0
R	27.2	15.6	18.0	18.8	10.3	19.0

Visual Observations on Specimens.

Unprotected Duralumin specimens examined after corrosion-fatigue test showed a considerable amount of pitting, irregularly distributed over the surface of the test-pieces. Fig. 11 (Plate I) shows specimen M15, with a fatigue crack. A few small areas still show the original polishing marks, but in general the surface has suffered chemical attack. Anodized and lanolined Duralumin specimens subjected to corrosion-fatigue test showed, after washing off the salt deposit, no noticeable corrosion to the unaided eye. With a hand lens, slight pitting of the surface could be seen in some cases. Fig. 12 (Plate II) illustrates the appearance of specimen R3 (anodically treated and lanolined) after corrosion-fatigue test; this specimen remained unbroken after 54.6 million cycles at ± 4.78 tons/in.². Fatigue-cracks can, however, be seen in the photograph. Cadmium-plated specimens all showed a pronounced tendency for the cadmium deposit to crack and flake off during corrosion-fatigue tests. As would be expected, no consistent benefit was derived from the coatings.

In the case of the zinc-plated samples, the deposits appeared to adhere well during the corrosion-fatigue tests.

The aluminium-sprayed samples examined after corrosion-fatigue tests showed considerable pitting, which appeared to extend to the Duralumin base.

In the case of the varnished and enamelled specimens subjected to corrosion-fatigue tests, no tendency was observed for any of the enamel films to crack or become detached from the metal base, whether the Duralumin had been anodically treated or not. When the test-pieces had been washed free from salt deposit in hot water after corrosion-fatigue test, no indication of corrosion of the underlying metal was discernible with the unaided eye.

Examination of Fractures.

The fractures in the corrosion-fatigue tests were of the serrated type usually associated with failure under corrosion-fatigue. From the

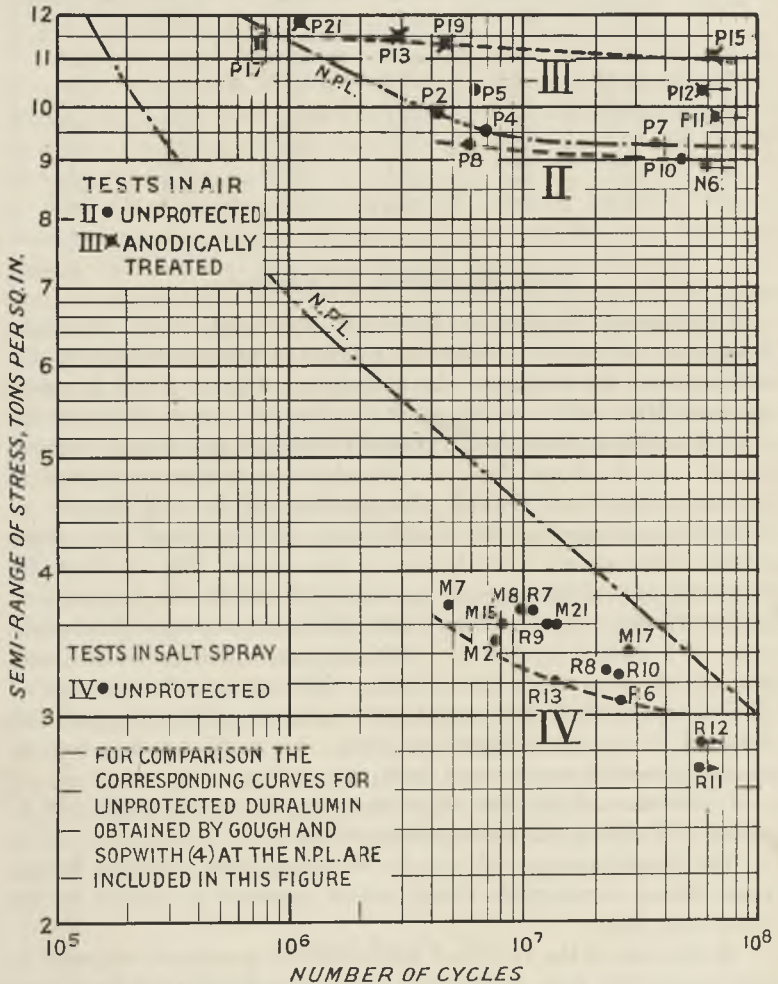


Fig. 3.—Ordinary Fatigue Tests of Unprotected and Anodically Treated Duralumin and Corrosion-Fatigue Tests of Unprotected Duralumin.

colour of the different parts of the fractures it could be seen that the corrosion-fatigue cracks had penetrated very deeply before final rupture occurred.



FIG. 11.—Specimen M15 (Unprotected Duralumin Tested in Salt-Spray) Showing Fatigue Crack after 8.09 million cycles of ± 3.60 tons/in.² Stress. $\times 6$.

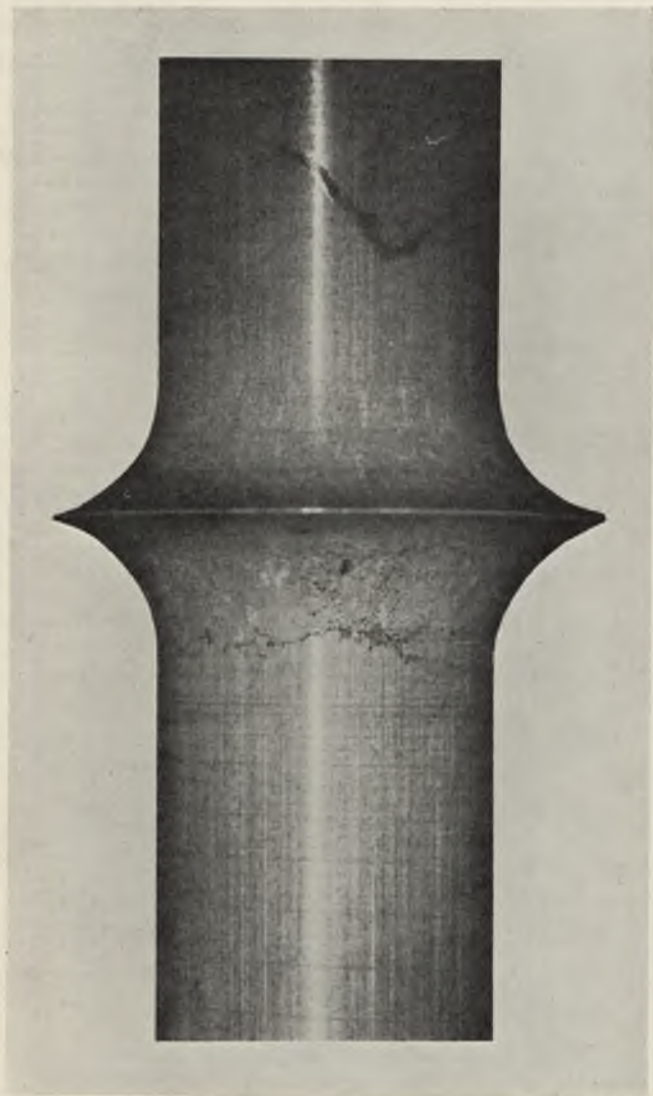


FIG. 12.—Specimen R3 (Anodically Treated and Lanolined Duralumin Tested in Salt-Spray) Showing Cracks after 54.6 million cycles of ± 4.78 tons/in.² Stress. $\times 6$.

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Microscopical examination of sections at the fracture of samples R10, unprotected, and D2, anodized and lanolined, showed that the cracks followed a trans-crystalline path.

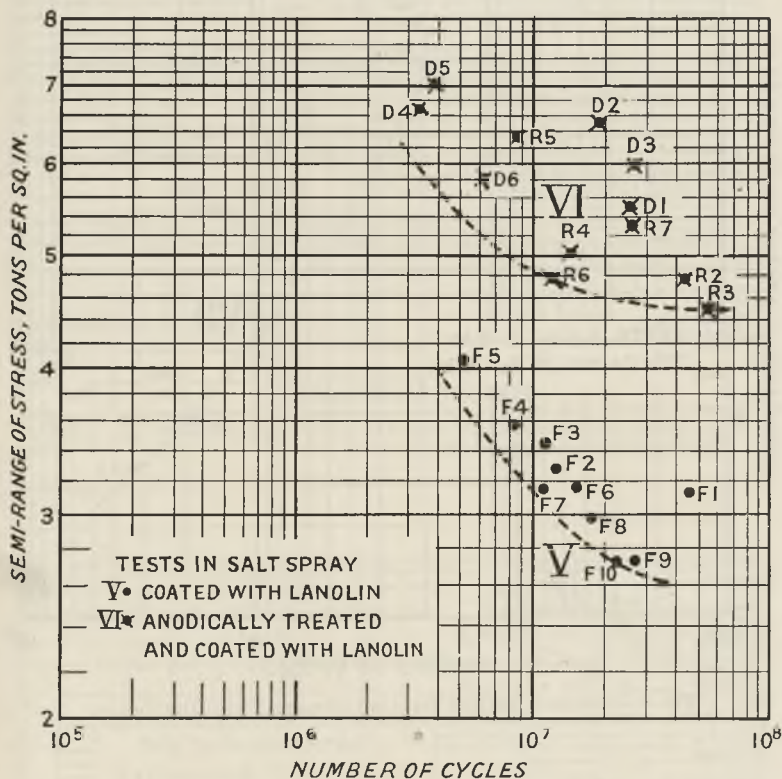


FIG. 4.—Corrosion-Fatigue Tests of Lanolin-Coated Duralumin (both with and without prior anodic treatment).

Discussion of Results.

The stress-endurance (S/N) curves are plotted in Figs. 3-10. It will be seen that the results are subject to considerable variation in many cases, as shown by the "scatter" of the individual results. Suggested curves have been drawn to include the lowest values obtained, since the mean value is of little practical interest. Probable values of safe limiting stress have been read from these curves for endurance of 10 million and 50 million cycles, and these values have been collected

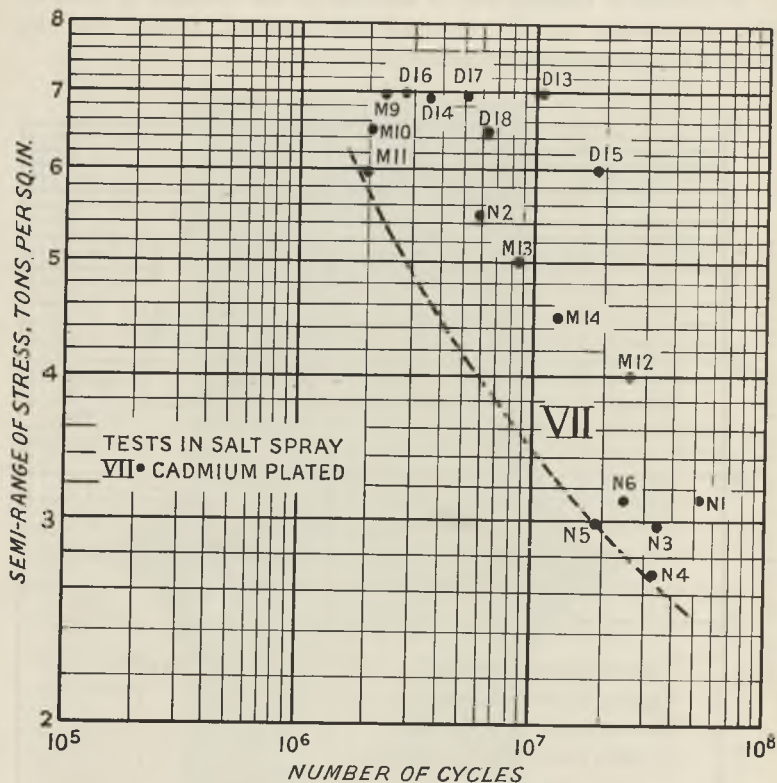


Fig. 5.—Corrosion-Fatigue Tests of Cadmium-Plated Duralumin.

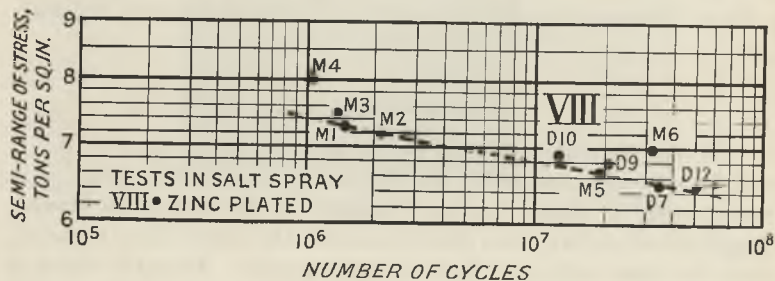


Fig. 6.—Corrosion-Fatigue Tests of Zinc-Plated Duralumin.

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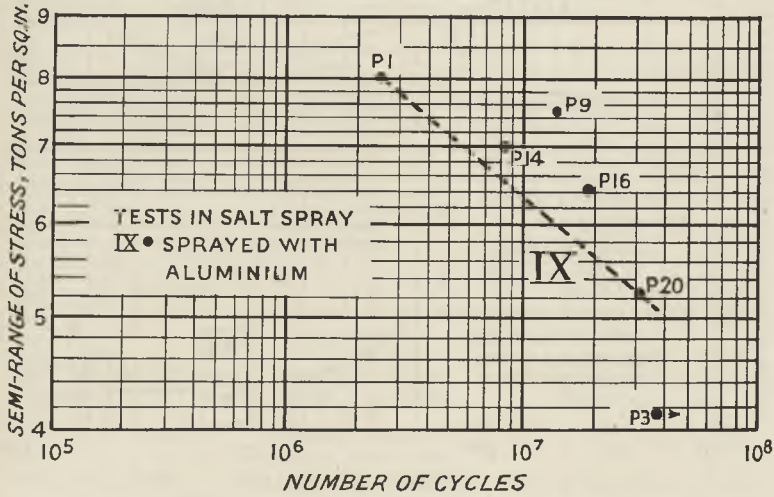


FIG. 7.—Corrosion-Fatigue Tests of Duralumin Sprayed with Aluminium.

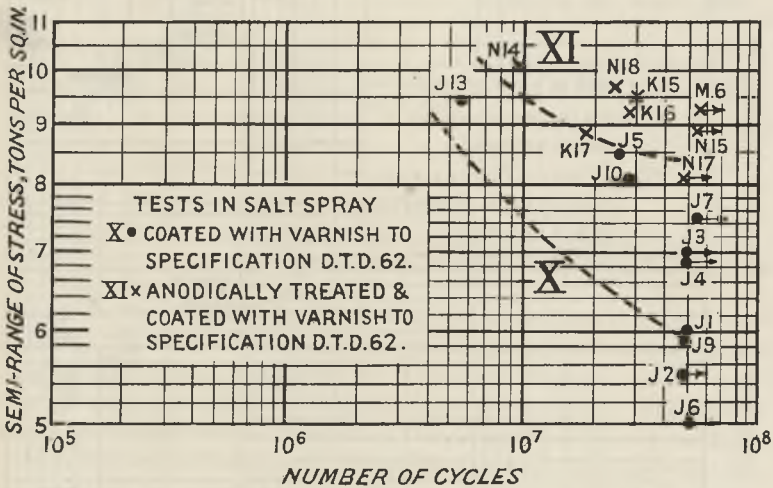


FIG. 8.—Corrosion-Fatigue Tests of Duralumin Coated with Varnish to Air Ministry Specification D.T.D. 62 (both with and without prior anodic treatment).

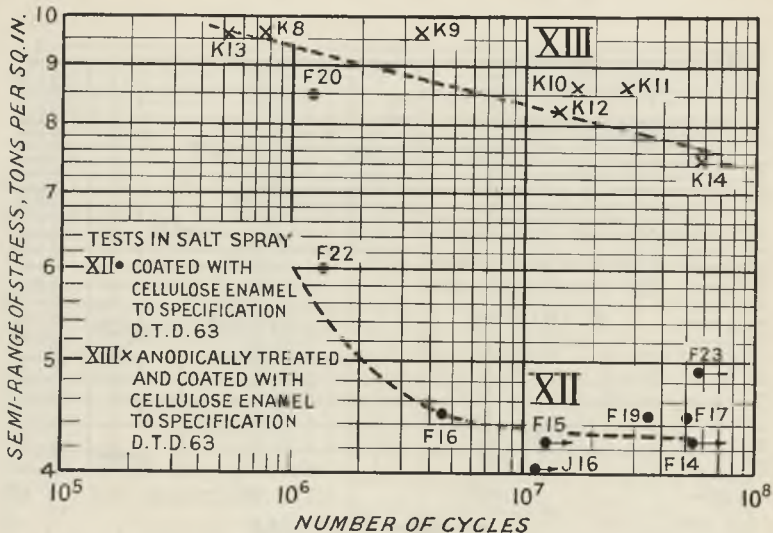


Fig. 9.—Corrosion-Fatigue Tests of Duralumin Coated with Cellulose Enamel to Air Ministry Specification D.T.D. 63 (both with and without prior anodic treatment).

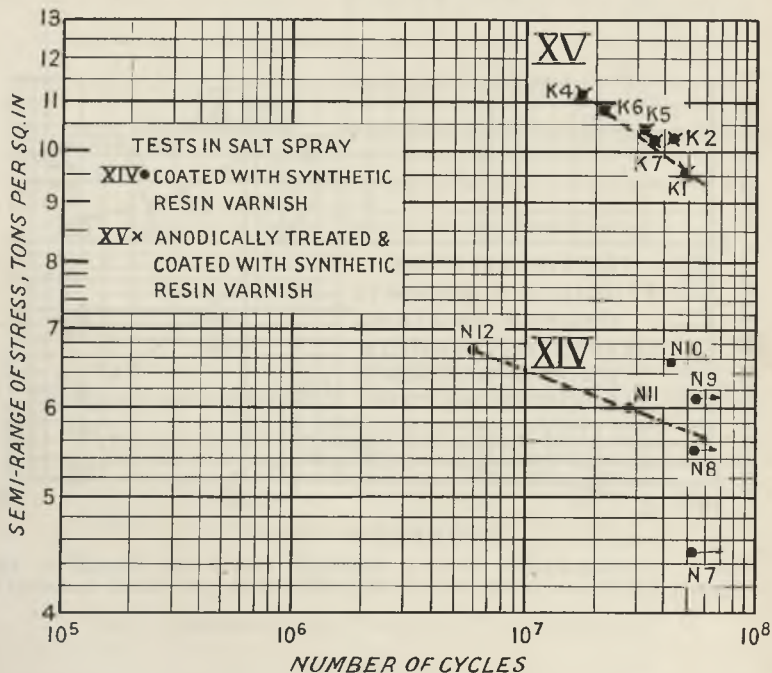


Fig. 10.—Corrosion-Fatigue Tests of Duralumin Coated with Synthetic Resin Varnish (both with and without prior anodic treatment).

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in Table IV, together with the same values expressed as ratios of the static tensile strength of the unprotected material in air.

TABLE IV.—*Summary of Results. Fatigue Tests of Duralumin, Unprotected and Protected, in Air and in Salt Spray.*

Graph No.	Test in Air or Salt-Spray.	Treatment.		Endurance Limits Reversed Bending Stresses, tons/in. ² .		Endurance Ratio.	
		Protective Surface Treatment.	Supplementary Organic Protective.	10 Million Cycles.	50 Million Cycles.	10 Million Cycles.	50 Million Cycles.
III	Air	anodic	...	± 11.2	± 11.0	0.42	0.41
XV	S.S.	anodic	synthetic resin varnish (stoved)	± 12.2	± 9.5	0.45	0.35
II	Air	...	...	± 9.1	± 9.0	0.34	0.33
XI	S.S.	anodic	pigmented oil varnish to Spec. D.T.D. 62	± 9.5	± 8.3	0.35	0.31
XIII	S.S.	anodic	cellulose enamel to Spec. D.T.D. 63	± 8.3	± 7.7	0.31	0.29
VIII	S.S.	zinc-plated	...	± 6.8	± 6.4	0.25	0.24
X	S.S.	...	pigmented oil varnish to Spec. D.T.D. 62	± 7.5	± 5.9	0.28	0.22
XIV	S.S.	...	synthetic resin varnish (stoved)	± 6.4	± 5.7	0.24	0.21
IX	S.S.	sprayed with aluminium	...	± 6.3	± 4.8	0.23	0.18
VI	S.S.	anodic	lanolin	± 4.8	± 4.5	0.18	0.17
XII	S.S.	...	cellulose enamel to Spec. D.T.D. 63	± 4.4	± 4.3	0.16	0.16
IV	S.S.	...	...	± 3.3	± 3.0	0.12	0.11
V	S.S.	...	lanolin	± 3.1	± 2.6	0.12	0.10
VII	S.S.	cadmium-plated	...	± 3.5	± 2.5	0.13	0.09

N.B.—Since the above endurance limits are based on a comparatively small number of tests, the numerical values should be regarded as approximate only.

Tests in Air.—The fatigue limit range of stress for untreated Duralumin, ± 9.1 tons/in.² at 10 million cycles, agrees fairly well with the value ± 9.25 tons/in.² obtained by Gough and Sopwith on material from the same consignment using the rotating beam test. The higher fatigue limit stress range for anodized Duralumin (± 11.1 at 10 million cycles) observed in the present investigation has not been recorded by any previous investigators. The Duralumin bars used by McAdam and Matthaes appear to have given rather variable results in the fatigue tests in air, and the variation seems to have been sufficiently great to prevent any definite indication of the influence of anodic oxidation.

Gerard and Sutton : Corrosion-Fatigue Properties

Tests in Salt-Spray.—The tests were made at the rate of 2000 cycles of stress per minute. For an endurance of 10 million cycles, therefore, the corrosion-fatigue specimens would be subject to continuous corrosion for a period of $3\frac{1}{2}$ days, and for 50 million cycles, for a period of 17 days.

Effect of Lanolin.—The corrosion-fatigue tests of specimens coated with lanolin grease showed that no benefit was gained by the presence of lanolin alone. (Gough and Sopwith found that a coating of lanolin grease did not affect the fatigue limit of mild steel, brass, copper, and cupro-nickel when tested in air.) In the present results, the effect of a coating of lanolin grease appears disadvantageous at long endurances, the fatigue limit then being somewhat lower than that of untreated material. This may be due to increased severity of the attack on a few small anodic areas compared with that occurring when anodic areas are larger or more abundant.

Electroplating.—Electrodeposits of cadmium gave no apparent improvement in corrosion-fatigue properties of the treated Duralumin specimens. The deposits appeared to be insufficiently adherent for efficient protection. At an early stage of each test it could be seen that the electrodeposit was becoming separated from the alloy base, and in many cases the deposit on the heavily stressed portion of the test-piece flaked away completely. Although the two batches of test-pieces were prepared by different methods and plated in different baths, there was little difference in the behaviour of the deposits under corrosion-fatigue tests. The electrodeposits of zinc gave a substantial improvement in the corrosion-fatigue range of the Duralumin, and the two types of zinc deposit investigated gave practically identical improvement.

Metal-Spraying.—The sprayed coatings of aluminium gave a substantial improvement in corrosion-fatigue range, but the improvement was not so well maintained at long endurance as that given by the zinc electrodeposits.

Organic Protectives.—In the tests of samples coated with organic protectives it was found that considerable improvement in corrosion-fatigue properties was afforded by the enamel or varnish film alone; from this point of view the synthetic resin varnish (stoving) and pigmented oil varnish (D.T.D. 62) gave the best results. Cellulose enamel (D.T.D. 63) was not so effective.

Anodic Treatment Supplemented with Organic Protectives.—With each of the protectives mentioned above, anodic oxidation of the material prior to application of the enamel or varnish resulted in a very much greater degree of improvement in corrosion-fatigue properties than that obtained with the enamel or varnish applied to the untreated Duralumin

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surface. The best results were obtained with the synthetic resin stoving enamel on anodically-treated material, the corrosion-fatigue properties in this case being superior to the fatigue properties in air of the uncoated material. In the stoving operation the samples are heated to 100° C. for 2 hrs., but it appears unlikely that this thermal treatment would have any appreciable effect on the fatigue properties of the Duralumin itself, the tensile properties not being appreciably affected. Good results were also obtained with pigmented oil varnish D.T.D. 62, on anodically treated Duralumin, the corrosion-fatigue limit at 10 million cycles being apparently higher than the fatigue limit in air of the untreated Duralumin for the same endurance. The results of tests of anodically treated samples coated with cellulose enamel D.T.D. 63, were not so good as those obtained with the synthetic resin varnish, or with the pigmented oil varnish D.T.D. 62.

GENERAL CONCLUSIONS.

The experiments have shown that the fatigue and corrosion-fatigue properties of Duralumin are improved appreciably by surface treatments of the types capable of affording general protection against corrosion.

Gough and Sopwith have shown that some metals tested in air under ordinary laboratory conditions may suffer some form of corrosion-fatigue, since specimens tested *in vacuo* give higher values of fatigue limiting stress. This may explain why the addition of a suitable protective coating on Duralumin in the present series of tests increases the fatigue limiting stress above that which is obtained from tests of the unprotected material in air.

The benefit of anodic oxidation treatment before application of enamels and varnishes is shown in marked degree.

REFERENCES.

- ¹ D. J. McAdam, "Corrosion-Fatigue of Non-Ferrous Metals," *Proc. Amer. Soc. Test. Mat.*, 1927, **27**, (II), 102-127.
- ² K. Matthaes, "Statische und dynamische Festigkeitseigenschaften einiger Leichtmetalle," *Jahrb. deut. Versuchsanst. Luftfahrt*, 1931, 439-484.
- ³ Gough and Sopwith, "Atmospheric Action as a Factor in Fatigue of Metals," *J. Inst. Metals*, 1932, **49**, 93-112.
- ⁴ Gough and Sopwith, "Some Comparative Corrosion-Fatigue Tests Employing Two Types of Stressing Action," *J. Iron Steel Inst.*, 1933, **127**, 301-332.

MEETINGS OF OTHER SOCIETIES

MONDAY, NOVEMBER 19.

INSTITUTION OF ELECTRICAL ENGINEERS, WESTERN CENTRE.—Professor F. Bacon: "The Fatigue of Metals, with Special Reference to Diesel Engines and Steam Turbines." (South Wales Institute of Engineers, Cardiff.)

ROYAL SOCIETY OF ARTS.—Dr. H. Dingle: "Modern Spectroscopy." First of Three Cantor Lectures. (The Society, John St., Adelphi, London, W.C.2, at 8 p.m.)

WEDNESDAY, NOVEMBER 21.

ELECTRODEPOSITORS' TECHNICAL SOCIETY.—D. J. Macnaughtan: "Some Experiences During My Visit to America." (Northampton Polytechnic Institute, St. John St., Clerkenwell, London, E.C.1, at 8.15 p.m.)

MONDAY, NOVEMBER 26.

ROYAL SOCIETY OF ARTS.—Dr. H. Dingle: "Modern Spectroscopy." Second of Three Cantor Lectures. (The Society, John St., Adelphi, London, W.C.2, at 8 p.m.)

WEDNESDAY, NOVEMBER 28.

MANCHESTER ASSOCIATION OF ENGINEERS.—Dr. J. H. Patterson: "The Fundamentals of Electric Welding." (College of Technology, Sackville St., Manchester, at 7.15 p.m.)

FRIDAY, NOVEMBER 30.

COMPANY OF ARMOURERS AND BRASERS IN THE CITY OF LONDON.—Professor F. C. Thompson: "The Deformation of Metals (with Special Reference to Wire Drawing)." First of Three Lectures. (Royal School of Mines, Prince Consort Rd., South Kensington, London, S.W.7, at 8 p.m.)

MONDAY, DECEMBER 3.

ROYAL SOCIETY OF ARTS.—Dr. H. Dingle: "Modern Spectroscopy." Third of Three Cantor Lectures. (The Society, John St., Adelphi, London, W.C.2, at 8 p.m.)

FRIDAY, DECEMBER 7.

COMPANY OF ARMOURERS AND BRASERS IN THE CITY OF LONDON.—Professor F. C. Thompson: "The Deformation of Metals (with Special Reference to Wire Drawing)." Second of Three Lectures. (Royal School of Mines, Prince Consort Rd., South Kensington, London, S.W.7, at 8 p.m.)

MANCHESTER ASSOCIATION OF ENGINEERS.—W. E. Ballard: "Protective Metallic Coatings by the Wire Spraying Process." (Engineers' Club, Albert Sq., Manchester, at 7.15 p.m.)

TUESDAY, DECEMBER 11.

INSTITUTE OF BRITISH FOUNDRYMEN, LANCASHIRE BRANCH, BURNLEY SECTION.—A. Jackson: "Points for Practical Foundrymen—Contraction, Shrinkage, Chill, and Camber." (Municipal College, Ormerod Rd., Burnley, at 7.15 p.m.)

THURSDAY, DECEMBER 13.

ROYAL AERONAUTICAL SOCIETY.—Dr. W. H. Hatfield: "Recent Research in Metallurgy." (Royal Society of Arts, John St., Adelphi, London, W.C.2, at 6.30 p.m.)

FRIDAY, DECEMBER 14.

COMPANY OF ARMOURERS AND BRASERS IN THE CITY OF LONDON.—Professor F. C. Thompson: "The Deformation of Metals (with Special Reference to Wire Drawing)." Third of Three Lectures. (Royal School of Mines, Prince Consort Rd., South Kensington, London, S.W.7, at 8 p.m.)

THURSDAY, DECEMBER 20.

NORTH-EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS, TEES-SIDE BRANCH.—Dr. W. P. Inglis: "Metallurgical Aspects of Certain Recent Industrial Developments." (Cleveland Scientific and Technical Institution, Corporation Rd., Middlesbrough, at 7.30 p.m.)

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METALLURGICAL ABSTRACTS

(GENERAL AND NON-FERROUS)

Volume 1

NOVEMBER 1934

Part 11

I.—PROPERTIES OF METALS

(Continued from pp. 441-442.)

***The Properties of Aluminium and Two of Its Alloys at Elevated Temperatures.** F. M. Howell and D. A. Paul (*Metals and Alloys*, 1934, 5, 176-179).—Tables and curves are given showing the variation in tensile strength, yield-point, and elongation after heating to temperatures up to 300°-400° F. (150°-205° C.) samples of (A) commercially pure aluminium; (B) an alloy of A with 1.25% manganese; (C) an alloy of B with 1% magnesium; the samples were tested in the hard (80% reduction), half-hard, and annealed states. Prolonged heating at 200°-300° F. (93°-150° C.) does not materially soften any of the materials, but at 300° F. (150° C.) the hardness of all but half-hard B decreases slightly. An increase of 20% in the yield-point is produced by long heating of strain-hardened A and B at 212° F. (100° C.) or at 300° F. (150° C.), probably due to the removal of internal strain. Above 300° F. (150° C.) the fully hardened materials lose strength more rapidly than the half-hard; the latter require a temperature of about 100° F. (38° C.) more than the former for complete softening.—A. R. P.

***Properties of Evaporated Films of Aluminium over Chromium.** Robley C. Williams (*Phys. Rev.*, 1934, [ii], 46, 146).—A note. Satisfactory mirrors can be prepared by evaporating a film of chromium on to glass, and then covering it with a film of aluminium. When first deposited the film is comparatively soft, but it is hardened instantly by washing in water or alcohol, and is then scarcely affected by rubbing with a blunt steel instrument. The reflectivity is as good as that of pure aluminium (Williams and Sabine, *Astrophys. J.*, 1933, 77, 316). The aluminium layer can be removed by a solution of potassium hydroxide or sodium chloride without removing the chromium, whilst a method for dissolving chromium placed on glass enables the double film to be removed, without injury to the glass surface.—W. H.-R.

***Studies on Explosive Antimony. I.—The Microscopy of Polished Surfaces.** C. C. Coffin and Stuart Johnston (*Proc. Roy. Soc.*, 1934, [A], 146, 564-570).—The appearances of polished surfaces of explosive antimony, as determined by microscopic examination before and after explosion, are described and illustrated.—J. S. G. T.

***The Nuclear Spins and Magnetic Moments of the Isotopes of Antimony.** S. Tolansky (*Proc. Roy. Soc.*, 1934, [A], 146, 182-198).—The nuclear spin of each of the isotopes, 121 and 123, of antimony is 5/2, but the nuclear magnetic moment of the former is 1.37 times that of the latter.—J. S. G. T.

***Transformation of Boron into Beryllium 8.** F. Kirchner (*Naturwiss.*, 1934, 22, 480).—A brief note. The nuclear transformation of boron bombarded with rapid protons leads, according to measurements of the range of the α -particles emitted, apparently to the formation of an excited beryllium nucleus.—J. W.

†**Calcium: Its Metallurgy and Technology.** C. L. Mantell and Charles Hardy (*Electrochem. Soc. Preprint*, 1934, Sept., 187-203).—The properties, characteristics, preparation, and applications of calcium in chemistry and metallurgy are presented. The metal has been found useful in the purification of

* Denotes a paper describing the results of original research.

† Denotes a first-class critical review.

lead and the preparation of its alloys; the deoxidation and degasification of copper and its alloys; as a metallurgical addition agent in connection with leaded bronzes and miscellaneous non-ferrous alloys; the purification of cast iron and steel; the betterment of commercial grades of nickel, aluminium, beryllium, magnesium, and other metals, as well as a reducing agent for some of the rare metal oxides.—S. G.

***The Production of Metals of the Cerium Group.** Félix Trombe (*Electrochem. Soc. Preprint*, 1934, Sept., 231-235).—A miniature cell for fused chloride electrolysis was developed, capable of handling very small quantities of rare-earth metal chlorides. With a purified carbon anode, a molybdenum rod cathode, and a fluoride-porcelain cup to catch the metal as formed, high-purity cerium, lanthanum, and neodymium metal were produced which were spectroscopically free from calcium and aluminium and contained but very small percentages of silicon and iron present as impurities. The physical properties of these pure metals were determined. The metals are all very malleable and relatively soft.—S. G.

Action of Reducing Gases on Copper Contaminated with Cuprous Oxide. M. Artignan (*Chim. et Ind.*, 1934, Special No., (April), 575-578; *C. Abs.*, 1934, 28, 5380).—Fissuring of copper boiler plates in service is shown to be due to reduction of cuprous oxide present in the copper. The mechanism of the reaction is essentially the same with all reducing gases (hydrogen, carbon monoxide, hydrocarbons): diffusion of the gas into the metal, reduction of the cuprous oxide, diffusion outward of the gaseous products of reduction (water vapour, carbon dioxide). As the rates of diffusion of the gases through the metal are inversely proportional to the squares of their densities, considerable pressure builds up in the cavities containing the cuprous oxide (particularly in the case of hydrogen and carbon monoxide) before the reduction products can escape, frequently causing rupture of the cavities. Determination of the loss in weight of a test-bar when heated to redness in hydrogen would seem to furnish a convenient test, and might be included advantageously in technical specifications. It is suggested that a maximum of 0.030% of cuprous oxide be stipulated.—S. G.

***The Effect of Oxygen on the Properties of Copper.** W. Broniewski and S. Jaślan (*Prace Zakładu Metallurgicznego Politechniki Warszawskiej*, 1933, 3, 93-101).—[In Polish, with French summary.] See *J. Inst. Metals*, 1933, 53, 226.—S. G.

A Bibliography of Indium, 1863-1933. Herbert A. Potratz and John B. Ekeley (*Univ. Colorado Studies*, 1934, 21, 151-187).—S. G.

***The Indium Isotope 113.** M. Wehrli (*Naturwiss.*, 1934, 22, 289).—A brief preliminary note. The band spectrum of indium shows the presence of the isotope of atomic weight 113 in the ratio 14 : 1.—J. W.

Lithium. Hans Osborg (*Electrochem. Soc. Preprint*, 1934, Sept., 361-374).—Lithium metal and lithium alloys are now being produced on a large commercial scale. The physical and chemical properties of the metal are briefly reviewed and compared with those of other members of the alkali metal group. Important technical applications include the treatment of molten copper and bronzes with lithium-calcium (50 : 50, 30 : 70) alloy. An exceptionally pure and high-conductivity copper is obtained. The lithium-calcium alloy added to molten cast iron, carbon steel, and stainless irons and steels greatly improves their physical properties. Lithium added to magnesium increases its corrosion-resistance and tensile strength. Less than 0.5% lithium added to aluminium-zinc alloys develops mechanical properties similar to mild steel.

—S. G.

***Preparation of Samples of Magnesium and of Calcium Purified by Sublimation in Vacuum and of Ingots of These Metals or of Their Alloys Obtained by Fusion under Argon.** J. Hérenguel (*Chim. et Ind.*, 1934, Special No., (April),

701–703; *C. Abs.*, 1934, **28**, 5380).—Magnesium can be obtained in a high state of purity by sublimation in vacuum of purified commercial magnesium. Fusion in an atmosphere of argon carried out on charges of the order of 20–30 kg. gives exceptionally sound ingots. Calcium is amenable to the same treatments.—S. G.

Laws of Vapour Pressure of Mercury. C. Codegone (*Ricerche ingegneria*, 1933, **1**, (6), 195–197; *Sci. Abs.*, 1934, [B], **37**, 209).—Between -40° and 700° C. the relation of mercury pressure (kg./m.²) and absolute temperature ($^{\circ}$ C.) is given by $\log_{10} p = 10.12723 - 3250/T - 0.30 \log_{10} T - 0.00018T$. C. discusses the derivation of this formula, and gives tables from -40° to 700° C. (every 10° to 450°) showing p in mm. of mercury as calculated from the formula and as deduced at various temperature ranges from experiments by Knudson, Herz, Ramsey and Young, Menzies, Cailletet and Colardeau and Rivière, Callendar and Griffiths, Jenkins, v. Woitinek, and Volmer and Estermann. The agreement is extremely close. Another table gives p (kg./m.²) from the formula and dp/dT for each 10° from 0° to 700° C.—S. G.

***Capillary Depression of Mercury in Wide Tubes.** Josef Stulla-Götz (*Physikal. Z.*, 1934, **35**, 404–407).—The capillary depressions of mercury at 8° C. in glass tubes of diameter 27–50 mm. were determined by an interferometer method. The depression becomes zero in tubes of diameter 45 mm. and greater.—J. S. G. T.

***Influence of the Adsorption of Atoms and Molecules on the Photo-Effect in Mercury (Excitation of Adsorbed Molecules).** H. Cassell and W. A. Schneider (*Naturwiss.*, 1934, **22**, 464–465).—A short preliminary note.—J. W.

***The Structure and Gas Content of Nickel Films Produced by Cathodic Sputtering.** Wilhelm Büssel and Friedrich Gross (*Z. Physik*, 1934, **87**, 778–799).—Nickel films produced by cathodic sputtering in hydrogen have a hexagonal structure with axial ratio $c/a = 1.63$ if they are not heated too severely. By heating the films at 400° C. either during or after production a cubic structure is produced. If the films are produced in an atmosphere comprising neon and helium, sufficient hydrogen is derived from that adsorbed in the nickel and the walls of the vessel to ensure that the structure of the films is hexagonal. If the percentage of hydrogen is reduced sufficiently, films having a cubic structure are produced. Hydrogen is evolved from all the films when they are heated to 700° C. When nickel is sputtered in nitrogen, in the absence of appreciable amounts of hydrogen, films possessing a space-centred tetragonal structure are obtained. In addition, a hexagonal structure having an axial ratio $c/a = 1.315$ is produced, together with nickel oxide. By heating above 200° C. the tetragonal phase is transformed into the hexagonal phase ($c/a = 1.315$) and finally into the cubic phase.—J. S. G. T.

Change of [Electrical] Resistance of Nickel, Iron, and Bismuth in Alternating Magnetic Fields of Audible Frequencies. J. Müller (*Z. Physik*, 1934, **88**, 277–291).—A description is given of an experimental method for determining changes of electrical resistance of a metal in weak alternating magnetic fields of audible frequencies, and results obtained with nickel, iron, and bismuth are discussed.—J. S. G. T.

[Magnetic] Permeability of Nickel and Iron for Very Small Wave Lengths, $\lambda = 4-10$ m. J. Müller (*Z. Physik*, 1934, **88**, 143–160).—A bolometric method for determining the high-frequency resistance of wires for very short waves is described. The method is tested by results obtained with a platinum wire and then applied to nickel and iron wires. In the case of nickel an effect due to frequency on the effective permeability of the wire at various points of the magnetization curve was not found; in the case of iron, however, the effective permeability decreased with increasing frequency, the decrease becoming greater as the circular magnetization produced in the interior of the wire became less.—J. S. G. T.

***The Freezing Point of Platinum.** F. Hoffmann and C. Tingwaldt (*Physikal. Z.*, 1934, **35**, 434-436).—The freezing point of platinum is found to be $1773.8^{\circ}\text{C} \pm 1^{\circ}\text{C}$.—J. S. G. T.

***Spontaneous Change of the Optical Transparency of Thin Silver Foil.—I, II.** A. Jagersberger and F. Schmid (*Z. Physik*, 1934, **88**, 265-269; **89**, 557-563).—(I.—) Spontaneous changes in the optical transparency of thin silver films are found to be analogous to those deduced from measurements of the electrical resistances of sputtered thin silver films. The phenomenon is attributable to three effects, *viz.*, structural change, gas adsorption, and chemical change. (II.—) The dependence of optical transparency on thickness of film is investigated, and it is found that there is a lower limiting thickness characterizing only the structural change, but not the gas effect. The structure of the films is discussed.—J. S. G. T.

***On the Atomic Weights of Niobium and Tantalum.** O. Hönigschmid (*Naturwiss.*, 1934, **22**, 463-464).—A short preliminary note. New determinations gave: niobium = 92.91 ± 0.01 ; tantalum 180.89.—J. W.

Notes on Tantalum and Niobium. W. R. Schoeller (*Sands, Clays, and Minerals*, 1933, **1**, (3), 40-42).—A short general account of the occurrence, properties, and uses of tantalum and niobium.—I. M.

†The Production and Utilization of Thorium and Uranium. J. W. Marden (*Electrochem. Soc. Preprint*, 1934, Sept., 153-160).—Two methods have been found to give a sufficiently pure and stable metal powder for sintering and working. The working properties of the two metals are discussed. Three principal uses found for these metals are described. The photoelectric properties of thorium and uranium are used in measuring restricted portions of the ultra-violet spectrum. Thorium has proved particularly useful in glow discharge lamps. Both metals have been used in X-ray tubes, and in certain conditions may come to be of considerable commercial importance.—S. G.

†Vanadium. B. D. Saklatwalla (*Electrochem. Soc. Preprint*, 1934, Sept., 161-166).—Only the more recent developments are taken into consideration, without attempting to survey the old voluminous literature. Some of the newer theories evolved as to the metallurgical effects of vanadium are discussed, especially as this forms probably the first published record of them. The fundamental properties of the vanadium atom as such are discussed, as it is considered that they are different from those of any other atom and responsible for some of its important technical effects.—S. G.

***Measurements Employing Liquid Helium. XXIII.—Superconductivity of Vanadium.** W. Meissner and H. Westerhoff (*Z. Physik*, 1933, **87**, 206-209).—Vanadium is found to become superconducting at $4.4^{\circ}\text{--}4.3^{\circ}\text{abs}$.—J. S. G. T.

***The Thermal Resistivity and the Wiedemann-Franz Ratio of Single-Crystal Zinc.** C. A. Cinnamon (*Phys. Rev.*, 1934, [ii], **46**, 215-221).—The guard-tube method has been used to determine the thermal resistivity at 57°C . for 13 large single crystals of very pure (99.99+%) zinc. The thermal resistivity obeys the Voigt-Thomson symmetry relation, and the Wiedemann-Franz ratio is the same for all orientations of the crystal, and equals 7.15×10^{-6} watt ohm/ $^{\circ}\text{C}$. at 57°C ., which is within 11% of that predicted by the Sommerfeld theory. The two principal thermal conductivities are $\lambda_0 = 1.009^{\circ}\text{C}$ and $\lambda_{90} = 1.068^{\circ}\text{C}$ watts/cm./ $^{\circ}\text{C}$. at 57°C . Results are also given for crystals with a mosaic structure, and for specimens which were intentionally strained.—W. H.-R.

***The Diffusion of Metals [Zinc and Cadmium] in Mercury.** Fritz Weischel (*Z. Physik*, 1933, **85**, 29-35).—A method of measuring changes of concentration due to diffusion of a metal in mercury, dependent on measurement of electrical conductivity, is described and is applied to determine the diffusion coeffs. of zinc and cadmium in mercury. The results obtained are compared with those obtained by other observers. In the case of zinc the diffusion coeff. is found to depend on the concentration; such dependence is not so evident in the case of cadmium.—J. G. S. T.

On the Purity of Metals 2000 Years Ago. August Ebeling (*Z. Metallkunde*, 1934, 26, 116–118).—Some notes are given on the purity of lead pipes found at Pompeii and of a sample of Roman lead found at Spalato-Solana (cf. *J. Inst. Metals*, 1930, 43, 406). A large hand-forged copper nail from the Lake Nemi ship (about A.D. 40) contained copper nearly 99.6, iron 0.26, nickel 0.087, silver 0.018, arsenic 0.015, and silicon 0.007%. The nail was only slightly corroded, and had a Brinell hardness of 71 kg./mm.², a tensile strength of 24.6 kg./mm.², and an elongation of about 15%.—M. H.

***Periodic Fluctuations in Metal.** E. G. Herbert (*Metallurgia*, 1934, 10, 153–154).—Read before the British Association, 1934. A discussion of further work on periodic hardness fluctuations induced in metals by mechanical, thermal, and magnetic disturbances includes experiments on nickel in which the elastic and periodic fluctuations after magnetic disturbance were measured. The experiments suggest that the modulus of elasticity is not a stable property, but is liable to fluctuate; that the fluctuations are periodic in character; that they can be induced by suitable magnetic or thermal disturbance; and that they may be caused by the action of stray fields the character of which has not been identified, but which can be intercepted by shielding the specimen.

—J. W. D.

***Crystal Plasticity.—I, II, III.** E. Orowan (*Z. Physik*, 1934, 89, 605–613, 614–633, 634–659).—The following matters are discussed: (I.—) plasticity at low temperatures and Becker's formula; (II.—) the dynamic conception of crystal plasticity; (III.—) the mechanics of slip.—J. S. G. T.

***Dependence of the Elasticity of Torsional Oscillations on Frequency.** Dankwart Schenk (*Z. Physik*, 1934, 88, 626–633).—Results obtained with wires of copper, brass, aluminium, nickel, and glass show that the modulus of torsion of these materials may either decrease or increase with the frequency of oscillation. The results can be utilized to ascertain whether the limiting torsional tenacity has been exceeded or not in the course of the experiments.

—J. S. G. T.

***A Study of the Influence of the Intercrystalline Boundary on Fatigue Characteristics.** H. J. Gough, H. L. Cox, and D. G. Sopwith (*J. Inst. Metals*, 1934, 54, 193–220; discussion, 220–228).—Alternating torsional stress tests were made on aluminium specimens, each consisting of 2 crystals having the boundaries differently disposed. Deformation during the tests was studied by close observations of the slip-bands produced with special attention to markings in the vicinity of the intercrystalline boundaries. The authors suggest that intercrystalline boundaries may considerably strengthen the constituent crystals against fatigue, but the observed effects of the boundaries on the distribution and amount of slip are very small. In the discussion *D. Hanson* considered that there was now little doubt that the resolved shear stress law applied in the case of aggregates. *U. R. Evans* referred to the form of cavity resulting from corrosion-fatigue and recent research work by Gould at Rangoon. *B. P. Haigh* asked for information on the direction followed by cracks in jumping from one slip plane to another. *C. H. Desch* suggested that the time factor may be of importance in connection with the effect of crystal boundaries, and that experiments at very high and very low stress cycle frequencies would be of interest. *C. F. Elam* mentioned that cracks do not always follow planes of slip, and that the "herring-bone" structure observed by the authors had also been observed in β -brass crystals. *F. Hargreaves* asked for information on removal of effects of fatigue stresses by heat-treatment.—H. S.

The Fatigue of Metals. A. Löbner (*Giesserei*, 1934, 21, 248–249).—A short note on the causes and effects of fatigue, and the principles of the various dynamic methods for investigating the fatigue of metals.—A. R. P.

Crystal Structure and Endurance Properties. P. Scherrer (*Bull. Assoc. Suisse Élect.*, 1934, 25, 458–463).—A lecture to the Zürich Physical Society.

The ordinary mechanical properties of solids acting in accordance with Hooke's law may be deduced from the lattice theory of molecular structure and from recent studies of the mechanics of the atom, especially of inter-atomic attraction and repulsion. Plastic deformation, fatigue, and recrystallization phenomena should be explainable on the same basis, but correlation is not yet complete.—P. M. C. R.

***The Strength of Materials as Affected by Discontinuities and Surface Conditions.** F. C. Lea (*J. Soc. Glass Tech.*, 1932, **16**, 182–205; discussion, 205–209; and (summary) *Engineering*, 1932, **134**, 256–258, 280–281).—A series of repeated stress tests, mainly on steels, but of general metallurgical interest, was carried out in order to determine the effect on endurance strength of surface finish and of discontinuities. The influence of corrosive conditions is discussed and illustrated, and striking inferiority in mechanical properties is shown by springs heat-treated and left black, as compared with similar springs after machining and grinding. Parallel discrepancies are exhibited by cold-drawn wires. The results of both fatigue and impact tests are markedly affected by grooves, threading, keyways, and scratches. Nascent hydrogen due to electrolysis affects not the fatigue range, but the nature of the fracture. Nickel-plating has much the same effects as grooving, unless stresses have been eliminated from the coating, when results are normal. L. assumes stress concentrations at discontinuities, and, in the case of cold-drawn or heat-treated materials, at grain boundaries.—P. M. C. R.

The Mechanism of Creep in Metals. I. A. Oding (*Metallurg (The Metallurgist)*, 1934, **9**, (1), 14–24; *C. Abs.*, 1934, **28**, 5792).—[In Russian.] The mathematical relations between the softening of the specimen due to heating and the simultaneous hardening due to straining the specimen are developed. These relations hold well for mild carbon and chromium–nickel–molybdenum steels. By use of these formulæ O. claims that one short-time test is sufficient to determine the creep limit.—S. G.

The Strength of Materials at High Temperatures. H. J. Tapsell (*Métaux et Machines*, 1934, **18**, 202–206).—Cf. *Met. Abs.*, this volume, pp. 338, 339, 393. Resistance to flow is correlated with resistance to fatigue, tested by various methods, at temperatures from 100° to 600° C., for a series of steels and for 70:30 and 80:20 nickel–copper, phosphor–bronze, Elektron, and a heat-resisting nickel alloy. Pulsating stresses, *i.e.*, cyclic stresses not presenting alternating equal but opposite effects, are considered in relation to high-temperature flow. If the stress at any point in such a cycle exceeds the fatigue limit for the operating temperature, a “flow” fracture showing no sign of fatigue may be produced. The effects of different frequencies of inversion are shown graphically. Flow phenomena are considered of more importance than those of fatigue at high temperatures. The effect of corrosive media is to diminish noticeably the high-temperature endurance properties of the material as compared with those measured *in vacuo* or in air. Notched-bar shock tests on non-ferrous materials give decreasing values with increase of temperature, unless constitutional changes induce recrystallization. The results of static hardness tests at high temperatures are necessarily affected by the duration of the test, which in some instances becomes practically a compression test; similar considerations apply to such tests on soft materials at ordinary temperatures. Dynamic methods might be of value in determining resistance to forging and rolling.—P. M. C. R.

The Hardness of Electrolytic Metals. — Guichard, — Clausmann, — Billon, and — Lanthony (*Chim. et Ind.*, 1934, Special No., (April), 472–473; *C. Abs.*, 1934, **28**, 5380).—The hardness of electrolytic metals is due to their structure, and not to the presence of hydrides, as has been claimed.—S. G.

Swelling in Hydrogen of Metals and Alloys Containing Small Quantities of Oxide. — Guichard, — Clausmann, and — Billon (*Chim. et Ind.*, 1934, Special No., (April), 588; *C. Abs.*, 1934, **28**, 5380).—Certain metals and alloys,

when annealed in the presence of hydrogen, undergo either swelling or considerable fissuring. These phenomena are due to the presence of oxide in the metals; the hydrogen diffuses into the metal, reduces the oxide with the formation of H_2O , which attains a very high pressure capable of disrupting the metal. Hence, (1) metals containing oxide should not be annealed in an atmosphere containing hydrogen; (2) in determining oxygen in metals by heating in hydrogen and weighing the H_2O formed, it is essential to heat the metal to fusion in order to ensure complete liberation of the H_2O , and precautions should be taken to avoid spurting of the metal.—S. G.

Dissipation Constants in Solids. H. Walther (*Bell Lab. Record*, 1934, 12, 363–366; illustration, 382).—The tendency of a metal bar to “ring” when struck depends on its internal resistance to elongation and contraction. It is measured by its dissipation constant, Q , defined as the ratio of mechanical reactance to mechanical resistance. If μ is the internal viscosity (which varies inversely as the frequency f), and E is Young’s modulus, $Q = \frac{E}{2\pi f\mu}$. For the

measurement of Q , a slender bar is supported in its middle and magnetic receiver structures are placed near each end. One receiver is connected to an oscillator, by means of which the end of the bar is caused to vibrate. The degree to which the vibrations are transmitted along the rod is measured by observing the voltage induced in the other receiver. The dissipation constant of a metal depends on its condition of internal stress, but bears no relation to its other physical properties such as hardness or melting point. Average values are tabulated for various materials and vary from 30 for hard lead (200 for annealed lead) to 50,000 for annealed aluminium.—J. C. C.

Light Absorption by Metals. Alexander Smakula (*Z. Physik*, 1934, 88, 114–126).—The light absorption curves of aluminium, lead, tin, chromium, manganese, antimony, and bismuth in the region 700–186 $m\mu$ are shown to be related in a simple manner to atomic electric conductivities of these metals. The greater the light energy necessary to effect an electron transfer in the metal lattice the smaller is the atomic electric conductivity.—J. S. G. T.

***Reflection Factors of Various Materials for Visible and Ultra-Violet Radiation.** A. H. Taylor (*J. Opt. Soc. Amer.*, 1934, 24, 192–193).—Values are given for the reflection factors of various materials for light (from a tungsten lamp at approx. 2000° K.) and for monochromatic radiation of wave-length 2967 Å. The measurements were made with T.’s modified portable reflectometer, which is independent of comparison standards. Aluminium electrolytically brightened and treated by the Alumilite oxidation process gave high reflectivities, but was surpassed by an aluminium alloy (probably aluminium–magnesium) deposited on glass by sputtering in a high vacuum. [Note by abstractor: The legend for Fig. 1 of the paper is missing, but is to be found in the succeeding issue of the periodical, p. 228.]—R. G.

The Spontaneous Change of Transparency of Thin Metal Foil.—III. A. Jagersberger (*Z. Physik*, 1934, 89, 564–581).—A theory of the spontaneous change of transparency of thin metal films, based upon the optical dispersion formula relating to metals, is developed. The order of magnitude of the mass of gas adsorbed by such films is derived.—J. S. G. T.

Electrical Conduction in Thin Metal Films. A. Jagersberger (*Z. Physik*, 1934, 87, 513–517).—The experimental fact that the specific electrical resistance of very thin metal films increases rapidly with decreasing thickness of film is interpreted on the assumption that the number of free electrons per c.c. of the film decreases under these conditions.—J. S. G. T.

The Anomalous Electrical Conductivity of Thin Metals. H. Murmann (*Z. Physik*, 1934, 89, 426–430).—Experiments with thin films of silver produced by sublimation *in vacuo* show that the hypothesis of Wait and of Steinberg, that

the anomalous small conductivity of thin metallic films is attributable to the relatively small number of contacts between grains in the films, is untenable.
—J. S. G. T.

***Dependence of the Conductivity of Very Thin Metal Films on the Electrostatic Field.** R. Deaglio (*Naturwiss.*, 1934, 22, 525-526).—A short note. The influence of an electrostatic charge on the conductivity of a thin gold film was observed at a resistance of unit area of 10^8 - 10^{12} Ω_{\square} , producing an increase in the conductivity. The magnitude of the reduction in resistance is independent of the sign of the charge for films produced by vaporization *in vacuo*, but for films produced by cathodic sputtering it is greater for positive charges than for negative. Reductions of up to 50% in the resistance have been observed.—J. W.

***Experimental Detection of Resistance Charges in Thin Metal Films after Electrostatic Charging.** Alexander Deubner (*Naturwiss.*, 1934, 22, 239).—A short preliminary note. With small electrostatic charges and high accuracy in measurement of the resistance, small but detectable increases and decreases of the resistance of thin silver films have been observed. Although perfectly uniform films of bismuth have not yet been produced, the tests showed that no particularly large effect occurred such as would be expected from "electronic impoverishment."—J. W.

***The [Electrical] Conductivity of Metals.** N. F. Mott (*Proc. Phys. Soc.*, 1934, 46, 680-692).—If the electrical resistances of the pure metals are measured for the same amplitude of thermal oscillation of the atoms, they show a marked periodic character, being always 2 or 3 times greater for a monovalent element than for the divalent metal next to it in the periodic table. It is suggested that this variation is due to a smaller effective number of free electrons in the divalent metals. Bridgman's values of the change of resistance of metals under pressure are discussed and a quantitative theory is given of the behaviour of alloys and pure metals at low temperatures under pressure.—J. S. G. T.

***Crystal Structure and Electrical Properties.**—IV. O. Stierstadt (*Z. Physik*, 1934, 87, 687-699).—The conditions under which a determination of the electrical conductivity of a metal crystal in various directions in a magnetic field may be expected to afford means for deriving a model of the lattice symmetry of the crystal are discussed. Whereas the surface produced by plotting vectorially the electrical conductivity of a bismuth crystal, in the absence of a magnetic field, is an ellipsoid of rotation, the form of the surface, in the presence of a longitudinal electric field, is conditioned by the angles between the field and the crystal axes.—J. S. G. T.

The [Electrical] Resistance of Liquid Metals. N. F. Mott (*Proc. Roy. Soc.*, 1934, [A], 146, 465-472).—Assuming that the atoms in a liquid metal vibrate about slowly varying mean positions with a frequency ν_L , the ratio of ν_L to the atomic frequency of the solid is calculated from experimental values of latent heat and melting point. It is shown that, for normal metals, the change of electrical resistance on fusion of the metal can be accounted for by the change in atomic frequency. The bearing of this fact on theories of liquid structure is discussed.—J. S. G. T.

Bloch's Theory of Electrical Conduction. Erich Kretschmann (*Z. Physik*, 1934, 87, 518-534).—Bloch's theory of electrical conduction (*ibid.*, 1928, 52, 555) is criticized adversely.—J. S. G. T.

Theory of Superconduction. R. Schachenmeier (*Z. Physik*, 1934, 89, 183-209).—A mathematical theory of metallic superconduction, based on electron scattering and quantum theory, is developed.—J. S. G. T.

***Contacts Suitable for Instruments [Properties of Metals Used for Electrical Contacts].** H. Williams (*J. Sci. Instruments*, 1934, 11, 273-279).—The behaviour of metals used for electrical contacts is described with special reference to mechanical wear, electrical wear, reliability, and the characteristics of con-

facts, where very small voltages are present ("dry" contacts). Contact pressures of less than 20 gm. should be avoided if possible, and for all-round reliability twin dome-shaped contacts of pure silver are recommended, whilst for very small voltages platinum should be used. Other non-ferrous metals and alloys are also described, including iridium, palladium, tungsten, and noble metal alloys. The investigation was carried out for the (British) Post Office, and refers to contacts for comparatively small currents.—W. H.-R.

The Transverse Thermomagnetic Effect: A Method of Measurement. G. Schmidt Nielsen (*Phil. Mag.*, 1934, [vii], **18**, 575-579).—The Nernst-Ettingshausen effect is attributable (a) to direct action of the magnetic field on the electrons in the metal, and (b) to an indirect effect due to polarized molecules. Apparatus for distinguishing between these two is described. Results with a nickel tube show that the coeff. for effect (b) is $0.15 K$, where K is the coeff. of heat conduction. The effect (a) was too small to determine.—J. S. G. T.

Theory of the Hall-, Nernst-, Ettingshausen-, and Righi-Leduc Effects. N. Akulov (*Z. Physik*, 1934, **87**, 768-777).—A mathematical theory of these thermo-electric and thermomagnetic effects in ferromagnetic metals is developed. The law of anisotropy already derived for the magnetostriction effect is extended to include thermomagnetic and mechano-striction effects.—J. T.

Magnetostriction of Ferromagnetic Ellipsoids.—I. R. Becker (*Z. Physik*, 1934, **87**, 547-559).—A thermodynamic theory of magnetostriction is developed.—J. S. G. T.

Ferromagnetism. R. H. Fowler and F. C. Powell (*Proc. Camb. Phil. Soc.*, 1931, **27**, 280-289).—Mathematical.—S. G.

Theory of Thermomagnetic and Thermoelastic Phenomena. P. Chramov and L. Lwowa (*Z. Physik*, 1934, **89**, 443-446).—Changes in the values of the e.m.f.'s of nickel-copper and iron-copper thermocouples due to magnetization and to tensile stress are shown experimentally to be in agreement with Akulov's first rule (*ibid.*, 1928, **52**, 389; 1934, **87**, 768).—J. S. G. T.

Magneto-Elastic Torsion Experiments. R. Becker and M. Kornetzki (*Z. Physik*, 1934, **88**, 634-646).—Experiments which show the effect of external stresses on the direction of spontaneous magnetization of nickel and iron wires are described. Soft annealed iron and nickel wires exhibit an apparent plastic remanence which can be removed either by a longitudinal magnetic field or by alternating magnetization. The remanence is in accordance with the torsion attributable to a helical magnetic field. The effect of magneto-mechanical remanence on the damping of torsional oscillations executed by the wire is discussed.—J. S. G. T.

***Hysteresis Losses and the Area of the Hysteresis Loop.** L. W. McKeehan and R. M. Bozorth (*Phys. Rev.*, 1934, [ii], **46**, 527).—A note. Modern theory and experiment indicate that changes in magnetization occur by the reversal of a number of small domains. The interpretation of hysteresis losses is discussed from this point of view.—W. H.-R.

Effect of Temperature in Ferromagnetic Crystals. G. S. Mahajani (*J. Univ. Bombay*, 1933, **2**, (2), 132-151; *C. Abs.*, 1934, **28**, 5301).—The results of a previous paper (*J. Inst. Metals*, 1929, **42**, 430) are revised to take account of temperature effects in ferromagnetic crystals. These effects include translational displacement of atoms, as used by Born in treating the specific heats of crystals, and, in addition, liberation of the magnetic axes of the atoms. With this liberation assumed monochromatic, a provisional solution of the proposed equations explains qualitatively the experimental results of Weiss and Forrer (*J. Inst. Metals*, 1927, **37**, 396), but certain defects prevent a quantitative application. A picture of magnetization and hysteresis is drawn on the basis of this theory, which appears promising.—S. G.

The Diamagnetic Susceptibility of Atoms. Paul Gombás (*Z. Physik*, 1933, **87**, 57-61).—A formula for the diamagnetic susceptibility of atoms is derived

by application of the statistical theory due to Lenz and Jensen, and fairly satisfactory agreement between calculated and experimental values is found in the case of 12 elements, including the alkali and alkaline earth metals.

—J. S. G. T.

†**Methods and Results Relating to the Investigation of Isotopes.** J. Mat-tauch (*Physikal. Z.*, 1934, **35**, 567–621).—Work relating to isotopes is very thoroughly reviewed, and an extensive *bibliography* comprising 240 references is appended.—J. S. G. T.

***A New γ -Radiation of Artificially Radioactive Elements.** R. Fleischmann (*Naturwiss.*, 1934, **22**, 434–435).—A short note. Iron, aluminium, and silica emit γ -rays when bombarded with neutrons.—J. W.

II.—PROPERTIES OF ALLOYS

(Continued from pp. 442–445.)

***Note on the Influence of Gases in an 8% Copper–Aluminium Alloy on Normal and Inverse Segregation.** I. G. Slater (*J. Inst. Metals*, 1934, **54**, 103–105; discussion, 105–110).—The relationship between gas content and segregation in an 8% copper–aluminium alloy is studied. In small sand-cast ingots segregation was found to be inverse with very gassy melts, but to be normal with degassed melts. In the discussion T. Turner suggested that segregation might be the cause of gas liberation. N. P. Allen considered that there is some connection between inverse segregation and cavities. R. Genders regarded the results and others obtained by Höhne as support for the gas theory of inverse segregation. C. H. Desch stated that the gas theory of inverse segregation was at present the only acceptable one, and pointed out that the manner of liberation of gas during freezing was the important factor, the total quantity present being unimportant. D. Hanson regarded gas as an important factor in controlling inverse segregation, but considered that shrinkage effects are also of possible influence. G. L. Bailey considered the subject much more complicated than if dissolved gases alone were concerned. S. W. Smith pointed out that chill-castings were more suitable for the study of inverse segregation and interpreted the author's work as showing that the alloy showed inverse segregation whether gas-free or not. H. Moore mentioned the difficulty of explaining all cases of inverse segregation on the basis of the gas theory.—H. S.

***The Iron Corner of the System Iron–Manganese–Aluminium.** Werner Köster and Willi Tonn (*Arch. Eisenhüttenwesen*, 1933–1934, **7**, 365–366).—Thermal, dilatometric, and micrographic investigations on alloys containing up to 30% aluminium and 50% manganese reveal the existence of only α - and γ -solid solutions. The ($\alpha + \gamma$)-field stretches from the iron corner transversely across the range examined up to 40–50% manganese, where it is bounded by the field in which the β -manganese transformation occurs.—J. W.

Compensatable Nickel-Containing Aluminium Alloys. B. Trautmann (*Nickel-Ber.*, 1934, 81–86; *C. Abs.*, 1934, **28**, 5795).—Alloys of aluminium with nickel, copper, and manganese, and some with iron, silicon, and titanium also, which have found increasing use outside Germany, are investigated. The best-known of these alloys are the “Y” alloy developed in England at the N.P.L. and the “R.R.” alloys of the Rolls-Royce Co. These alloys are used chiefly for the manufacture of internal combustion engines. Data are given on the preparation of the alloys, the best methods of alloying, the most suitable materials for crucibles, as well as the physical and chemical properties of the alloys. The best casting temperature is 690°–730° C.—S. G.

***Aluminium-Silicon Alloys.** W. Broniewski and M. Śmiałowski (*Prace Zakładu Metallurgicznego Politechniki Warszawskiej*, 1933, **3**, 59–83).—[In Polish, with French summary.] See *J. Inst. Metals*, 1933, **53**, 10, 490.—S. G.

***Influence of Small Additions of Elements on the Properties of Aluminium Alloys.** Hideo Nishimura (*Suiyokwai-shi*, 1934, **8**, 379–390; *C. Abs.*, 1934, **28**, 5022).—[In Japanese.] Molten aluminium and aluminium alloy were treated with various chloride fluxes, such as $MnCl_2$, $NiCl_2$, $CoCl_2$, $CuCl$, $CuCl_2$; and quantities of nickel, manganese, cobalt, and copper dissolved in aluminium were determined. Manganese was the most easily dissolved in aluminium and aluminium alloys from the flux. The temperature of treatment was independent of the quantity added. The effect of a small amount of titanium (0.02–0.46%) on the ageing of aluminium alloys containing 4–5% copper was investigated by measurements of electrical resistivity and hardness, and the microstructure of the heat-treated alloys was examined. Titanium does not decrease the hardness of the alloys at higher temperatures.—S. G.

***The Reflectivity of Intermetallic Systems [Al-Si, Al-Mg, Al-Ag].** J. Wulff (*J. Opt. Soc. Amer.*, 1934, **24**, 223–226).—Values are given for the percentage reflection of aluminium-silicon, aluminium-magnesium, and aluminium-silver alloys for the region 2000–6000 Å. The specimens were polished optically and etched in extremely dilute solutions ($NaOH$, $NaOH + NaF$, and HNO_3) until the first microscopic indications of structure appeared. The compound Mg_3Al_2 showed high reflectivity, the alloys between this and the pure metals giving a simple mixture relationship of the limiting reflectivities. In the silicon alloys the low reflectivity of silicon in the visible spectrum becomes evident with as little as 20% present. The results given by the aluminium-silver system appeared anomalous in certain respects.—R. G.

Light Alloys for Cylinder Construction and Their Sliding Properties. O. Engelmann (*Metallbörse*, 1934, **34**, 501–502, 534–535).—The characteristics of a cylinder alloy are critically discussed, and the compositions of several light alloys on a silicon-aluminium basis which fulfil to a greater or lesser extent the requirements of cylinder alloys are given.—A. R. P.

A New Light Alloy [Ceralumin]. Anon. (*Nickel Bull.*, 1934, **7**, 99; *Met. Ind. (Lond.)*, 1934, **45**, 106; *Machinist (Eur. Edn.)*, 1934, **78**, 365E; *Found. Trade J.*, 1934, **51**, 59; *Metallurgia*, 1934, **10**, 85–86; *Aircraft Eng.*, 1934, **6**, 248; *Engineering*, 1934, **138**, 45; *Eng. Rev.*, 1934, **48**, 195).—Ceralumin is an aluminium alloy containing copper 2.5, nickel 1.5, magnesium 0.8, iron 1.2, silicon 1.2, and cerium 0.15%. When aged at 175° C. for 16 hrs. and quenched after heat-treating, it is known as Ceralumin "C", and has high tensile strength and Brinell hardness, but low ductility. If aged at room temperature for 5 days after heat-treating, the alloy is termed Ceralumin "D", and has lower tensile strength, but higher ductility. The mechanical properties of the alloy are tabulated.—J. H. W.

***The Eutectic of the Antimony-Lead System.** Otaker Quadrat and Jean Jiristě (*Chim. et Ind.*, 1934, Special No., (April), 485–489; *C. Abs.*, 1934, **28**, 5389).—From a study of 3 ingots of lead-antimony alloys containing 19.55 and 12.89% antimony that had been allowed to cool very slowly to ensure complete separation of excess antimony from the eutectic (which was confirmed by microscopic examination after etching), it is concluded that the eutectic contains 11.4–11.5% antimony instead of the generally accepted value of about 13%.—S. G.

***Thermal Expansion of Alloyed Bismuth Crystals in the Region of the Eutectic Melting Point [Bismuth-Lead and Bismuth-Tin Alloys].** A. Goetz, J. W. Buchta, and T. L. Ho (*Phys. Rev.*, 1934, [ii], **46**, 538).—A note. Single crystals of bismuth grown from melts containing from 1 to 5% of lead show a discontinuity in the thermal expansion at about 125° C. (the temperature of the lead-bismuth eutectic), although the concentrations are within the

limits of solid solubility. After numerous heatings the discontinuities become less marked, but still persist. Similar results are obtained with small percentages of tin, for which the eutectic temperature is 135° C. Small drops of the material are sometimes sweated out at the eutectic temperature, but this does not affect the diamagnetic qualities, whilst the lattice parameter shows no discontinuity at the above temperatures, and the specimens appear perfectly uniform and monocrystalline. It is concluded that the second metal is more concentrated in certain regions which are distributed uniformly. [Note by Abstractor: This work confirms the difficulties of obtaining perfect single crystals of solid solutions, but the difficulty of obtaining true equilibrium at these low temperatures suggests that many of these observations may be simply due to insufficient annealing.]—W. H. R.

Iron-Cobalt Alloys. G. A. Kelsall (*Bell Lab. Record*, 1934, 13, 10-11).—A brief account is given of the magnetic characteristics of alloys in the iron-cobalt series. The 50:50 alloy is remarkable for its high permeability at high flux density, having a higher permeability than Armco iron at flux densities above 13,000. The addition of up to 2% of vanadium does not affect the magnetic characteristics, but enables the alloy, which is otherwise brittle, to be cold-worked.—J. C. C.

***Magnetic Properties of Iron-Cobalt Single Crystals.** J. W. Shih (*Phys. Rev.*, 1934, [ii], 46, 139-142).—The magnetic properties of single crystals of iron-cobalt alloys containing 30, 40, 50, and 70% cobalt have been investigated. All these have the body-centred cubic structure, but those with 30 and 40% cobalt have $\langle 100 \rangle$, whilst those with 50 and 70% cobalt have $\langle 111 \rangle$ as the direction of easiest magnetization. This is in contradiction to the theory of Fowler and Powell (*Met. Abs.*, this volume, p. 485), according to which the direction of easy magnetization depends primarily only on the type of structure. According to Kussmann, Scharnow, and Schulze (*J. Inst. Metals*, 1933, 53, 182), a superlattice may be formed near the composition FeCo. The magnetization curves for the 70% cobalt alloy are in agreement with the theory of Akulov (*Z. Physik*, 1931, 67, 774; 69, 78). The specimens were prepared from very pure iron and 99.37% cobalt.

—W. H. R.

***Some Photoelectric Properties of Cuprous Oxide on Copper.** Wilbur E. Meserve (*Sibley J.*, 1934, 48, (6), 83-86).—The photoactivity of the wet and dry types of copper-cuprous oxide cell have been studied, using sinusoidally varied illumination. The response of the cell rapidly decreases with frequency. For any given frequency, the photo-potential is a linear function of the light intensity. Certain capacitance and resistance phenomena are described, and the phase-angle-frequency curve for the cell is reproduced. Results obtained with the wet type of cell are in agreement with Schottky's theory of the dry cell, and it is therefore suggested that the source of photo-activity is the same in both types.—P. M. C. R.

***Magneto-Striction of Ferromagnetic Alloys. II.—Measurements Relating to Iron and Cobalt.** Max Kornetzki (*Z. Physik*, 1934, 87, 560-579).—The linear and volume magneto-striction effects are investigated for 5 ellipsoids of iron in fields of strength up to 10,000 Oerstedt. The volume effect in pure iron is conditioned by 3 factors; in impure iron an additional factor has to be taken into account. The volume effect in cobalt is investigated up to a field strength of 10,000 Oerstedt. It is probable that all binary alloys of the iron-nickel-cobalt series, and possibly also the ternary alloys, exhibit a magneto-striction effect characterized by an increase of volume above saturation point.—J. S. G. T.

Beryllium-Copper Castings—Foundry Practice, Heat-Treatment, Properties. Edwin F. Cove (*Trans. Amer. Found. Assoc.*, 1933, 41, 330-346).—In melting

and alloying, the commercially available 12.5% Be-Cu alloy is added to thoroughly deoxidized copper protected by charcoal and borax glass, pouring at temperatures between 1050° and 1150° C. Solution heat-treatment consists of soaking at 800°–820° C. for 2 hrs. followed by quenching in cold water—after which the alloy is soft and readily machinable. Precipitation of the beryllide is brought about by heating at 275°–300° C. for about 3 hrs., which causes the maximum properties and slight volume decrease (0.001 in. per in. diameter). With articles liable to distortion the solution treatment should be preceded by normalizing at 800°–820° C., followed by cooling in air. The mechanical properties are given of cast alloys containing 1.79–2.45% beryllium, the optimum alloy 2.5% having a tensile strength of 50 tons/in.² with a yield at 40 tons/in.², and of rolled alloys (1.5–2.5% beryllium) in various conditions. The electrical conductivity varies considerably with the beryllium content and with the thermal treatment, the conductivity being increased more by beryllium than by the same amount of phosphorus. The thermal conductivity-temperature curve for the 2.5% beryllium alloy shows a sharp inflection at between 250° and 300° C. Some preliminary wear tests are reported, and applications indicated.—R. B. D.

***Magnetic Susceptibilities of Dilute Solutions of Nickel in Copper at Various Temperatures.** William H. Ross (*Phys. Rev.*, 1934, [ii], 46, 46–48).—The magnetic susceptibilities of copper-nickel alloys containing from 0 to 9.05% nickel by weight have been measured in an atmosphere of hydrogen at temperatures from –180° to +600° C. The specimens were prepared by slow cooling from the molten alloy, and most were unicrystalline. From room temperature to –180° C. there is rough agreement with the usual Curie-Weiss law, but above room temperature there is the equivalent of an abnormal increase in paramagnetism with increasing temperature. The diamagnetism of pure copper is diminished by the presence of nickel, and with more than about 4% nickel by weight the alloys are paramagnetic at all temperatures; specimens containing 7.72 and 9.05% nickel showed a minimum paramagnetic susceptibility in the region 0° to +200° C. The magnetic moment of the nickel atom in the lattice is calculated as 0.3–0.4 Bohr magnetons, and the meaning of this is discussed.—W. H. R.

***The Electrical Conductivity of Copper-Palladium Alloys with Ordered and Disordered Distribution of Atoms at Low Temperatures.** H. J. Seemann (*Z. Physik*, 1934, 88, 14–24).—The electrical resistances of six copper-palladium alloys containing from 37.9 to 52.8% (atomic) of palladium have been determined at –252.8° C., –195.41° C., and at 18° C. The work is an extension of previous work on copper-gold, copper-palladium, and copper-platinum alloys (see *J. Inst. Metals*, 1930, 44, 494, and *Met. Abs.*, this volume, p. 8). Whilst the specific resistances of the tempered alloys at room temperature are, to a variable amount, smaller than those of the quenched alloys, the decrease of resistance at low temperatures is not appreciably different in both cases. The constitution of the mixed phases of tempered copper-palladium alloys is discussed and work on the copper-platinum alloys is extended by an investigation of the alloy containing 22.9% (atomic) of platinum. In this case, the effect of tempering is to reduce the specific resistance of the alloy at room temperature to about $\frac{1}{4}$ of the value for the quenched alloy.—J. S. G. T.

***Contribution to the Precipitation Hardening of Copper-Silver Alloys.** R. Mitsche (*Z. Metallkunde*, 1934, 26, 159–160).—The hardness of silver-copper alloys with 92–95% copper quenched at 750° C. and tempered for 40–60 minutes at 300° C. further increases by 7–20% on subsequent storage at room temperature; no such effect is obtained with quenched but untempered alloys. The maximum hardening effect after tempering occurs with the saturated silver-rich solid solution alloy; the increase in hardness is about

132% with 5% copper, 143% with 8% copper, and only 42% with 30% copper.—M. H.

***A Study of Six Bearing Bronzes.** Oscar E. Harder and Carer S. Cole (*Trans. Amer. Found. Assoc.*, 1933, **41**, 314-329; and *Met. Ind. (Lond.)*, 1933, **42**, 639-642).—The bronzes the compositions of which ranged between copper 70-80, tin 5-10, lead 0-25, and zinc 0-3% were investigated for tensile and yield-strengths [the latter equivalent to English 0.1% proof stress.—*Note by Abstractor*], elongation, reduction of area, and modulus of elasticity at room temperature, Rockwell E and Brinell hardness at room temperature, Brinell at temperatures up to 230° C. Compression tests, in which the loads were increased by 2000 lb./in.² increments up to 100,000 lb./in.², produced curves of permanent deformation after each loading. The density was found in every case to have increased after the compression test. Pounding tests made on a machine of similar design to that of the Bureau of Standards showed that resistance to pounding is a function of the tin-copper ratio, whilst the presence of lead appears to decrease the resistance. The test-pieces, cast almost to testing size, were produced by four different foundries according to their own practice, which is detailed in the report, but which has not apparently had any effect on the results except where the "shake-out" time varied. A brief discussion followed.—R. B. D.

***Transformations in Copper-Tin Eutectoid Alloys.—I, II.** (I.—) I. Isaitchew and G. Kurdjumow; (II.—) W. Bugakow, I. Isaitchew, and G. Kurdjumow (*Metallurg (Metallurgist)*, 1934, (1), 25-34, 35-39).—[In Russian.] See *Met. Abs.*, this volume, p. 342.—N. A.

On the Dependence of the Capability of Strengthening (Work-Hardening) of α -Brass on Temperature. F. Sauerwald and H. Giersberg (*Z. Metallkunde*, 1934, **26**, 135).—A brief note. The degree of hardening produced by working (compressing) 72 : 28 brass is constant between 20° and about 500° C. No hardening occurs on working at above 700° C., which is the lower limit of the hot-working zone. Spontaneous recrystallization takes place between 400° and 600° C.; the structure is then more fine-grained than in the unworked condition.—M. H.

***The Transformation of β -Brass.** H. v. Steinwehr and A. Schulze (*Physikal. Z.*, 1934, **35**, 385-397).—The value of the heat tone in the region of transformation of β -brass, the thermoelectric power against platinum, the thermal expansion and the temperature coeff. of resistance of β -brass have been measured between 0° and about 600° C. The heat tone has the value 3.0 cal./gram, and is thus of the same order of magnitude as in the case of allotropic transformations. The results relating to expansion and electric resistance confirm previous results. The heat tone is not associated with one definite temperature, but is related to a considerable temperature interval, *viz.*, 430°-480° C. This is confirmed by the expansion and electrical measurements. The results as a whole confirm the conclusion derived by Straumanis and Weerts that the β -transformation is associated with a reversible transformation of a disordered into an ordered atomic distribution.—J. S. G. T.

***The Influence of Third Metals on the Constitution of Brass Alloys. VI.—The Influence of Iron. A Contribution to the Knowledge of the Ternary System Copper-Zinc-Iron.** O. Bauer and M. Hansen (*Z. Metallkunde*, 1934, **26**, 121-129).—*Cf. J. Inst. Metals*, 1933, **53**, 123. Earlier work on the constitution of the copper-rich alloys is briefly reviewed. The constitution of the ternary system within the range copper 100-52, and iron 0-2%, has been studied by thermal and micrographic investigation of vertical sections from the binary system copper-zinc. The solidification of the alloys with less than 70% copper and up to about 1% iron is similar to that in the copper-zinc system, the iron remaining dissolved in the α - and β -solid solutions and producing little, if any, increase in the liquidus temperature. The peritectic

reaction $\alpha + \text{melt} \rightleftharpoons \beta$ takes place over a very narrow temperature range and commences at only a few °C. lower than in the copper-zinc system. With more than 1% iron the iron-rich constituent crystallizes primarily and hence the liquidus temperature is raised considerably. The solubility of iron in α - and β -brass is about the same as in copper and similarly increases considerably with rise in temperature. The precipitation of α from β takes place, according to the temperature, either before or after the precipitation of the iron-rich constituent. The boundaries of the ($\alpha + \beta$) region are displaced slightly away from the copper side. The presence of primary iron-rich crystals causes a considerable grain refinement in cast α - and β -brass. The structure of recrystallized α -brass is also greatly refined by precipitation of iron-rich crystals in the solid state. Iron in α -brass produces temper-hardening (cf. *J. Inst. Metals*, 1932, 49, 263-264). Owing to the slow rate of precipitation of iron from solution in α -brass articles of this alloy are generally in the age-hardenable state.—M. H.

Nickel-Brasses. G. Dubercet (*Rev. Fonderie moderne*, 1934, 28, 193-194).—The properties of nickel-brasses from a consideration of the ternary equilibrium diagram of the copper-nickel-zinc alloys are discussed on the lines of an article by J. Cournot and F. Hiltbold in *Rev. Nickel*, 1934, 5, (1), 16-33; see *Met. Abs.*, this volume, p. 293.—J. H. W.

Studies on Cast Red Brass for the Establishment of a Basic Classification of Non-Ferrous Ingot Metals for Specification Purposes. C. M. Saeger, Jr. (*Trans. Amer. Found. Assoc.*, 1934, 5, (3), 67-96).—See *Met. Abs.*, this volume, p. 382.—R. B. D.

Dental Metals and Their Manipulation. E. W. Skinner (*Metal Progress*, 1934, 26, (2), 41-44, 58).—The development is traced of the alloys fulfilling the specialized requirements and rigid specifications of dental work. Gold must be used in the fully annealed state, or its welding properties are impaired. Gold-copper alloys are used for wiring, gold-platinum-palladium-silver-copper alloys for crown and bridge work. Zinc and tin are introduced into casting alloys to lower the melting point. Dental alloys should contain at least 50% of "noble" metal. Standards for the strength of wrought and cast alloys are given. The process of taking impressions is described. The influence of heat-treatment on mechanical properties is discussed, and requirements for certain types of alloy are tabulated. The important work of G. V. Black on the silver amalgams and in systematizing certain branches of dental metallurgy is described, and the constitution and valuable properties of dental amalgams are briefly considered.—P. M. C. R.

***Gold-Silver Alloys as a Type of Continuous Solid Solutions.** W. Broniewski and K. Wesolowski (*Prace Zakladu Metallurgicznego Politechniki Warszawskiej*, 1933, 3, 84-94).—[In Polish, with French summary.] See *J. Inst. Metals*, 1932, 50, 474.—S. G.

***Properties of Lead and Lead Alloy Cable Sheaths.** J. C. Chaston (*Elect. Communication*, 1934, 13, 31-50).—Sheath requirements for various types of cables are discussed. Ductility is needed for duct telephone cables; hardness and fatigue strength for aerial telephone and duct power cables. For armoured cables in trenches the sheath requirements are far less severe. Reviewing published data, it is pointed out that nearly all test-specimens have been machined from extruded rod or previously flattened sheath and that age-hardening has usually been ignored. In the work described, all tests have been made on sheath samples extruded from a cable press. The materials used were unalloyed lead, the alloys with 0.66, 0.8, and 1.0% antimony and the British Non-Ferrous ternary alloys No. 1 (antimony 0.5, cadmium 0.25) and No. 3 (tin 0.4, cadmium 0.15%). Age-hardening occurred in the No. 1 ternary and all the antimony alloy sheaths and is compared with the hardening of small samples cooled at different rates from the eutectic temperature.

The antimony alloys age nearly as rapidly after cooling in air as quenching in water, but the No. 1 ternary alloy is more sensitive to variations in the cooling rate. Fatigue tests were made on a rotating-beam machine using sheath specimens 22 in. long to ensure a central fracture. The alloy samples were first aged to their maximum hardness. The results with the lead sample, which does not age-harden, agreed well with earlier determinations and were little influenced by the condition of the sheath surface. Tensile tests at 2 rates of straining indicate lead sheaths to have by far the greatest ductility. Creep tests with longitudinal loading are compared with bursting tests at room temperature and 110° C. under prolonged internal pressure. An apparatus for immersion corrosion tests is described. A *bibliography* of 48 references is appended.—J. C. C.

***The Effect of Impurities on the Surface Tension of Type-Metal Alloys.** H. Vance White (*Bull. Virginia Polytech. Inst. Eng. Exper. Sta. Series*, No. 17, 1934, 51 pp.; *C. Abs.*, 1934, 28, 5795).—Oxidation increases the surface tension of all type-metals. In oxidizing conditions an increase in temperature causes an increase in surface tension. Arsenic, bismuth, cadmium, magnesium, potassium, and iron cause slight increases in surface tension of type-metal alloys in oxidizing conditions, zinc causes a great increase, and sodium causes a marked decrease.—S. G.

***Constitution and Properties of Alloys of Magnesium with Aluminium and Copper.** A. Portevin and P. Bastien (*Chim. et Ind.*, 1934, Special No., (April), 490-519; *C. Abs.*, 1934, 28, 5387).—Thermal analysis of ternary magnesium-aluminium-copper alloys rich in magnesium revealed the existence of (1) a liquidus comprising 4 primary zones corresponding, respectively, to the separation of the phases Mg, Mg₄Al₃, Mg₂Cu, and Mg₂Cu₃Al₂; (2) two ternary eutectics melt, respectively, at 412° and 484° C.; (3) two ternary solid solutions, one rich in magnesium and the other in Mg₄Al₃. These results were confirmed micrographically. The study of the physico-chemical properties was completed by the determination of hardness and expansion coeffs. of machinable alloys (aluminium + copper = or less than 15%). The αβ limit of the ternary solid solution rich in magnesium, which limit corresponds with the appearance of the constituent Mg₄Al₃, was clearly brought out. The curves plotted for densities and electrical conductivities confirmed the existence and defined the extent of the ternary solid solution rich in magnesium. Forging tests showed the possibility of forging ultra-light alloys with high copper contents (of the order of 12%) and of thus obtaining alloys possessing satisfactory mechanical characteristics, whilst at the same time retaining sufficient hardness and thermal conductivity (internal combustion engine pistons). The mechanical properties of alloys possessing industrial interest (aluminium + copper = or less than 15%) were studied in detail. The tests confirmed the need for replacing tensile strength tests by static bending tests in the case of alloys as cast, and the latter, which are much more accurate, are recommended for incorporation into specifications. The mechanical tests showed the existence among magnesium-aluminium-copper alloys of alloys possessing mechanical properties comparable to those of the Elektron alloys at present used in industry. Rotary bending tests showed that a certain number of the alloys, in the spun state, had fatigue limits close to 12-13 kg./mm.², *i.e.* of the same order of magnitude as those of aluminium alloys of the Duralumin type. Corrosion tests in media of known chemical composition showed that, with the same aluminium content, addition of copper increases the facility of corrosion, slowly in the case of attack in acid medium and rapidly in the case of attack in a saline medium. Addition of aluminium to magnesium-copper alloys decreases very rapidly the rate of corrosion in sea-water, and with 3% aluminium or more the mean rates of corrosion of ternary alloys become of the same order (this holds for aluminium + copper = or less than 15%).—S. G.

***Alloys of Magnesium Research. I.—The Constitution of the Magnesium-Rich Alloys of Magnesium and Nickel.** John L. Houghton and Ronald J. M. Payne (*J. Inst. Metals*, 1934, **54**, 275–284).—A study of the constitution of magnesium alloys containing up to 50% of nickel, by thermal and microscopic methods. Magnesium forms a eutectic with the compound Mg_2Ni at a temperature of 508° C. and a composition of 23.5% nickel. The solubility of nickel in solid magnesium is less than 0.1%.—H. S.

***Light Alloys for Aeronautical Purposes, with Special Reference to Magnesium.** Leslie Aitchison (*J. Roy. Aeronaut. Soc.*, 1934, **38**, 382–400; discussion, 401–412; and (summaries) *Mech. World*, 1934, **95**, 117–118, 148–149, 202; *Metallurgia*, 1933, **9**, 49–52).—The influence of added elements on magnesium is described and the properties of the more important magnesium alloys are discussed in comparison with those of aluminium alloys. Reference is made to welding of magnesium-rich alloys, welded tanks, chromate and selenium treatments for protection against corrosion, and applications of magnesium-rich alloys for the construction of aircraft parts.—H. S.

***Conductivity, Viscosity, and Density of Dilute Liquid Amalgams of the Alkaline Earth Metals.** G. R. Paranjpe and V. S. Patankar (*J. Univ. Bombay*, 1933, **2**, (2), 40–61; *C. Abs.*, 1934, **28**, 5321).—Amalgams containing up to 0.364% barium, 0.455% strontium, and 0.023% calcium were studied at 30°–32° C. The electrical conductivity and viscosity of barium and strontium amalgams do not change with time. In the system barium–mercury the conductivity decreases with increasing concentration of barium except for sharp increases at 0.130, 0.225, and 0.325% barium; but the conductivity increases uniformly with increasing concentrations of strontium or calcium. The viscosity increases with increasing concentration of barium and shows maxima at 0.120, 0.220, and 0.323% barium. The density decreases uniformly with increasing concentration of barium. Thus barium resembles sodium and potassium; strontium and calcium resemble lithium in amalgams. Theory is discussed. 21 references are given.—S. G.

***Alloys of Nickel and Barium.** D. W. Randolph (*Electrochem. Soc. Preprint*, 1934, Sept., 375–379).—A brief outline is given of some of the properties of nickel–barium alloys and a description of a new alloy of nickel, copper, and barium. A method has been developed for producing a stable electron-emitting surface without the use of the usual oxide coating, which will probably extend the use of these barium alloys in vacuum tube construction.—S. G.

***The Temperature Variation of the Thermoelectric Properties and the Specific Heat of Nickel–Chromium Alloys.** Alan W. Foster (*Phil. Mag.*, 1934, [vii], **18**, 470–488).—Accurate measurements of the thermoelectric power of nickel and two alloys of nickel with 1 and 2% of chromium indicate that these alloys show only 30% and 10%, respectively, of the change in the Thomson coeff. at the Curie point found in nickel. The two alloys show, respectively, 55% and 30% of the drop in specific heat shown by nickel at the Curie point.

—J. S. G. T.

***Large Barkhausen Discontinuities and Their Propagation in Nickel–Iron Alloys [and in Pure Nickel].—II.** Raymond E. Reinhart (*Phys. Rev.*, 1934, [ii], **46**, (6), 483–486).—Cf. Reinhart, *Met. Abs.*, this volume, pp. 236, 295. The relationships between longitudinal field, intensity of magnetization, and velocity of propagation of large Barkhausen discontinuities have been investigated for pure nickel and 10% nickel–iron alloy under torsion or tension. For pure nickel only the component of field in the direction of maximum compression affects the velocity of propagation, in contrast to the 10% alloy, for which only fields in the direction of maximum elongation affects the velocity. This difference may be connected with the magnetostrictive properties, since these are opposite in sign, but the matter is very complex, since, with other compositions, alloys with the same magnetostrictive properties do not always have the same properties as regards velocity of propagation.—W. H. R.



*On the Silver-Copper Alloys. W. Broniewski and S. Koślacz (*Prace Zakładu Metallurgicznego Politechniki Warszawskiej*, 1933, 3, 46-58).—[In Polish, with French summary.] See *J. Inst. Metals*, 1932, 50, 351.—S. G.

*Tests on Tin-Base and Lead-Base Bearing Metals. C. Jakeman and Guy Barr (*Tech. Publ. Internat. Tin Res. Council*, Series A, No. 6, 1934, 1-23).—See *J. Inst. Metals*, 1932, 50, 734.—S. G.

*On the Influence of the Rate of Cooling on the Structure of Eutectics. G. Tammann and G. Moritz (*Z. anorg. Chem.*, 1933, 214, 414-426).—With a small degree of undercooling compact, many-sided crystals separate from a molten metal on solidification, whereas with a high degree of undercooling crystal filaments grow throughout the metal. In the crystallization of eutectic melts the following experimentally observed phenomena are derived from the conditions of diffusion: (1) the ends of the crystal filaments of the various constituents of a binary, ternary, or polynary eutectic melt lie in the same front; (2) with increasing rate of crystallization, the filaments of the eutectic become finer, and may eventually become too fine for microscopic detection; (3) in a binary eutectic the cross-sections of the filaments in a section perpendicular to their axes are not irregularly distributed, but one kind of filament surrounds the other; (4) the rate of crystallization of a eutectic is considerably smaller than that of either of the constituents alone. The conditions which cause shrinkage of the filaments of a eutectic are discussed. The following eutectics have been examined: bismuth-cadmium, bismuth-lead, bismuth-tin, tin-zinc, tin-cadmium, cadmium-lead, cadmium-zinc, lead-tin, bismuth-cadmium-lead, bismuth-cadmium-tin, lead-cadmium-tin, zinc-cadmium-tin, bismuth-cadmium-tin-lead. Brief notes on the hardness of the tin-zinc eutectic depending on its structure, and on the tensile strength of wires drawn from a eutectic melt of cadmium, lead, and tin are included.

—B. Bl.

*The Isothermal Crystallization or Transformation of Constant Masses in Relation to Time. G. Tammann (*Z. anorg. Chem.*, 1933, 214, 407-413).—In the formation of crystallization centres on the surface of a melt or of a crystal during polymorphic transformation, the quantity of crystallized metal first increases proportionally to the time, but subsequently the rate decreases. In the case of a transformation in a metal containing crystallization centres distributed at random throughout its mass, the curve showing the amount of crystallized metal as a function of the time has an S-shape; thus if n transformation centres are formed per second, and these grow to spheres with a linear velocity of r mm./sec., the volume V_z crystallized in z seconds will be: $V_z = n \cdot \frac{\pi}{6} \cdot r^3 \cdot \frac{z^2(z+1)^2}{4}$; this expression, however, applies only to the begin-

ning of the transformation. As the volume of still untransformed material decreases with time, n becomes smaller, at first slowly, then more rapidly, and hence the growth of V_z gradually becomes smaller with time, until, when the crystallization spheres touch one another, a very sharp decrease in the growth of V_z occurs. Among the examples of this behaviour discussed are the transformation of monoclinic to rhombic sulphur, the decomposition of Al_2Zn_3 at 256° C., and the decomposition of nickeliferous and manganiferous austenite.

—B. Bl.

The Mechanism of Inverse Segregation. O. W. Ellis (*Trans. Amer. Found. Assoc.*, 1933, 41, 347-369; discussion, 377-380).—An introduction to a symposium on deoxidation and degasification of bronze foundry alloys.—R. B. D.

*The Mechanical Properties of Metals at Low Temperatures. II.—Non-Ferrous Materials. E. W. Colbeck and W. E. MacGillivray (*Trans. Inst. Chem. Eng.*, 1933, 11, 107-120; discussion, 120-123).—Most of the metals and alloys tested showed increased strength and ductility at low temperatures. Solder, however, was brittle, possibly as a result of formation of grey tin. A

specially constructed extensometer and a hydraulic testing machine with cryostat were used, the construction, manipulation, and calibration of which equipment are fully described in this and the preceding paper.—A. B. W.

Superconductivity and Its Theoretical Importance. Carl Benedicks (*Arkiv Mat. Astron. Fysik*, 1933, **A23**, 1–29; *C. Abs.*, 1934, **28**, 16).—See *J. Inst. Metals*, 1933, **53**, 699, and *Met. Abs.*, this volume, p. 165. The equilibrium diagrams of indium–lead, mercury–lead, bismuth–lead, tin–thallium, indium–thallium, and lead–thallium are considered with the corresponding curves for normal conductivity and superconductivity. It seems possible to reconcile the breaks in the superconductivity curves with the corresponding breaks in the equilibrium curves by means of the “phoretic” or “contact” theory of electrical conductivity. The indium–lead curves especially indicate that superconductivity appears in exactly the same manner between atoms of different elements as between atoms of the same element. Numerous observations of unexpected superconductivity phenomena, e.g., superconductivity of Au₂Bi, are examined and shown to fit well into the phoretic theory, but not into others. The arguments for and against the phoretic theory of electrical conductivity are restated and amplified.—I. M.

Metallurgy at the Leipzig Spring Fair, 1934. J. F. Kesper (*Werkstatt u. Betrieb*, 1934, **67**, 175–177).—Recently developed proprietary alloys of special interest are the Cekas series, containing varying proportions of nickel, chromium, and iron; Corrix, a copper–beryllium iron alloy; Aluminium AW 15; Anticorodal. Approximate analyses are given in most instances, and in each case mechanical and physical properties and special applications are described.—P. M. C. R.

Special Alloys. Anon. (*Z. ges. Giesserei-Praxis: Das Metall*, 1934, **55**, 268, 290, 310).—Cf. *Met. Abs.*, this volume, pp. 125, 172, 346. The composition, some properties, and applications of the following alloys are given: Harder McFarland alloy, Harper’s metal, Hardit, Hauvel’s bronze, Haynes’ metal, Helmet bronze, HéLouis platinum bronze, Heyne-Biddery (zinc alloy), Everdur, Helumin, Hibbo, Hiduminium, Hiorns metal, Hipernick, Hohenzollern bearing metal, Erhards’ type metal, Eureka, and Eutectal.—J. H. W.

III.—STRUCTURE

(Metallography; Macrography; Crystal Structure.)

(Continued from pp. 445–447.)

***The Small-Scale Structure of Surfaces.** G. P. Thomson (*Phil. Mag.*, 1934, [vii], **18**, 640–656).—Evidence derived from experiments on electron diffraction leads to the following conclusions. In some cases the material near the cleaved or natural face of a single crystal is correctly aligned to 10’ or less. The surface, apart from steps, is sometimes smooth, but sometimes carries narrow ridges less than 10⁻⁶ cm. thick. In many cases the surface is broken into small regions of the order 10⁻⁵ cm. These regions sometimes keep their parallel alignment; they are most likely to be distorted in metals. Etching leaves a surface of projections and ridges many of which are not more than a small multiple of 10⁻⁷ cm. thick. Some surfaces of polycrystalline aggregates carry projections not more than about 10⁻⁶ cm. thick. Such surfaces are formed by deposition of evaporated metal, by cathodic sputtering, and by etching. Heat-treatment and, sometimes, merely keeping, may produce recrystallization associated with increase in the size of individual crystals, and often their orientation in preferred directions. Polishing of metals produces an amorphous surface layer not usually flat, but covered with ridges or waves.—J. S. G. T.

Some Statistical Properties of an Annealed Alpha-Grain Aggregate.—III. R. G. Johnston and W. G. Askew (*Met. Ind. (Lond.)*, 1934, **45**, 219–221).—The mathematical reasons for using “mean intercepts” (equal to the ratio of the mean area of a grain to its mean width) are given. It is suggested that possible and convenient items for specifying grain-size are: (1) mean area; (2) mean intercept; (3) high limit of maximum diameter. Since mean values alone may be misleading, it is further suggested that the largest maximum diameter to be tolerated in a half- or quarter-plate field $\times 100$, and the values of the mean intercept above and below which the pattern will be regarded as unsuitable be given. See *Met. Abs.*, this volume, pp. 298, 420.—J. H. W.

A Microscopic Analysis of Sprayed Metals. T. W. Lippert (*Iron Age*, 1934, **134**, (9), 8–13).—A description of the microscopic aspect of sprayed metal coatings is given, and observations are made representing elaborations of laboratory research as reported by — Schenk (Berlin) and H. Reininger (Leipzig).—J. H. W.

Smoothing and Etching. H. B. Pulsifer (*Metal Progress*, 1934, **26**, (2), 31–34).—Improvements in hand-finishing technique include the use of a moist pat or flat pile of abrasive for the final polish. A very slightly concave surface is given, but if the specimen is not too thick in proportion to its area, the degree of rounding does not impair the sharpness of the photographic image at magnifications up to $\times 1000$. The process is described in detail, with the necessary adaptations in the case of softer materials. Work is greatly accelerated by the application of a light etch at intervals during finishing. P. advises certain modifications in etching methods, notably slow etching in dilute reagents. Appropriate reagents are indicated for various classes of materials.—P. M. C. R.

A Theory of Temperatures of Fusion, Recrystallization, and Polymorphic Transformation Temperatures. L. Tarschisch (*Physikal. Z.*, 1934, **35**, 469–471).—A mathematical theory, based on considerations of lattice energy and results derived by Lindemann, for deducing the temperatures of fusion, recrystallization, and transformation, is briefly discussed.—J. S. G. T.

***Surface Magnetization in Ferromagnetic Crystals.** L. W. McKeegan and W. C. Elmore (*Phys. Rev.*, 1934, [ii], **46**, 226–228).—Photographs are shown of the patterns formed by a colloidal suspension of ferric oxide on an etched disc of single-crystal silicon-iron resting on the core of an electromagnet. On reversing the field the dark lines of the pattern become white spaces and *vice versa*. The results suggest that the surface layer is composed of roughly cubical blocks of length about 2μ along each edge magnetized parallel to the surface either along a $\langle 100 \rangle$ direction or a $\langle 110 \rangle$ direction.—W. H.-R.

***Theory of the Heat-Treatment of Magnetic Materials.** R. M. Bozorth (*Phys. Rev.*, 1934, [ii], **46**, 232–233).—A note. A permeability of more than 600,000 has been obtained by heat-treating Permalloy (65% nickel) in a magnetic field, and a theory of this effect is developed. B. assumes that when a ferromagnetic substance cools through the Curie point in the absence of a magnetic field, small domains become magnetized to saturation along the $\langle 100 \rangle$ directions. Magnetostrictive stresses then arise which tend to make the domain expand in the direction of local magnetization and contract at right angles to it. This change of shape is prevented by the restraining action of surrounding domains, but if held for a sufficient time at a high enough temperature (below the Curie point) plastic flow is assumed to take place, and on this hypothesis a satisfactory explanation of the effects of temperature, rate of cooling, &c., is obtained.—W. H.-R.

***X-Ray Investigations Relating to Calcium at High Temperatures.** L. Graf (*Physikal. Z.*, 1934, **35**, 551–557).—Above 450°C . calcium can exist with a cubic space-centred lattice or with hexagonal closest-packed spherical

lattice; *pure* calcium occurs in the latter form only. A second transformation occurs at about 300° C., and a third, occurring at about 218° C., characterizes *pure* calcium.—J. S. G. T.

***Lattice Energy Due to Lattice Distortion of Cold-Worked Copper.** W. A. Wood (*Phil. Mag.*, 1934, [vii], 18, 495–505).—Cold-working is shown, by X-ray crystal analysis, to produce an irregular expansion of the crystal lattice of copper, and the increase of latent energy due to the production of maximum lattice distortion in copper is shown to be of the order 1.7 cal./grm.—J. S. G. T.

X-Ray Investigations of the Fine Structure of Copper. F. Lihl (*Z. Physik*, 1934, 89, 537–545).—It is shown that there is parallelism between the fine structure details of copper and of iron subjected to various stresses. Lattice distortions on fracture are dependent only on the energy supplied to the lattice.—J. S. G. T.

On the X-Ray Absorption Spectrum of the Alloy AuCu. Takesi Hayasi (*Naturwiss.*, 1934, 22, 90).—Note on a paper by Coster and Veldkamp (*Z. Physik*, 1932, 74, 191).—J. W.

***Surface Magnetization in Ferromagnetic Crystals [of Nickel].—II.** L. W. McKeehan and W. C. Elmore (*Phys. Rev.*, 1934, [ii], 46, 529–531).—A note. The patterns formed by a magnetic colloid on a plane nearly parallel to the [100] plane of a single crystal of nickel have been studied in a magnetic field normal to the surface. The colloid particles collect into dots, and when the field is reversed the positions of the dots change so that prominent dots with the field in one direction occur in places which are featureless when the field is reversed. The patterns are quite different from those previously found for iron (*ibid.*, p. 226) in agreement with the difference in crystal structure. The bearing of the patterns on the nature of the elementary domains is discussed.—W. H. R.

***On the Constitution of Metallic Sodium.** E. Wigner and F. Seitz (*Phys. Rev.*, 1934, [ii], 46, 509–524).—Cf. Wigner and Seitz, *J. Inst. Metals*, 1933, 53, 352. The wave mechanical electron theory of metals is extended for the lattice of sodium. The results show that the electrons behave almost as if they were free. The slight discrepancies are discussed, and when suitable corrections are made a good agreement is obtained between the observed and calculated values for the binding energy and lattice constant.—W. H. R.

***Solid Solution Formation in Single- and Multi-Crystalline Material.** E. Schmid and G. Siebel (*Z. Physik*, 1933, 85, 36–55).—Changes of lattice constants accompanying changes of composition in single crystals of the series of alloys aluminium-magnesium, zinc-magnesium, and silver-copper agree, within the limits of experimental error, with those characterizing the corresponding multi-crystalline alloys. The saturation limits of the solid solution formation of the aluminium-magnesium and silver-copper series of alloys, determined for single crystals, agree with those found by other observers for the multi-crystalline alloys. Wiest's results to the contrary (*ibid.*, 1932, 74, 225; 1933, 81, 121) are discussed, but are not satisfactorily explained.—J. T.

A Type of Lattice Distortion which might Render a Crystal Plastic. M. Polanyi (*Z. Physik*, 1934, 89, 660–664).—If a lattice distortion be conceived in which n atoms in one lattice atomic layer become apposed to $n + 1$ atoms in the other, then the thrust resistance in the slip plane is reduced to about $1/n$ of its value in the undisturbed lattice.—J. S. G. T.

The Structure of Metals in Comparison with Other Crystal Structures. P. Niggli (*Schweiz. mineralog. petrog. Mitt.*, 1931, 11, 290–295).—Cf. *Z. Krist.*, 1931, 77, 140–145.—S. G.

X-Ray Investigation of Fine Structure as an Aid in Electroplating. I.—Principles of Fine Structure Examination by X-Rays. H. Reininger (*Metallwaren-Ind. u. Galvano-Tech.*, 1934, 32, 259–262, 283–285, 360–362, 383–384, 409–410, 427–429).—The principles, on which the method of examining the

lattice structure of metals by X-rays is based, are explained at length with reference to numerous diagrams.—A. R. P.

***Fourier Integral Analysis of X-Ray Powder Patterns.** B. E. Warren and N. S. Gingrich (*Phys. Rev.*, 1934, [ii], 46, 368–372).—A method is developed for the harmonic analysis of X-ray powder patterns, so that the experimental scattering curves yield directly a radial distribution function giving the number of atoms at any distance from a given atom.—W. H.-R.

***A Fourier Series Method for the Determination of the Components of Interatomic Distances in Crystals.** A. L. Patterson (*Phys. Rev.*, 1934, [ii], 46, 372–376).—Theoretical.—W. H.-R.

The X-Ray Investigation of Crystal Structure. W. E. Schmid (*Arch. tech. Messen*, 1934, 4, (37), T94).—A brief summary of the fundamental conception and of the chief methods of investigating crystal structure by the use of X-rays is illustrated by an account of constitutional work by Westgren and Phragmén on certain zinc-copper alloys (see *J. Inst. Metals*, 1931, 47, 25).—P. M. C. R.

IV.—CORROSION

(Continued from pp. 448–449.)

***Numerical Results Relating to Chemical Methods of Cleaning Light and Ultra-Light Metals after Corrosion.** Marcel Chaussain and Henri Fournier (*Rev. Mét.*, 1934, 31, 201–211).—Cf. *Met. Abs.*, this volume, p. 242. The influence of immersion in nitric acid (*d* 1.33) at various temperatures, on aluminium and Duralumin is examined from the point of view of amount of metal dissolved. At 15°–35° C. the loss of metal is small; with less concentrated acid the loss is greater. The rate of loss in concentrated acid is greatest in the first few minutes, and afterwards steady, but corroded metal dissolves faster than uncorroded on account of increased surface. In cleaning magnesium alloys, chromic acid causes very little loss of metal provided it is free from sulphuric acid as impurity. Chromic acid solution to which silver chromate or both silver and barium chromates had been added showed practically no continuous attack on magnesium. Potassium bichromate did not attack magnesium, but gave incomplete cleaning and required an inconveniently long time.—H. S.

***The Effect of Heat-Treatment on the Corrosion of High-Purity Aluminium.** F. A. Rohrman (*Electrochem. Soc. Preprint*, 1934, Sept., 121–128).—A study is made of the corrosion of carefully annealed, high-purity cast aluminium which had been subjected to different quenching temperatures. When nearly identical samples of this metal were given the same annealing treatment, yet subjected to different quenching temperatures, a very great difference was noted in their behaviour in hydrochloric acid solutions. Furnace-cooled samples and those quenched from a few degrees above room temperature show a slightly greater initial rate of attack, whilst those quenched from the higher temperatures show a decided intergranular attack which finally results in their complete disintegration. No definite reasons are presented to account for the anomalous behaviour, although several possible explanations are discussed.

—S. G.

†**The Corrosion of Light and Ultra-Light Alloys.** P. Bastien (*Chim. et Ind.*, 1934, 32, 10–20).—The alloys of aluminium and magnesium are, as is well known, susceptible to atmospheric and other corrosion. B. discusses the reactions between these metals and their alloys and corroding agents, the acceleration of corrosion, the determination of rates of attack and methods of testing, and the results obtained in the manufacture of materials resistant to

corrosion. For the purposes of the review, corrosive action is divided into 3 phases: (1) uniform dissolution; (2) local attack; (3) intercrystalline. The measurement of the progress of corrosion is discussed under the following heads: (1) by determination of weight and volume of gas disengaged; (2) by alteration in mechanical properties; (3) by change in reflecting power; (4) by amount of heat liberated. The influence of impurities in increasing the corrodibility of aluminium and magnesium has been recently studied, and results and curves showing the effects are included.—W. A. C. N.

An Improved Test to Determine the Reactivity of Aluminium and Aluminium Alloys. H. Rohrig (*Light Metals Research*, 1934, 3, 22-24).—Translated from *Korrosion u. Metallschutz*, 1934, 10, 38-39. See *Met. Abs.*, this volume, p. 302.—J. C. C.

Aluminium in the Brewing Industry and Its Corrosion. H. Hoffman (*Petit J. Brasseur*, 1934, 42, 10-11; *C. Abs.*, 1934, 28, 5171).—A brief description of the application and corrosion of aluminium in the brewing industry.—S. G.

Corrosive Effect on Metal of Certain Cleansing and Disinfecting Agents Important in the Dairying Industry. W. Mohr and R. Kramer (*Proc. World's Dairy Congr., Milan*, 1934, Sect. II, 111-114; *C. Abs.*, 1934, 28, 5543).—The addition of water-glass protects aluminium against soda solutions, but not against potash. The chromates increase protection of aluminium against potash. Many commercial preparations contain these substances. Alloys are attacked by phosphates only if the alloy is of a basic nature such as zinc, tin, zinced-iron, or aluminium. Corrosion is never observed if the alloy contains a noble metal such as copper or nickel. Milk promotes corrosion by cleansing agents based on water-glass, trisodium phosphate, and chlorine compounds. In such cases the utensils should be thoroughly washed with water.—S. G.

Aluminium. R. Seligman (*Sci. J. Roy. Coll. Sci.*, 1934, 4, 33-40; *C. Abs.*, 1934, 28, 5013).—A review of the properties of aluminium and some of its alloys, especially their resistance to chemical corrosion.—S. G.

†**On the Relation Between Rate of Dissolution, Nature of the Solvent, and Lattice Forces in Copper Single Crystals.** R. Glauner (*Korrosion III, Bericht über die III. Korrosionstagung, Berlin*, 1933, 36-41).—Recent work on the rate of dissolution of different crystal faces of single crystals of copper in various acids containing dissolved oxygen or hydrogen peroxide is reviewed and the results are briefly summarized.—A. R. P.

***Resistance of Stainless Alloys and "Aluminium-Bronzes" to Phosphoric Acid.** O. T. Vehr and M. M. Romanov (*Metallurg (Metallurgist)*, 1934, (1), 48-57).—[In Russian.] See *Met. Abs.*, this volume, p. 424.—N. A.

***Influence of Metallic Impurities on the Corrosion of Lead in Sulphuric Acid Production.** V. K. Pershke (*Khimstroï*, 1934, 6, 284-287; *C. Abs.*, 1934, 28, 5933).—[In Russian.] Different samples of pure lead (Kahlbaum) alloyed in various proportions with antimony, bismuth, tin, copper, zinc, and silver were exposed to the action of commercial lead-chamber acid containing 1.72% N oxides (based on nitric acid) at 20° C. for 40 hrs. and at 200° C. for 6 hrs. The tabulated results show that bismuth has the greatest corrosive influence, tin somewhat less, antimony and copper very little, if at all, and zinc and silver in the cold have no effect and at 200° C. retard the corrosion. 27 references are given.—S. G.

***The Corrosion and Protection of Magnesium and Its Alloys.** G. D. Bengough and L. Whitby (*J. Roy. Aeronaut. Soc.*, 1934, 38, 413-431).—Paper read before the Institution of Chemical Engineers in 1933; see *Met. Abs.*, this volume, p. 179.—H. S.

***Silver Alloys Resistant to Blackening by Sulphurization.** H. Forestier (*Chim. et Ind.*, 1934, Special No., (April), 589-591; *C. Abs.*, 1934, 28, 5388).—The resistance of silver alloys used in goldsmiths' work to blackening under the action of sulphur can be considerably increased, without any great

increase in price, by replacing copper by cadmium or antimony, with or without addition of a ternary constituent.—S. G.

***Action of Nitric Acid on Tin.** G. S. Kasbekar and A. R. Normand (*J. Univ. Bombay*, 1933, 2, (2), 111–122; *C. Abs.*, 1934, 28, 4996).—In 28 experiments excess nitric acid acted on tin, both in known amounts; the time of complete reaction and the composition of the resulting products were studied as functions of the concentration of nitric acid and of temperature. Analyses are expressed as Sn^{2+} , Sn^{4+} , NO , N_2O , N_2 (the last 3 representing the total volume of gas evolved), NH_3 and NH_2OH ; HNO_2 and N_2H_4 are negligible in the experimental conditions. With increase of temperature or of concentration of nitric acid the amounts of Sn^{4+} and of gaseous products increase, whilst Sn^{2+} , NH_3 , and NH_2OH decrease. Equations proposed for the separate reactions are ($A = \text{HNO}_3$, $Aq = \text{H}_2\text{O}$): $3\text{Sn} + 16A = 3\text{Sn}^{4+} + 4\text{NO} + 8Aq$; $2\text{Sn} + 10A = 2\text{Sn}^{4+} + \text{N}_2\text{O} + 5Aq$; $5\text{Sn} + 24Aq = 5\text{Sn}^{4+} + 2\text{N}_2 + 12Aq$; $4\text{Sn} + 9A = 4\text{Sn}^{2+} + \text{NH}_3 + 3Aq$; $5\text{Sn} + 14A = 4\text{Sn}^{2+} + \text{Sn}^{4+} + 2\text{NH}_2\text{OH} + 4Aq$. The last process is in a class by itself. These equations account satisfactorily for the quantitative data, and are thus to be accepted as representing the actual modes of reduction of the excess nitric acid by nascent hydrogen.

—S. G.

***Investigations on Resistant Alloys for the Potassium Salt Industry.** V. K. Pershke (*Chim. et Ind.*, 1934, Special No., (April), 531–535; *C. Abs.*, 1934, 28, 5385).—Phase diagrams are given of the systems copper–aluminium–nickel–iron and copper–aluminium–zinc–iron. The velocity of corrosion of the binary, ternary, and quaternary alloys in solutions of sylvinit, carnallite, and magnesium chloride was measured, and corrosion found to be most rapid in magnesium chloride. Alloys with compositions near to the regions of solid solution showed the greatest resistance. The most resistant contained copper 82.5, aluminium 8.2, nickel, 5.1, iron 3.8%. The alloys are 5–6 times as resistant as ordinary brasses and bronzes, and possess superior mechanical properties.—S. G.

***Corrosion of Metals by Hydrochloric Acid, Chlorine, and Carnallite.** V. K. Pershke and L. A. Pecherkina (*Khimstroï*, 1934, 6, 140–141; *C. Abs.*, 1934, 28, 5029).—[In Russian.] Iron and copper alloys subjected to the action of gaseous hydrochloric acid and chlorine and carnallite at temperatures of 300°–700° C. showed highly destructive corrosion.—S. G.

Corrosion and Corrosion-Resistant Alloys for the Cellulose and Paper Industries. Fritz Ohl (*Metallbörse*, 1934, 24, 645–646, 714).—Tabulated data are given for the corrosion of various chromium–nickel alloys and non-rusting steels in acid and alkaline solutions and in gas mixtures containing sulphur dioxide such as are used in the paper industry.—A. R. P.

***Corrosion of Metals in the Process of Phenylation of Peri Acid.** Z. N. Suirkin and S. P. Smirenskii (*Anilinokrasochnaya Prom.*, 1934, 4, 221–226; *C. Abs.*, 1934, 28, 5389).—[In Russian.] The tests were made with various alloys of iron, cast iron, lead, and aluminium in an enamelled kettle by phenylating purified $1.8\text{-H}_2\text{NC}_{10}\text{H}_6\text{SO}_3\text{H}$ (I) (contaminated with about 7% $1.5\text{-H}_2\text{NC}_{10}\text{H}_6\text{SO}_3\text{H}$ (II), 10% NaCl and 1–1.5% iron sludge) with and without the addition of one or more of the impurities. All tested alloys of iron showed considerable corrosion; the effect is somewhat increased with the addition of iron sludge and II and is doubled with 10% NaCl . Analogous results were obtained with commercial I. Cast iron is similarly affected, the addition of iron sludge producing greater corrosion than that with iron. Cast irons containing silicon show better resistance to corrosion, and are practically non-corrodible with 9–14% silicon. The addition of chromium or nickel shows no improvement in the resistance. Lead is inferior to iron and cast iron; the addition of iron sludge and II increases the corrodibility, whilst the addition of sodium chloride decreases it. Aluminium (aluminium 98.98, iron 0.8, and

silicon 0.28%) is practically not corroded with pure and commercial I free from sodium chloride, the corrosion increasing in proportion to the added sodium chloride.—S. G.

†**Inter-crystalline Corrosion in Various Metals and Alloys, Especially in Non-Rusting Steels.** A. Fry and P. Schafmeister (*Korrosion III, Bericht über die III. Korrosionstagung, Berlin, 1933, 12-22*; discussion, 22).—Recent work is critically reviewed and the conclusions are summarized. For the development of inter-crystalline corrosion the following conditions are essential: a weak corrosive medium, precipitation of constituents or segregation of impurities along the grain boundaries, the presence of macro- or micro-tensile stresses. The removal of only one of these sources of trouble completely stops inter-crystalline corrosion; this is particularly illustrated by the case of nickel-chromium stainless steel.—A. R. P.

Corrosion of Metal Structures Due to Stray Currents. O. Scarpa (*Compt. rend. congr. internat. élect.*, 1932, 9, 223-254; *C. Abs.*, 1934, 28, 5796).—A review, together with many additional data and illustrations upholding the electrochemical theory of corrosion.—S. G.

Combating Electrolysis (Corrosion) Due to Stray Currents. M. Horioka, M. Iwasa, and T. Kyogoku (*Compt. rend. congr. internat. élect.*, 1932, 9, 255-258; *C. Abs.*, 1934, 28, 5796).—A brief outline of researches carried out in government laboratories in Tokyo.—S. G.

Electrolysis of Underground Pipes. R. Gibrat (*Bull. Assoc. Suisse Élect.*, 1934, [v], 4, 749-842).—The question of soil corrosion is reviewed theoretically. G. considers that over-simplification of the problem has led to wrong conclusions, and advances an analysis based on integro-differential equations, as the only method of taking into account the various masses and reactions concerned. The use of Schlumberger's apparatus, the theoretical basis of which is fully discussed, is described in 2 cases—one in which lead cable sheathing suffered severe attack in the neighbourhood of tram-lines, and a second where supply cables, although present, played little part in the attack, which accompanied the presence of chlorides in the soil.—P. M. C. R.

Note on the Preparation of Specimens for Corrosion Tests of Sheets. Albert Portevin (*Rev. Mét.*, 1934, 31, 212-213).—When sheet specimens for mechanical tests are machined to dimensions before being exposed to corrosion tests, the results of tests differ from those obtained on specimens machined from sheet samples which have been subjected to the corrosion test as such, and frequently show great variation in themselves. This is due to preferential attack on the edges of the specimens. P. shows that the loss of metal from sheets due to corrosion, per unit of surface exposed decreases with increase of surface exposed.—H. S.

***Measurement of the Effects of Corrosion by Diminution of the Results of the KWI [Siebel and Pomp] Cupping Test.** J. Cournot and H. Fournier (*Rev. Mét.*, 1934, 31, 193-200).—Cf. *Mét. Abs.*, this volume, p. 80. Discs having a central hole are pressed so that the hole is in the centre of the depression, the test being continued until a crack or cracks commence to develop from the edge of the hole. Specimens which had been subjected to a spray of artificial sea-water for 2 months were tested alongside unexposed pieces. The results obtained on Duralumin and brass showed very marked reduction by corrosion as regards both the load applied and the extent of the deformation. On materials less susceptible to inter-crystalline corrosion, Armco iron, Monel metal, &c., a much smaller reduction was observed. The KWI (Siebel and Pomp) test showed up the effect of corrosion more than the Persoz test.—H. S.

Study of Corrosion of Thin Sheet Test-Pieces. Marcel Prot and N. Goldowski (*Chim. et Ind.*, 1934, Special No., (April), 555-556; *C. Abs.*, 1934, 28, 5390).—In order rapidly to determine the liability to pitting, a sheet is ground down to a thickness of 0.1 ± 0.01 mm., formed into a cylinder 70 mm. in diameter by

60 mm. high, and subjected to the action of the corroding solution. Pitting appears in a period of from a few hrs. to a few days.—S. G.

Notes on Accelerated Tests of Marine Corrosion. E. Herzog and G. Chaudron (*Chim. et Ind.*, 1934, Special No., (April), 572-574; *C. Abs.*, 1934, 28, 5390).—A brief discussion of the importance of the condition of the dissolved oxygen and of the composition of the saline solution on the results and interpretation of such tests.—S. G.

***Colour Macroscopy with p_{H} Indicators.** Marcel Prot and N. Goldowski (*Rev. Mét.*, 1934, 31, 214-218; and *Chim. et Ind.*, 1934, Special No., (April), 442-443).—Corrosion effects due to couples in heterogeneous metallic subjects are revealed by applying an electrolyte containing a mixture of indicators constituting a universal p_{H} indicator. After pickling or etching the pieces, the authors apply a 10% solution of gelatine containing the indicators. Colorations are seen after several hours. In light alloys the zones of maximum corrosion appear orange-red in a blue background; subsequent corrosion tests show strong attack at the places where red coloration was observed in the coloroscopic test. The test is used to observe the effect of rivets, inserts of various kinds, welds, heat-treatments, &c.—H. S.

Corrosion and Protection of Metals. U. R. Evans (*Chim. et Ind.*, 1934, Special No., (April), 158-168).—A review, with a bibliography of 54 references.—S. G.

Why Do Some Metals Resist Oxidation? K. Heindhofer and B. M. Larsen (*Metal Progress*, 1934, 26, (3), 34-37).—Resistance to oxidation is attributed to the ability to form an impenetrable, coherent, and self-repairing protective film of oxide. Such films may thicken very greatly at high temperatures, protection then depending on the following: low dissociation pressure of oxide as compared with that of partial pressure of the oxygen in the enveloping atmosphere at working temperature; non-volatility of oxide; temperature of oxidation. Temperature-oxidation curves are shown for palladium and iron, and time-scale-formation curves for certain nickel-iron, chromium-iron, and chromium-nickel alloys.—P. M. C. R.

Work of the "Commission aéronautique pour l'étude de la corrosion."—I. R. Cazaud (*Rev. Mét.*, 1934, 31, 386-395).—A survey of the work of the commission on corrosion of iron. Special attention is paid to passivity.—H. S.

V.—PROTECTION

(Other than Electrodeposition.)

(Continued from pp. 449-451.)

***Repair and Upkeep of Metal Hulls and Floats for Hydroplanes.** R. Lecocuvre (*Chim. et Ind.*, 1934, Special No., (April), 547-554; *C. Abs.*, 1934, 28, 5390).—After a review of the present status of the problem, an outline is given of tests at present being carried out by the Commission de Recherches contre la Corrosion des Produits Métallurgiques de l'Aviation, on the possibility of protecting from further attack light alloys that have undergone a certain amount of corrosion. Promising results have been obtained along 3 lines: treatment of the corroded surface (without removing existing corrosion) by an oxidizing process; application of a pitch-phenol coating (cf. Aubert and Pignot, *Rev. Mét.*, 1929, 26, 310-312); application of a metal coating by hot-spraying.—S. G.

Chemical and Electrochemical Surface Treatment of Aluminium. W. Wiederholt (*Light Metals Research*, 1934, 3, 122-129).—Translation of a paper read before the Verein deutscher Chemiker. The principles of chemical and

electrochemical treatments for forming oxide coatings on aluminium are discussed. Chemical treatments depend on the fact that solutions having a p_H value between 4 and 8 have no marked dissolving action on the metal. In the acid region there is a well-marked induction period, and pitting and etching result. In alkali solutions, however, attack proceeds uniformly regardless of the presence of impurities, being finally brought to a standstill by the formation of insoluble compounds. Alkali solutions of various complexity are used for chemical treatments, acid solutions for electrochemical treatments. Variations in the character of the current and temperature of the electrolyte change the character of the anodically produced film.—J. C. C.

***Prevention of Corrosion of Aluminium and Its Alloys.** Masahiro Tazaki (*Tetsu to Hagane*, 1934, 20, 42–46; *C. Abs.*, 1934, 28, 5028).—[In Japanese.] Anodic oxidation in a mixture of potassium and sodium nitrates at 220°–50° with a.c. potential of 100 v. and current density of 4 amp./cm.² for 1 hr. for aluminium and at 500°–10° with a.c. potential of 65 v. and current density of 4 amp./cm.² for 30 minutes for Duralumin gave good protection against corrosion in sea-water. The tensile strength was scarcely changed.—S. G.

Anodic Oxidation of Aluminium and Its Alloys. H. Sutton (*Compt. rend. congr. internat. elect.*, 1932, 9, 123–127).—A review.—S. G.

Corrosion-Resistant Coating of Aluminium Alloys. Anon. (*Apparatebau*, 1934, 46, 102–103).—The corrosion-resistance of age-hardenable aluminium alloys containing copper and coated with aluminium is increased if the alloy sheet is at first coated with a very thin cadmium layer. This intermediate layer prevents copper from diffusing into the outer aluminium layer on heat-treatment.—M. H.

***Electrolytic Treatment of Zinc.** Joseph Schulein (*Electrochem. Soc. Preprint*, 1934, Sept., 357–360).—When zinc or zinc-treated articles are treated as a.c. electrodes in a chromic bath, the zinc surface is chemically changed and the corrosion-resistance is greatly increased. The zinc compound formed on the surface is not definitely known, nor is the theory of the reaction as yet satisfactorily formulated. Preliminary results on the corrosion-resistance of electro-galvanized steel treated by this chromic acid process are recorded.—S. G.

Method of Coating Metals or Alloys by Displacement of Other Metals Having a More Marked Electropositive Character. H. Forestier (*Chim. et Ind.*, 1934, Special No., (April), 592–594; *C. Abs.*, 1934, 28, 5389).—By displacement of the metal from one of its salts by another metal that is less electropositive, in organic solvents, adherent deposits similar to, although thinner than electrolytic deposits are obtained.—S. G.

Metal Coatings as Corrosion Protectives on Iron. Sven Brenner (*Tek. Tids. Uppl. C., Bergsvetenskap* 64, 1934, 33–36; *C. Abs.*, 1934, 28, 5026).—The extent to which metal coatings, produced by dipping or electroplating, may attack the base metal through their electrochemical properties if the coating is damaged is studied. To determine this it is recommended to couple a small surface of the base metal to a large surface of the coating and to measure the current in the circuit when immersed in the corrosive solution. The method is very sensitive, and gives a good illustration of possible corrosive conditions. (Cf. following abstract.)—S. G.

Metal Coatings as Corrosion Protectives on Iron. Sven Danieli (*Tek. Tids. Uppl. C., Bergsvetenskap* 64, 1934, 56; *C. Abs.*, 1934, 28, 5797).—D. disagrees with the conclusions advanced by Brenner (preceding abstract) that the experimental determinations of the corrosion-resistance of galvanized iron by the method described are decisive for all practical applications. D. cites the results of practical comparative investigations of the corrosion-resistance of hot-galvanized and electrolytically galvanized iron, showing that the latter, even when carrying a considerably thinner zinc coating than the former, may be the preferable one.—S. G.

Method for the Determination of the Quality of Tinning of Tinned Copper Wire. A. R. Matthis (*Ingénieur chimiste*, 1934, 18, 48-57).—The various methods of testing used in different countries are discussed. The Glover test and the similar test used in Australia, which depend on alternating dilute hydrochloric acid pickling and sulphide treatment to detect removal of the coating, have the disadvantage of testing only a small specimen, and the solution methods of Schürmann and Blumenthal and of Rossem and Dekker are undesirably lengthy. In the method proposed by M. a long representative specimen is used, the surface exposed being 0.04 m.². Thin wire is wound on a glass bobbin and thick wire shaped by winding on a wooden mandrel. The specimen is immersed in ammonia (0.910) for 5 minutes, the containing vessel being slowly revolved horizontally. The ends of the wire are covered with wax. Estimation of the copper dissolved may be by electrolysis or by colorimetric test. Where the wire has already been in contact with rubber insulation it is given a preliminary soaking in benzine. Any film of sulphide or oxide is readily attacked by ammonia, and does not affect the subsequent test.—R. G.

***Investigations of the Quality of Tinplate for Canning Foods.—II, III.** Gulbrand Lunde and Erling Mathiesen (*Tids. Hermetikind.*, 1933, 19, 346-356; 20, 17; *C. Abs.*, 1934, 28, 5389).—(II.—) The quality of tin-plate for cans was tested by thorough physical, chemical, and microscopic examination of the metal. Brittleness along (not across) the grain of the rolled metal is a major source of weakness. Defective and deficient tinning were sometimes observed. The proportion of tin which alloys with the iron is an important factor; so is the texture of the iron, which should be very fine-grained. Lead content was always low. Porosity tests were also made. (III.—) Tests on 11 specimens for thickness, brittleness, pitting, behaviour, and thickness and porosity of the tin showed that quality has improved since previous tests.

—S. G.

A New Galvanizing Process. Anon. (*Draht-Welt*, 1934, 27, 500-501).—A brief abstract of a wire galvanizing process giving an operation sequence which includes wiping after hot-dipping and "galvannealing." (See *Met. Abs.*, this volume, p. 351).—A. B. W.

Electro galvanizing of Iron Barrels. A. Wogrinz (*Kalt-Walz-Welt* (Monthly Suppt. to *Draht-Welt*), 1934, (7), 54-55).—Specifications of plant, labour, and working schedule for preparation and plating of barrel bodies and rims with zinc. Refers only to the use of proprietary plating materials.—A. B. W.

†Advances in the Painting of Aluminium and Aluminium Alloys. —Eckert (*Korrosion III, Bericht über die III. Korrosionstagung, Berlin, 1933*, 61-65; discussion, 65-67).—The principles underlying the painting and lacquering of aluminium and its alloys are briefly discussed. Adherence in all cases is better on artificially oxidized surfaces than on mechanically roughened surfaces. Good finishes can be obtained by baking artificial resins on to surfaces oxidized by the M.B.V. process. The effect of pigments is discussed.—A. R. P.

***Investigations on Anti-Rusting Paints, with Special Reference to Under-Water Painting.** A. V. Blom (*Bull. Assoc. Suisse Élect.*, 1934, 25, 365-370).—An exhaustive series of paint exposure tests is described, covering a minimum testing period of 2 yrs. Immersion was either continuous, alternating water and sunny atmosphere, or alternating water and dull atmosphere, and ordinary weathering tests were made in comparison. Among materials tested, oil paints containing aluminium powder free from lead suffered complete destruction, excepting the weathered sample, which sustained surface attack only. With red- or white-lead priming, completely immersed samples showed attack of varying degrees of severity. The sample exposed to alternating immersion and dull atmosphere was unaffected, whilst alternate immersion and exposure to sunlight caused attack varying between slight surface effects and complete destruction. Aluminium paint over a special priming of synthetic resin gave

somewhat improved results, but the alternation of immersion and sunlight proved destructive in most cases. The general conditions of effective application are discussed.—P. M. C. R.

VI.—ELECTRODEPOSITION

(Continued from p. 452.)

***The Electrodeposition of Ternary Alloys of Cadmium, Tin, and Zinc.** Lawrence E. Stout and Bernard Agruss (*Electrochem. Soc. Preprint*, 1934, Sept., 345-356).—Ternary alloys of cadmium, zinc, and tin can be deposited from solutions containing the complex cyanides of cadmium and zinc, sodium stannate, sodium hydroxide, and free sodium cyanide. Excellent resistance to corrosion is offered by deposits high in tin. Almost without exception alloys with even small tin contents withstand salt-spray better than non-tin bearing deposits. Deposition of cadmium is favoured over the deposition of tin and zinc. A comparatively large concentration of tin in the bath is required to produce an appreciable tin content in the deposit. An increase in the cadmium and tin concentrations in the bath produces an increase in their compositions in the deposit. Increasing the zinc concentration of the bath decreases the content of that metal in the deposit at low current densities. At higher current densities zinc behaves similarly to cadmium and tin. At 20° C. the tin and zinc contents of the deposits decrease, whilst the cadmium content increases with increasing current density. At 2 amp./dm.² the tin and zinc contents of the deposit increase, whilst the cadmium content decreases with increasing temperature. At 0.5 amp./dm.² the zinc content of the deposit decreases with increasing temperature. The behaviour of tin and cadmium do not change.—S. G.

The Action of Iron on the Conductivity of Chromium Plating Baths. Oskar Krämer (*Metallwaren-Ind. u. Galvano-Techn.*, 1934, 32, 262-263).—Cf. *Met. Abs.*, this volume, p. 307. The presence of iron in the electrolyte narrows the range within which bright deposits are obtained and reduces considerably the throwing power.—A. R. P.

Research Points Way to Improved Methods of Chrome-Plating. Joseph Geschelin (*Automotive Ind.*, 1934, 71, (5), 134-136).—A discussion of recent specifications for the chromium plating of zinc die-cast parts. Considerably thicker deposits are recommended, on an undercoating of nickel which may itself be applied over copper; the direct deposition of nickel on zinc is in process of investigation. Specifications are quoted for chromium plating intended for severe and for moderate degrees of exposure, a basis now generally adopted for classifying automobile parts in preference to accelerated spray testing.

—P. M. C. R.

Chromium Plating in the Pulp and Paper Industry. D. H. Bissell (*Paper Ind.*, 1934, 16, 174-177; *C. Abs.*, 1934, 23, 5663).—A discussion of the advantages of the use of chromium-plated pulp- and paper-making equipment.

—S. G.

Development of Chromium Plating in Great Britain. E. A. Ollard (*Compt. rend. congr. internat. élect.*, 1932, 9, 115-118).—A review.—S. G.

***Adhesion of Electrolytic Copper Deposits.** Pierre A. Jacquet (*Electrochem. Soc. Preprint*, 1934, Sept., 309-334).—Certain hydrophilic colloids (proteins and their disintegration products) form adsorption films on metal surfaces (copper, nickel, iron, platinum), and these films materially reduce the adhesion of electrolytic deposits to such surfaces. On the basis of the adsorption phenomenon, J. has evolved a method for the determination of the degree of adhesion of electrodeposits on any basis metal. As a rule, results are reproducible to

about 10–20%. The measurements are limited by the distortion of the deposit, this limit being a function of the thickness of the deposit. For copper deposited on nickel, a thickness of 0.30 mm. (12 mil.) is sufficient for the study of the effect of various factors on the degree of adhesion of electrodeposit to basis metal. The less the mechanical strain developed in the copper plate during deposition, the better will it adhere to the nickel. During the operation of an acid copper sulphate bath a gradual but continuous change in the composition of the bath takes place. This ageing of the bath is indicated by the determinations of the degree of strain developed in the successive deposits from the same bath. The ageing of the bath has a marked effect on the adhesion of the copper to the nickel. The ageing appears to be due to a progressive enrichment of the electrolyte in cuprous ions. For strongly adherent deposits it has been shown by chemical tests, H_2S and $K_4Fe(CN)_6$, that after pulling off the copper deposits from the basis nickel surface, a copper layer or residual film remains on the nickel surface, nearly always continuous. Thus the force necessary to detach the copper deposit from the basis metal does not correspond with the true adhesion of the deposit, but represents what might be termed a shearing stress of the copper. When copper is deposited from a copper bath with a very low content of free sulphuric acid, the true adhesion of the deposit seems to be very high, but the shearing stress is very low. This fact might be explained by the presence of a certain quantity of cuprous oxide in the metal. The physical state of the basis nickel surface has a great effect on the adhesion of the electrolytic copper: the adhesion is very poor on emery-scratched surfaces. As a rule, it is better on polished nickel surfaces than on roughened electrolytic ones.—S. G.

***A Study of Diffusion on Copper-Plated Zinc-Base Die-Castings.** Wilhelm F. Castell (*Electrochem. Soc. Preprint*, 1934, Sept., 175–185).—Zinc-base die-castings are generally copper-plated before nickel and chromium plating. Between the electroplated copper deposit and the zinc in the base-metal a diffusion action takes place. The rate of this diffusion depends largely on the temperature to which the plated parts are exposed. At elevated temperatures, between 220° and 450° F. (105° and 232° C.), the diffusion is quite rapid, whilst under normal temperatures only a very small amount of copper has been found alloyed with the zinc. Failures of the plated deposit on zinc-base die-castings on outdoor exposure could not be traced to this diffusion, but were found to be due to surface defects, both in the casting and in the electrodeposits.—S. G.

Nickel-Plating Duralumin. E. Decarrière and A. Hache (*Chim. et Ind.*, 1934, Special No., (April), 595–596; *C. Abs.*, 1934, 28, 5763).—Excellent adherence of the nickel deposit and increased resistance to corrosion can be obtained by using a combination of cementation and electrolysis under appropriate conditions. The following conditions are satisfactory: (1) With zinc as auxiliary metal: the Duralumin is quenched from 500° C., cleaned by short treatment with 1 + 4 hydrochloric acid, and washed in running water, immersed for 3 minutes at atmospheric temperature in a 28° Bé solution of sodium zincate, washed in running water, dried, heated for 24 hrs. at 150° C., cleaned by rapid treatment with 1 + 9 hydrochloric acid, and nickel-plated in two stages: (a) in a "neutral" bath containing 75 gm./litre of nickel and ammonium sulphate (to avoid dissolving the deposited zinc), (b) in an "acid" bath (p_H 5.3) containing 250 gm./litre of nickel sulphate, 20 gm. nickel chloride, and 20 gm. boric acid. Adherence of the nickel deposit is assured by a final heat-treatment of 24 hrs. at 150° C. (2) With antimony as auxiliary metal—obtained with a hydrochloric acid solution containing 20 gm./litre of antimony chloride which may be applied to the aluminium surface by means of absorbent cotton, thus eliminating non-adherent particles: after washing in running water, nickel-plating is carried out in a single salt acid bath, and the operation is completed by heat-treatment of 24 hrs. at 150° C.—S. G.

The Nickel Plating of Zinc in a Barrel. Albert Hirsch (*Met. Ind. (N.Y.)*, 1934, 32, 274; and *Met. Ind. (Lond.)*, 1934, 45, 208).—Cf. *Met. Abs.*, this volume, p. 21. The grease derived from the press is removed by tumbling the articles in a barrel with a mixture of maplewood sawdust and powdered pumice for 5 hrs. at 30 r.p.m. The slightly roughened articles are then degreased in a solution containing sodium carbonate 30, trisodium phosphate 30, and sodium hydroxide 15 grm./litre, and copper-plated in a barrel using a bath containing cuprous cyanide 22.5 and sodium cyanide 34 grm./litre at 140°–170° F. (60°–77° C.) (current density 4 amp./ft.² at 12 v.). After burnishing the copper plate with steel diagonals in a barrel, the articles are nickel-plated for 1 hr. at 6–12 v. and 90°–140° F. (32°–60° C.) in a solution containing nickel sulphate crystals 105–210, nickel chloride crystals 22.5–47, boric acid 15, sodium perborate 0.75 grm./litre, and sufficient ammonia to give a p_{H} of 7.6–8.—A. R. P.

***The Variations of the Electro-Potential of Nickel with the Acidity.** L. Colombier (*Compt. rend.*, 1934, 199, 408–409).—The electro-potential of nickel was measured after heating the metal in a current of hydrogen, and then *in vacuo* to remove the occluded hydrogen. In experiments to investigate the variations of the potential with the acidity of the electrolyte, the acidity was determined with quinhydrone, the electrolyte being a solution of pure nickel sulphate with increasing additions of sulphuric acid. The potential of nickel heated for 1 hr. at 500° C. *in vacuo* was found to be independent of the acidity up to the point at which it is exactly equal to that of a hydrogen electrode in the same electrolyte. For greater acidity ($p_{\text{H}} < 4$), the potential curve of nickel is parallel to that of the hydrogen potential. Results of the same order were obtained with un-heat-treated nickel (*i.e.* more or less passive metal). The results of these experiments agree with the hypothesis of the recovery of nickel in passivation in air by a film of oxide, but the nature of this oxide must be assumed to be modified by annealing *in vacuo*.—J. H. W.

Automatic Nickel Plating in Great Britain. E. J. Dobbs (*Compt. rend. congr. internat. élect.*, 1932, 9, 112–115).—A review.—S. G.

British Standard Specifications for Nickel Ammonium Sulphate and Nickel Sulphate for Electroplating. ——— (*Brit. Stand. Inst.*, No. 564, 1934, 10 pp.).—S. G.

A Convenient Method for the Control of Nickel Plating: The Drop Test. G. Millot (*U.sine*, 1932, 41, (14), 37–39).—A *résumé* of the effect of the several variable process factors on the characteristics of the coating of nickel and a description of a method of determining the thickness of the deposit by measuring the time taken by successive drops of a solution of nitric and sulphuric acids to penetrate the coating.—R. B. D.

***Rhenium Plating.** Colin G. Fink and P. Deren (*Electrochem. Soc. Preprint*, 1934, Sept., 381–384).—Bright, hard deposits of rhenium metal were obtained from various aqueous rhenium solutions. Rhenium plates very rapidly and has a great throwing power. Deposits of any desired thickness can be obtained. The deposit is very resistant to hydrochloric acid. Detailed bath formulæ are given. Rhenium may be co-deposited with other metals.—S. G.

***The Co-Deposition of Tungsten and Iron from Aqueous Solutions.** M. Leslie Holt (*Electrochem. Soc. Preprint*, 1934, Sept., 147–152).—Iron is present in "tungsten" deposits obtained from aqueous tungsten plating baths. Removal of iron from the plating bath by continued use results in a depleted bath. A depleted bath can be regenerated by the addition of small amounts of iron. This iron is, however, present with tungsten in the cathode deposit.—S. G.

Recent Progress in Electroplating Zinc and Cadmium. S. Wernick (*Compt. rend. congr. internat. élect.*, 1932, 9, 118–122).—A review.—S. G.

Electrodeposition of Metals in Great Britain: General Introduction [to Symposium]. D. J. Macnaughtan (*Compt. rend. congr. internat. élect.*, 1932, 9, 97–98).—Introductory remarks.—S. G.

Recent British Researches on Electrodeposits. A. W. Hothersall (*Compt. rend. congr. internat. elect.*, 1932, 9, 99-111; *C. Abs.*, 1934, 28, 5763).—A brief review of nickel, chromium, copper, silver, zinc, and cadmium deposition as practised in Great Britain. Other researches on hardness of deposit, porosity, ductility, a.c., &c., are also referred to.—S. G.

Electrodeposition of Metals. L. G. Scott (*Lecture Three of the Eleventh Series of Printing Trade Lectures*, 1932, 24 pp.).—The processes of electroplating are explained from first principles, and the application of plating to the printing trade is described in simple language.—A. R. P.

Some Further Electrochemical Principles Applied in Electrodeposition. II.—Secondary Electrodes (Concluded). Samuel Field (*Met. Ind. (Lond.)*, 1934, 45, 205-206).—See *Met. Abs.*, this volume, p. 431. Consideration is given to the application of the principles of secondary electrodes to the design of plating tanks, so that they themselves shall not act as secondary electrodes, and to the use of perforated secondary electrodes for keeping the anolyte and catholyte apart, as in the Castner cell.—J. H. W.

Determination of the Protective Value and Thickness of Electroplated Coatings. Joachim Korpiun (*Metallwaren-Ind. u. Galvano-Tech.*, 1934, 32, 364-368).—Methods are described for measuring the corrosion-resistance by the salt-spray test, the porosity by the ferroxyl and other tests, and the thickness of electroplates of various metals by chemical and micrographic means.—A. R. P.

Measuring the Thickness of Electro-Plates. Fred Carl (*Met. Ind. (N.Y.)*, 1934, 32, 95-96).—See *Met. Abs.*, this volume, p. 135.—A. R. P.

Economic Use of Electricity in the Plating Shop. L. C. Pan (*Metal Cleaning and Finishing*, 1934, 6, 279-282, 294; *C. Abs.*, 1934, 28, 5345).—The cost of electricity in electroplating may be excessive for any one of the following reasons: a wrong-sized generator, operating at low efficiency, rheostats over-rated in voltage-drops, corroded points and contacts in the circuit, undersized bus-bars and conductors, high electrolyte resistance, high anode polarization, high anode current density, and low cathode efficiency. P. specifies proper equipment to be used and adjustments to be made for efficient operation.

—S. G.

Equipment Used in Electroplating. W. A. Koehler (*Metal Cleaning and Finishing*, 1934, 6, 219-224).—A review.—S. G.

How to Estimate Plating Costs. Harold Karet (*Met. Ind. (Lond.)*, 1934, 45, 207-208; and *Met. Ind. (N.Y.)*, 1934, 32, 275-276).—Abstract of a report read to the Master Electro-Platers' Institute (U.S.A.).—J. H. W.

VII.—ELECTROMETALLURGY AND ELECTROCHEMISTRY (Other than Electrodeposition.)

(Continued from pp. 452-453.)

***The Normal Potential of Beryllium.** Frederick H. Getman (*Electrochem. Soc. Preprint*, 1934, Sept., 93-102).—The conductance of aqueous solutions of beryllium perchlorate was measured at 25° C. The data for the dilute solutions were found to conform to Onsager's equations $\Lambda = \Lambda_0 \times (0.2329 \Lambda_0) + 72.38 \sqrt{c}$. Measurements of the e.m.f. of cells of the type $\text{Be} - m\text{Be}(\text{ClO}_4)_2 - \text{sat'd KCl} - \text{sat'd KCl}, \text{Hg}_2\text{Cl}_2 - \text{Hg}$ at 25° C. were made at values of m ranging from 0.215 to 0.00022. The e.m.f. was found to be a linear function of the logarithm of the concentration. From the resulting data the corresponding values of the normal electrode potential of beryllium were calculated. It has been pointed out that beryllium probably enters the solution as Be^+ rather than Be^{++} ; on this assumption, the normal potential has been calculated to be $\text{Be}, \text{Be}^+, E_0 = 1.13 \text{ v.}$ —S. G.

†**A Review of the Electrochemistry of Gallium.** H. C. Fogg (*Electrochem. Soc. Preprint*, 1934, Sept., 221–229).—The electrochemical behaviour of gallium in aqueous solutions is critically reviewed. Electro-refining of gallium using acid sulphate solutions has so far not met with much success; there is a marked tendency for iridium and zinc to codeposit with the gallium.—S. G.

***The Electrolysis of Rare Earth Metal Salts in Non-Aqueous Solvents.** B. S. Hopkins and L. F. Audrieth (*Electrochem. Soc. Preprint*, 1934, Sept., 139–146).—Systematic determinations of the solubility of rare earth salts in various non-aqueous solvents have been commenced as a preliminary to a more extended study of the electrochemical behaviour of the resulting solutions. Efforts to discharge rare earth metals from solutions of their salts in various non-aqueous solvents have been unsuccessful. Electrolysis of saturated alcoholic solutions of rare earth chlorides using a mercury cathode results in the formation of the corresponding amalgams. Amalgams of neodymium, cerium, lanthanum, samarium, and yttrium have been prepared electrolytically.—S. G.

***Electrolytic Production of Tungsten Metal from a Fused Phosphate Bath.** Shoo-Tze Leo and Tsing-Nang Shen (*Electrochem. Soc. Preprint*, 1934, Sept., 129–137).—The electrolytic production of tungsten in a fused phosphate bath, originally suggested by Hartmann, was investigated. It was found that the current efficiency and energy efficiency can be much improved upon if the electrolysis is performed at a temperature higher than those suggested by Hartmann and when using a higher current density. A temperature of 900° C. and a current density of 35 amp./dm.² seem to give the best result. The best composition of the electrolyte with respect to current efficiency was found to be that selected by Hartmann, namely 7 mols. of sodium pyrophosphate, 3 mols. of sodium metaphosphate, and 4 mols. of tungsten trioxide, but without addition of sodium chloride. The best current efficiency was 88.08%. On the basis of energy efficiency, an electrolyte containing 7 mols. sodium pyrophosphate, 3 mols. sodium metaphosphate, 4 mols. tungsten trioxide, and 15 mols. sodium chloride seems to be most favourable. A yield of 469.9 gm. of tungsten per kw.-hr. was obtained.—S. G.

IX.—ANALYSIS

(Continued from pp. 453–454.)

Quantitative Analysis with the Microscope by the "Point" Method. A. A. Gagolev (*Eng. and Min. J.*, 1934, 135, 399–400).—See also *Trans. Inst. Econ. Mineral., Moscow*, 59. A number of points are distributed uniformly over a thin section of the material to be analyzed, and the number of points falling on each constituent is then determined by a rapid method of counting. The probable error is expressed by the formula $\delta = 0.67\sqrt{\frac{A(100-A)}{n}}$, where δ is the probable error of determination, n the total number of points taken, and A the percentage of the constituent contained in the material. Mechanical devices are a feature of the apparatus.—R. Gr.

What Can the Smelter Expect from the Spectrograph? W. Kroll (*Mettall u. Erz*, 1934, 31, 201–204).—An account is given of the use of the spectrograph in determining the nature and amount of impurities in commercial and specially purified metals such as Zn, Pb, and Cu; recent work on the subject is briefly described.—A. R. P.

Application of Methods of Quantitative Spectral Analysis to Metallurgical Problems. Raymond Breckpot (*Chim. et Ind.*, 1934, Special No., (April), 597–601; *C. Abs.*, 1934, 28, 5776).—A discussion of the advantages of quanti-

tative spectral analysis by the method developed by B. (see *Met. Abs.*, this volume, p. 511), and of the services it can render in metallurgy.—S. G.

***The Sensitivity of Chemical Analysis by Means of X-Rays.** A. Faessler (*Z. Physik*, 1934, **88**, 342–345).—The sensitivity of chemical analysis by means of X-rays depends on the element concerned and the nature of the excitation of its spectrum. With cathode-ray excitation the sensitivity is increased if the sample being analyzed is in the form of a metal soldered to the anticathode. For most massive alloys 1 part per 100,000 of metal present can be detected; for powders the proportion of a metal detectable is 1 part in 20,000. The method employing excitation with X-rays is, in general, less sensitive than the method employing cathode rays, but the sensitivity can be increased by increasing the time of exposure. Some elements, e.g., Rb, Sr, and Zr, can be detected with greater accuracy by employing X-rays than by the use of cathode rays.—J. S. G. T.

***On a New Drop Reaction of Beryllium.** A. S. Komarovskiy and N. S. Poluektoff (*Mikrochemie*, 1934, **14**, 315–317).—A drop of a 0.025% solution of *p*-nitrobenzeneazo-orcinol in NaOH is placed on a filter paper, a drop of the Be solution allowed to fall on the middle of the spot, and another drop of the reagent added. An orange-red colour indicates the presence of Be; Mg gives a brownish-yellow colour. Zn interferes in the test, but the colour it produces is discharged on addition of a drop of 25% KCN solution, which also removes colours due to hydroxides of Ni, Co, Cu, Cd, and Ag. The sensitivity is $1 : 2 \times 10^5$ for Be alone or $1 : 6.6 \times 10^4$ for Be in the presence of 750 times as much Zn.—A. R. P.

***Qualitative Detection of Bismuth with Sulphur Containing Reagents. II.—Detection with Phenylthiohydrazonesulphhydrate.** J. V. Dubský and J. Trtřílek (*Z. anal. Chem.*, 1934, **96**, 412–415).—See *Met. Abs.*, this volume, p. 454. Acid or neutral chloride solutions of Bi give orange to red precipitates with a solution of the K salt of $C_6H_5NSC \cdot SC \cdot (SH)N$; sensitivity 1.2×10^{-6} gm. Under similar conditions Ag gives light yellow, Pb canary-yellow, Hg yellow, Cu brownish-yellow, Cd white, Ni green, and Sn and Sb brown to yellow precipitates. The preparation of the reagent is described.—A. R. P.

***On the Detection of Selenium and Tellurium in the Presence of One Another.** N. S. Poluektoff (*Mikrochemie*, 1934, **15**, 32–34).—In HCl solution Se gives a brown spot (Se + I) with KI on filter paper which becomes red (Se) on addition of $Na_2S_2O_3$; Te under similar conditions gives a brown spot (K_2TeI_6) which is subsequently decolorized. Sensitivity of the test I : 25,000. Alkali stannites give a black spot on filter paper with alkali tellurites, whilst alkali selenites give no reaction; sensitivity for Te I : 41,000.—A. R. P.

***On the Detection of Zinc by Induced Precipitation.** P. Krumholz and J. Vasquez Sanchez (*Mikrochemie*, 1934, **15**, 114–118).—A solution containing 0.01% Co gives no precipitate with $K_2Hg(SCN)_4$ solution, but an immediate blue precipitate in the presence of as little as 2 p.p.m. of Zn. On shaking with $(C_2H_5)_2O$ the precipitate collects at the interface.—A. R. P.

***The Use of the Potential-Forming System Metal/Metal Anion for Potentiometric Volumetric Analysis.** Erich Müller and Kurt Mehlhorn (*Z. anal. Chem.*, 1934, **96**, 173–175).—Cr as K_2CrO_4 can be titrated with $BaCl_2$, using a Pt or Au indicator electrode instead of a Cr electrode (cf. Brintzinger and Jahn, *Met. Abs.*, this volume, p. 89), since the electrode actually measures the change in hydroxyl ion concentration due to hydrolysis of the chromate. The method is applicable only when the solution has the same p_H as a solution of potassium chromate.—A. R. P.

***On the Determination of Gas in Aluminium by Means of the Hot-Extraction Method.** K. Steinhäuser (*Z. Metallkunde*, 1934, **26**, 136–139).—The apparatus for the hot-extraction of gas from Al has been improved by replacing the H.-F. induction furnace with a Silite resistor furnace with three magnetic coils around

the crucible to produce a thorough rotation of the melt. The preliminary treatment of the sample before inserting into the furnace has a very important effect on the amount of the gas extracted. Even by a careful cleaning of the sample with a grease solvent (ether, alcohol, or benzene), it is impossible to clean completely the surface of the sample. Well reproducible results are obtained only if the sample is subsequently heated at about 300° C. Normally the gas content of commercial Al does not exceed about 0.5 cm.³/100 grm.—M. H.

The Analytical Determination of Aluminium and the Light Metals. O. Engelmann (*Metallbörse*, 1934, **24**, 567, 598–599, 630–631).—A detailed description is given of a scheme, based on known methods, for the complete analysis of all types of industrial Al alloys.—A. R. P.

***Rapid Estimation of Antimony and Arsenic in Coppers and Bronzes.** G. Misson (*Chim. et Ind.*, 1934, Special No., (April), 434; *C. Abs.*, 1934, **28**, 5775).—The method consists in adding a small quantity of pure Sn to the sample (this is unnecessary with bronzes containing at least 8 times as much Sn as Sb) and treating with HNO₃; As and Sb are retained in the SnO₂ precipitate; the latter is dissolved in H₂SO₄, reduced with pure Sn, and the solution is titrated with standard bromate solution, giving As + Sb. As is determined on a separate 5 grm. portion by precipitation with NH₄ molybdate and weighing the precipitate after drying at 100° C.—S. G.

The Spectral Analysis of Copper. Raymond Breckpot (*Chim. et Ind.*, 1934, Special No., (April), 220–229; *C. Abs.*, 1934, **28**, 5776).—Fractional distillation phenomena of the more volatile constituents complicate quantitative spectral analysis in the electric arc. Whilst very intense on the anode, these selective fractional distillation effects are practically eliminated if the sample to be examined is placed on the cathode. Curves for the determination of Pb, Bi, Ag, As, and Sb in Cu have been made. Representative average values are obtained by operating on copper oxide powders prepared from appropriate solutions. This technique enables concentration scales to be readily established, whereas these cannot always be produced from alloys of known composition. Estimation of the spectral intensity is carried out by a simple method by means of a filter or a rotating notched sector.—S. G.

***The Determination of Minute Amounts of Copper by Means of Its Catalytic Action.** Friedrich L. Hahn (*Mikrochemie*, 1934, **14**, 280–282).—The method is based on the measurement of the time required for a red solution of Fe(CNS)₃ containing Na₂S₂O₃ to fade to a given shade; this depends on the amount of Cu present.—A. R. P.

***Determination of Gold by Photometric Titrations.** Shizo Hirano (*Kōgyō Kwagaku Zasshi (J. Soc. Chem. Ind. Japan)*, 1934, **37**, (4); *C. Abs.*, 1934, **28**, 5363).—[In Japanese, with English abstract in supplemental binding, pp. 178–179.] AuCl₃ in solution is reduced with SnCl₂ to form a colloidal solution, which develops a purple colour. The colour change was measured with a caesium photoelectric cell and a suspension-type galvanometer. A curve of SnCl₂ solution added *versus* the galvanometer reading gives a definite break at the end-point of titration. The acidity of the Au solution must be kept below 0.05*N* and excess Cl₂ water must be added to keep all of the Au in the trivalent state. Cu, Pb, and small amounts of Fe do not interfere, but larger amounts of iron must be removed before titration. Data and a diagram of the circuit are appended.—S. G.

***Contribution to the Micro-Electrolytic Determination of Lead.** Hermann Brantner and Friedrich Hecht (*Mikrochemie*, 1933, **14**, 30–39).—In the absence of much Cu good results in the micro-electrolytic deposition of PbO₂ can be obtained only by careful regulation of the HNO₃ concentration in the electrolyte, the current density, the temperature, and the time of deposition. Addition of urea does not improve the results. The procedure is therefore not recommended.—A. R. P.

Contribution to the Quantitative Determination of Magnesium by Kolthoff's Method Using Titan Yellow. Carl Urbach and R. Baril (*Mikrochemie*, 1934, **14**, 343-361).—The method is made more rapid and accurate by comparing the colour of the test solutions with that of standards containing known amounts of Mg.—A. R. P.

Modified Hydrogen Evolution Method for Metallic Magnesium, Aluminium, and Zinc. Raymond H. Kray (*Indust. and Eng. Chem. (Analyt. Edn.)*, 1934, **6**, 250-251).—A modification of the Meyer apparatus for determining metallic Mg, Al, and Zn by measuring the amount of H_2 evolved on dissolution in acid, is described and illustrated.—A. R. P.

***Gravimetric Determination of Thallium as Cobaltinitrite and Its Separation from Other Metals.** Sikazo Nisihuku (*Kōgyō Kwagaku Zasshi (J. Soc. Chem. Ind. Japan)*, 1934, **37**, (4); *C. Abs.*, 1934, **28**, 5364).—[In Japanese, with English abstract in supplemental binding, p. 180.] Tl was determined as $Tl_3[Co(NO_2)_6]$. The reagent, which keeps well at room temperature, is prepared by mixing a solution of 28.6 gm. of $Co(NO_3)_2$ and 50 c.c. of 50% $HCOOH$ in 500 c.c. with a solution of 180 gm. $NaNO_2$ in 500 c.c. When a solution of Tl salt containing 5% $HCOOH$ is treated with this reagent at 30°-50° C., a scarlet crystalline precipitate is formed. After 30 minutes filter through a glass filter, wash with cold H_2O , and dry at 120° C. for 1 hr.—S. G.

Use of Solid Carbon Dioxide in the Determination of Tin. H. I. White (*Indust. and Eng. Chem. (Analyt. Edn.)*, 1934, **6**, 234).—Addition of about 0.5 in.³ of solid CO_2 for cooling the reduced Sn solution and guarding against ingress of air before the I titration is recommended.—A. R. P.

***Determination of Zinc in Crude Zinc Ashes, Zinc Oxide, and Zinc [Galvanizing] Residues.** C. Boy (*Metall u. Erz*, 1934, **31**, 357-358).—The sample (12.5 gm.) is extracted with warm 1:2 HNO_3 (150 c.c.) and the solution filtered into a 1-l. graduated flask. The residue and filter paper are returned to the beaker and evaporated with HNO_3 and H_2SO_4 to destroy organic matter, a 2:1 mixture of the concentrated acids being added drop by drop to the hot liquor when fumes of H_2SO_4 are evolved; after dilution the solution is filtered into the graduated flask and diluted to 1 l., 100 c.c. of which are evaporated completely to dryness. The residue is dissolved in 5 c.c. of HCl and 30 c.c. of H_2O , 65 c.c. of H_2S water are added, and the precipitate is removed; the filtrate is boiled to expel H_2S , oxidized with HNO_3 , and treated with H_2O_2 and NH_4OH to precipitate Fe and Mn. After dilution to 250 c.c., 100 c.c. are filtered through a dry paper for the determination of Zn by the usual $K_4Fe(CN)_6$ method.—A. R. P.

X.—LABORATORY APPARATUS, INSTRUMENTS, &c.

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

(Continued from p. 454.)

***Apparatus for Thermal Analysis of Metal Samples.** John L. Houghton (*Chim. et Ind.*, 1934, Special No., (April), 439-441; *C. Abs.*, 1934, **28**, 5379).—In order to overcome certain defects in Rosenhain's furnace (a 1-m. refractory vertical tube, having a 15 cm. nickel-chromium heating coil round the top, water cooling at the bottom, and through which the sample and thermocouple are displaced as required), a furnace has been designed, and is described, which can be displaced up or down, while the sample remains stationary.—S. G.

On a New Universal Microscope. P. Ramsthaler (*Z. wiss. Mikroskopie*, 1933, **50**, 63-72).—A new metallurgical microscope is described and illustrated

in which the microscope and camera are fixed together in one pedestal, not using an optical bench. The light from the specimen passing vertically downwards through the objective is reflected at an angle from a mirror in the foot of the pedestal on to the photographic plate. Light is provided by a low-voltage lamp in the pedestal and passes *via* a small mirror into the illuminator. The remainder of the apparatus is the same as that of the ordinary microscope. —B. Bl.

Microscope Illuminator. Anon. (*J. Sci. Instruments*, 1934, 11, 299).—Describes a small illuminator for oblique illumination made by James Swift and Son, Ltd. The apparatus screws on to the nose of the microscope, and contains a small lamp and condenser.—W. H.-R.

***A New Source of Illumination Adapted to Photography and Low-Power Microscopy.** Wilbur D. Courtney and Ralph Schopp (*Science*, 1934, 80, 189).—A note. A small neon lamp with the glass tube bent into a spiral placed round the objective is a satisfactory source of illumination for observing opaque objects with a binocular or other microscope.—W. H.-R.

Polishing and Lapping Machine. Anon. (*J. Sci. Instruments*, 1934, 11, 302).—This machine, made by Messrs. A. Gallenkamp and Co., Ltd., is fitted with four turntables 8 in. in diameter and provided with spring belts to secure discs of emery paper, &c. The tables can be driven at 1000, 900, 800, and 750 r.p.m.—W. H.-R.

***On the Shortening of the Time of Exposure of X-Ray Photographs Using Reflection Diaphragms.** E. Nähring (*Z. tech. Physik*, 1934, 15, 151–155).—The total reflection of X-rays from polished glass or metal surfaces is utilized for the concentration of the rays for structural examination of metals. With a small camera aperture up to 100-fold increase in intensity can thus be obtained, and sharp X-ray diagrams are produced with exposures which are only slightly greater than those used generally with lead diaphragms of large diameter. Examples are given.—J. W.

A Reflecting Polaroscope for Photoelastic Analysis. Raymond D. Mindlin (*Rev. Sci. Instruments*, 1934, 5, 224–228).—A polaroscope adapted to analysis of stress distribution in parallel plates and to three-dimensional analysis is described.—J. S. G. T.

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

(Continued from pp. 455–456.)

†**The Testing of Metallic Materials.** E. Skerry (*Aircraft Eng.*, 1934, 6, 111–114, 139, 140).—See also *Met. Abs.*, this volume, p. 254. Hardness testing with the Rockwell machine and Shore scleroscope is described, also the Herbert “Cloudburst” machine, the Herbert pendulum hardness tester, the Izod impact machine and test. The “Erichsen” test, bend tests for strip and wire, torsion testing, tensile testing at high temperatures, and methods of crack detection are described briefly.—H. S.

Inspection of Die-Castings. E. Stevan (*Met. Ind. (Lond.)*, 1934, 45, 222).—A brief discussion is given of the principal points to be discussed in the inspection of die-castings.—J. H. W.

***Procedure for the Study of Distribution of Elastic Stress in Metallic Specimens.** Albert Portevin and Michel Cymboliste (*Rev. Mét.*, 1934, 31, 147–158).—A full account of an investigation previously described in summary. See *Met. Abs.*, this volume, p. 197.—H. S.

The Optical-Polarization Method of Investigating the Distribution of Stresses in Structural Elements. A. Thum and ——— Wunderlich (*Arch. tech. Messen*, 1934, 4, (38), 199–1101).—The principle of the photoelastic method of locating

stresses is explained, and the apparatus is described, with a diagram of the optical system. But for its fragility and high price, glass would be the most suitable material for models: other possible materials are discussed. A diagrammatically illustrated account of the course of polarized light through the model explains the alternation of light and dark areas and the effect of rotating the model. Methods of quantitatively determining normal and impressed stresses are classified and described. A diagram of the interferometer is given, and a *bibliography* is appended.—P. M. C. R.

***The Stresses in Thick-Walled Cylinders of Mild Steel Over-Strained by Internal Pressure.** Gilbert Cook (*Proc. Inst. Mech. Eng.*, 1934, 126, 407-437).—The experiments described refer to ferrous alloys, but the results and theory are of general interest. A theoretical investigation is made of the stress distribution across the walls of thick cylinders submitted to internal pressure so that the elastic limit of the material is exceeded. Up to a certain pressure the interior metal may be over-strained whilst the exterior is still elastic. The deformation in the over-strained part is then small, and the effects are different from cases where over-strain produces much plastic flow. In partly over-strained cylinders the maximum shear stress in the elastic region varies as over-strain proceeds, whilst at the internal surface the effect of the over-strain is to reduce the circumferential tensile stress, and to set up an axial compressive stress. With sufficient wall thickness all three principal stresses at the internal surface may become compressive whilst the exterior is still elastic. At higher pressures where the whole metal is over-strained the observed pressures agreed with those calculated by assuming a constant shear stress equal to that observed during plastic yield of the material in tension. With increasing pressure the tensile stresses are greatest at the outside of the cylinder, and rupture begins there.

—W. H. R.

Testing Cable Sheath for Fatigue. C. H. Greenall (*Bell Lab. Record*, 1934, 13, 12-16).—Five types of fatigue testing machines which have been used in the course of investigation on the fatigue endurance of lead and lead alloys and cable sheaths are illustrated and briefly described. A typical endurance curve is given of extruded 1% antimony-lead alloy as determined on the latest machine. This machine, which appears to be of the "constant-deflection" type, takes 126 specimens, is provided with temperature control, permits the testing of specimens at various thicknesses of cable sheath, and enables allowance to be made for fluctuations in sheath thickness around the circumference.

—J. C. C.

Fatigue Testing of Wire. Anon. (*Aircraft Eng.*, 1934, 6, 251-253).—A description of the machine designed by Haigh and Robertson in which the wire is stressed as an Euler strut and caused to revolve on its own axis while so stressed.—H. S.

***Transverse Tests on Sand-Cast Aluminium Alloy Bars.** C. E. Phillips and J. D. Grogan (*J. Inst. Metals*, 1934, 54, 89-98; discussion, 99-102).—An investigation to determine the value of the transverse test in the measurement of ductility of alloys of low elongation value. Results of transverse tests do not yield any information concerning ductility which is not obtained equally readily from the tensile test when a high degree of accuracy of measurement is available. In discussion G. Meikle considered that the transverse bend test would be easier to carry out and more reliable than the tensile test on alloys of low ductility. H. Moore raised the question of the extensive use of the transverse bend test on cast iron. J. G. Pearce referred to the long bars used in transverse tests of cast iron and the tangent method of determining elastic modulus.—H. S.

***Strength Tests of Thin-Walled Duralumin Cylinders in Compression.** Eugene E. Lundquist (*Tech. Notes Nat. Advis. Cttee. Aeronautics*, No. 473, 1933, 1-20).—The stress at failure of thin-walled Duralumin cylinders by

elastic buckling of the walls is given by the expression $S_c = K_c E$, where K_c is a non-dimensional coeff. which varies with the dimensions and imperfections of the cylinder, and E is the modulus of elasticity. Wrinkling prior to failure does not apparently reduce the stress at failure, and a change from welded to riveted seams also has little effect for large fabricated cylinders. After failure the wave-lengths of the wrinkles in the direction of the axis are equal to those of the circumferential wrinkles. The number of the latter varies inversely with the ratio of length to radius (l/r), and for a given radius/thickness (r/t) ratio seems to approach a constant value at the larger values of l/r . The compressive stress at failure is independent of l when $l > (3-5) \cdot \lambda_a/2$ where $\lambda_a/2 = \pi r / (0.91 \sqrt{r/t})$. Transverse stiffness to prevent failure by elastic buckling must therefore be spaced at a distance $< (3-5) \cdot \lambda_a/2$.—A. R. P.

***Calculation of the Elongation of Metal Test-Pieces for Any Gauge Length.** Alfred Krusch and Wilhelm Kuntze (*Arch. Eisenhüttenwesen*, 1933, 7, 305-309; and *Mitt. Material., Sonderheft* 24, 1934, 145-149).—Comparison of the elongation values for metals obtained in various countries is rendered difficult, since different gauge-lengths for tensile specimens are used in the different countries. An expression has therefore been developed for calculating for any desired gauge-length the total elongation at fracture from the values obtained for the reduction in area and uniform elongation, or from the uniform elongation and total elongation at fracture at another gauge-length. The two "shape factors" in the expression have been determined experimentally; they can be read directly from a generally applicable curve for any of the usual gauge-lengths, and for extremely small gauge-lengths they can be calculated from two equations. The effect of the chucks of the machine on the elongation values for the conversion from short to long rods or *vice versa* can also be read from a curve. The "shape factors" do not depend on the material under test, but on the geometry of the "cone of flow," *i.e.* on the reduction in area and the position of fracture in the gauge-length. The conversion expressions are therefore applicable to any material as long as this is uniform within the gauge-marks, whether the test-piece is round or flat. With thin strips the effect of the reduction in area is so small that it need not be taken into the calculation.—J. W.

An Improved Bend Tester. Anon. (*Bell Lab. Record*, 1934, 13, 29-30).—A brief, illustrated description of a bend tester for sheet metal which is motor driven and incorporates improvements in detail to provide a constant angle of bend, a better clamping and tensioning device, and greater flexibility in the adjustable guides.—J. C. C.

How Sharply Can a Metal Part be Bent? G. R. Gohn (*Bell Lab. Record*, 1934, 12, 230-234; and (abstract) *Iron Age*, 1934, 133, (17), 22-23).—To determine the minimum safe forming radius of a metal, samples 3 in. \times $\frac{3}{4}$ in. are bent in a punch press with a series of eleven accurately-ground 90° V-shaped punches, one ground to a sharp edge and the others with radii ranging from 0.0156 in. to 0.25 in. As the selection of the minimum safe radius involves the personal element, a further test has been introduced. Tests are made over three mandrels of different radii with an Amsler bend-test machine, the results plotted, and the radius over which fracture would occur after 5 bends determined. This radius, plus a small constant, is found to correspond closely with that obtained by the previous method.—J. C. C.

***Minimum Dimensions of Test-Samples for Brinell and Diamond Pyramid Hardness Tests.** G. A. Hankins and C. W. Aldous (*J. Inst. Metals*, 1934, 54, 59-88).—The effect of variation in dimensions of test-samples for hardness tests was determined on copper, aluminium alloy, and several steels. It was concluded that for accurate work the width of test-specimen should be $4\frac{1}{2}$ times the diameter of the Brinell impression. The limiting value of ratio of thickness of specimen to depth of impression appeared to depend on the

character of the material, being 6 for mild steel, 15 for copper, and more than 20 for spring steel. For diamond pyramid hardness tests the ratio of thickness of specimen to diagonal of impression of $1\frac{1}{2}$ is satisfactory for most sheet metals, with the exception of soft copper and soft brass. In the discussion *M. Cook* considered it unfortunate that the authors had suggested drastic limitations, not justified by the evidence, in the applications of useful tests. Results with an accuracy of 5% could be obtained at much lower ratio values than those given. The high values given for soft copper and brass and other features were criticized in detail. *A. G. C. Gwyer* requested information on aluminium, since it now appeared that the thickness ratio limits in B.S.I. Specifications Nos. 427 and 240 were no longer universally applicable. *R. L. Smith* agreed with the authors' conclusions, but directed attention to the probable hardening effects of the grinding of the taper-thickness specimens used and gave results of test experiments. *D. Hanson* suggested that the limitations shown by the authors' tests were affected by the use of a very hard support for the test-specimen, and that the usefulness of the test might be extended by using one of similar hardness to the specimen. *T. H. Turner* referred to the variation in hardness which might occur in a specimen and the minimum distance between impressions. *G. A. H.*, in reply, did not regard it as essential to apply his suggested limits for all routine hardness testing. The use of a soft anvil should be investigated for soft metals. Normal procedure in spacing tests was to use a limit of 5 times the diameter of impression. *C. W. A.*, also in reply, gave some results on aluminium. For pyramid tests the thickness ratio limit was above 1.5, but for practical purposes a ratio as low as 0.5 could be used. Further results dealing with *M. Cook's* criticism were given. *A. Portevin* gave data and curves showing the results of his work on dimensional limits, including the thickness of electro-deposits. These agreed with the authors' conclusions. In the investigation on electrodeposits, observations were made of the penetration of pyramids or cones under increasing load. A graph was given showing the determination of the thickness at which the hardness becomes independent of the basis metal.—*R. G.*

***Effect of Thickness on the Accuracy of Rockwell Hardness Tests on Thin Sheets.** *R. L. Kenyon* (*Amer. Soc. Test. Mat. Preprint*, 1934, June, 10 pp.).—From tests made on mild steel sheets of varying thicknesses it is shown that accurate Rockwell hardness figures can be obtained on any thickness of sheet which does not show a bulge on the lower side after the test. A minimum thickness of sheet for any material is considered to be that which shows a deviation of less than two units from the true hardness when measurements are made on sheet of various thicknesses prepared by etching in acid, then polishing.—*A. R. P.*

***A Contribution on Static and Dynamic Hardness Testing.** *Ernst Schmidmer* (*Forschungsarbeiten Metallkunde u. Röntgenmetallographie*, 1934, (5), pp. 102).—Gives a summarized review of the theory of hardness testing together with new experimental results on non-ferrous metals. These include copper, brasses containing 10, 15, 20, 38, and 42% zinc, respectively, a ternary copper-zinc-manganese alloy (Mn 2, Zn 37.5%), and complex nickel-tin-manganese-iron, and copper-aluminium alloys. The experimental results include static cone and ball tests under different loads, and dynamic tests in which a ball or cone is driven into the metal. The experimental data are original, but most of the theoretical section is an illustration of principles which are generally known. The data would be of greater value if further details were given of the heat-treatment and exact condition of the materials used.—*W. H. R.*

Relation of Hardness of Non-Ferrous Metals to Strength and Workability. *J. R. Townsend* (*Metal Progress*, 1934, 26, (2), 35-40).—The principle and method of the Meyer hardness test are considered in some detail, Meyer's

suggestion of using as a basis of calculation the mean pressure supported by the metal—*i.e.*, quotient of load by projected area of indentation—giving in T.'s opinion the closest approach to the ideal method. The Rockwell test is said to give the closest commercial approximation to the latter. A table shows the relation between Rockwell hardness and tensile strength for high brass sheet and Grade A nickel-brass-silver. From a study of the curves obtained by plotting pressure (as above) against diameter of impression is derived the relation $P = ad^n$, where P is the pressure, a the resistance of the material to penetration, and n indicates the "work-hardenability" of the material. A modified Brinell machine is described, which permits the measurement of the load required to produce unit penetration, and the advantages and limitations of penetration measurement are discussed. Some applications of Erichsen and reverse bending tests, with certain anomalous results in the case of Everdur, are described, and results of reverse bending tests are tabulated for 18 alloys.—P. M. C. R.

RADIOLOGY

Testing the Structure of Heavy Metal Products by γ -Rays. M. Widemann (*Glasers Ann.*, 1934, 114, 41-43, 49-53).—Examples of the uses and limitations of the method for detecting faults in metal articles are described.—J. W.

XII.—TEMPERATURE MEASUREMENT AND CONTROL

(Continued from p. 436.)

A New Radiation Thermocouple. Saburō Numakura (*Rep. First Sec. Electrotech. Lab., Tokyo*, 1931, 6, (2), 53-55; *Jap. J. Eng. Abs.*, 1934, (11), 33).—[In Japanese.] Tellurium and bismuth were deposited on very thin cellophane film by cathodic sputtering. The typical characteristics of these radiation thermocouples are :

Dimensions, mm.			Resistance, Ohms.	Radiation Sensitivity ($\mu V/mW/cm.^2$).	Time lag, Seconds.	
Length.	Breadth.	Thickness.				
1.1	0.7	0.001	4400	14.8	0.3	in air
4.0	0.3	0.001	15000	200	2.5	in vacuo

—S. G.

Thermo-Elements with Curved Characteristics. G. Keinath (*Arch. tech. Messen*, 1934, 4, (37), T97-r98).—The influence of the cold-junction temperature of a thermo-couple is increased when the thermo-electric force of the element does not increase proportionally with the difference of temperature between hot and cold junctions. The work of Rohn and of Kulbusch and Kulmin on the nickel-copper and nickel-iron alloys is discussed (*Z. Metallkunde*, 1924, 16, 297; *Präzisionsindustrie (Moscow)*, 1933, (3) and (4)), and subsequent work is quoted in connection with the employment of vanadium, chromium, molybdenum, and tungsten for the negative, and aluminium, copper, titanium, tellurium, zirconium, molybdenum, and cobalt for the positive limb of the element. The materials most suited for base-metal elements are, according to Kulbusch, nickel and nickel with 20-25% copper and a small admixture of manganese to obviate red-shortness. The properties of certain suitable alloys as regards corrosion by acids and salt fluxes are discussed.—P. M. C. R.

***The Speed of Response of a Thermopile-Galvanometer System.** A. V. Hill (*J. Sci. Instruments*, 1934, 11, 246-247).—The rate of deflection of a galvanometer attached to a thermopile suddenly exposed to radiation is examined theoretically.—W. H.-R.

A Rheostat with Coarse and Continuous Fine Adjustment [for Use with Optical Pyrometers]. F. A. Cunnold and M. Milford (*J. Sci. Instruments*, 1934, 11, 265).—The ordinary tubular resistance in which a slider touches several turns of wire is not suitable for accurate adjustment of optical pyrometers. In the rheostat described, contact is made with one wire only, the tubular resistance being revolved about its axis for the fine adjustment; an additional device is provided for the preliminary rough adjustment.—W. H.-R.

Automatic Temperature Recorder Controller. Anon. (*J. Sci. Instruments*, 1934, 11, 259).—A note. Describes a combination of the Negretti and Zambra "Mersteel" (mercury in steel) temperature recorder, and their temperature controller operating on the compressed-air principle.—W. H.-R.

Indicating Time-Cycle Temperature Controller. Anon. (*J. Sci. Instruments*, 1934, 11, 298).—Describes an indicating time-cycle controller, made by Messrs. Negretti and Zambra, for use with either a thermocouple or resistance thermometer. The desired temperature is obtained by a setting pointer which is moved by a revolving cam cut to a shape which gives the desired variation of temperature with time.—W. H.-R.

Adjustable and Fixed-Setting Thermostat Controls. Anon. (*J. Sci. Instruments*, 1934, 11, 299-301).—Describes two thermostat controls using bi-metallic elements and made by the General Electric Company. They are made primarily for water-heater control, but are suitable for other purposes.
—W. H.-R.

XIII.—FOUNDRY PRACTICE AND APPLIANCES

(Continued from pp. 456-457.)

***Study of Foundry Properties of Metals and Binary Alloys.—I, II.** P. Bastien (*Rev. Mét.*, 1934, 31, 270-281, 324-329, 369-373).—(I.—) Castability is studied by the method of Guillet and Portevin and the effect of superheating the liquid metal is examined both by experiment and by theoretical treatment. Specific heat, latent heat of freezing, and melting point are at least as important as viscosity in the factors affecting castability. Castability of binary alloys is studied in relationship to constitution. (II.—) The castability of magnesium alloys is studied, also the influence of successive remelting operations and the influence of the nature of the sand on castability of magnesium alloys and Alpac. While magnesium has a very low value of castability, additions of aluminium and copper effect marked improvement. The first few remeltings of a 6% aluminium alloy result in an improvement of castability, attributed to increase in aluminium content by loss of magnesium, but later re-meltings cause reduction in castability, attributed to oxide and nitride content of the metal. The nature of the sand is an influential factor, affecting the castability of both magnesium and Alpac. Shrinkage in the mould is studied both for chill and sand moulds, and with magnesium-aluminium alloys, magnesium-copper alloys, and magnesium-aluminium-copper alloys as the materials of the castings.—H. S.

Controlled Directional Solidification.—II. George Batty (*J. Amer. Soc. Naval Eng.*, 1934, 46, 299-315).—See *Met. Abs.*, this volume, p. 257. The procedure adopted in producing castings by means of the reversal system designed to promote controlled directional solidification is considered in relation to castings such as gear blanks, which, on account of their design,

require more than one feed head. Two types of such castings cast by the "30-degree reversal" system which both require different systems of heading and gating are discussed. The "100-degree reversal" system and the use of external chills for heavy sections are illustrated by considering various types of steel castings.—J. W. D.

[Discussion on] **Non-Ferrous Foundry Practice.** (*Found. Trade J.*, 1934, 50, 414-415; 51, 5-6, 18).—Abstract of the discussion before the Institute of British Foundrymen of the papers: "Cast Red Brass," by C. M. Saeger, Jr., and "Studies on Cast Bronzes," by F. W. Rowe. See *Met. Abs.*, this volume, pp. 363, 383.—J. H. W.

***On the Decomposition of Cuprous Oxide by Carbon Monoxide and the Deoxidation of Red Brass by Reitmeister's Method.** H. Nipper and P. Röntgen (*Giesserei*, 1934, 21, 86-89).—Cuprous oxide is readily reduced by carbon monoxide, and molten copper can, therefore, be deoxidized by passing this gas through it. The mechanism of the reaction has been investigated from laboratory tests on the equilibrium of the reaction $\text{Cu}_2\text{O} + \text{CO} = 2\text{Cu} + \text{CO}_2$.

—A. R. P.

Preparation and Casting of Magnesium Alloys. E. T. Richards (*Metallbörse*, 1934, 24, 761-762, 794, 826-827).—The following are discussed: melting conditions, use of fluxes, preparation of sand moulds, mould dressings, and casting procedure.—A. R. P.

Recent Developments in Brass Die-Casting Methods. Herbert Chase (*Machinery* (N.Y.), 1934, 40, 653-655).—Three Polak die-casting machines have been in use for over 2 years at the Titan Metal Manufacturing Co., and will produce about one million brass castings this year. The metal is heated in electric furnaces, and is held within 10° F. (5° C.) of the temperature required. Maximum die life is about 20,000-50,000 pieces. One of the most successful die steels contains carbon 0.3-0.4, chromium 1.75, vanadium 0.5, tungsten 10-12%. Suitable die-casting alloys include yellow brasses, nickel silvers, aluminium-bronzes, and "Tinicosil," a copper alloy containing zinc 41.0, lead 1.0, and nickel 16.0%. The composition and properties of typical alloys are tabulated.—J. C. C.

On Die-Casting. Hermann Christen (*Schweiz. Bauzeit.*, 1933, 102, 195-198).—A short review of the process and its applications.—J. W.

Grain Structure Control Insures Mould Permeability Control. H. W. Dietert and F. Valtier (*Trans. Amer. Found. Assoc.*, 1933, 41, 175-186; discussion, 186-192).—The permeability of sand is greater if the grains are rounded than if they are of angular shape, and is influenced more by the fine than by the coarse material. The shape of the particles has little effect on the green or dry strengths of moulds, but baked oil-bonded cores made from round grained sand are materially stronger than those made from angular sand. The effects of grain-size are described in detail in the paper and are considered at length in the discussion.—R. B. D.

Effect of Silt on the Bonding Strength of Sand. H. Ries and R. C. Hills (*Trans. Amer. Found. Assoc.*, 1933, 41, 158-166; discussion, 166-167).—An increase of silt decreases both the compressive and tensile strengths, but has less effect on a fine- than on a coarse-grained sand. Clean silica silt has less bonding power than natural ("clayey") silt. Increase of moisture (within the limits 4-8%) caused decrease of strength and permeability.—R. B. D.

Reviews Report on Routine Methods for Testing Green Sands. H. Ries (*Trans. Amer. Found. Assoc.*, 1933, 4, (5), 11-14).—A concise review in which the methods devised and selected by (1) the A.F.A. committee and (2) the I.B.F. committee are compared and contrasted.—R. B. D.

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

(Continued from p. 457.)

The Classification, Properties, and Utilization of Non-Ferrous Scrap Metals and Alloys. Anon. (*Metallurgia*, 1934, 10, 47-48, 79-81, 117-118).—The increasing need for accuracy in the composition of non-ferrous alloys and their proper utilization, when the articles for which they have been used become scrap metal is considered. The problem is discussed with a view to the more profitable use of such scrap metals and alloys as copper wire, copper clippings, miscellaneous copper scrap, yellow metal scrap, yellow metal turnings and borings, brass stampings, miscellaneous brass scrap, scrap tin materials, lead scrap metals, aluminium scrap metals, and zinc scrap. The influence of magnesium, silicon, and aluminium on brass is also reviewed.—J. W. D.

The Recovery of Smelter Dust and Oxide at a Secondary Metals Plant. William Romanoff and C. O. Thieme (*Met. Ind. (N. Y.)*, 1934, 32, 237-239).—A description of the methods used in cooling furnace gases and collecting therefrom suspended zinc oxide derived from the reverberatory smelting and refining of brass scrap at a large American works.—A. R. P.

Electrometallurgical Refining of Alloys of the Noble Metals. W. Graulich (*Deut. Goldschmiede-Zeit.*, 1933, 36, 48-50; *C. Abs.*, 1934, 28, 5341).—The use of the electrolytic treatment of noble metal wastes presupposes a rather rich alloy to begin with, which can be obtained only by the use of an electrolytic preliminary separation. Two processes are described: that of Carl for noble metal tailings and that of Siemens and Halske for plated wastes. The first uses an electrolyte of alkali perchlorate which is stirred by compressed air. The material to be refined is anodically dissolved except for its gold and platinum content, which remains at the anode. The cathodic sludge sinking to the bottom consists of metallic silver mixed with some copper. The plate refining baths are a type of bath for the separation of copper and use a hydrochloric acid electrolyte. The noble metals collect as anode sludge, the silver as silver chloride. The current density, energy efficiency, and temperature of the baths are given.—S. G.

XV.—FURNACES AND FUELS

(Continued from p. 433.)

Oil-Fired Rotary Melting Furnace. Anon. (*Mech. World*, 1934, 95, 595).—A rotary oil-fired furnace suitable for non-ferrous metals and alloys, including copper, brass, bronze, pure nickel, and cupro-nickel, is illustrated and described. The holding capacities vary from $\frac{1}{2}$ ton to 3 tons. Air for combustion is preheated in a special type of metallic recuperator. The oil-burner is designed to burn any medium grade of fuel-oil or the lighter grades of tar-oil.—F. J.

***A Reverberatory Furnace for Melting Aluminium.** Gotthard E. Lenk (*Metall u. Erz*, 1934, 31, 103-105; and (translation) *Light Metals Research*, 1934, 3, 12-16).—The hearth is of octagonal shape slightly elongated, has four oil burners in one side, a door in each of the sides perpendicular to this side, and flues in all the other sides; the furnace will melt charges of up to 6500 kg. of aluminium.—A. R. P.

A Ten-Kilowatt Granular Carbon Resistance Furnace. J. W. Cuthbertson (*Metallurgia*, 1934, 10, 141-147).—A description is given of a carbon-resistance furnace capable of quickly raising 12-15 lb. of metal to 1600° C. or more, and which is extremely suitable for metallurgical research. The electrical con-

ditions and electrodes are very fully discussed and data dealing with electrode dimensions and thermal losses, thermal losses through the furnace wall, efficiency, and upkeep are also fully considered. Special attention is given to the selection and grading of material for the resistor element, and information on suitable refractories for furnace and crucible is also included. Notes on the operation of the furnace are appended.—J. W. D.

***Investigations of Silicon Carbide-Containing Heating Units Operated in the Open Air.** L. Nawo and Wilhelm Meyer (*Elektrowärme*, 1934, 4, 140-141; *C. Abs.*, 1934, 28, 4984).—Silit, Globar, and Quarzilit were tested in the range 800°-1400° C. They were practically identical in open air when in the horizontal position. Heat conductivity is 20 cal./m./hr./° C. from 1000° to 1400° C.—S. G.

Electric versus Fuel-Fired Furnaces. K. Mertens (*Elektrowärme*, 1934, 4, 132-136; *C. Abs.*, 1934, 28, 4983).—Several examples are given to show that in spite of high cost of electric energy the economy of electric furnaces for metallurgical and ceramic purposes can be improved largely by recuperation of heat so that electric furnaces can easily compete with fuel-fired furnaces.—S. G.

***Fundamental Laws of the Design of Electric Smelting Furnaces.** Mikio Mukaiyama (*J. Inst. Elect. Eng. Japan*, 1931, (515), 343-356; *Jap. J. Eng. Abs.*, 1934, (11), 16).—[In Japanese.] M. proposes that the diameter of the electrode should be determined by the short-circuit current density of the electrode (or critical short-circuit current density of the electrode), which is quite different from the so-called allowable current density. The short-circuit current depends strictly on the diameter of the electrode, as well as on the physical properties of the materials to be used. For a certain electric power input, the diameter y of the fused zone in the furnace around the electrode depends on the diameter x of the electrode, and can be denoted by $y = mx + k$, where x and y are given in mm. and cm., respectively, m and k are constants depending on the current or power input. From this value of y the mean radius R of the furnace can be calculated by the formulæ :

$$R = \frac{(2 + \sqrt{3})y}{2\sqrt{3}}$$

M. gives an example of the design of a 200-kw. electric smelting furnace with 3-phase current and of some operating data for large furnaces in connection with his new laws.—S. G.

†The Use of Metals in the Construction of Furnaces.—I. M. Bassal (*Rev. Mét.*, 1934, 31, 299-323).—Read at the Congrès du Chauffage Industriel. See *Met. Abs.*, this volume, p. 365.—H. S.

***The Temperature History and Rate of Heat Loss of an Electrically-Heated Slab.** Albert B. Newman and Louis Green (*Electrochem. Soc. Preprint*, 1934, Sept., 279-292).—If a slab of homogeneous material is subjected to a heat input at a constant rate into one face while the other face is exposed to a fluid medium, the ratio rate of heat loss to the medium rate of heat input will vary from zero at the start to unity after a steady state has been reached. The temperatures of both faces will increase until the final steady values are attained. If the heat supply is cut off at some instant, either before or after the steady state is reached, the slab will eventually cool down to the temperature of the fluid medium, but the temperature history of the two faces would be difficult to predict without mathematical analysis. A practical case is that of an electric furnace being heated up to a desired temperature by means of a uniform kilowatt input, and then being allowed to cool down after the heat supply is discontinued. In this case the temperature history of the inner face of the wall could be taken approximately as the temperature history of the furnace, and the temperature of the fluid medium would be

that of the air in the room. This paper presents a mathematical analysis of the general case, and the results are translated into values and curves for application to practical cases.—S. G.

XVI.—REFRACTORIES AND FURNACE MATERIALS

(Continued from p. 439.)

Constitution and Properties of Bauxites as Refractory Materials. B. Long (*Céramique*, 1933, 36, 1-12; *C. Abs.*, 1934, 28, 3855).—Bauxites are made up of the minerals kaolinite, diaspore, and gibbsite. Hematite and goethite are frequently associated and must be less than 5% for refractory use. Technical data on refractory bauxites include load test data, expansion curves, and spectrographs showing changes taking place in firing.—S. G.

Refractory Cements and Lutes. W. O. Lake (*Sand, Clays, and Minerals*, 1933, 1, (3), 56-58).—The properties required of a refractory cement of good quality are enumerated.—I. M.

Refractory Cements. Practical Tests. W. O. Lake (*Sands, Clays, and Minerals*, 1934, 2, (1), 35-39).—See also preceding abstract. Gives results of practical tests.—I. M.

†**The Selection of Refractories for Use in Engineering Industries.** W. J. Rees (*Fuel Econ. Rev.*, 1934, 13, 50-53).—The physical characteristics of refractories are briefly reviewed.—J. S. G. T.

XVII.—HEAT-TREATMENT

(Continued from p. 458.)

Salt Baths for Dural. F. H. Trembly, Jr. (*Machinist (Eur. Edn.)*, 1934, 78, 497).—The use of a bath of molten salt for the heat-treatment of Duralumin aeroplane parts is briefly described.—J. H. W.

XVIII.—WORKING

(Continued from pp. 458-460.)

Development of Cold-Rolling Machines. Wilhelm Fass (*Stahl u. Eisen*, 1932, 52, 1261-1270; and (abstract) *Technique moderne*, 1933, 25, 622-623).—Several new modifications of Krupp sheet and strip rolls are described. Information is given on the cooling and lubrication of bearings and on the advantages and disadvantages of 4- and 6-high rolls, &c. A discussion follows.—J. W.

New Distant Recording Apparatus for Rolling Pressures. René W. P. Leonhardt (*Iron and Steel Ind.*, 1934, 7, 259-261).—A measuring device suitably equipped to permit of distant readings and, if necessary, to give a continuous record of the pressure in rolling mills is provided by an elastic plate power gauge, in which the pressure-indicating devices as well as the recording devices are designed in an entirely new and interesting manner. This gauge is fully described and illustrated by means of diagrams and photographs.—J. W. D.

Copper Wire-Drawing. A. G. Arend (*Met. Ind. (Lond.)*, 1934, 44, 579-580).—The design of wire-drawing mills, the cooling of the wire, rod making, the process of wire-drawing, and the precautions to be taken for improving the quality of copper wire are discussed.—J. H. W.

Development of Wire Research. F. C. Thompson (*Wire Industry*, 1934, 1, 9-11, 51-54, 85-88).—Surveys the results of researches carried out at Manchester University on wire-drawing during the last twelve years, dealing with power consumption, pull, the effects of die angle, shape and material as well as lubrication on the foregoing, and also with the properties of drawn material.

—A. B. W.

Wire-Drawing at the Higher Speeds. J. B. Nealey (*Iron Age*, 1934, 134, 16-18, 80).—The accurate drawing of copper wire at speeds of 6000 ft./minute and higher, and the plant required to effect this are described.—J. H. W.

Practical Aids for the Evaluation Starting Sizes in Wire-Making. H. (*Draht-Welt*, 1934, 27, 547-548).—Gives formulæ and tables for reductions in area, diameters, and mechanical properties after various treatments.—A. W.

Making Brass Chains. A. G. Arend (*Met. Ind. (Lond.)*, 1934, 45, 243-244).—The manufacture of chains from thin yellow brass ingots in one operation is described.—J. H. W.

Aluminium Alloy Tubes. Anon. (*Aircraft Eng.*, 1934, 6, 291).—A description of the production of tubes in "RR 56" alloy at the works of Reynolds Tube Co., and of the principal properties of the tubes.—H. S.

Considerations of Machining Technique Based on Workshop Trials. H. Schallbroch (*T.Z. prakt. Metallbearbeitung*, 1933, 43, 347-350, 381-385).—A review of the properties of certain materials with special reference to their behaviour in the lathe. The results mainly refer to steels and irons, but they have some application to the testing of non-ferrous metals and alloys by similar methods. Several curves indicate the relationships between the factors under observation—speed of cutting and rate of advance; speed of cutting and hardness; speed of cutting and tensile strength.—W. A. C. N.

Economic Cutting Speed in Finishing. W. Leyensetter (*Maschinenbau*, 1932, 11, 257-259).—A series of investigations on machinability, wear, and surface finish by means of the pendulum process is described and discussed. The curves obtained, whilst of general interest, apply actually to steels and to cast iron.—P. M. C. R.

XIX.—CLEANING AND FINISHING

(Continued from pp. 460-461.)

***The Bullard-Dunn Electrochemical Metal Descaling Process.** Colin G. Fink and T. H. Wilber (*Electrochem. Soc. Preprint*, 1934, Sept., 251-261).—The development of the electrochemical descaling process is described and the underlying principles are discussed. The metal article to be descaled is made the cathode in a hot acid sulphate bath containing a small amount of metal salt such as tin sulphate. A protective film of tin or other metal is progressively formed over the cleaned points or areas, and all pitting, etching, smudge formation, and permanent embrittlement so common in ordinary acid or electric-pickling are avoided. The use of silicon alloy anodes inhibits the oxidation of ferrous ions present in the electrolyte. A long life of the electrolyte is thereby assured, thus doing away with the objectionable, frequent renewals of electrolyte required by the older processes.—S. G.

Electrolytic Degreasing. Fritz Schäfer (*Metallwaren-Ind. u. Galvano-Tech.*, 1934, 32, 408-409).—Compositions of various degreasing solutions are given, with details of the method of preparation and use.—A. R. P.

Metal Cleaning and Metal Cleaning Compounds. H. C. Bernard (*Met. Ind. (N. Y.)*, 1934, 32, 235-236).—A simple, non-technical discussion of the practical problem of preparing metal surfaces for plating.—A. R. P.

Cleaning Prior to Plating. R. J. Piersol (*Metal Cleaning and Finishing*, 1934, 6, 229-234).—A review.—S. G.

Cleaning Articles to be Plated. W. A. Koehler (*Metal Cleaning and Finishing*, 1934, 6, 283-286).—A review.—S. G.

Fly Ash for Cleaning Turbine Blades. Edward Luxemburg (*Power Plant Eng.*, 1934, 38, 408).—Suspended matter in steam tends to adhere to turbine blading, gradually encrusting it with a thin, very hard scale. Sand-blasting proved too drastic a method of removal, but the substitution for sand of "fly ash," *i.e.* the ash resulting from the combustion of pulverized coal, effected thorough cleaning without any damage to the blades.—P. M. C. R.

Rinsing in the Surface Finishing of Metal Articles. H. Krause (*Illust. Zeit. Blechindustrie*, 1934, 63, 854-855).—Surface defects attributed to poor quality or to an unsatisfactory process are frequently caused by inadequate rinsing, after pickling, degreasing, or plating. Without frequent changes of rinsing water, the corrosive effect of bath residues becomes cumulative. Directions are given for maintaining a steady flow of clean water through the rinser, or, alternatively, for the use of a series of baths. Hot water is recommended for the final rinse. Certain precautions are necessary in using neutralizing or degreasing rinses.—P. M. C. R.

Producing a Patina on Zinc Sheet. Anon. (*Illust. Zeit. Blechindustrie*, 1934, 63, 965).—The comparatively poor adhesion and the tendency to exfoliation sometimes shown by paint and lacquer have led to the frequent adoption of chemical processes for producing on zinc an artificial patina. Methods are briefly described for the formation of deep grey, green, or copper surface finishes, and it is stated that a plain zinc finish can be produced on a surface already coppered.—P. M. C. R.

The Measurement of Surface Finish. Anon. (*Machine moderne*, 1934, 28, 131).—A brief description of the University of Michigan surface-testing apparatus, illustrated by a diagram, and by specimen curves with descriptions of material and of working of the samples concerned.—P. M. C. R.

Polishing Powders and Earths. Arthur Jones (*Sands, Clays, and Minerals*, 1933, 1, (4), 47-50).—General.—I. M.

On Grinding Wheels and Smearing. Anon. (*Werkzeug* (Suppt. to *Maschinenkonstrukteur*), 1933, 9, (15/16), 145).—The mechanism of grinding is reviewed, and the phenomena of smearing are attributed to the great heat produced by the friction of variously oriented cutting particles on the material to be worked. Careful selection of grades, speeds, and lubricants will obviate smearing to a great extent; the cutting of such soft materials as lead, copper, tin, and zinc requires in addition a carefully regulated pressure. Excessive lubrication may actually promote smearing. The cleaning of grinding wheels which have been damaged by smearing is discussed: special appliances are available at small cost. Chemical cleaning requires considerable caution.—P. M. C. R.

Boron Carbide: A New Crystalline Abrasive and Wear-Resisting Product. Kaymond R. Ridgway (*Electrochem. Soc. Preprint*, 1934, Sept., 293-308).—The production of a new abrasive carbide of boron, and difficulties encountered in commercializing the process, are outlined. The crystallization of the new product is described. Its hardness is compared with the known hardness of diamond and silicon carbide. A series of tables shows the comparative strength properties of the new product compared with crystalline materials and metallic alloys of similar nature. Specific resistivity and temperature coeff. of resistance data are given, and the coeff. of expansion is compared with that of certain known crystalline materials. Evidence is presented for a new formula for boron carbide. Industrial applications of the new product are briefly tabulated.—S. G.

XX.—JOINING

(Continued from pp. 461-463.)

Preparation of Solder in Melting Kettles. Werner Frölich (*Chem. Zeit.*, 1934, 58, 237-238).—For the manufacture of large quantities of solder in iron kettles the latter should be set in brickwork over a hard coal fire so arranged that the heat is distributed evenly around the sides and the bottom. The metal should never be heated above 300° C., and the surface should be covered with an ammonium chloride flux, or steam should be blown through the molten charge for 3-5 minutes to remove oxide inclusions. If iron moulds are used for casting, they should be preheated to allow the alloy to cool slowly; the same effect but a better surface appearance is obtained by the use of marble moulds. Care should be taken to avoid introduction of arsenic or zinc into the alloy, but addition of 1-1.5% of antimony is recommended to increase the resistance to corrosion and to improve the surface appearance.

—A. R. P.

Soft Solders and Soldering Fluxes. E. E. Halls (*Sheet Metal Ind.*, 1934, 8, 175-176, 186, 231-232, 244, 299-300).—A description is given of the manufacture of solders, the principles of soldering, and the use and function of various fluxes. All types of work requiring soft solders can be performed by the use of one of the following four alloys: (i) tin 65, antimony 0-1%, (ii) tin 50, antimony 2.5-3%, (iii) tin 40, antimony 2-2.4%, (iv) tin 30, antimony 1-1.7%, lead forming the remainder in all cases. A tolerance of $\pm 1\%$ in the tin figure is allowable.—A. R. P.

Automatic [Brazing] Furnaces for Speed and Uniformity. J. Freeze (*Elect. J.*, 1934, 31, 283-284).—A brief description of the working of an automatic loading device and furnace for brazing copper coils to steel cans. The assembly of coil and can is placed in the furnace at 1700° F. (927° C.) and removed after a predetermined time when brazing is complete.—J. C. C.

New-Type Installation Equipment Built of Arc-Welded Aluminium. A. F. Davis (*Metallurgia*, 1934, 10, 111).—A brief description is given of an arc-welded aluminium distillation equipment for a new chemical process, which is probably the first of its kind to be fabricated by means of arc welding. The equipment consists of two condensers with 140 tubes in each, 2 drip tanks, and 2 receiving tanks. 8-in. piping connects the condensers and the still, and this piping was fabricated complete by arc-welding from aluminium sheets. Welds were tested under 100 lb. pressure, and no flaws were found in any of the welds.—J. W. D.

The Joining of Tubes by Welding. H. Thomas (*Illust. Zeit. Blechindustrie*, 1934, 63, 971-974, 998-999).—An illustrated discussion of possible methods of welding the elements of flexible metal tubing.—P. M. C. R.

Contribution to the Question of Welding Stresses. Hans Bühler and Wilhelm Lohmann (*Elektroschweissung*, 1934, 5, 141-145, 165-170).—A review of previous work is followed by an account of results obtained from a modification of the method of Sachs for determining the internal stresses in cylinders. Circular plates (or short cylinders) are used in order that longitudinal stresses may be neglected. A concentric deposit of weld metal is made on each face, and the change in diameter of the cylinder is measured as a central hole is bored and its diameter increased. The experiments are made with steel samples; the effect of annealing and the difference in stress-effect between electric arc and oxy-acetylene welding are determined.—H. W. G. H.

†**The Scientific Basis of Autogenous Welding.** A. Portevin (*Aciers spéciaux*, 1933, 8, 384-399).—Extract from a lecture given to the Journées de la Soudure autogène appliquée aux Constructions Navales, 399-401. The function of

autogenous welding is to join pieces of metal together so that a homogeneous junction is effected. This requires the application of sound metallurgical practice, and the foundations on which the process is based are set out and elaborated. In the appendix, the properties of the material at and adjacent to the weld are described.—J. H. W.

New Resistance Welding Electrode Alloys. J. J. Kelly (*J. Amer. Weld. Soc.*, 1934, 13, (7), 11).—Beryllium-copper is recommended.—H. W. G. H.

Electric Resistance Welding Machines. C. A. Hadley (*Weld. J.*, 1934, 31, 173-177).—The principles of the process and the factors to be considered are discussed. The rating, voltage, and current consumption, as influenced by the design of machine, are explained. The application of automatic timing control is described, and a useful summary of the various types is given.—H. W. G. H.

The New Methods of Oxy-Acetylene Welding Medium and Thick Sheets. R. Meslier (*Bull. Soc. Ing. Soudeurs*, 1934, 5, 1297-1306; and *Rev. Soudure autogène*, 1934, 26, (245), 8-12; also (in part) *Weld. Ind.*, 1934, 2, 179-181, 192).—The method of welding vertically upward in two runs is described and tables are given showing times and consumptions of gases and welding rod for various thicknesses of material. In this method of welding two operators work from opposite sides of the sheets to be butt welded, these being held vertical. The blowpipes move from bottom to top, preceded by the welding rods.—H. W. G. H.

The Kinematics of Oxy-Acetylene Welding. R. Granjon (*Rev. Soudure autogène*, 1934, 26, (245), 2-5; and *Weld. Ind.*, 1934, 2, 149-152).—Experience with automatic welding indicates that many of the complicated movements made by the hand of the welder are unnecessary and even harmful. Lack of precision, it is thought, makes continuous correction necessary, and this takes the form of lateral and vertical movements of the welding flame.—H. W. G. H.

***Experimental Investigations on the Question of Pressure in High-Pressure Acetylene Plant.** W. Rimarski and M. Korschak (*Autogene Metallbearbeitung*, 1934, 27, 209-215, 225-232).—After a review of the literature on the subject, experiments are described to determine the explosion pressures resulting from the ignition of air-acetylene, oxygen-acetylene mixtures, and pure acetylene, at various initial pressures from 0 to 3 kg./cm.². The experiments were carried out in a 40-l. steel vessel connected to a pipe-line 16 m. long, both being fitted with pressure indicators of the indentation type. In order to check the accuracy of these indicators under the rapid applications of pressure, confirmatory tests were made in a duplicate vessel fitted with brass bursting discs, which were calibrated statically. The results are tabulated in detail and show that generators tested to 10-12 kg./cm.² cannot be considered "explosion-proof."—H. W. G. H.

Advantages of Distributing Acetylene Under Pressure for Welding, and Means for Ensuring Safety in Pressure Installations. C. S. Milne (*Weld. Ind.*, 1934, 2, 137-143).—See *Met. Abs.*, this volume, p. 209.—H. W. G. H.

Study of the Temperature of the Oxy-Acetylene Flame. D. Séférian (*Rev. Soudure autogène*, 1934, 26, (245), 6-7).—S. discusses a recent thesis by Pierre Montagne, in which the proportions of the constituents of the oxy-acetylene flame and its temperature are calculated for varying proportions of oxygen to acetylene. The results agree closely with those obtained by Ribaud and S. (see *Met. Abs.*, this volume, p. 209), the maximum theoretical temperature being obtained with an oxygen : acetylene ratio of 1.5, whereas, in practice, it is obtained when the ratio is about 1.2. Both calculation and experiment agree on a figure of about 3100° C.—H. W. G. H.

XXI.—INDUSTRIAL USES AND APPLICATIONS

(Continued from pp. 464-469.)

Light Alloys for Cylinders and Their Sliding Properties. O. Engelmann (*Metallbörse*, 1934, **24**, 501-502, 534-535, and (abbreviated translation) *Aluminium Broadcast*, 1934, **4**, (29), 8-9).—The requisite properties of a good cylinder alloy are discussed, and various types of light metal alloys which have found application in the construction of cylinders and pistons for internal combustion engines are described, with brief notes on their structure, heat-treatment, and sliding properties.—A. R. P.

†**Aluminium Alloys for Pistons [of Internal Combustion Engines].** R. Sterner-Rainer (*Werkstofftechnisches Kolloquium, Staatl. Materialprüf. Tech. Hochschule, Darmstadt*, 1933, (2), 20-25).—Aluminium alloys, especially those containing silicon, have many advantages over cast-iron alloys for the manufacture of pistons, e.g. a low density, a small heat capacity but good heat conductivity, a low coeff. of expansion, and a high resistance to wear. These points are illustrated by graphs and diagrams.—A. R. P.

†**Comparative Values of Piston Alloys.** Otto Steinitz (*Glaser's Ann.*, 1933, **113**, 36-39).—A complete scheme for the representation of the comparative values of heavy and light metal pistons of all kinds cannot yet be given. The present position in this respect is briefly reviewed.—J. W.

Aluminium Alloy Pistons. A. G. Arend (*Aircraft Eng.*, 1934, **6**, 211, 214).—The casting of pistons is described, reference being made to the influence of pouring temperature on the quality of the casting, and the factors affecting flow of metal in the mould. Points affecting machining of pistons are discussed.—H. S.

Air-Cooled Aero Engines. A. H. R. Fedden (*Automobile Eng.*, 1934, **24**, 223-228, 259-262, 293-298).—In a discussion of the possible future developments of air-cooled aero engines, a section is devoted to the development of aircraft engine materials (pp. 294-295). The value of non-ferrous light alloys for aircraft engines depends on their strength and stability at elevated temperature, and the creep stress and other physical properties of cast and forged magnesium alloys are compared with those of cast and forged aluminium alloys. Consideration is also given to the applications and to the limitations of magnesium alloys for various parts, and to the advantages which may be expected from their future development and use. The possibility of using beryllium alloys is also referred to.—J. W. D.

†**Aluminium Castings for Aircraft.** N. F. Budgen (*Aircraft Eng.*, 1934, **6**, 207-208, 214).—A survey of the more important aluminium castings used in aircraft, dealing with properties and scope of the alloys, melting and casting technique, heat-treatment, &c.—H. S.

***Some Developments in Aircraft Construction.** H. J. Pollard (*J. Roy. Aeronaut. Soc.*, 1934, **38**, 651-676; discussion, 677-686).—A survey of structural features of metal construction of aircraft with special attention to stiffness and stability. Welding is discussed, and results of fatigue tests on electric spot welds in aluminium alloy 4S are given.—H. S.

Aluminium Alloys in Bodywork. W. Kuster (*Deut. Motor Z.*, 1933, May; and (translation) *Aluminium Broadcast*, 1933, **4**, (14), 10-18).—The distribution and magnitude of the stresses produced in the body-work of commercial vehicles are discussed, and it is concluded that only heat-treated aluminium alloys are suitable for replacing steel. In designing light metal bodies, the special characteristics of these materials must be kept in mind. The elastic modulus is only about one-third that of steel. All workshop operations should be done below 150° C., rivets should be cold driven, and welding avoided.

Reference is made to a new type of construction using specially shaped beams so that all members are equally stressed. This type of framework is claimed to result in additional weight savings of 10-15%.—J. C. C.

Passenger Coaches of Aluminium in the United States. F. Witte (*Organ Fortsch. Eisenbahnwesens*, 1934, **89**, (15), 291-294).—An account of 2 coaches built for the Chicago Pullman Co. The larger is an "observation" car, the other being of the coach type, with extensive streamlining. A system of interlocking parts reduces riveting to a minimum. Steel is used only in wheels, axles, springs, and brake-shoes, and as occasional reinforcement for aluminium. Elastic limit, ultimate tensile stress, elongation, compressive strength, shear strength, Brinell hardness, analysis, and application are tabulated for the alloys used.—P. M. C. R.

The Economy of Aluminium Tank Cars. Anon. (*Petroleum Z.*, 1934, **30**, (32), 77).—An account of the recent popularization of aluminium tank-car construction in Austria. A cast-iron benzine tank of 3000 kg. capacity weighs 1800 kg., as against 1000 kg. in aluminium, *i.e.* the paying load is increased by 45%, with an equivalent saving in motor spirit, oil, and wear on tyres. The substitution of aluminium for iron is estimated to pay for itself within a year.—P. M. C. R.

Aluminium in Architecture and the Building Trades. Walther Zarges (*Metallbörse*, 1934, **24**, 683, 697-698, 729-730).—A description of the numerous uses to which aluminium has been put in building construction is given together with notes on methods of welding and joining the metal and its alloys and on means for protecting them from corrosion.—A. R. P.

The Alfol Heat Insulation Process. A. v. Zeerleder (*Schweiz. Bauzeit.*, 1934, **103**, 47-49).—The properties and uses of aluminium foil for heat insulation are described.—J. W.

Copper Tube for Distribution Lines. Anon. (*Bull. Copper Brass Res. Assoc.*, 1934, (78), 2-3).—The use of copper tube for distributing petroleum for heating orchards, &c., is described and illustrated.—J. S. G. T.

Strip of Copper Used to Permanently Seal New Concrete Highway Joint. Anon. (*Bull. Copper, Brass Res. Assoc.*, 1934, (78), 4).—The use of copper sheet as jointing material in the construction of 320 miles of highway in Illinois is described and illustrated.—J. S. G. T.

***Advances in Telegraphy with References to the Construction of Pupin Coils.** R. Goldschmidt (*Z. tech. Physik*, 1934, **15**, 95-99).—Recent improvements in Pupin coils involve the use of a specially treated 50:50 iron-nickel alloy (Isoperm) in the form of sheet, strip, or wire; these coils are more satisfactory than those made of pressed iron powder.—J. W.

Low Hysteresis and Stable Alloys for Telegraphy (Isoperm). O. Dahl and J. Pfaffenberger (*Z. tech. Physik*, 1934, **15**, 99-106).—*Cf. Met. Abs.*, this volume, p. 295. The development of Isoperm alloys is shortly described. The advantages of these alloys for cores over pressed dust cores of iron, &c., are a smaller coil with the same hysteresis or an improvement in the electromagnetic values with the same size of core.—J. W.

Seamless Tantalum Tubing. Anon. (*Siemens Rev.*, 1934, **10**, (2), 48).—Note on the introduction of tantalum tubing of bores from 14 to 40 mm. by Siemens and Halske. Wall thicknesses from 0.5 to 3 mm. and lengths up to 10 mm. may be obtained.—R. Gr.

Titanium in Metallurgy. M. A. Hunter and A. Jones (*Electrochem. Soc. Preprint*, 1934, Sept., 209-219).—The metal titanium can be produced in the pure state and finds a limited use in metallurgy. Alloys of titanium with iron, copper, aluminium, nickel, and manganese are also available as sources of supply and find extensive applications. In addition to its use in the iron and steel industry, in the Konel alloys in which nickel predominates, titanium increases strength at high temperatures by conferring age-hardening pro-

erties on the alloy to which it is added. Copper-titanium alloys are capable of being age-hardened and have interesting possibilities. In aluminium alloys, titanium plays only a minor rôle.—S. G.

Zirconium and Its Compounds: Commercial Applications. A. Cochet (*Chim. et Ind.*, 1934, Special No., (April), 704-714).—A general discussion.—S. G.

Plain Bearing Design, Construction, and Composition. Anon. (*Lubrication*, 1934, 20, (2), 13-24).—A discussion of the relationship between lubricating practice and bearing design is followed by a summary of the constitution and properties of the bearing metals. The ternary diagram giving the freezing points of the relevant region of the copper-tin-lead alloys is reproduced, and the compositions and applications of 12 copper-base bearing alloys are tabulated. A discussion of the tin-, lead-, and zinc-base white metals includes a table of analyses for 10 alloys, and a series of curves showing their temperature and compression relations. Melting procedure, preparation of the shells, and pouring conditions and technique are reviewed, and a list is given of data required for correct bearing design.—P. M. C. R.

Bearing Stresses in Diesel Motor Engines. H. J. Stephan (*Automobiltech. Z.*, 1934, 37, 425-426).—The satisfactory performance of Diesel engine bearings does not depend entirely on efficient lubrication. Actual melting occurs less often than cracking and shattering of the metal. A study of bearing problems under all types of moving conditions has established that the unequal thermal expansion of the white-metal bearing and the bronze of the casing is the principal cause of internal stresses and consequent cracking under normal lubrication. Among preventive methods, S. proposes that the body of the bearing should consist of lead-bronze, with a thin coating of white-metal to diminish friction.—P. M. C. R.

Bearing Problems in the Motor Diesel Engine. Anon. (*Automobiltech. Z.*, 1934, 37, 426-427).—Owing to the high stresses to which connecting-rod bearings are subjected in use, it is suggested that lead-bronze casings carrying a thin coating of "Gittermetall" would obviate cracking and crushing through the superior strength of the bearing alloy. American experience is adduced, however, that a lead-bronze containing copper 63, lead 35, sulphur 0.4, and a zirconium-silicon compound 1.5% was superior to the ordinary bearing bronzes. The structure of the Ricardo crankshaft bearing is described and shown in diagram, as is that of a Diesel connecting rod bearing.—P. M. C. R.

The Metallization of Radio Valves with Nitrocellulose-Bonded Metal Coatings. Anon. (*Synthetic and Applied Finishes*, 1933, 4, 280-285; *Res. Assoc. Brit. Paint Manuf. Rev.*, 1934, (37), 23).—The two main methods for coating radio valves: (1) application of a coating of metal or alloy without binding material, and (2) application of a "bronze" nitrocellulose lacquer, are described in detail. The first method may be carried out by immersion, electro-deposition, spraying, &c.—S. G.

Turbine Blading Stresses. Sydney D. Scorer (*Mech. World*, 1934, 95, 3-4).—The forces acting on turbine blades are analyzed, and the methods of fastening the blades adopted by various manufacturers are illustrated and discussed.—F. J.

***Valve and Valve Seat Wear.** C. G. Williams (*Aircraft Eng.*, 1934, 6, (63), 141-144).—Special attention is paid to sinkage of valves of internal combustion engines in their seats during running. The influence of temperature and closing velocity of the valve, and the working temperatures of valves and seats are investigated. For operating temperatures up to 750° C. wear of the seats increases with temperature rapidly, afterwards decreasing sharply with further increase of temperature.—H. S.

Gaskets for Pressure Vessels and Heat Exchangers. C. O. Sanstrom (*Chem. and Met. Eng.*, 1934, 41, 130-134).—Joints in pressure vessels may be

made up with gaskets and packing of various materials, including metals, e.g. steel, copper, Monel metal, aluminium, and lead, as well as alloys of these and other metals. To have the advantage of the elasticity of steel and the malleability and corrosion-resistance of copper, steel gaskets are copper-plated to a thickness of several thousandths of an inch. The spiral "threads," formed in machining the flanges, embed themselves in the copper, with good results. Various types of gasket, methods of bolting, pressures involved, &c., are discussed. In one instance a copper wire was set in a square groove in the shell flange, and the tongue of the cover flange bore on it with such force as to cause the copper wire to form a circular groove in the steel tongue, the wire itself being only slightly deformed.—F. J.

Non-Ferrous Metals in Electrotechnics. R. Schulze (*Metallbörse*, 1934, **24**, 680-682).—A review of the properties and uses of copper, aluminium, lead, nickel, and chromium and their alloys in the electrical industry.—A. R. P.

Electrical and Mechanical Features of the Field Building. Anon. (*Power Plant Eng.*, 1934, **38**, 306-313).—Aluminium conductors are employed in the low-voltage electrical distribution system of the Field Building, Chicago. The rigid bus-bar arrangement was selected as being less expensive than cable loop construction, and channel-shaped conductors of 99.4% aluminium were installed. An account is given of the method of assembly and of jointing.
—P. M. C. R.

Non-Ferrous Metals in Building. Anon. (*Illust. Zeit. Blechindustrie*, 1934, **63**, 832).—Various types of roofing are among the exhibits at the (German) Building Exhibition which illustrate the uses of non-ferrous metals. A bitumen-coated thin copper sheet affords excellent protection with great durability and considerable sound-deadening effect. Zinc tiling is stated to give good results and an ornamental effect, and either aluminium or bronze sheet may be backed with mill board. Numerous applications to household furnishing and fittings are enumerated.—P. M. C. R.

XXII.—MISCELLANEOUS

(Continued from pp. 469-471.)

Walter Rosenhain. Léon Guillet (*Rev. Mét.*, 1934, **31**, 330-331).—A note on the work and services to science of Rosenhain with tributes to and expressions of appreciation of his contributions to international conferences, &c.
—H. S.

***The Development of Metallurgy.** G. Tammann (*Z. Metallkunde*, 1933, **25**, 3-5).—I. M.

Method for Studying Complex Phenomena: Application to Metallurgical Investigations. R. de Fleury and H. Portier (*Chim. et Ind.*, 1934, Special No., (April), 448-453; *C. Abs.*, 1934, **28**, 5375).—Mathematical. The method consists essentially of an interpretation by analytical geometry of equilateral-triangular graphical representations.—S. G.

Roman Mining in Britain. G. Clement Whittick (*Trans. Newcomen Soc.*, 1931-1932, **12**, 57-84).—An account is given of what is known of Roman activities in mining lead, copper, and other ores in Britain and of the methods adopted in smelting these ores and refining the metals. The weight and silver content of, and the inscription on, numerous pigs of lead found in various British localities are tabulated.—A. R. P.

The Occurrence of Tin and Copper near Byblos. G. A. Wainwright (*J. Egyptian Archaeology*, 1934, **20**, 29-32).—Evidence is adduced which indicates that the Egyptians obtained their tin for the manufacture of bronze from Byblos in the Kesrwan district of Lebanon.—A. R. P.

The United States Copper Industry. Anon. (*Metallurgia*, 1934, 10, 69-70).—The problem created by the relatively low average percentage of copper in American ore reserves together with reduced consumption of copper is discussed, and consideration is given to the outlook for profitable research in developing new uses for metallic copper, copper alloys, and copper compounds.

—J. W. D.

Metallurgical Departments of the Ural Nickel Works. B. V. Lipin and N. Ya. Zlokazov (*Zvetnye Metally (The Non-Ferrous Metals)*, 1933, (6), 60-74; *C. Abs.*, 1934, 28, 5009).—[In Russian.] A description of the nickel works at Verkhni Ufaley (Ural).—S. G.

Energy Sources in Metallurgical Plants in South Russia. A. Sheftel (*Domez*, 1934, (2/3), 15-22).—S. G.

Manufacture of Metal Goods in China. Anon. (*Illust. Zeit. Blechindustrie*, 1934, 63, 810, 835).—A survey of the resources and methods of the Chinese metal-working industries, with brief accounts of some of their more important branches.—P. M. C. R.

Construction of Cylindrical Envelopes Working under Pressure. Étienne Audibert and André Raineau (*Ann. Office National Combustibles liquides*, 1934, 9, (2), 203-279).—Part of a course of instruction on phenomena of catalysis and hydrogenation, instituted by the (French) National Society for Research on Treatment of Fuels. Pp. 203-241 are of general metallurgical interest, and give theoretical analyses of several problems of flow and elasticity, including the distinction between plastic flow and elastic deformation; the temperature variations of the longitudinal modulus of elasticity, Poisson's ratio and of the elastic limit; methods of determining rate of plastic flow. Calculations of total deformation lead to the conclusion that at the instant under consideration the specimen is under stresses similar to elastic stresses, but that it has different coeffs. of longitudinal and transverse elasticity. A discussion of the relation between molecular structure and elastic deformation emphasizes the distinction between elastic and plastic deformation. The case is considered of a metallic specimen working (a) below, (b) above the temperature of plastic flow. Conditions of elastic equilibrium are discussed for cylindrical envelopes working at a uniform temperature below the flow-point, especially from the point of view of the selection of suitable factors of safety and of the choice of testing methods. Varying temperature conditions are also considered. Practical deductions from the foregoing concern the provision of proper thermal insulation and the selection of the optimum working temperature.—P. M. C. R.

XXIII.—BIBLIOGRAPHY

(Continued from pp. 471-472.)

(Publications marked * may be consulted in the Library.)

- ***Abbott, Lester E.** *Sensitivity of X-Ray Examination of Metal Defects.* (Bell Telephone System Technical Publications, Metallurgy, Monograph B-803.) Med. 8vo. Pp. 7, with 5 illustrations. 1934. New York: Bell Telephone Laboratories, Inc., 463 West St.
[Reprinted from *Iron Age*, 1934, 133, 12-14, 72.]
- ***Alloys.** *Directory of Iron, Steel, and Non-Ferrous Alloys used in Design of Machines.* Third Edition. (Supplement to *Machine Design*, 1933, Sept.) Demy 8vo. Pp. 30. 1933. Cleveland, O.: Johnson Publishing Co., Penton Bdg. (25 cents.)
- ***Altper, Hermann.** *Die Drahtseile, ihre Konstruktion und Herstellung.* Zweite verbesserte und erweiterte Auflage. Demy 8vo. Pp. v + 152, with 58 illustrations. 1931. Halle (Saale): Martin Boerner. (R.M. 6.50.)

- ***American Society for Testing Materials.** *Service Characteristics of the Light Metals and Their Alloys.* Prepared by Sub-Committee VII of Committee B-7 on Light Metals and Alloys, Cast and Wrought. Med. 8vo. Pp. 33. 1934. Philadelphia, Pa.: The Society, 260 S. Broad St. (50 cents.)
- ***American Society for Testing Materials.** *Year-Book.* Med. 8vo. Pp. 245. 1934. Philadelphia, Pa.: The Society, 260 S. Broad St.
- Andrejew, N. S.** *Aufgaben über die Massanalyse.* [In Russian.] Pp. 116. 1934. Leningrad: Gipromesa. (Rbl. 2.50.)
- Atack, F. W., and R. T. Elworthy.** Edited by. *Chemists' Year Book, 1934.* American data by **F. M. Turner.** Fcap. 8vo. Pp. 1189. 1934. Manchester: Sherratt & Hughes, Ltd. (21s. net.)
- ***Bain, H. Foster, and Wm. G. Schneider.** *Copper.* Demy 4to. Pp. 20. 1933. New York: Copper and Brass Research Association.
- Bayley, Thomas.** *A Pocket-Book for Chemists.* Edited by **R. Ensoll.** Ninth Edition. Fcap. 8vo. Pp. 476. 1934. London: E. and F. N. Spon, Ltd. (8s. 6d. net.)
- ***Below, A. F.** *Some Properties of Light Alloy Sheets.* [In Russian.] Pp. 48, with 32 illustrations. 1933. Moscow and Leningrad: Zvetmetisdat. (Rbl. 1.20.)
- ***Bhagvat, R. N.** *Metals.* Roy. 8vo. Pp. viii + 221 + viii, illustrated. Bombay: The Author, St. Xavier's College, Cruickshank Rd. (Rs. 3.)
- ***Billiter, Jean.** *Prinzipien der Galvanotechnik.* Med. 8vo. Pp. iv + 326, with 86 illustrations. 1934. Wien: Julius Springer. (Geb., R.M. 25.50.)
- ***Birmingham Aluminium Casting (1903) Company, Limited.** *Magnesium Alloys, with Special Reference to Elektron.* Compiled for the use of Engineers and Designers by the British Elektron patent owners and licensed manufacturers. With a Foreword by C. R. Fairey. Second edition. Med. 8vo. Pp. x + 123, illustrated. 1934. Birmingham: The Company, Smethwick.
- ***Bloch, Felix.** *Die Elektronentheorie der Metalle.* (Sonderdruck aus Handbuch der Radiologie, Band VIII.) Roy. 8vo. Pp. 226-278, with 8 illustrations. 1933. Leipzig: Akademische Verlagsgesellschaft m.b.H. (R.M. 4.50.)
- ***Brillouin, Léon.** *Conductibilité électrique et thermique des Métaux.* (Actualités scientifiques et industrielles, 89. Réunion internationale de chimie-physique.) Roy. 8vo. Pp. 71 + 3, with 18 illustrations. 1934. Paris: Hermann et Cie, 6 Rue de la Sorbonne. (18 francs.)
- ***British Aluminium Company, Limited.** *Aluminium in Shipbuilding.* (No. 363.) 7 in. × 9 in. Pp. 52, illustrated. 1934. London: The British Aluminium Co., Ltd., Adelaide House, King William St., E.C.4.
- ***British Drug Houses, Ltd., and Hopkin and Williams, Ltd.** "*Analar*" *Standards for Laboratory Chemicals.* Being improved standards for the analytical reagents formerly known as "A.R." Demy 8vo. Pp. xvi + 295. 1934. London: The British Drug Houses, Ltd., Graham St., N.1; Hopkin and Williams, Ltd., Cross St., E.C.1. (3s. 6d.)
- ***British Standards Institution.** *British Standard Engineering Symbols and Abbreviations.* (No. 560.) Med. 8vo. Pp. 62. 1934. London: British Standards Institution, 28 Victoria St., S.W.1. (3s. 9d. post free.)
- ***British Standards Institution.** *British Standard Specifications for Nickel Ammonium Sulphate, and Nickel Sulphate for Electroplating.* (No. 564.) Med. 8vo. Pp. 10. 1934. London: British Standards Institution, 28 Victoria St., S.W.1. (2s. 2d. post free.)

- ***Brödner, Ernst.** *Zerspanung und Werkstoff. Ein Handbuch für den Betrieb.* Demy 8vo. Pp. x + 173, with 154 illustrations. 1934. Berlin: VDI-Verlag G.m.b.H. (Geb., R.M. 5; VDI-Mitglieder, R.M. 4.50.)
- ***Canada.** *Canadian Trade Index.* Annual Issue of 1934. Roy. 8vo. Pp. 842. 1934. Toronto: Canadian Manufacturers' Association, Inc., 14th Floor, 67 Yonge St. (\$6.00.)
- ***Cazaud, R.** *Métallurgie: à l'usage des ingénieurs, maîtres de forges, directeurs et contremaitres d'usines métallurgiques de fonderies de métaux, &c.* 50e. édition. Post 8vo. Pp. xx + 345 + 84 + xlii, with 54 illustrations. 1934. Paris: Dunod. (Relié, 20 francs.)
- Centro d'informazioni del nickel.** *Le Nickel. Leghe non ferrose.* 4to. Pp. 38. 1933. Milano: Archetipografia.
- Chemical Markets, Inc.** *Chemical Guide-Book, 1934.* Tenth Edition. Pp. 695. 1934. New York: Chemical Markets, Inc., 25 Spruce St.
- ***Clarke, S. G.** *A Rapid Test of Thickness of Tin Coatings on Steel.* (Technical Publications of the International Tin Research and Development Council, Series A, No. 12.) Sup. Roy. 8vo. Pp. 525-528. 1934. London: International Tin Research and Development Council, 378 Strand, W.C.2.
[Reprinted from *Analyst*, 1934, 59, 525-528.]
- ***Climax Molybdenum Company.** *Molybdenum, 1934.* 8 × 10½ in. Pp. 74, illustrated. 1934. New York: Climax Molybdenum Co., 295 Madison Ave.
- Cole, Arthur H., and Karl W. Bigelow.** *A Manual of Thesis-Writing: for Graduates and Undergraduates.* Demy 8vo. Pp. ix + 48. 1934. New York: John Wiley and Sons, Inc. (\$0.75); London: Chapman and Hall, Ltd. (4s. net).
- ***Dawidenkow, N. N.** *The Mechanical Properties and the Testing of Metals.* [In Russian.] Second edition. Part I. Pp. 136 + 4 plates. 1933. Leningrad: Isd. Kubutsch. (Rbl. 3.)
- ***Dejean, P., et S. Gerszonowicz.** *État actuel de l'essai de fragilité des métaux.* Pp. iii + 103, with 63 illustrations. 1934. Paris: Dunod. (20 francs.)
- ***Department of Scientific and Industrial Research.** *Deterioration of Structures of Timber, Metal, and Concrete Exposed to the Action of Sea-Water.* Fourteenth (Interim) Report of the Committee of the Institution of Civil Engineers. Edited by John Purser and H. J. Grose. Med. 8vo. Pp. iv + 56, with 19 plates. 1934. London: H.M. Stationery Office. (1s. 6d. net.)
- Department of Scientific and Industrial Research.** *The Industrial Application of X-Ray Crystal Analysis: Facilities Provided by the National Physical Laboratory.* Roy. 8vo. Pp. 15 + 4 plates. 1934. London: Department of Scientific and Industrial Research.
- ***Desch, Cecil H.** *The Chemistry of Solids.* (The George Fisher Baker Lecture-ship in Chemistry at Cornell University.) Med. 8vo. Pp. xi + 213, with frontispiece and 55 illustrations. 1934. Ithaca, N.Y.: Cornell University Press (\$2.50); London: Oxford University Press (Humphrey Milford) (11s. 6d. net).
- Dorfman, J. G., and I. K. Kikoin.** *Physics of Metals. The Electrical, Optical, and Magnetic Properties.* [In Russian.] Pp. 551. 1934. Leningrad and Moscow: Gos. techn.-theoret. isd. (Rbl. 7.)
- ***Dutoit, Paul.** *Sur le Potentiel Métal/Solution dans les Dissolvants autres que l'Eau.* (Actualités scientifiques et industrielles, 93. Réunion internationale de chimie-physique.) Roy. 8vo. Pp. 12, with 10 illustrations. 1934. Paris: Hermann et Cie, 6 Rue de la Sorbonne. (4 francs.)

- ***Engelhardt, Victor.** Herausgegeben von. *Handbuch der technischen Elektrochemie.* Dritter Band. *Die technische Elektrolyse im Schmelzfluss.* Bearbeitet von P. Camescasse, G. Eger, H. Fischer, K. Illig, V. Makow, I. J. Moltkehansen, W. Schmidt, H. v. Steinwehr, H. Suchanek, und A. v. Zeerleder. Roy. 8vo. Pp. ix + 565, with 183 illustrations. 1934. Leipzig: Akademische Verlagsgesellschaft m.b.H. (Brosch., R.M. 50; geb., R.M. 52.)
- Erasmus, A. A., und L. A. Erasmus.** *Deutsch-russ. techn. Wörterbuch.* 3. verb. u. erg. Auflage. ii + 1148 spalten. 1934. Moscow: Ogis. (Rbl. 5.)
- Fedotjew, P. P.** *Die Elektrolyse in der Metallurgie.* Teil II.—*Die Elektrolyse geschmolzener Substanzen.* [In Russian.] Pp. 318. 1934. Leningrad: Goschimtechisdat. (Rbl. 2.80.)
- ***Fuss, V.** *Metallographie des Aluminiums und seiner Legierungen.* Med. 8vo. Pp. viii + 219, with 203 illustrations in the text and 4 folding pp. of diagrams. 1934. Berlin: Julius Springer. (R.M. 21; geb., R.M. 22.50.)
- Greber, E.** *Céramique: terresucites, produits réfractaires, faiences, grès, porcelaines.* Pp. 642. 1934. Paris: Société Française d'Edit. littéraires et techniques. (40 francs.)
- ***Handy and Harman.** *18th Annual Review of the Silver Market. The Gold Situation in the Arts and Industries, 1933.* Cr. 8vo. Pp. 51, with 3 charts. 1934. New York: Handy and Harman, 82 Fulton St.
- ***Hirsch, Alcan.** *Industrialized Russia.* With a Preface by Maurice Hindus. Demy 8vo. Pp. 309, illustrated. 1934. New York: The Chemical Catalog Co., Inc. (\$3.00.)
- Hütte.** Des Ingenieurs Taschenbuch. Herausgegeben vom Akad. Verein Hütte e.V. in Berlin. 26, Neubearb. Auflage. Band 4, Lieferung 1. (Bogen 1-27.) Pp. xvi + 580. 1934. Berlin: Ernst u. Sohn. (Ausg. mit Lw.-Decke M. 8.50; mit Ldr.-Decke M. 10.)
- ***Ingleson, H.** *The Action of Water on Lead, with Special Reference to the Supply of Drinking Water. Summary of Existing Knowledge.* (Department of Scientific and Industrial Research, Water Pollution Research, Technical Paper No. 4.) Med. 8vo. Pp. vi + 115. 1934. London: H.M. Stationery Office. (2s. net.)
- ***Institute of Chemistry of Great Britain and Ireland.** *Register of Fellows, Associates, and Students.* Demy 8vo. Pp. 414. 1934. London: The Institute, 30 Russell Sq., W.C.1.
- Jacquet, A., et D. Tombeck.** *Éléments de métallurgie.* Pp. viii + 263. 1934. Paris: Dunod. (Br., 17 francs; cart., 19 francs; relié, 22 francs.)
- ***Jakeman, C., and Guy Barr.** *Tests on Tin-Base and Lead-Base Bearing Metals.* (Technical Publications of the International Tin Research and Development Council, Series A, No. 6.) Med. 8vo. Pp. 23, with 6 illustrations. 1934. London: International Tin Research and Development Council, 378 Strand, W.C.2.
[A reprint of a report to the British Non-Ferrous Metals Research Association of an investigation carried out at the National Physical Laboratory. See abstract, *J. Inst. Metals*, 1932, 50, 734.]
- Joralemon, Ira B.** *Romantic Copper: Its Lure and Lore.* 8vo. Pp. ix + 294. 1934. New York and London: D. Appleton-Century Co. (\$3.00.)
- Kaschtschenko, G. A.** *Lehrbuch der allgem. Metallographie.* Band I.—*Grundlagen der Metallographie, Theorie der Krystallisation von Metallen und Legierungen u. über die metallograph. Methoden ihrer Unters.* [In Russian.] Pp. 236. 1934. Leningrad, Moscow, and Swerdlowsk: Metallurgisdat. (Rbl. 3.)

- ***Kelly's Directories, Ltd.** *Kelly's Directory of the Engineering, Hardware, Metal, and Motor Trades throughout England, Scotland, and Wales.* Twenty-First Edition. $6\frac{3}{4} \times 10\frac{1}{4}$ in. Pp. lvi + 2628 + 116. 1934. London: Kelly's Directories, Ltd., 186 Strand, W.C.2. (45s.)
- ***Koch, H. Föppl, O.** *Die Biegewechselfestigkeit einer Keilverbinding (Passfederanordnung) und die Erhöhung der Dauerhaltbarkeit durch das Oberflächendrücken.* Von H. Koch. *Einer neue Keilform mit besserer Dauerhaltbarkeit der Welle.* Von O. Föppl. (Mitteilungen des Wöhler-Instituts, Braunschweig, Heft 20.) Demy 8vo. Pp. iv + 68, with 39 illustrations. 1934. Berlin: NEM-Verlag G.m.b.H. (R.M. 3.60.)
- ***Kuhn, Paul.** *The Torsional Stiffness of Thin Duralumin Shells Subjected to Large Torques.* (Technical Notes, National Advisory Committee for Aeronautics, No. 500.) [Mimeographed.] 4to. Pp. 8 + 14 illustrations. 1934. Washington, D.C.: National Advisory Committee for Aeronautics.
- Lachtin, A. N.** *Apparatus for Temperature Measurement in the Chemical Industry.* [In Russian.] Pp. vi + 214. 1934. Moscow: Wiritochimikow. Chimfak.
- ***Lea Manufacturing Company.** *Buffing and Polishing Methods. Reference Book and Complete Instruction Manual.* Third Edition. Med. 8vo. Pp. 56. 1934. Waterbury, Conn.: Lea Manufacturing Co. (\$1.00.)
- ***Lincoln Electric Company.** *Procedure Handbook of Arc Welding Design and Practice.* Enlarged Edition. Med. 8vo. Pp. viii + 454, with 495 illustrations. 1934. Cleveland, O.: The Lincoln Electric Co. (\$1.50.)
- ***Look, O. H.** *Resonanz zwischen Mast- und Leitungseilschwingungen und die Dämpfung dieser Schwingungen mit Resonanz-Dämpfern.* (Mitteilungen des Wöhler-Instituts, Braunschweig, Heft 21.) Demy 8vo. Pp. iv + 61, with 47 illustrations. 1934. Berlin: NEM-Verlag G.m.b.H. (R.M. 3.60.)
- ***Lucas, Francis F.** *Late Developments in Microscopy.* (Bell Telephone System Technical Publications, Metallurgy, Monograph B-792.) Med. 8vo. Pp. 47, with 32 illustrations. New York: Bell Telephone Laboratories, 463 West St.
[Reprinted from *J. Franklin Inst.*, 1934, 217, 661-707.]
- Majanz, A. D. Cobalt.** [In Russian.] Pp. 128. 1934. Moscow, Leningrad, and Swerdlowsk: Metallurgisdat. (Rbl. 2.25.)
- Martini, C.** *Elementi di saldatura ossiacetilenica elettrica.* IIIe. Corso. Anno 1933-1934.—XII. Pp. 46. Milano: A. Berinzaghi.
- v. Meier, F.** *Die Kosten der Lichtbogenschweißung.* Pp. 32, with 26 illustrations. 1934. Berlin: VDI-Verlag G.m.b.H. (R.M. 1.90; VDI-Mitgl., R.M. 1.70.)
- ***Meyer, W. Föppl, O.** *Die Drehwechselfestigkeit genuteter Stäbe und die Erhöhung der Dauerhaltbarkeit durch Oberflächendrücken.* Von W. Meyer. *Die Qualifikation der Werkstoffe mit Hilfe der Werkstoffdämpfung.* Von O. Föppl. (Mitteilungen des Wöhler-Instituts, Braunschweig, Heft 18.) Demy 8vo. Pp. iii + 73 + 8, with 42 illustrations. 1934. Berlin: NEM-Verlag G.m.b.H. (R.M. 3.60.)
- Moltkehausen, I. J., and G. Eger.** *Natrium, Kalium, Lithium, Rubidium, und Cäsium.* Pp. 127. 1934. Leipzig: Akademische Verlagsgesellschaft m.b.H.
- ***Moore, Herbert F., and Glen N. Krouse.** *Repeated-Stress (Fatigue) Testing Machines Used in the Materials Testing Laboratory of the University of Illinois.* (University of Illinois Bulletin, Vol. XXXI, No. 30; Circular No. 23, Engineering Experiment Station.) Med. 8vo. Pp. 36, with 24 illustrations. 1934. Urbana, Ill.: Engineering Experiment Station, University of Illinois. (40 cents.)

- *National Research Council of Japan. *Report*. Volume II, No. 2. April 1932–March 1933. Med. 8vo. Pp. ii + 71–144. 1934. Tokyo: National Research Council of Japan, Imperial Academy House, Ueno Park.
- *Nordheim, Lothar. *Die Theorie der Thermoelektrischen Effekte: Legierungen, Unvollständige Ketten, Benedickseffekt*. (Actualités scientifiques et industrielles 131. Réunion internationale de chimie-physique 1933.) Roy. 8vo. Pp. 23 + 3, with 7 illustrations. 1934. Paris: Hermann et Cie, 6 Rue de la Sorbonne. (6 francs.)
- Permanent Consultative Committee on Official Statistics. *Guide to Current Official Statistics of the United Kingdom. Volume 12 (1933: Being a Systematic Survey of the Statistics Appearing in all Official Publications issued in 1933)*. Roy. 8vo. Pp. 345. 1934. London: H.M. Stationery Office. (1s. net.)
- *Portevin, Albert. *Introduction à la Chimie des Alliages Métalliques*. (Extrait du Traité de chimie minérale, Tome XII.) Sup. Roy. 8vo. Pp. 179–271, with 85 illustrations. 1934. Paris: Masson et Cie.
- Portevin, Albert. *Introduction à l'Étude des traitements thermiques des produits métallurgiques*. Pp. 120, and 66 illustrations. 1934. Paris: Aciers Spéciaux, Métaux et Alliages, 4 Rue Férou.
- Puppe, J., und G. Stauber. *Walzwerkswesen*. Band II. Pp. 524. 1934. Düsseldorf: Verlag Stahleisen. (Geb., R.M. 110.)
- *Rapatz, Franz. *Die Edelmehle*. Zweite, gänzlich umgearbeitete Auflage. Demy 8vo. Pp. viii + 386, with 163 illustrations. 1934. Berlin: Julius Springer. (Geb., R.M. 22.80.)
- *Rideal, Eric Keightley. *On Phase Boundary Potentials*. (Actualités scientifiques et industrielles, 83. Réunion internationale de chimie-physique.) Roy. 8vo. Pp. 17, with 5 illustrations. 1934. Paris: Hermann et Cie, 6 Rue de la Sorbonne. (4 francs.)
- *Ritchey, James. *Patternmaking*. A Practical Treatise for the Patternmaker on Woodworking and Wood Turning, Tools and Equipment, Construction of Simple and Complicated Patterns, Modern Moulding Machines and Moulding Practice. Revised by Walter W. Monroe, Charles Wm. Beese, and Philip Ray Hall. Med. 8vo. Pp. vi + 237, with 359 illustrations. 1933. Chicago, Ill.: American Technical Society. (\$1.75.)
- Sarchi, N. I. *Untersuchung der Einwirkung von metallischen Pobjedit-Platten auf rohe und thermisch bearbeitete Spezialstähle*. [In Russian.] Pp. ix + 120 + iv. 1934. Leningrad: Isd. Artil. akad. RKKA. (Rbl. 4.50.)
- Shaanow, W. A., and W. L. Zegelski. *Arc Welding with Metal Electrodes*. [In Russian.] Pp. ii + 158. 1934. Moscow and Leningrad: Gosmaschmetisdat. (Rbl. 1.50.)
- Shdanow, G. S. *Unters. kristallin. Orientierungen in Krystallen u. Legierungen mit Hilfe von Polfiguren. Unters. der Struktur bearbeiteter Metalle mittels Röntgenstrahlen*. [In Russian.] Pp. 72. 1934. Moscow, Leningrad, and Swerdlowsk: Metallurgisdat. (Rbl. 1.75.)
- *Stoner, Edmund C. *Magnetism and Matter*. Demy 8vo. Pp. xv + 575, with 87 illustrations. 1934. London: Methuen and Co., Ltd. (21s. net.)
- *Trinks, W. *Industrial Furnaces*. Volume I. Third Edition. Med. 8vo. Pp. x + 456, with 359 illustrations. 1934. New York: John Wiley and Sons, Inc.; London: Chapman and Hall, Ltd. (37s. 6d. net.)
- Tschernuchin, A. E. *English-Russian Technical Dictionary*. Pp. xxix + 1213. 1934. Moscow and Leningrad: Gos. techn.-theoret. isd. (Rbl. 10.)

- ***University of Bristol.** *Calendar, 1934-1935.* Med. 8vo. Pp. 352. 1934. Bristol: The University. (2s.)
- ***Väth, A.** *Der Schleuderguss.* Med. 8vo. Pp. viii + 107, with 81 illustrations. 1934. Berlin: VDI-Verlag G.m.b.H. (Brosch., R.M. 6.90; VDI-Mitgl., R.M. 6.20.)
- Wiechell, H. G.** *Über die Veredlungsfähigkeit der Gusslegierung Aluminium + 9% MgZn₂ nach ihren mechanischen und Korrosionseigenschaften.* (Forschungsarbeiten über Metallkunde und Röntgenmetallographie. Herausgegeben von Maximilian Frhr. von Schwarz. Folge 13.) Pp. 52, with 30 illustrations. 1934. Munich: Verlag Fritz & Joseph Vogrieder. (R.M. 3.)
- ***Wiecker, Hermann.** *Die Biegewechselfestigkeit genuteter Stäbe und die Erhöhung der Dauerhaltbarkeit durch das Oberflächendrücken.* (Mitteilungen des Wöhler-Instituts, Braunschweig, Heft 19.) Demy 8vo. Pp. iii + 52, with 22 illustrations. 1934. Berlin: NEM-Verlag G.m.b.H. (R.M. 2.70.)
- ***Wiss, Ernst.** Bearbeitet von. *Arbeiten mit dem Schneidbrenner.* (Ausgewählte Schweisskonstruktionen, Band 6.) Herausgegeben vom Fachausschuss für Schweisstechnik im Verein deutscher Ingenieure. Format DIN A4, vi + 94 Text- und Bildblätter mit deutschem und englischem Text. 1934. Berlin: VDI-Verlag G.m.b.H. (R.M. 9; VDI-Mitgl., R.M. 8.10.)
- Zimmermann, Franz.** *Kerbzähigkeit von Schweissmassen im geschweissten Werkstück im Temperaturbereich von -195° bis +200° C.* (Berichte aus d. Institut für mechanische Technologie und Materialkunde d. Technische Hochschule, Berlin, Heft 4.) 4to. Pp. v + 50. 1934. Berlin-Charlottenburg: Studentenhaus-Druck. (nn. M. 2.50.)

THESES.

- ***Evers, Alfred.** *Über die Festigkeitseigenschaften von unvergüteten und vergüteten Aluminium-Sandguss-Legierungen im Vergleich mit Gusseisen und Stahlguss.* (Technischen Hochschule, München.) 8 in. × 11½ in. Pp. 63, with 7 photomicrographs and 30 line illustrations (12 plates). München: Techn. Hochschule Bibliothek.
- ***Lutz, Otto.** *Recherches sur les dosages et la separation du nickel et du zinc.* Université de Genève. (Thèse No. 888.) Med. 8vo. Pp. 21, with 2 illustrations. 1930. Geneva: Bibliothèque de l'Université.
- ***Neumann, Friedrich.** *Die Verschweissung von Kupfer mittels des elektrischen Lichtbogens und die hierbei erreichten Festigkeiten.* (Technischen Hochschule, Berlin.) Med. 8vo. Pp. v + 49, with 87 illustrations. 1933. Berlin: Techn. Hochschule Bibliothek.
- ***Schück, Alfred.** *Die aluminiumreichen Legierungen des Dreistoffsystems Aluminium-Zinn-Mangan.* (Sächsischen Technischen Hochschule zu Dresden.) Demy 4to. Pp. 28, with 12 plates. 1934. Dresden: Institut für Metallurgie und Werkstoffkunde an der Techn. Hochschule, Helmholtzstr. 7.
- ***Schuhknecht, Wolfgang.** *Spektralanalytische Untersuchung von Kupfer-Blei-Legierungen.* (Universität Leipzig.) 8vo. Pp. 96, illustrated. 1934. Leipzig: Bibliothek der Universität.

NEW PERIODICAL.

Aluminium. Fachorgan zur Förderung der gesamten Industrie des Aluminiums und seiner Legierungen. Vol. I, No. 1 (Sept. 1934). Aluminium-Zentrale G.m.b.H., Berlin W. 9, Potsdamer Str. 23a. Published monthly. (R.M. 5 per quarter.) [Note: This publication supersedes the two German periodicals *Aluminium* and *Hauszeitschrift d. V.A.W. u.d. Erflwerk A.G. für Aluminium.*]

XXIV.—BOOK REVIEWS

(Continued from pp. 473-476.)

Arsenical and Argentiferous Copper. By J. L. Gregg. With a Foreword by H. Foster Bain. (American Chemical Society Monograph Series.) Med. 8vo. Pp. 189, with 56 illustrations. 1934. New York: The Chemical Catalog Co., Inc. (\$4.00.)

The author explains in his "Acknowledgments" that this monograph was prepared at the Battelle Memorial Institute "under the sponsorship of the Calumet and Hecla Consolidated Copper Company, which requested that an impartial survey of the properties of arsenical and argentiferous copper be made." This survey has been most admirably carried out, and a notable service has been thereby rendered to all metallurgists.

The monograph consists of eight chapters with an Appendix and a Bibliography. Chapter I deals with the history of copper and copper mining, the development of copper mining and copper refining, and the classification of copper by origin and uses; Chapter II with the fundamental physical and chemical properties of copper itself and with the uses of copper; whilst in Chapter III a brief account is given of the geology, concentration, and smelting of Lake ores, which are the main source of arsenical and argentiferous copper in the United States; the refining and casting of copper and its mechanical working.

In Chapter IV, which describes the constitution of arsenical and argentiferous coppers, and in Chapters V and VI, which are concerned with their electrical and thermal properties and with their mechanical properties respectively, there is given a very large amount of up-to-date and reliable information on the properties of copper, constituting a most valuable summary of existing knowledge. Chapter VII gives a short account of the corrosion of arsenical copper and brass, and in the concluding chapter the uses of arsenical and argentiferous copper are carefully reviewed.

This volume will be read with interest and profit by metallurgists generally as well as manufacturers and users of copper, and it will rank as a standard book of reference.—O. F. HUDSON.

Manufacture of Seamless Tubes, Ferrous and Non-Ferrous. By Gilbert Evans. Cr. 4to. Pp. 187, with 129 illustrations. 1934. London: H. F. & G. Witherby, 326, High Holborn, W.C. 1. (40s. net.)

This book describes, within the scope of some 150 pages, present-day plant and processes used in the production of ferrous and non-ferrous seamless tubes. Such a subject cannot be treated in a very detailed manner in so small a book, but in fourteen short chapters the author gives a thoroughly practical description of tube-making, and has collected together much information hitherto available only in scattered papers. The work is divided into two sections—ferrous and non-ferrous, the former being not only of interest from the point of view of steel tube production, but also indicating the evolution of non-ferrous tube-making plant from steel-tube machines.

The ferrous section contains a brief history and description of various patents, followed by a chapter on piercing, rolling, and reducing, including descriptions of the Mannesmann, Stiefel, Pilger, plug mill, Erhardt, and Wellman-Seaver push-bench methods. The Diescher process is briefly mentioned. A short chapter on hot-drawing follows, the cold-drawing process being dealt with in the non-ferrous section. Brief mention is made of reheating furnaces, and this section is concluded with general observations and a reference to a bibliography of seamless steel tubing. The foregoing covers American, Continental, and English practice.

In the non-ferrous section, in addition to descriptions of piercing, extrusion, and cold-drawing processes, chapters on the copper refinery for billet casting, brass shell casting, annealing and pickling, inspection testing, stocktaking, and factory organization are included. The whole section provides an exceedingly good outline of the operations carried out in a non-ferrous tube works. In particular, the chapters on piercing, extrusion, brass shell casting, and cold-drawing are written in a thoroughly practical manner. A bibliography of references to fuller descriptions of plant, &c., would have enhanced the value of this section.

The author has intentionally omitted more than brief reference to the metallurgical side of tube manufacture, it being claimed that much information is available elsewhere. The value of the book would have been considerably increased if more attention had been given to the quality and properties of the product.

This work should be of use to the layman who desires to obtain a general idea of the trade and to those engaged on the production side of tube manufacture. It is not sufficiently detailed or critical to be of use to the engineer or technician who is concerned with the installation and maintenance of plant or control of products. The metallurgist who is already familiar with

the methods of tube making will find little to assist him in dealing with problems of fabrication of the many non-ferrous alloys now produced in tube form. The book is well printed on good paper and contains numerous good illustrations—W. L. GOVIER.

Chemische Technologie der Neuzeit. Begründet und in erster Auflage herausgegeben von Otto Dammor. In zweiter erweiterter Auflage, bearbeitet und herausgegeben von Franz Peters und Herm. Grossmann. II Band, 2 Teil. 4to. Pp. xvi + 888, with 343 illustrations. 1933. Stuttgart: Ferdinand Enke. (Geh., R.M. 93; geb., R.M. 98.)

This part of the second volume of Dammor's treatise on modern chemical technology deals with all the metals, including such rare metals as rhenium, germanium, indium, and gallium, but excluding lithium, potassium, barium, strontium, and zirconium; it provides a complete review of modern practice in the treatment of metallic ores for the recovery of the valuable metals contained therein, together with accounts of the methods employed in refining the metals and of the uses of the metals in industry.

The first sections deal with the metallurgy of iron and steel (192 pp.), and these are followed by sections on the non-ferrous metals, sometimes taken singly and in other cases in groups of metallurgically related metals. The individual sections are written by specialists in the particular subject dealt with, and this probably accounts for the differences in the treatment accorded to the various metals; thus the lead section occupies 88 pp., that on silver 82, copper 61, zinc 63, and mercury 35 pp., whereas only 25 pp. are devoted to aluminium and 11 pp. to magnesium. The principal non-ferrous alloys seem to have been dealt with in part 1 of this volume, but in some sections in this part equilibrium diagrams of alloy systems are given, and in others there are brief notes on industrial alloys; thus in the aluminium section there are 2 pp. on the light alloys, including a mere 4 lines on Duralumin, whereas of the 11 pp. in the magnesium section 5 are required for a description of the properties and uses of Elektron.

The sections on copper, lead, zinc, silver, gold, nickel and cobalt, mercury, bismuth, and tin are on the whole well written, and give a good account of modern practice in these fields; more space might, however, have been given with advantage to descriptions of the New Jersey Zinc Co.'s continuous process for the distillation and rectification of zinc, and Broken Hill practice in the continuous refining of lead. A few lines might also have been spared for a brief account of the Ashcroft process of treating lead and zinc ores; although this process has not so far proved a commercial success it is of considerable scientific interest, and probably has great possibilities if only a suitable refractory can be developed. Space could have been made for these processes by omitting the brief notes of unworkable patents which appear throughout the book, as well as rather lengthy descriptions of some procedures which are now solely of historical interest. Methods of analysis given in some sections should also be omitted, since they are, of necessity, incomplete and of only limited application.

The book is well printed on good paper, the illustrations and diagrams are well reproduced and provide the reader with an adequate idea of the construction of modern metallurgical plants, and on the whole the descriptive matter affords an excellent review of modern process metallurgy. Misprints are few and of minor importance. The work can be thoroughly recommended to all engaged in the treatment of metalliferous ores and in the smelting and refining of ferrous and non-ferrous metals.—A. R. POWELL.

Allgemeine Metallkunde. Von E. Piwowarsky. Med. 8vo. Pp. viii + 248, with 295 illustrations. 1934. Berlin: Gebrüder Borntraeger. (Geh., R.M. 14.50; Geb., R.M. 15.80.)

The object of this book is to provide a general review of physical metallurgy in the light of modern theory. It is not intended in any way as a handbook or dictionary of metallurgical facts, and specific examples are given only by way of illustration of the particular points under discussion. For example, in discussing the equilibrium diagram of binary systems the only ones discussed in detail are the iron-carbon, copper-zinc, and copper-tin systems. This is a great advantage, and serves to emphasize the basic laws, and theoretical interpretation which it is the author's object to lay before the reader. In this way the author is able in a comparatively small space to consider many of the advances in modern physics which have a bearing on metallurgical theory, but which seldom find a place in the ordinary text-book.

The book is divided into ten chapters, dealing broadly with crystallization, alloy systems, the properties of melts and the process of solidification, gases in metals, mechanical properties, recrystallization and structure, age-hardening, corrosion, and physical properties. The book succeeds very well in its object, and we know of no other that covers such a wide field in a manner so readable. It can be recommended to the advanced student who is looking rather for general principles than for detailed facts. The book is profusely illustrated, and well indexed, although the work of German authors is given rather undue preference. In the unbound edition the pages are not cut, which makes it inconvenient to handle.—C. J. SMITHELLS.

Métallurgie. Par R. Cazaud. 50e. édition. Post 8vo. Pp. xx + 345 + 84 + xlii, with 54 illustrations. 1934. Paris: Dunod. (Relié, 20 francs.)

This is a small pocket handbook of the familiar type dealing with metallurgical matters in a highly condensed form, and giving a variety of statistics. Certain new material has been added in this edition—the chapter on mechanical properties, especially the portion dealing with hardness, has been enlarged; the paragraphs dealing with fatigue have been extended and a new chapter has been included dealing with the cementation and nitriding of steel. At the end of the book is a large section dealing with French factory legislation.—W. A. C. NEWMAN.

Metals. By R. N. Bhagvat. Roy. 8vo. Pp. viii + 221 + viii, illustrated. Bombay: The Author, St. Xavier's College, Cruikshank Rd. (Rs. 3.)

This book is peculiar in its conception. The author is imbued with the idea that chemistry and metallurgy are essential to the world's progress, that they are neglected sciences, and that it will serve a very useful purpose if "something of everything of the chemistry of metals is given in as non-technical language as possible without harming the scientific side of the subject." The result is a compilation of more or less elementary facts and principles covering the whole range of the production and utilization of ferrous and non-ferrous metals and also of fuels. It is a little difficult to fathom for whom the book has been specifically written, as it assumes in parts a popular character, whilst in others it is strictly technical. Moreover, the English in places approaches the meaningless. It may possibly be concluded that the book will be most suitable for the author's associates and for technical men in India who have acquaintance with the English language. In this country there are many more suitable books for those to whom a very general idea of metallurgy may be desirable.—W. A. C. NEWMAN.

Korrosion III. Bericht über die Korrosionstagung 1933 am 14. November 1933, in Berlin veranstaltet von Deutsche Gesellschaft für Metallkunde, Verein deutscher Ingenieure, Verein deutscher Eisenhüttenleute, Verein deutscher Chemiker. Demy 8vo. Pp. iv + 79. 1934. Berlin: VDL-Verlag G.m.b.H. (Br., R.M. 5.)

This book contains the papers read at the third annual Corrosion Symposium in Berlin together with the discussions; there are eight papers, and all are of non-ferrous interest. The subjects covered embrace corrosion and fatigue, intercrystalline corrosion, effects of heat-treatment on the resistance to corrosion of bronze condenser tubes, the protection of aluminium and its alloys with paints, and the corrosion-resistance of bronze and Duralplatt. All interested in problems associated with the corrosion and protection of metals will find something of value in a study of these papers by well-known workers in this field.—A. R. POWELL.

A.S.T.M. Standards on Preservative Coatings for Structural Materials [Paints, Varnishes, Lacquers, and Paint Materials]. Prepared by Committee D-1 on Preservative Coatings for Structural Materials. Med. 8vo. Pp. 350, illustrated. 1933. Philadelphia, Pa.: American Society for Testing Materials, 260 S. Broad St. (\$1.25.)

This pamphlet contains standard or tentative specifications for 21 pigments (including aluminium and bronze powders), 7 oils and thinners, 5 varnish materials, 17 lacquers and lacquer materials, and 3 miscellaneous materials; in addition 17 standard methods of test are given for pigments, 6 for oils and thinners, 4 for varnish materials, 3 for lacquer materials, and 7 for miscellaneous materials. There is also a list of standard definitions of terms relating to paint specifications.—A. R. POWELL.

Rezepte für die Maschinen- und Metallwaren-Industrie (500 Vorschriften für die Werkstatt). Von Hugo Krause. Dritte, verbesserte Auflage. Pp. vii + 232. 1934. Leipzig: Max Jänecke. (R.M. 4.60; geb., R.M. 6.00.)

This is a collection of 500 practical recipes for the workshop, covering such subjects as casting and pouring of metals; preparation of moulds; composition and preparation of alloys; working of metals and care and operation of machines for this purpose; annealing, tempering, hardening, and other heat-treatment of metals and alloys; welding, soldering, and joining of metals; cements and adhesives; surface treatment of metals for protection against corrosion and for artistic effect; and non-metallic constructional materials. The recipes will provide an adequate answer to many questions which arise in the workshop, and their usefulness is testified to by the fact that three editions of the book have appeared within a relatively short period of years. The experience which the author has had as editor of and contributor to a technical journal has largely assisted him in making a suitable selection of information which will be of the greatest benefit to the largest number of practical workmen. An adequate alphabetical index provides a ready means of finding any information required at a moment's notice. The book is well printed on good paper, and the price demanded is well within the reach of the average worker in metal workshops.—A. R. POWELL.

Der Schleuderguss. Von A. Vath. Med. 8vo. Pp. viii + 107, with 81 illustrations. 1934. Berlin: VDI-Verlag G.m.b.H. (Brosch., R.M. 6.90; VDI-Mitgl., R.M. 6.20.)

Very few, if any, books have previously been written on centrifugal casting. This volume essays to give in a concise form the principal features of modern Continental practice, and it may be said at once that it is well worthy of perusal.

A short history of the process is first given, and is followed by a discussion of its theoretical basis, which involves considerable mathematical exposition. Three important factors by which centrifugal castings will be compared with what may be termed "still" castings are grain-size, segregation, and liberation of gases. To these the author gives especial attention, and devotes a chapter to their elucidation. There follows a section on the materials of which the moulds should be made, and the average life which they may be expected to have in normal work. In the second part of the book are given detailed descriptions of many commercial processes for making centrifugal castings, and also individual sections on the characteristics—composition, properties, &c.—of cast iron, steel, and non-ferrous metals in this class of work. In each case the discussion embraces consideration of such matters as melting, influence of centrifugal action on the composition and specific gravity, defects peculiar to the process, tube manufacture, annealing following casting, testing, special processes, and the production of solid bearings.

Throughout, the author has in mind the needs of the practical man, and reviews most of the problems the latter is likely to meet. A very excellent bibliography concludes the volume.

—W. A. C. NEWMAN.

Industrial Furnaces. By W. Trinks. Volume I. Third edition. Med. 8vo. Pp. x + 456, with 359 illustrations. 1934. New York: John Wiley and Sons, Inc.; London: Chapman and Hall, Ltd. (37s. 6d. net.)

The third edition of this well-known and eminently useful book is a considerable advance on the previous one. More than half has been rewritten, and the results of much research have been included. Mathematical investigations into both furnace construction and operation have been widely extended. The utility of the book and of its companion volume has been emphasized in previous reviews. The opinions then expressed are endorsed in their fullest sense.—W. A. C. NEWMAN.

Fortschritte des Chemischen Apparatewesens - Elektrische Öfen. Herausgegeben von Adolf Brauer und Josef Reitstötter. Dargestellt an Hand der Patentschriften des Deutschen Reiches unter Mitwirkung Zahlreichen Fachgenossen mit Unterstützung der Dechema, Deutsche Gesellschaft für chemisches Apparatewesen, E.V. Lieferung 1. Imp. 8vo. Pp. iv + 64 + 96 + 16. 1934. Leipzig: Akademische Verlagsgesellschaft m.b.H. (R.M. 20.)

This handbook is the first of a series of volumes dealing with various phases of the electric furnace industry with special reference to the patent literature on the subject. It may be arbitrarily divided into two parts, the first of which is concerned mainly with descriptive matter, whilst the second is devoted to abstracts of German patent specifications.

The first part contains an interesting review of the development and characteristics of arc furnaces embracing both indirect and direct arc heating. It deals at some length with auxiliary features, such as electrode design, automatic regulation, and the methods of feeding the current; then follow some sections describing briefly the construction of resistance furnaces, including heating elements and other details of design, only very few of which are incorporated in modern plant. The first part ends with a discussion of induction furnaces employing a closed iron yoke or circuit. Throughout this first part of the book complete references are made to German patent literature, and a list of specifications is given at the end of each section.

The second part is devoted entirely to patent literature, and contains an abstract of almost every important German specification dating from 1881 to 1911. It will be realized that these are now of little other than historic interest, and it is to be hoped that subsequent volumes will bring this subject up to date. It would then be of considerable service to electric furnace designers.

The book concludes with a classified numerical list of U.S. patent specifications.

—A. G. ROBIETTE.

Theory of Industrial Gas Heating. By Peter Lloyd. With a Foreword by Stephen Lacy. Demy 8vo. Pp. x + 104, with 27 illustrations. London: Walter King, Ltd., 11 Bolt Court, Fleet St., E.C.4. (6s.)

This book has been published at a timely moment, when there is intense competition between the various methods for the production and application of heat energy, and it is increasingly important to understand the principles underlying them. It has been written by one who has

had experience with the Gas Light and Coke Company at the Watson House research station, and therefore has considerable authority.

In six chapters the whole field of gas heating is covered in a concise yet thoroughly competent manner. In the first chapter, the discussion embraces the different fuels from which a heating medium may be chosen, and the second, the properties of town gas, the calculation of calorific power, flue losses, and the composition of flue gases. One of the most instructive sections is the third, in which the development of the modern industrial burner and its characteristics and efficiency are reviewed. As is the case throughout the book, the illustrations are clear and adequately explained by the text.

The succeeding two chapters deal with features of design in a commendable way. Therein are discussed the manipulation of industrial appliances, control of combustion, draught, heat transfer, and heating efficiency. The mathematical basis of much of the work is given in a not too complicated manner, and serves to broaden the application of the text.

The book can be thoroughly recommended to all those interested in gas heating, whether for industrial or domestic purposes, for although the title specifically mentions the former, there is much matter which may be of direct interest for the latter.—W. A. C. NEWMAN.

Theory of Elasticity. By S. Timoshenko. (Engineering Societies Monographs.) Med. 8vo. Pp. xvi + 416, with 203 illustrations. 1934. New York: McGraw-Hill Book Co., Inc. (\$5.00); London: McGraw-Hill Publishing Co., Ltd. (30s. net.)

The number of treatises on the theory of elasticity available to the engineer is sufficiently few for the publication of any new work to be worthy of notice; but were the number legion, the publication of this treatise would still be a noteworthy event. Professor Timoshenko's aim has been to make available to the practical engineer the more detailed and exact methods of the theory of elasticity in their application to the numerous problems for which the elementary considerations used in works on the strength of materials are inadequate. With the object that the book should be comprehensible to the reader without special mathematical training, the approach into the intricacies of the subject has been carefully graduated, and attention has been concentrated on specific problems, the solutions of which are worked out in considerable detail.

The first seven chapters are devoted to consideration of problems of plane stress or plane strain, and in these chapters the reader is familiarized with the solution of problems by the use of stress functions. The essential similarity of the method of solution in every case is well brought out, so that when attention is turned to problems on three dimensions, the additional complexity appears to be merely arithmetical. The use of polarized light for the investigation of problems of plane stress and of the membrane and electrical analogies in the solution of the torsion problem is very well explained; but the space given to these practical methods is perhaps rather more than is justified in view of the title of the book. In one or two problems the explanation of the solution appears to be insufficient. Thus, in the case of the ring stressed by forces across a diameter, it is found that the mean tension across the sections under the loads is not zero, but no explanation of the equilibrium of the half ring is attempted; also, in consideration of the bending of beams with very wide flanges, it is assumed that the stress in the flange decreases with increase of the distance from the web; but the distribution of displacements is not discussed.

Apart from these minor blemishes, Professor Timoshenko may claim to have achieved his object. Not only does the book make available to the practical engineer all the more important results of the theory of elasticity, it should also indicate how the methods of exact theory may be applied to other particular problems.—H. L. COX.

The Diffraction of X-Rays and Electrons by Amorphous Solids, Liquids, and Gases. By J. T. Randall. Med. 8vo. Pp. xii + 290, with 197 illustrations. 1934. London: Chapman & Hall, Ltd. (21s. net.)

Laue's discovery of the diffraction of X-rays by crystals marked the beginning of a new epoch in physical science. The discovery by Debye and Scherrer in 1916 that amorphous solids and liquids exhibit this same phenomenon appears to be more wonderful still; and what shall we say of the discovery that even gases possess a sufficient residue of regularity of molecular arrangement to produce diffraction of X-rays? This subject of the diffraction of X-rays by amorphous solids, liquids, and gases is a comparatively young one, but already its literature is extensive. The same is true of electron diffraction, which is ideally suited to the investigation of surface structure, as electron beams do not penetrate far into a material. Here the wide-spread literature of these subjects is collected together, and, so far as I am aware, made conveniently available for the first time. The book is essentially one for the specialist; the metallurgist will be interested principally in the sections dealing with the investigation of surface structures, and the transition from the solid to the liquid state. An intelligent appreciation of the work demands considerable mathematical knowledge on the part of the reader. The book is well got up and is reasonably priced.—J. S. G. THOMAS.

- (1) **On Phase Boundary Potentials.** By Eric Keightley Rideal. Pp. 17.
 (2) **Conductibilité Électrique et Thermique des Métaux.** Par Léon Brillouin. Pp. 71 + 3. (3) **Sur le Potentiel Métal/Solution dans les Dissolvants autres que l'Eau.** Par Paul Dutoit. Pp. 13. (4) **Nouveaux Résultats Expérimentaux sur l'Effet Electro-Thermique Homogène.** Par Carl Benedicks. Pp. 23 + 3. (5) **Die Theorie der Thermoelektrischen Effekte: Legierungen, Unvollständige Ketten, Benedickseffekt.** Von Lothar Nordheim. Pp. 23 + 3. (Actualités scientifiques et industrielles. Réunion internationale de chimie-physique.) 1934. Paris: Hermann et Cie. [Price (1) 4 frs., (2) 18 frs., (3) 4 frs., (4) 8 frs., (5) 6 frs.]

These handy little booklets are reprints of addresses delivered by experts in the respective subjects, before the Réunion Internationale de Chimie-Physique in 1933, and published under the general title "Actualités Scientifiques et Industrielles." The complete series of reprints is an extensive one; it commences with the 1929 series of reprints, and now includes (up to the 1933 series) 78 separate reprints. The scientific standing of the respective authors is sufficient to recommend each booklet to those interested. It will be sufficient if their contents are briefly indicated.

(1) Here Professor Rideal discusses the phenomenon of the occurrence of a change of potential at a surface of discontinuity, *e.g.*, at a metal/gas, liquid/gas, liquid/liquid, or liquid/solid interface. Recent experimental results and experimental researches are briefly reviewed. (2) In this Professor Brillouin discusses brilliantly the modern mathematical theory of electrical and thermal conduction by metals. The treatment makes very heavy demands on modern mathematical theory as developed by Dirac and the author. (3) Professor Dutoit reviews experimental work, due to Heyrovsky, Rossier, Del Boca, and others, relating to the measurement of single potential differences between a metal and solutions in solvents other than water, *e.g.*, in liquid ammonia, alcohol, acetone, and pyridine. (4) Members of the Institute of Metals will remember the brilliant May Lecture delivered before the Institute on thermoelectric effects in 1920. There Professor Benedicks demonstrated, conclusively so far as the reviewer is concerned, the occurrence of a drop of potential in a homogeneous metal in which a temperature gradient is established. Moderately and hesitatingly he suggested the name "Benedicks effect" for the phenomenon. The existence of the effect has been hotly disputed—Borelius, Bridgman, Rumpf are numbered amongst its opponents. Here Professor Benedicks explains briefly the phoretic theory of metallic conduction, replies to some of his critics, cites new experiments relating to the Benedicks effect, refers to experiments which establish the existence of an inverse Benedicks effect, *i.e.* the production of an electrothermic gradient of temperature in a homogeneous metal in which a potential gradient is established, and convincingly assures himself of a place amongst the most brilliant of modern experimental physicists. And, Heaven knows, the *experimental* physicist is needed these days! (5) In this M. Nordheim discusses briefly the modern theory of metallic conduction, and thermoelectric effects. It is interesting to note that the occurrence of a Benedicks effect in a homogeneous circuit is to be anticipated under certain conditions.

—J. S. G. THOMAS.

Handbuch der Technischen Elektrochemie. Unter Mitwirkung zahlreicher Fachleute. Herausgegeben von Victor Engelhardt. Dritter Band.—**Die technische Elektrolyse im Schmelzfluss.** Bearbeitet von P. Camescasse, G. Eger, H. Fischer, K. Illig, V. Makow, I. J. Moltkehansen, W. Schmidt, H. v. Steinwehr, H. Suchanek u. A. v. Zeerleder. Roy. 8vo. Pp. ix + 565, with 183 illustrations. 1934. Leipzig: Akademische Verlagsgesellschaft m.b.H. (Brosch., R.M. 50; geb. R.M. 52.)

The third volume of the "Handbook" deals exclusively with the production of metals by electrolysis of fused electrolytes. (The earlier volumes have been reviewed in *J. Inst. Metals*, 1931, 47, 506; 1933, 53, 176, 607, 687.) Each chapter has been written by an eminent authority, so that the subject-matter may be relied upon implicitly.

The book opens with a general account of the theory of electrolysis of fused electrolytes, in which the various factors are discussed in considerable detail. The subsequent chapters deal with the commercial processes for the production of the alkali metals (by Moltkehansen), the alkaline earth metals (by Makow), magnesium (by Camescasse), aluminium (by v. Zeerleder), beryllium (by Illig), and the cerium metals (by Suchanek). A short account of the preparation of the heavy metals by similar methods which have no industrial importance concludes the volume.

The treatment throughout appears to be very thorough, particularly in the case of aluminium, which occupies more than one-third of the book. This volume will be a welcome addition to those which have already been so well received.—C. J. SMITHELLS.

A Text-Book of Fire-Assaying. By Edward E. Bugbee. Second Edition. Med. 8vo. Pp. xi + 299, with 51 illustrations. 1933. New York: John Wiley & Sons, Inc. (\$3.00); London: Chapman & Hall, Ltd. (16s. 6d.).

In preparing the second edition of this well-known text-book the author has thoroughly revised the old sections and incorporated therein a number of new methods of determining gold and silver in complex ores and products; in addition, an entirely new chapter of 42 pages is included dealing with the assay of ores and products containing the platinum metals. These changes have considerably enhanced the value of the book both to students and practical assayers, and have made it one of the best English text-books on the subject. The chapter on platinum, while not providing by any means an exhaustive treatise on the subject, does give a student an excellent introduction to this most difficult branch of assaying, at any rate so far as ores and similar low-grade materials are concerned; a description of the analysis of high-grade products and alloys for all the platinum metals would occupy at least double the space of the chapter in this book.

The book starts from first principles, and the chemistry of all the reactions involved is clearly explained. The various assaying procedures for all types of precious metal ores and low-grade metallurgical products are described in detail, together with standard practice for sampling and assaying all grades of gold and silver bullion. The book can be thoroughly recommended for the use of students taking assaying courses in universities and technical institutes; it should also prove invaluable as a work of reference in the field and in the library of custom assayers.—A. R. POWELL.

The Practice of Spectrum Analysis with Hilger Instruments, Including a Note on the Various Types of Emission Spectra. Compiled by F. Twyman. Sixth Edition. Pp. 58. 1933. Adam Hilger, Ltd. (3s. 6d.)

Recent advances in the technique of spectrographic analysis have been so great that this method now provides the most rapid means of determining all the metallic constituents of any substance; not yet, however, is it as accurate as chemical analysis for determining the major constituents of any material, but it has the distinct advantage over chemical analysis that only a milligramme or less of material need be used, and it is therefore the only method available when the sample must not be destroyed. Accuracy of 5–10% of the percentage of every metal present is guaranteed by the use of modern spectrographic apparatus, and the technique is readily acquired by any intelligent laboratory assistant with very little practice.

Messrs. Hilger are one of the world's leading manufacturers of high-precision spectrographic apparatus, and in this little book their Managing Director, Mr. Twyman, presents an admirable *exposé* of the whole technique of using the Hilger apparatus; in this he has had the able assistance of the leading British exponents of spectrographic analysis. A complete account is given of ways and means of exciting spectra, the taking and reading of spectrograms, the various types of spectra, and the use of spectrographic analysis in the quantitative determination of small quantities of metals. Copious references to books and papers on various aspects of the subject should further assist the reader to obtain an intimate acquaintance with this useful and fascinating branch of analysis. Now that the profound effects which very small quantities of impurities have on the properties of metals and alloys is becoming more fully realized, the use of the spectrograph in metallurgical laboratories should continually increase. A perusal of this little book will convince those who have not yet had any experience with this method of analysis how simple and rapid it really is.—A. R. POWELL.

VDI. Jahrbuch 1934. Die Chronik der Technik. Pp. xii + 189. 1934. Berlin: VDI-Verlag G.m.b.H. (Brosch, R.M. 3.50.)

This little book is intended to provide a brief review of progress in the various branches of engineering during the years 1931–1933 and to indicate future trends. The field covered is extremely wide, ranging from atomic physics through building and constructional materials, fuels, electrotechnology, and vehicle construction to refrigeration, food conservation, and patent law. Considering the size and scope of the book and the fact that the reviews occupy only two-thirds of every page, the remaining third being reserved for references, it is obvious that only the most outstanding advances can be mentioned, and these only in a relatively superficial manner. The 5500 references, however, should provide the reader with means for pursuing further any subject in which he is particularly interested; unfortunately, the greater number of these references are to German publications, and consequently the reader is apt to form rather a one-sided idea of world progress in engineering technology.—A. R. POWELL.



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