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INSTITUTE OF METALS

and

METALLURGICAL ABSTRACTS

AUGUST, 1934

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

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METALLURGICAL ABSTRACTS

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

INSTITUTE NEWS AND ANNOUNCEMENTS

Autumn Meeting, Manchester, September 3–6.

MEMBERS are reminded that the Twenty-Sixth Annual Autumn Meeting will be held in Manchester from September 3 to 6, in accordance with the printed programme which was sent to all members on July 2. Any member who has not had a copy of the programme, or has lost or mislaid the one originally sent, should request a duplicate from the Secretary as soon as possible. The Reply Form which accompanied the programme should be returned immediately if it is proposed to take part in the meeting.

It is expected that a considerable proportion of members visiting Manchester will desire to stay at the University Hostel, Ashburne Hall. Applications for accommodation should be made *not* direct to the Warden at the Hostel, but to the Honorary Local Secretary of the Manchester Meeting, Mr. J. A. Tod, B.Sc., The Broughton Copper Company, Ltd., Manchester.

Members attending the meeting should bring with them copies of the *Monthly Journal* containing any of the papers that they intend to discuss in Manchester. Separate copies of the papers are not available.

Informal Gathering after Autumn Lecture.

At the suggestion of the Council the Local Committee have arranged for an informal gathering to be held in the Banqueting Hall, Midland Hotel, directly after the Autumn Lecture on Monday, September 3. It is hoped, in this way, that members may be able to meet one another and the Council. Transport will be provided to the Midland Hotel from the College of Technology, where the Lecture will be given at 7.30 p.m. by Dr. J. L. Haughton on " The Work of Walter Rosenhain."

Candidates for membership whose applications are in the Secretary's hands by noon on August 30 will be entitled to take part in all functions connected with the Manchester meeting.

Supper-Dance in November.

The Council is arranging, in co-operation with the London Local Section of the Institute, for a supper and dance to be held on Friday, November 30, 1934. It will take place in Thames House, Millbank, S.W.1. The price of tickets, to be obtained from the Secretary of the Institute of Metals, will be 6*s*. each. Further details will be announced later.

Next Year's Meetings.

The Twenty-Seventh Annual General Meeting of the Institute will be held in London on March 6–7, 1935, the meeting again taking place, thanks to the courtesy of the Institution of Mechanical Engineers, in the Hall of that Institution. In the evening of March 6 the Annual Dinner will be held at the Trocadero Restaurant, Piccadilly Circus.

The Twenty-Fifth Annual May Lecture will be given, also at the Institution of Mechanical Engineers, on May 8, 1935. The name of the Lecturer and the subject of the Lecture will be announced in due course.

Educational Tour.

In view of the success that attended the Institute's first Students' Educational Tour last spring, when a party of 40 visited Belgium, the Council is proposing to arrange for another continental tour to take place shortly after Easter, 1935. Suggestions regarding such a tour will be welcomed and should be addressed to the Secretary.

Annual Subscriptions.

All members, except those who pay their subscriptions by means of Bankers Orders, should by now have received notifications from the Secretary to the effect that their subscriptions for the current financial year, which began on July 1, 1934, are now due. The amount payable is £3 3*s*. or £1 1*s*. in the case of Student Members. **The Finance Committee earnestly request members to be good enough to remit their subscriptions without requiring the despatch of further "reminders."** In this way more than £100 would be saved to the Institute. This sum represented the cost to the Institute in postage, stationery, and clerical labour, in

sending out subscription "reminders" during the past year. By paying their subscriptions promptly members not only obviate this unnecessary expenditure, but they also ensure the undelayed receipt of their *Journals*.

Sir Charles Parsons Memorial Fund.

Members of the Institute of Metals have contributed the sum of £50 14*s*. towards the Sir Charles Parsons Memorial Fund, which formed the subject of a circular letter sent to all members, at the request of the Royal Society, in March last. The Fund is still open, and contributions to it will be gladly received. These should be sent to the Secretary of the Institute of Metals; an official acknowledgment to each contributor will be made by the Secretary of the Royal Society.

Use of Cinematograph by Research Workers.

The Scientific Research Panel of the Advisory Council to the British Film Institute, the Chairman of which is Professor J. L. Myres, O.B.E., of the British Association for the Advancement of Science, is endeavouring to obtain, from all possible sources, information regarding the extent to which the cinematograph has been used by scientific research workers and to secure details of the difficulties encountered in so doing and the ways in which they are being met. It is further desired by the Panel to compile a list of films that have been specially made by individuals in connection with scientific investigations and experiments, but not put into circulation through the ordinary commercial channels.

The Council of the Institute desires to assist the Panel in its enquiry, and will be glad if members possessing the information required will communicate it to the Secretary of the Institute of Metals, giving technical details such as the type of camera used in the preparation of the films.

When this information has been collected it is the intention of the Panel to compile a memorandum which would set out the progress made so far, directing attention to the many ways in which a film might be used, giving particulars regarding special apparatus that is already available, and pointing out how the interest of scientific research would be served by a greater use of the cinematograph.

K.W. Institut für Metallforschung.

The Kaiser Wilhelm Institut für Metallforschung, which until recently was situated in Berlin-Dahlem, is being moved to Stuttgart, where it will be connected with the Technische Hochschule. Dr. G. Masing, Berlin, Dr. W. Rohn, Hanau, and Dr. W. Köster, Krefeld, were approached regarding the directorships of the Institut. Because of their business interests the first two gentlemen were unable to accept, but Dr. Köster accepted. He has been appointed at the same time Professor of Applied Metallurgy in the Technische Hochschule, Stuttgart. The Institut will consist of three sections under one roof: Applied Metallurgy, directed by Professor Dr. W. Köster; X-Ray Metallurgy, directed by Professor Dr. R. Glocker; and the Physical Chemistry of Metals, directed by Professor Dr. G. Grube. The management of the Institut is in the hands of Professor Dr. W. Köster.

PERSONAL NOTES

Mr. William Ernest Alkins, Head of the Research Department of Messrs. Thomas Bolton & Sons, Ltd., Oakamoor, received the degree of Doctor of Science of the Victoria University of Manchester on July 6.

Mr. R. Chadwick has been awarded the degree of M.A. of the University of Cambridge.

Mr. J. E. Garside has graduated B.Sc. (Tech.) in the University of Manchester.

Privatdozent Dr.-phil. M. Hansen, scientific co-worker in the Kaiser Wilhelm Institut für Metallforschung, Berlin-Dahlem, from 1925 to 1933, and since then in the Staatl. Materialprüfungsamt, left Berlin on July 31 in order to join the Dürener Metallwerke, Düren (Rheinland). Dr. Hansen has been a member of the Institute since December, 1925, and an abstracter for the *Journal* since 1926.

Mr. F. W. Harris, M.Sc., is now associated with Revere Copper and Brass Inc., Taunton–New Bedford Division, Taunton, Mass., U.S.A.

Professor Dr. F. Körber, who directs the Kaiser Wilhelm Institut für Eisenforschung, took a prominent part in the ceremony at Düsseldorf on June 2 and 3 in connection with the laying of the foundation stone of the new buildings of the Institut.

Mr. W. Murray Morrison, Vice-Chairman and Managing Director of The British Aluminium Company, Ltd., has been elected Chairman of the London Branch of the Clan Morrison Society. Mr. Murray Morrison has been made Commander of the Order of St. Olaf by the King of Norway in recognition of his pioneer work in the establishment of the aluminium industry in Norway.

Mr. F. E. Rebbeck, Chairman and Managing Director of Harland & Wolff, Ltd., Belfast, has been appointed a Director of the Northern Counties Committee of the London, Midland and Scottish Railway Company.

Geheimrat Professor Dr. G. Tammann, an Honorary Member of the Institute, and senior member of the Deutsche Gesellschaft für Metallkunde, received a warm welcome when the latter society held its annual Meeting in Göttingen on July 6–8. Many friends and scholars were very glad of the opportunity to see Geheimrat Tammann once again.

Mr. R. Taylor, B.A., B.Sc., has received the degree of Ph.D., from Cambridge University.

Mr. J. H. Watson, M.C., B.Sc., A.R.S.M., of the Royal Mint, London, has received the degree of Ph.D. in Metallurgy of the University of London.

Dr.-Ing. H. Wieland, Ulm a/Donau, has suffered a bereavement by the death of his brother Ulrich Wieland, who, as a member of the German Himalaya Expedition, died with two of his colleagues in a snowstorm on Mount Nanga-Parbat.

Marriage.

Haughton : Gayler,—On July 24, 1934, John L. Haughton to Marie L. V. Gayler, youngest daughter of the late Mr. William and Mrs. Gayler.

Obituary.

Mr. Arthur Bowker died in Sheffield on July 11. A member of the Institute of Metals since 1923, Mr. Bowker was a prominent member of the Sheffield Local Section.

Mr. Frank Guyver Britton, Director and Manager of the Toyo Babcock Kabushiki Kaisha, died suddenly at his home in Japan on June 3, 1934, in his 56th year. A member of the Institute since 1929, Mr. Britton was a resident of Yokohama for thirty years, during which time he took a very active part in the affairs of the European community as well as those of the Japanese.

Dr.-Ing. Karl Leo Meissner, of Düren (Rheinland), Germany, died on July 21 at the early age of 40 years. Dr. Meissner was a frequent contributor to the *Journal*, and attended many of the Institute's meetings in England and on the Continent. He had been a member since 1926.

Addresses Required.

The Secretary will be pleased to receive the present addresses of the following :

Cunningham, R. O.
Gilder, F. M.
Jelley, H.
Larin, A. A.
Malden, Lieut.-Commander G. C.
Westcott, P. J.

Membership Additions.

The following were duly elected on May 9, 1934 :—

As Members.

Bews, William James Linklater, Antwerp, Belgium.
d'Auvigny, Henry Antoine, Paris, France.
Davies, Ernest Allen, M.C., Whaley Bridge.
Jacques, Frank, Manchester.
Kirsebom, Gustaf Newton, M.A., Bristol.
Rice-Oxley, Francis Bowyer, B.A., London.
Sanders, Alexander, Avonmouth.

WELSH, William Cameron, B.Sc., A.R.S.M., Eaglescliffe.
ZWANZIG, Walter, Dr.-Ing., London.

As Student Members.

ARMSTRONG, Denys George, Bedford.
ASHBY, Cyril Lawrence George, B.Sc., London.
BRADLEY, Alan Ludwig, Sheffield.
FORREST, George Kenneth, Birmingham.
READMAN, John Abercromby, Lockerbie.
SALLITT, Lieut. William Baines, B.A., London.
WHITWORTH-JONES, Henry Lewis, London.

The following were duly elected on July 12, 1934 :—

As Members.

BOSQUI, Francis Lawrence, Nkana, Northern Rhodesia.
BUTTERFIELD, Leslie John, B.Sc., Purley.
COLES, Carl Featherstone, B.Sc., Ewell.
COSBIE, Arthur James Curtin, London.
DÖRGE, Friedrich, Dr.-Ing., Düren (Rhld.), Germany.
GORDON-LUHRS, Lieut.-Col. Henry, C.M.G., T.D., London.
MACDONALD, George, B.Sc., Edinburgh.
MILBOURN, Maurice, B.Sc., A.R.C.S., Birmingham.

PAPER No. 678. This paper is not to be reprinted, wholly or in part, until presented (and then only with due acknowledgment) at a meeting to be held on September 3-6, 1934, in Manchester. The Institute as a body is not responsible for the statements or opinions expressed in this paper, on which **written discussion** may be sent to the Secretary not later than October 1, 1934.

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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.

ELONGATION VALUES OF COPPER AND COPPER-RICH ALLOYS.*

By MAURICE COOK, Ph.D., M.Sc.,† MEMBER, and EUSTACE C. LARKE.‡

SYNOPSIS.

A study has been made of the effect on elongation values of dimensional variations in test-pieces of copper and copper alloys in strip form. H.C. copper, 70 : 30 and 64 : 36 brass, 80 : 20 cupro-nickel, and 95 : 5 gilding metal have been investigated, and it has been found that varying the length of parallel portion on 0·5-in. wide test-pieces from 1·5 to 8·5 in. has no appreciable effect on the total elongation values measured on a 1-in. gauge-length. Varying the metal thickness between 0·125 and 0·020 in. does not sensibly affect the elongation, but with metal thinner than 0·02 in. the elongation values decrease with decreasing thickness. With variation in width from 0·25 to 1·5 in. the elongation decreases with decreasing width, the effect being smaller as the gauge-length is increased. Variation in the rate of strain between the limits of 0·06 and 0·55 in. per inch of gauge-length per minute does not appear to affect the elongation values.

The effect of gauge-length on elongation values has been considered in detail for the five materials in the soft condition and for 70 : 30 brass of varying hardness, and a study made of the distribution of elongation along the gauge-length. Values for total and uniform elongation have been obtained and compared with those derived from characteristic formulæ such as those of Unwin, Bach, Bertella, and Krupkowski. The extent of the effect of the local elongation due to necking has been investigated and its influence in connection with the effect of position of the fracture on the elongation considered.

IT is quite generally known that the elongation values obtained in the tensile testing of metallic specimens may be very considerably influenced by the shape and dimensions of the test-pieces used. The present work, which is concerned only with copper and copper-rich alloys in the form of strip material, was undertaken to ascertain the effect of variation in gauge-length on elongation values and the nature of these values. The effect of form of test-specimen on elongation values on other materials in strip form has been studied by several investigators, including Templin,[1] Nichols, Taylerson, and Whetzel,[2] and Kenyon,[3] but no such systematic data on copper alloys in strip form appear to have been

* Manuscript received May 7, 1934.

† Assistant Research Manager, I.C.I. Metals, Limited, Witton, Birmingham.

‡ Physical Testing Laboratory, I.C.I. Metals, Limited, Witton, Birmingham.

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

published hitherto. The effect of thickness, length, and width of parallel portion, rate of extension, and varying thickness on the elongation values has also been examined.

In the course of the investigation, five materials, namely, 70 : 30 and 64 : 36 brass, H.C. copper, 80 : 20 cupro–nickel, and 95 : 5 gilding metal, have been considered. Many of the results obtained are similar for the different materials examined, and it has not, therefore, been considered necessary to reproduce all the experimental results. The effect of thickness, width, rate of extension, and varying hardness has therefore been recorded only for 70 : 30 brass, which serves as a typical example of the materials examined, whilst results obtained with other materials are given to illustrate the effect of varying length of parallel portion and varying gauge-length.

The same procedure for measuring elongation over varying gauge-lengths has been adopted throughout the work. In order to ensure that

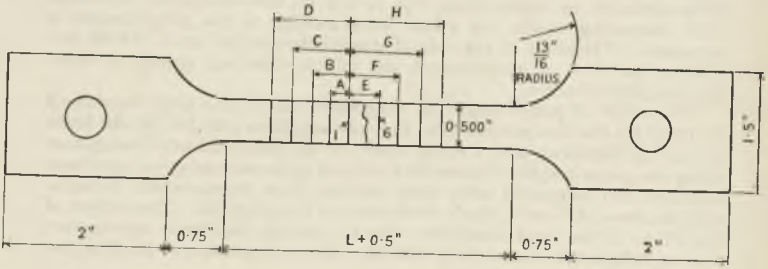

Fig. 1.

the fracture occurred approximately at the centre of the parallel portion, each test-piece was slightly reduced in width and tapered towards the centre for a distance of 1 in. each side to the extent of 0·002 in. Each test-piece was marked from end to end of the parallel portion in equal increments of 0·125 in., a Vernier height-gauge reading to 0·001 in. being used for the purpose. After testing, the lengths of the extended gauge-marks of each of the two halves of the test-pieces were measured, as illustrated in Fig. 1, with a travelling microscope, reading to 0·0004 in. In this illustration it will be seen that taking line (1) as the datum line for that half of the test-piece which is to the left of the fracture, the distances A, B, C, D, &c., were measured. Similarly with reference to line (6) as the datum line, distances $(F - E)$, $(G - E)$, $(H - E)$, &c., were also measured. Finally the broken halves were placed together, the distance E was measured, and the percentage elongations were calculated on the original lengths of $(A + E)$, $(B + F)$, $(C + G)$, $(D + H)$, &c. The reduced widths and thicknesses were also measured

microscopically, the percentage reduction of area being then obtained in the usual way.

Effect of Length of Parallel Portion.

Before considering the effect of variation in gauge-length on elongation values, it is necessary to know whether, with a fixed gauge-length, varying the length of the parallel portion has any appreciable effect on the values obtained. In order to establish this point 0·5 in. wide test-pieces of all five materials with parallel lengths of 1·5, 2, 2·25, 4·5, 6·5, and 8·5 in. were broken, and with reference to a gauge-length of 1 in., the percentage elongation values obtained from these tests are illustrated in Fig. 2, from which it will be seen that the percentage elongation in

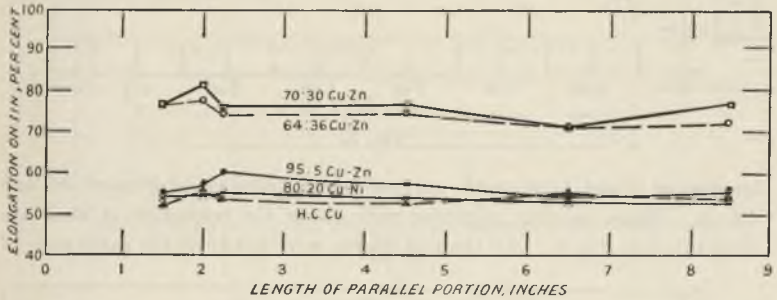

Fig. 2.

general is not appreciably affected by the length of the parallel portion over the range considered.

Effect of Thickness.

To determine the effect of thickness, 0·5 in. wide test-pieces of 70 : 30 brass with an 8-in. gauge-length were cut from 16 samples ranging in thickness from 0·125 to 0·010 in. The gauge-length on these test-pieces was accurately divided as already indicated into $\frac{1}{8}$-in. lengths. Elongation values for all the gauge-lengths ranging from 0·25 to 8 in. were determined, and those obtained on 2-in. gauge-lengths are shown in Fig. 3. The reduction of area and tensile strength values are also shown in this figure. All samples of the series subsequent to the first one were annealed together to ensure uniformity of temper, the tensile strength values indicating that this required uniformity was secured. The results obtained indicate that variation in thickness of the test-piece between the limits 0·125 and 0·020 in. does not appreciably affect the elongation values.

Effect of Width of Parallel Portion.

The effect of variations in width of the parallel portion from 0·25 to 1·5 in. has been determined on test-pieces of 70 : 30 brass with gauge-

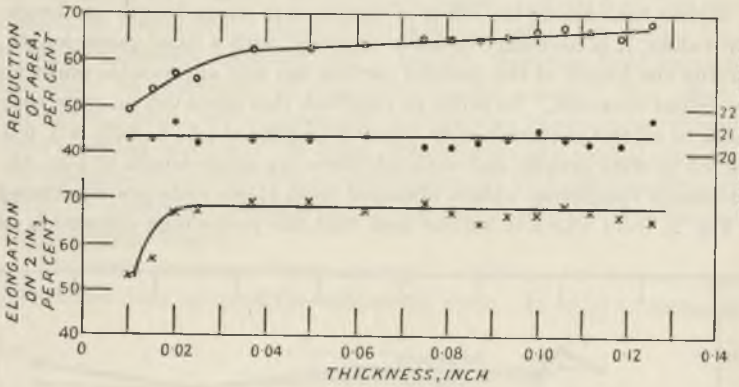

Fig. 3.

lengths of 2 and 4 in. with corresponding parallel lengths of 2·5 and 4·5 in. These results, together with those for reduction of area, are illustrated in Fig. 4. All the test-pieces were cut from the same piece of

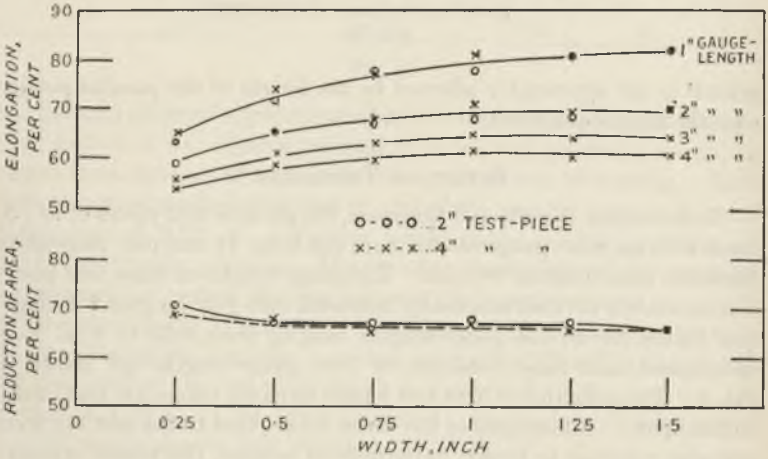

Fig. 4.

strip, which was 0·06 in. thick. In addition to measuring the elongation of the test-pieces on the maximum gauge-lengths of 2 and 4 in. on the two series of specimens, measurements of elongation were also made

on gauge-lengths of 1 in. for both series and on gauge-lengths of 2 and 3 in. on the 4-in. series. The results indicate that the elongation values tend to increase with increasing width, and although for the range of widths considered the actual amount is appreciable, the evidence shows that the curves tend to flatten out rapidly. The curves also show clearly that the effect of width on elongation values decreases with increasing gauge-length. The form of the fracture as the width was increased showed an interesting feature, for with the narrow specimens the break was normal to the axis of the test-piece and deviated from this position in a regular manner as the width increased, until at the maximum width considered, namely, 1·5 in., it occurred at an angle of about 65° to the axis. This observation agrees well with that of Sachs and Stenzel [4] on test-pieces of bronze strip.

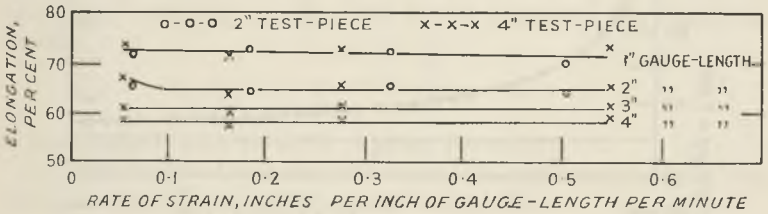

Fig. 5.

Effect of Rate of Strain.

The results of percentage elongation measurements over gauge-lengths of 1, 2, 3, and 4 in. on 70 : 30 brass test-pieces 0·060 in. thick pulled in a tensile machine at different rates are illustrated in Fig. 5. Within the lengths considered, it would seem that the rate of strain has no appreciable effect on elongation values.

Effect of Gauge-Length.

The effect of gauge-length on elongation values was determined on specimens machined to allow of a maximum gauge-length of 8 in. The gauge portion of the test-specimens was 0·5 in. wide and 0·06 in. thick. Each test-piece was accurately marked as already described, the parallel portion being divided from end to end in equal increments of 0·125 in., this enabling a range of gauge-lengths varying from 0·25 to 8 in. to be used. The percentage elongation was then calculated for each of the 32 gauge-lengths, and curves showing these results are given in Fig. 6. The reduced widths and thicknesses were also measured microscopically and the percentage reduction of area was calculated. By reference to the curves in Fig. 6 it will be seen that the percentage elongation decreases

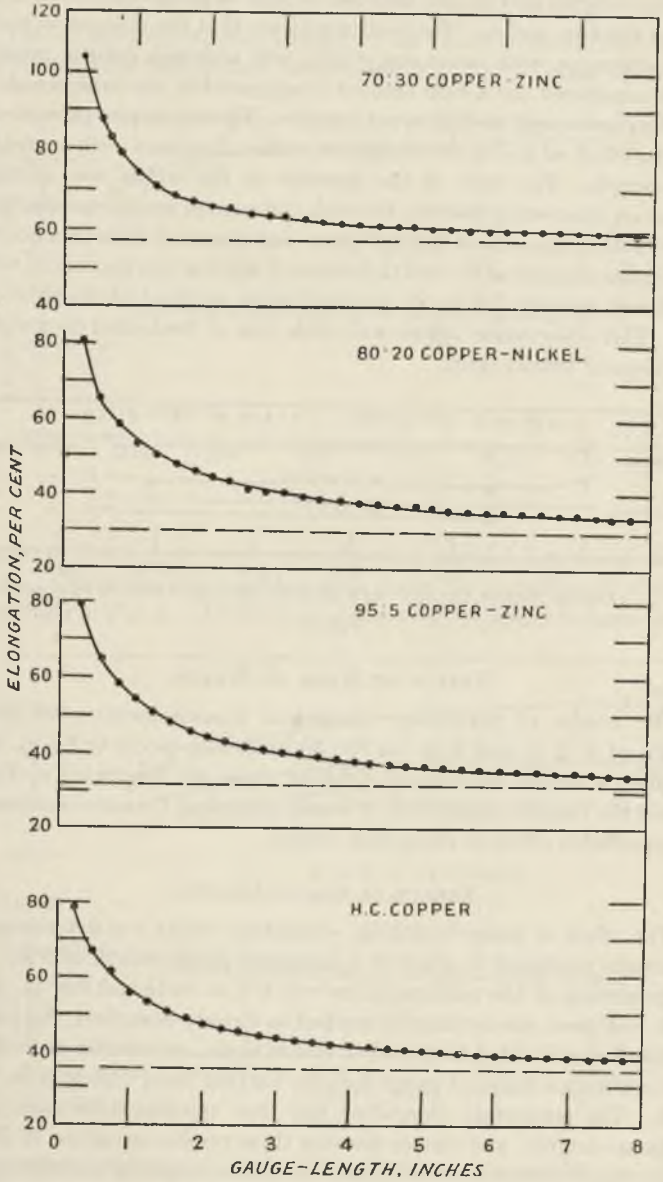
70:30 COPPER-ZINC
80:20 COPPER-NICKEL
95:5 COPPER-ZINC
H.C. COPPER
ELONGATION, PER CENT
GAUGE-LENGTH, INCHES
120
100
80
60
40
20
0
1
2
3
4
5
6
7
8

FIG. 6.

with increasing gauge-length, the curves tending to become asymptotic to a line parallel to the abscissa.

The effect of shape and gauge-length of test-pieces on elongation values have been the subject of much study, and Barba [5] as long ago as 1880 stated that geometrically similar test-pieces yielded similar elongation values. Unwin [6] deduced the following expression for connecting the elongation with gauge-length :—

$$e = a + \frac{C\sqrt{A}}{L} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad \text{(I)}$$

e being the percentage elongation on any gauge-length L, a the value of the percentage elongation as L approaches infinity, C a constant for the material under consideration, and A the initial cross-sectional area. This relationship has also been put forward independently by Tetmajer, Tiedemann,[7] and others, In 1902 Bach [8] suggested the empirical formula

$$e = a + \frac{K}{\sqrt{L}} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad \text{(II)}$$

K being defined as a constant for a given material.

In 1922 Bertella [9] proposed an exponential relationship which was later put forward by Oliver [10] in the following form :—

$$e = KL^a \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad \text{(III)}$$

where e and L are the percentage elongation and gauge-length respectively, K and a being constants for any given material, the former being a function which was found to vary with the initial cross-section.

Later Krupkowski [11] put forward the following relationship :—

$$e = a + \frac{C - a}{k.m.(C - a) + 1} \quad . \quad . \quad . \quad . \quad \text{(IV)}$$

where e is the percentage elongation, a the value of the percentage elongation as the gauge-length approaches infinity, C a function of the reduction of area, m the quotient of the gauge-length and a function of the initial area, and k a constant for the material under consideration.

According to Krupkowski, if m is the length between gauge-marks expressed as diameter of the test-piece, then $m = \frac{L}{d}$, d being the original diameter of the test-piece if its section is circular and an equivalent quantity if otherwise. Since the experimental work has been confined to rectangular test-pieces, d has been taken as the diameter of a test-piece of equivalent area to that of the rectangular test-piece. In these several relationships only IV includes the reduction of area which occurs when a tensile test-piece is broken.

All these formulæ can be used for obtaining the elongation on any gauge-length from elongation measurements on two different gauge-lengths obtained directly on one specimen. The experimental results are shown in Fig. 6, and a full comparison has been made with these values and those calculated from the several formulæ. Whilst the details of this comparison are not reproduced, a number of percentage elongation values on gauge-lengths of 0·25, 0·75, 2, and 7 in., as calculated from formulæ I, II, and IV, are given in Table I, as well as those actually observed, the latter values on 1 and 8 in. gauge-lengths being used in computing the former. In the same table are included reduction of area, tensile strength, and Diamond Pyramid hardness values, and also the calculated values to which the actually determined curves tend to become asymptotic. Values for total percentage elongation calculated from these formulæ are in excellent agreement with the actually determined values on gauge-lengths above 1 in. for all five materials. Between gauge-lengths of 0·75 and 8 in. the results calculated from the three formulæ agree to within $\pm$ 2 per cent. elongation of the actually determined values, with two exceptions, which are 2·8 and 2·9 per cent. On smaller gauge-lengths, however, there is greater divergence between the results obtained from the formulæ and experimentally determined values. In this region the results calculated from the formula of Bach are closer to the experimentally derived values than are those determined from the other two formulæ.

If in the case of formulæ I, II, and IV percentage elongation values are plotted against the corresponding function of the gauge-length, the observed values can be connected by a straight line over the range from 8 in. down to about 1 in. This indicates that between these limits of gauge-length the formulæ are correct in the sense that it is possible to obtain from them values for elongation which are the same as those obtained by direct experimental determination. On the other hand, for a similar range of gauge-lengths, it will be seen by reference to Fig. 7, where the logarithms of percentage elongation values are plotted against the logarithms of gauge-lengths for all five materials in the soft condition, that the lines connecting these experimental points are not straight, and for this reason no results calculated from formula III are given in Table I. The results shown in Fig. 7 do not agree with those of O'Neill and Cuthbertson,[12] who showed a straight-line relationship for soft copper between the gauge-lengths of 1 and 5 in.

Analysis of the four formulæ already referred to shows that as the gauge-length approaches zero the percentage elongation according to formula IV approaches a constant value for any given material, while according to formulæ I, II, and III the percentage elongation approaches

TABLE I.—*Calculated and Determined Elongation Values on Copper Alloys in the Annealed Condition.*

Material.	Total Elongation on 0·25 in., Per Cent.				Total Elongation on 0·75 in., Per Cent.				Total Elongation on 2 in., Per Cent.				Total Elongation on 7 in., Per Cent.				Uniform Elongation, Per Cent.			Tensile Strength, Tons/in.².	D.P. Hardness (10 Kg.).	Reduction of Area, Per Cent.
	Observed.	I.	II.	IV.	Observed.	I.	II.	IV.	Observed.	I.	II.	IV.	Observed.	I.	II.	IV.	I.	II.	IV.			
70 : 30 Cu–Zn	108·0	132·0	101·5	113·5	81·8	82·4	80·1	81·6	67·1	66·9	68·8	67·3	60·3	60·3	60·5	60·3	57·6	51·0	57·3	20·9	65	68·6
64 : 36 Cu–Zn	109·5	123·0	95·6	105·5	77·2	78·5	76·4	77·7	65·3	64·6	66·3	64·9	58·5	58·6	58·8	58·5	56·2	50·2	55·8	21·2	66	65·8
80 : 20 Cu–Ni	81·2	121·5	84·4	89·7	58·4	61·2	58·4	59·7	44·2	42·3	44·6	43·2	34·1	34·1	34·4	34·2	30·9	22·8	30·2	21·3	71	60·0
95 : 5 Cu–Zn	80·0	121·5	84·3	106·5	58·7	61·6	58·8	60·9	44·3	42·9	45·2	43·1	34·9	34·9	35·3	34·8	31·7	23·8	31·4	16·3	59	78·2
H.C. Cu	78·3	114·5	83·6	90·4	61·0	61·8	59·4	60·9	46·3	45·3	47·3	45·9	38·1	38·2	38·4	38·0	35·4	28·2	34·6	15·7	57	61·8

TABLE II.—*Calculated and Determined Elongation Values on Cold-Worked* 70 : 30 *Brass.*

	Total Elongation on 0·25 in., Per Cent.					Total Elongation on 0·75 in., Per Cent.					Total Elongation on 2 in., Per Cent.					Total Elongation on 7 in., Per Cent.					Uniform Elongation, Per Cent.			Tensile Strength, Tons/in.²	D.P. Hardness No. (10 Kg.).	Reduction of Area, Per Cent.
	Observed.	I.	II.	III.	IV.	Observed.	I.	II.	III.	IV.	Observed.	I.	II.	III.	IV.	Observed.	I.	II.	III.	IV.	I.	II.	IV.			
1H	131·5	161·0	115·0	...	131·0	83·6	86·3	82·7	...	79·7	65·0	62·8	65·8	...	63·5	53·0	52·8	53·2	...	52·8	48·8	38·9	48·2	21·2	63	73·3
2H	107·5	129·0	91·7	...	106·7	68·3	68·8	66·0	...	67·9	51·4	50·1	52·4	...	50·5	42·5	42·0	42·4	...	42·0	38·8	31·0	38·4	23·5	97	70·6
3H	93·7	124·0	79·6	...	80·6	50·7	52·4	49·0	...	49·0	31·5	30·0	32·8	...	31·1	20·8	20·4	20·9	...	20·5	16·6	7·2	15·6	26·8	122	57·4
4H	75·6	98·8	59·6	...	63·4	34·6	35·1	32·3	...	33·2	15·2	15·2	17·7	...	16·2	6·6	6·6	7·1	...	6·8	3·2	−5·2	2·4	31·3	151	54·4
5H	64·0	73·1	43·8	67·5	47·5	25·0	24·9	22·8	24·2	23·7	9·8	9·9	11·8	9·7	10·7	3·3	3·5	3·6	2·9	3·7	0·9	−5·8	0·5	35·1	162	49·3
6H	47·2	50·9	30·1	48·8	33·8	17·6	17·3	15·7	17·4	16·5	6·8	6·8	8·1	6·9	6·8	2·3	2·3	2·5	2·1	2·4	0·5	−3·9	0·2	39·2	172	41·8
7H	40·0	43·8	25·8	40·5	27·6	14·6	14·7	13·4	14·4	13·8	5·8	5·7	6·8	5·8	6·2	1·8	1·8	1·9	1·8	2·0	0·2	−3·6	−0·1	40·8	186	35·5

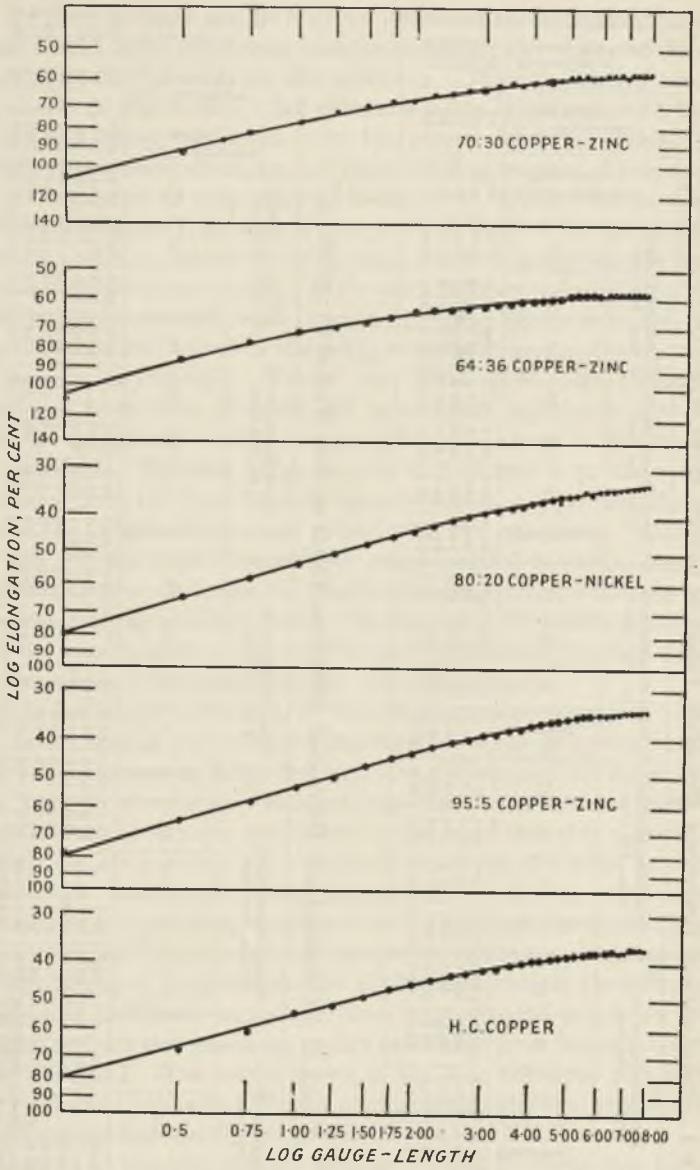

Fig. 7.

infinity. Formula IV indicates that the position at which the curves derived from it intersect the ordinate represent the maximum values

of the percentage local elongation. At the other extreme, formulæ I, II, and IV indicate that the percentage elongation approaches a constant value as the gauge-length approaches infinity, whereas according to formula III, as the gauge-length approaches infinity the percentage elongation approaches zero, a condition which is contrary to experience. The constant values indicate for each material the percentage elongation which is independent of the gauge-length and not affected by the fracture. In other words, it represents the maximum value of uniform elongation of the material.

Uniform Elongation.

The total elongation as measured on broken tensile test-pieces includes the uniform elongation which occurs between the gauge-marks, together with the local elongation due to "necking" at the fracture. This value of elongation is not so characteristic for the material as the uniform elongation which constitutes a more accurate measure of the workability, ductility, or drawing quality. The chief requirements of materials for deep-drawing is the property of being able to withstand a large amount of elongation without local thinning or contraction, in other words, a high value for the uniform elongation. As the gauge-length is increased the effect of the local elongation decreases and the value for the total elongation approaches that of the uniform elongation. It is for this reason that the total elongation figures obtained on comparatively large gauge-length specimens are regarded as a more reliable indication of drawing quality than elongation values obtained on shorter gauge-lengths, because as the gauge-length increases the effect of local elongation becomes increasingly less, as is shown in Fig. 6, until its effect becomes very slight and the value obtained approaches that of the uniform elongation. As already noted, values for uniform elongation can be calculated from the formulæ from measurements of the total elongation on two different gauge-lengths on the test-specimen. Values obtained from equations given by Unwin and Krupkowski are almost identical, and for the different materials considered the average of these values are shown as horizontal broken lines in Fig. 6, being in fact the horizontal asymptotes of the curves. Values calculated from the formula of Bach are lower in each case than those obtained from these other formulæ, as will be seen from the results in Table I.

For the materials under consideration it is possible to determine experimentally the uniform elongation by other methods than that of measuring the total elongation on two different gauge-lengths and then calculating the uniform elongation from one of the several available formulæ. One method suggested by Vietórisz [13] consists of observing

the initial position of the maximum load on a load/extension curve. This experiment has been carried out with 70 : 30 copper–zinc, 64 : 36 copper–zinc, 80 : 20 cupro–nickel, 95 : 5 copper–zinc, and H.C. copper, using a specimen with a parallel length of 6·5 in., the width and thickness of the parallel portions being 0·500 and 0·125 in., respectively. The test-pieces were each provided with symmetrical gauge-marks, 2, 4, and 6 in., and intermediate observations were made during the tensile test. The elongations on each of the three gauge-lengths, together with the accompanying reduction of width and thickness, were measured at load increments of, generally, 0·10 ton, the results in the case of the 70 : 30 brass being plotted in Fig. 8.

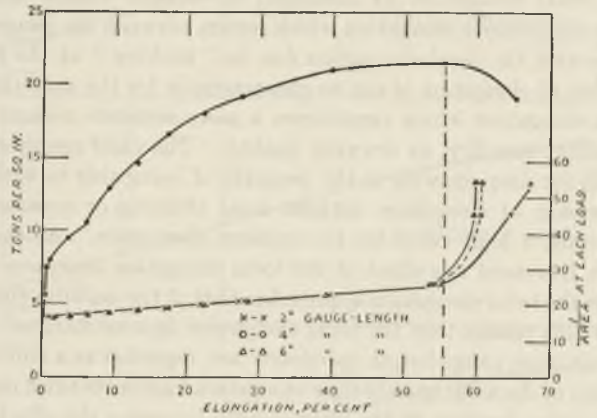

Fig. 8.

The lower curve in this figure was obtained by plotting the reciprocal of the area measured at each load against the corresponding percentage elongations for each of the gauge-lengths considered. By reference to this curve it will be seen that the percentage elongation from the beginning of the test to the point when the maximum load is first sustained by the specimen is independent of the gauge-length, and is therefore inversely proportional to the area at each load. In other words, the curve shows that the percentage elongation increases uniformly from the beginning of the test until the first application of the maximum load. The value of the uniform elongation may be obtained from the load/extension curve by drawing a line from the point indicating the beginning of the application of the maximum load to the abscissa, the value so obtained being strictly true only when the line drawn to meet the abscissa is parallel to that portion of the curve which lies below the limit of proportionality. Values of the maximum uniform elonga-

tion were also calculated for each of the samples tested, using the two gauge-lengths 2 and 6 in. and the corresponding percentage elongations, the resulting values being the mean of those derived from formulæ I and IV. In the case of the 70 : 30 brass, this value is represented by a vertical broken line in Fig. 8. For all the materials considered the differences between the experimental values and those calculated did not exceed 3 per cent. elongation.

The maximum uniform elongation may also be determined on one specimen by direct measurements if the gauge-length has been suitably sub-divided. This is based on the assumption that at distances appreciably removed from the fracture the elongation which results is not affected by the elongation caused by necking prior to fracture. It has been stated, however, that the value cannot be satisfactorily derived from measurements of test-pieces taken after fracture, and according to Kuntze and Sachs [14] uniform elongation continues after necking or local elongation has commenced. Haigh and Jones,[15] in a study of tensile tests on lead specimens, considered that for practical purposes it is essential to distinguish between stable distributed, that is, uniform elongation, and local elongation, and stated that an approximate value of the range of stable distributed elongation can be ascertained by measuring the elongation on a short gauge-length far removed from the fracture. The distribution of percentage elongation over the maximum gauge-length considered of 8 in. is shown in Fig. 9, for the five materials studied. These curves were obtained by measuring the percentage increase of each original 0·25 in. length, starting at one end of the parallel portion and passing in 0·125 in. increments through the fracture until the other end of the gauge-length was reached. The horizontal lines drawn through the curves for each of the five materials represent the average of the uniform elongation values calculated from the formulæ of Unwin and Krupkowski, and at distances removed from the fracture more than about 0·75 in. the elongation over the 0·25 in. gauge-lengths approximates to the uniform elongation. Local variations or "necking," of course, occur, and for this reason the method cannot be regarded as constituting an altogether satisfactory means of measuring local elongation, although generally the errors are not large and, as will be seen from Fig. 11, the irregularities tend to be less in magnitude with harder materials.

Effect of Position of Fracture.

As previously noted, the effect on the total elongation value of the extension due to local contraction consequent upon fracture decreases with increasing gauge-length, as the curves in Figs. 6 and 10 show.

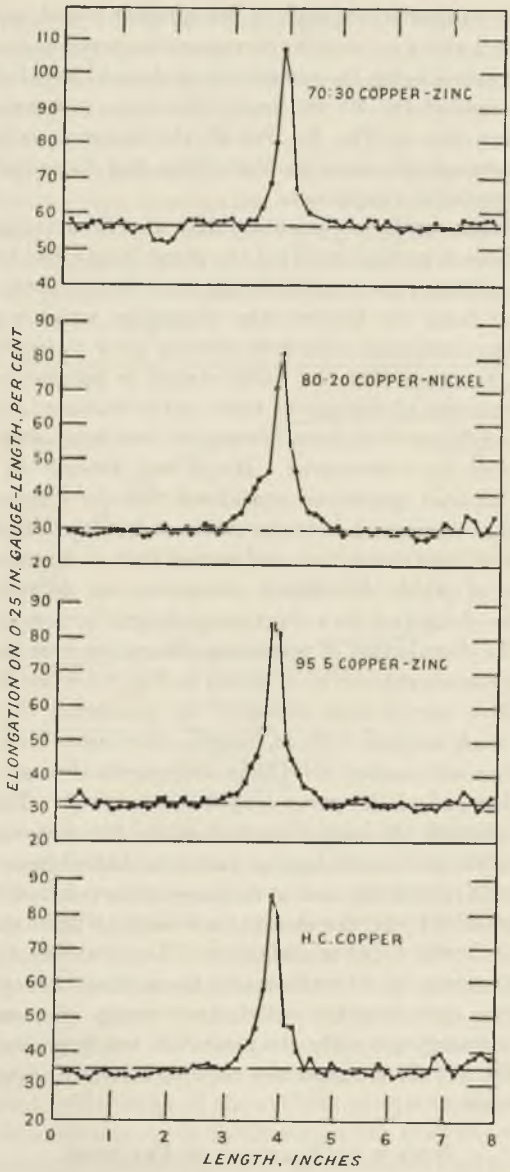

Fig. 9.

How far the extension due to necking extends along the length of the specimen varies with different materials, and for different types of test-

pieces, but the evidence which has been obtained in the course of this investigation, as shown by Figs. 9 and 11, suggests that it is very local in character for the materials considered and the forms of test-pieces used. In this connection a point of considerable practical importance emerges with regard to the testing of these materials, namely, the influence of the position of fracture. As already described, total elongation values have been measured on many different gauge-lengths of each of the five materials, and specimens with a maximum gauge-length of 8 in. sub-divided into 0·125 in. divisions have been utilized for determining the effect of position of fracture. On such specimens it is possible to measure the total elongation relative to an original gauge-length of 2 in. with the fracture occurring at various positions between the gauge-marks by the simple expedient of moving the gauge-length relative to the fracture. An analysis which has been made in this manner of the data obtained for the five materials indicates that, provided the fracture does not occur nearer than 0·5 in. to an extended gauge-mark, the value of the total elongation on an original gauge-length of 2 in. is not reduced by more than about 2 per cent. elongation. Specifications commonly require that the fracture should occur within the middle third of the gauge-length, and British Standards Institution specification No. 485, Part 1, 1933, for tensile tests on thin strip and sheet, where flat specimens 0·5 in. wide with a 2·5 in. parallel length and 2 in. gauge-length are standardized, states that the fracture must occur within the middle half of the gauge-length. The results which have been obtained suggest that, for the material under consideration with this form of test-piece, no appreciable effect on the value of the total elongation over an original distance of 2 in. will be observed, provided that the fracture occurs within the middle two-thirds of the extended gauge-marks.

As would perhaps be expected, the data also show that the effect of the position of fracture on the total elongation values decreases with increasing gauge-length. With regard to gauge-lengths less than 2 in., the value of the total elongation rapidly decreases as the fracture approaches one or other of the extended gauge-marks. For the five materials under consideration at a thickness of 0·060 in. using a 1 in. gauge-length, the difference between the total elongation values for a central fracture and one 0·125 in. from an extended gauge-mark is about 8 per cent. elongation. In order to note the effect of the nearness of the radius to the fracture, specimens with a parallel length of 2·5 in. and gauge-lengths of 2 in. were deliberately fractured at various points between the gauge-marks. These observations confirm the finding that the effect of position of fracture on the total elongation, when measured across an original gauge-length of 2 in., is not appreciable

unless it occurs within 0·5 in. of an extended gauge-mark, provided that the parallel portions of the test-pieces are 0·5 in. longer than the maximum gauge-length required.

Elongation Measurements on Cold-Rolled 70 : 30 Brass.

Elongation measurements have also been made on specimens cut from 70 : 30 brass strip, which had been subjected to progressive amounts of cold-rolling. Commencing with material in the soft condition at a thickness of 0·250 in., a series of seven samples was obtained

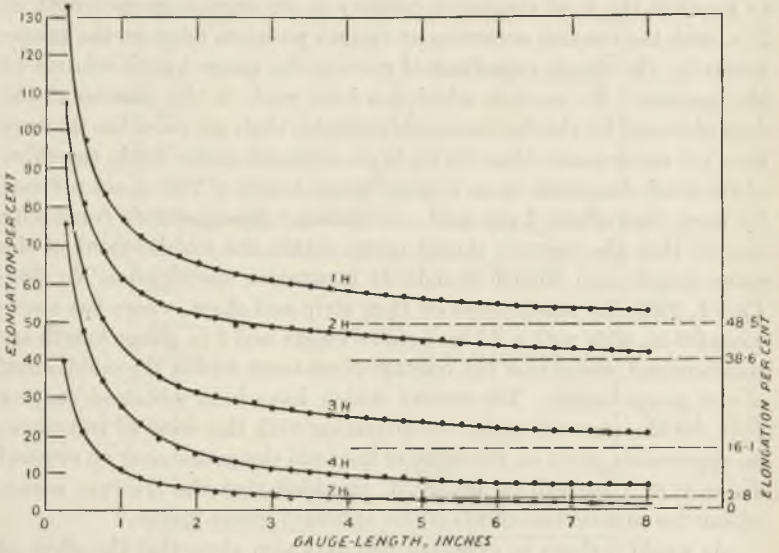

Fig. 10.

down to a thickness of 0·100 in. with 10 per cent. reductions in thickness between each sample. Test-pieces cut from these were accurately marked before testing and measured microscopically, as previously described.

The results for five of the samples showing variations in elongation values with gauge-lengths ranging from 0·25 to 8 in. are illustrated in Fig. 10, from which it will be seen, as in the case of the soft materials, that the elongation decreases as the gauge-length increases. The horizontal lines shown in this figure represent the horizontal asymptotes of the curves. Each of these experimental results has been compared with those calculated from the several formulæ, the values both calculated and observed on gauge-lengths of 0·25, 0·75, 2, and 7 in. being

given in Table II. For the purpose of calculation observed elongations on gauge-lengths of 1 and 8 in. were used.

By reference to Table II, it will be seen that for gauge-lengths ranging from 0·75 to 8 in. all the calculated values agree to within less than $\pm$ 3 per cent. elongation of the observed values, except in one instance, when the value calculated from IV is 3·9 per cent. elongation lower than the observed value of 83·6 per cent. With regard to the values calculated for the minimum gauge-length of 0·25 in., it is of interest to note that while there is a fairly constant difference of about 16 per cent. elongation between observed values and those calculated from formula II, the order of the accuracy of the calculated values derived from I and IV reverses, the values calculated from IV being in excellent agreement with the observed results for the two softest samples, whereas for the three hardest samples the closest agreement is obtained with formula I.

If the observed elongation values, together with the corresponding gauge-lengths, are plotted in a similar manner to the curves shown in Fig. 7, interesting results are obtained. For the softest sample, the points lie on a curve, but with progressive increases in hardness the curves tend to become straight lines. With sample No. 5H, for example, it is possible to connect all points from a 0·25 in. gauge-length to a 5·5 in. gauge-length with a straight line, and in the case of the hardest sample this is possible for the whole range of values from 0·25 to 8 in. gauge-length. Thus it will be seen for the harder samples that as the uniform elongation of the last three is negligibly small, being in fact less than 1 per cent., values for the total elongation calculated from the Bertella relationship, *i.e.* formula III, will be in agreement with the observed values, because the condition exists of zero uniform elongation which is necessary in applying this equation. Values calculated from this equation are therefore included in Table II for the last three samples.

The distribution of the elongation over the total length of the test-pieces is illustrated for five of the samples in Fig. 11, the horizontal broken lines, which are superimposed on the curves, representing the average of the values for the uniform elongation as calculated from formulæ I and IV. As in the case of the soft materials shown in Fig. 9, a certain amount of subsidiary necking takes place on the softer samples. With regard to the position of the horizontal lines which represent the uniform elongation, it would appear in the case of the two softer samples that the calculated values are slightly higher than the observed values, whereas for samples Nos. 4H and 7H the agreement of the experimental values with those calculated is excellent. A similar agreement was found for samples 5H and 6H, which, in order to avoid confusion, are not included in this illustration.

It will be seen from Table II that the uniform elongation values rapidly decrease with increasing hardness, and samples Nos. 5H, 6H, and 7H, which were reduced respectively 50, 60, and 70 per cent. in

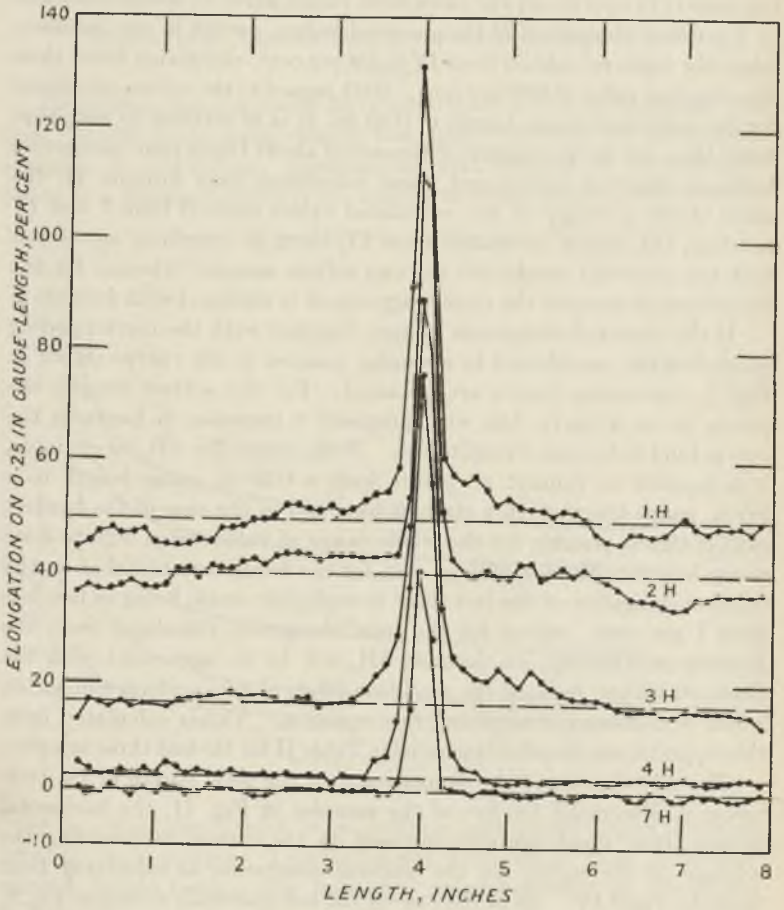

Fig. 11.

thickness by cold-rolling, have practically zero uniform elongation. In other words, the material which has been reduced this amount in thickness cannot be stretched without local thinning or contraction.

Summary.

In the testing of flat test-pieces 0·5 in. wide of H.C. copper, 70 : 30 and 64 : 36 brass, 80 : 20 cupro–nickel, and 95 : 5 gilding metal, varying

the length of parallel portion from 1·5 to 8·5 in. has no appreciable effect on the total elongation values on 1 in. gauge-lengths.

If the metal thickness is varied between 0·125 and 0·020 in., the elongation values as measured on specimens of 2 in. gauge-length and 0·5 in. wide in the parallel portion do not appear to be affected, but with metal thinner than 0·02 in. the elongation values decrease rapidly with decreasing thickness.

With variations in width from 0·25 to 1·5 in. measured on specimens 0·06 in. thick, the elongation decreases with decreasing width, the effect being smaller as the gauge-length is increased.

Measurements on specimens of varying gauge-length up to 4 in. show that varying the rate of strain between the limits of 0·06 and 0·55 in. per in. gauge-length per minute does not affect the elongation values.

A detailed study has been made of the effect of gauge-length on elongation values, also of the distribution of elongation along the gauge-length of all five materials in the soft condition, and also for 70 : 30 brass subjected to progressively increasing amounts of cold-rolling. Values for total and uniform elongation have been obtained and compared with those derived from characteristic formulæ, such as those of Unwin, Bach, Bertella, and Krupkowski. Values obtained from the formulæ of Unwin, Bach, and Krupkowski for total elongation on gauge-lengths upwards of 0·75 in. agree extremely well with the actually determined values. Uniform elongation values derived from the Bach formula do not agree with observed values so well as those derived from the other two formulæ. With soft materials it is not possible to obtain from the Bertella formula values for comparison with actually determined values, for it has been found that when the logarithms of percentage elongation values are plotted against the logarithms of gauge-lengths, the lines connecting the experimental points are not straight, or at best can be regarded as straight only over a very limited range of gauge-lengths. As might be expected, the formula is found to be applicable for hard materials which possess little or no uniform elongation.

The extent of the effect of the local elongation due to necking has been investigated, and it has been found that provided that fracture does not occur nearer than 0·5 in. of a gauge-mark, the value for total elongation is not appreciably affected by the position of fracture.

Acknowledgment.

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THE DEFORMATION LINES IN ALPHA BRASS.*

By CARL H. SAMANS,† Ch.E., M.S., PH.D., MEMBER.

SYNOPSIS.

A microscopic study of 70 : 30 brass single crystals of two different orientations which had been reduced 50 per cent. in thickness by cold-rolling revealed the presence of many of the so-called "lines of deformation." X-ray determinations, by the Davey–Wilson method, of the orientations in the rolling plane showed conclusively that the markings were mechanical twins parallel to octahedral planes.

INTRODUCTION.

DURING the course of a study of the effect of cold-rolling on the orientation of single crystals of 70 : 30 brass several specimens were secured which offered conclusive proof of the nature of the "lines of deformation" frequently observed in face-centred cubic metals. This note is a brief description of two of these specimens.

EXPERIMENTAL PROCEDURE.

Two sections approximately 1 in. long, $\frac{1}{2}$ in. wide, and $\frac{1}{8}$ in. thick were cut out of a single crystal made by a modification of Bridgman's‡ method of slow cooling from a melt. The first of these, specimen O, was oriented with an octahedral, (111), plane approximately in the rolling plane and a dodecahedral, [$\bar{1}$01], direction in the rolling direction, whilst the second, specimen C, had a cube, (001), plane approximately in the rolling plane, and a cube, [$\bar{1}$00], direction in the rolling direction.

These were reduced 50 per cent. in thickness by cold-rolling through a set of hand rolls 7 cm. in diameter. After rolling, the specimens were given a deep etch in nitric acid in order to remove the "flowed" layer on the surface, and were then mounted in solder for further examination. The polishing and etching treatments given in preparing the specimen

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† Chase Brass & Copper Co., Waterbury, Conn., U.S.A. This paper is a section of a dissertation to be presented to the Faculty of the Graduate School of Yale University in partial fulfilment of the requirements for the degree of Doctor of Philosophy.

‡ P. W. Bridgman, *Proc. Amer. Acad. Arts Sci.*, 1925, **60**, 305.

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

for microscopic examination were made with great care, because it was known from previous work, notably that of Vogel,* that lines of deformation would be produced by polishing if care were not taken. The final stages of polishing and etching with a mixture of ammonium hydroxide and hydrogen peroxide were repeated several times as an additional safeguard.

The Davey–Wilson † method was used to determine the orientations of the specimens. In this method X-rays, reflected from the surface of an oscillating crystal, are recorded on two films, one of which is stationary, whilst the other oscillates with the specimen. Since reflection from a given plane, according to Bragg's law, can occur only for a definite angle of incidence, spots on the stationary film will be fairly sharp whether or not the reflecting plane is " bent " or otherwise distorted. Only the resolution of the K_α-doublet will be affected. On the other hand, distortion will cause the spots on the oscillating film to be spread over an area, and may even make them too indistinct to be measured unless the plane is close-packed. The poles of planes, then, the reflections of which are recorded on both films can be located exactly, whilst those of planes the reflections of which are on the stationary film alone can be fixed only as lying within fairly restricted limits on a definite stereographic small circle.

Micrographic and X-Ray Studies of Specimen O.

A microscopic examination of the surface of specimen O showed numerous " lines of deformation," of which those shown in Fig. 1 (Plate I) are typical. Four distinct sets of these markings are visible, making angles with the rolling direction of approximately 90°, + 63°, + 4°, and — 60°, clockwise angles from the rolling direction being considered positive, and counter-clockwise negative.

The X-ray determination of the surface orientation gave the orientation for the matrix which is plotted stereographically in Fig. 2. In these projections, poles located from spots on both films are designated by ⊙, those from spots on the stationary film only by ×, and those plotted to complete the projection by ⊡.

In addition to these spots, however, the stationary film had recorded nine others, almost mirror images of the first set, which could not be explained by the matrix orientation. In Fig. 3 these spots are plotted on a projection of the matrix orientation that has been twinned on the (111) plane. This orientation is seen to account for all nine extra spots, the stereographic small circles which are the *loci* of their

* R. Vogel, *Z. anorg. Chem.*, 1921, **117**, 271–280.
† T. A. Wilson, *Gen. Elect. Rev.*, 1928, **31**, 612.

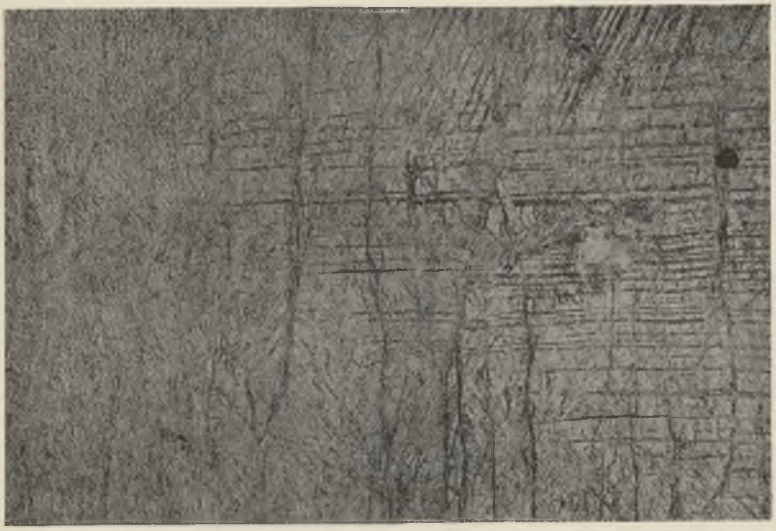

FIG. 1.—Surface of Specimen O Etched with NH_4OH H_2O_2. × 100.
Rolling Direction Horizontal.

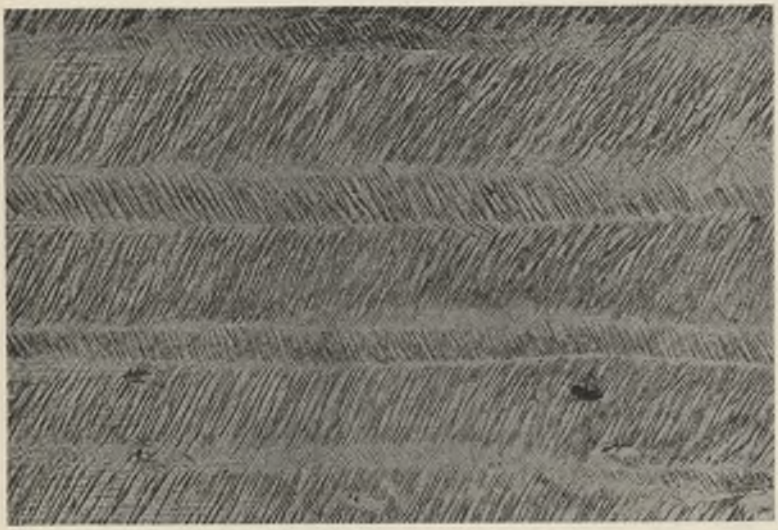

FIG. 4.—Surface of Specimen C Etched with NH_4OH H_2O_2. × 100.
Rolling Direction Horizontal.

poles corresponding in every case with a similar pole on the projection.

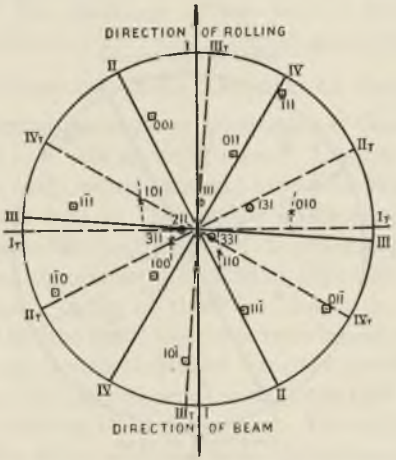

FIG. 2.—Comparison of Traces of the Lines of Deformation with the Matrix Orientation of Specimen O.

FIG. 3.—Orientation of Fig. 2 Twinned on (111), Showing Agreement of Extra Spots from Films of Specimen O.

The surface is thus shown to contain two orientations, one of which is derived from the other by twinning on the (111) plane. These orientations were redetermined several times, all of the films agreeing within a few degrees.

In Fig. 2 the traces of the lines of deformation are also plotted on the projection of the matrix orientation. The dashed lines represent

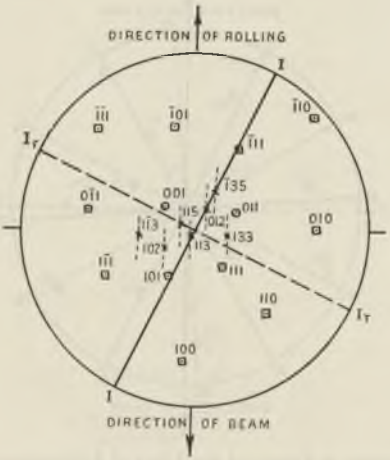

FIG. 5.—Comparison of Traces of the Lines of Deformation with the Matrix Orientation of Specimen C.

FIG. 6.—Orientation of Fig. 5 Twinned on ($\bar{1}11$), Showing Agreement of Extra Spots from Films of Specimen C.

the traces of the "lines of deformation" and the full lines the great circles normal to these traces which must be the *loci* of the planes causing them. There is a reasonable agreement between the traces and the poles of the octahedral planes. The irregular wavy markings approxim-

ately perpendicular to the rolling direction correspond with the traces of the (111) plane and must be, therefore, the material producing the twin reflections. The markings of this set of the four would be expected to reflect, as they are by far the most numerous and prominent.

Micrographic and X-Ray Studies of Specimen C.

In the undeformed specimen of orientation C there were four slip systems subjected to a high shearing stress. Consequently, the structure after a 50 per cent. reduction might have been expected to be quite complex. In about half of the surface a microscopic examination showed this expectation to be fulfilled. The other portion of the specimen, however, had deformed into lamellæ approximately parallel to the rolling direction. Some of these are shown in Fig. 4 (Plate I). It was originally thought that these were twin bands, but this idea was rejected when it was found that they were not parallel to octahedral planes. Attention was then directed to the lines that had been formed in the bands as a result of the deformation. The angles made with the rolling direction by these markings were approximately $-64°$ in the wide bands and $+59°$ in the narrow ones.

Whilst most of the X-ray films made from this specimen showed the orientations of both the lamellæ, the author was particularly fortunate to secure one which showed only the orientation of the wider bands. In Fig. 5 the trace of the lines of deformation in these bands has been plotted on the projection of the matrix orientation. It is seen that the pole of the $(\bar{1}11)$ plane lies very near the great circle perpendicular to the trace. In Fig. 6 the additional spots of the X-ray film which could not be explained by the major orientation are plotted on an orientation derived from that shown in Fig. 5 by twinning on the $(\bar{1}11)$ plane. The agreement is also excellent in this case. These lines of deformation are, then, the edges of thin mechanical twins parallel to the octahedral plane, $(\bar{1}11)$.

Conclusions.

On the basis of X-ray and microscopic evidence, the lines of deformation observed in cold-rolled single crystals of 70 : 30 brass have been shown to be the edges of thin mechanical twins parallel to octahedral planes.

Acknowledgments.

The author wishes to offer sincere thanks to Dr. C. H. Mathewson of Yale University, and to Dr. D. K. Crampton of the Chase Brass & Copper Co., without whose assistance this work could not have been carried out. To Mr. H. L. Burghoff much credit is also due for making the single crystals and preparing the specimens for rolling.

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METALLURGICAL ABSTRACTS

(GENERAL AND NON-FERROUS)

Volume 1 AUGUST 1934 Part 8

I.—PROPERTIES OF METALS

(Continued from pp. 337–340.)

The Reflecting Power of Aluminium and Its Alloys in Different Regions. D. H. Clewell and J. Wulff (*Phys. Rev.*, 1933, [ii], **44**, 952).—Abstract of a paper read before the American Physical Society. The reflecting powers of aluminium, beryllium, magnesium, silicon, and silver alloys have been measured throughout the region 2000–7000 A. at normal incidence by photographic intensity studies and by photoelectric measurements. The polished alloys have been compared with films of the same metals in reflecting power. Electron diffraction and chemical studies permitted a control of physical and chemical composition of the films. Here component metals were evaporated at the same time from different filaments at the proper temperature and separately. From the above data, the most efficient reflectors for the region of 2000–7000 A. have been determined: aluminium–silicon 2000–3000 A.; aluminium–silver 3000–6000 A. An alloy film containing aluminium 85, silver 10, and silicon 5% has approximately the same reflecting power (80–85%) from 2300–5800 A.—S. G.

Magneto-Resistance of Bismuth Films at Low Temperature. C. T. Lane (*Phys. Rev.*, 1934, [ii], **45**, 733–734).—A note. Thin films of bismuth were prepared by evaporation on to strips of mica. With a current passing parallel to the long side of the film, the change in resistance produced by a magnetic field of about 16 kilogauss parallel to the surface of the film was measured at + 20° and — 180° C. With comparatively thick films (0·5–4·0 μ) the change at — 180° C. is much greater than at + 20° C., the ratio diminishing slightly as the film becomes thinner. At about 0·4 μ the curve changes direction abruptly, and indicates that the magneto-resistance will be independent of temperature for zero film thickness. This is explained by assuming that the diamagnetism of bismuth is due to electrons moving in long free paths in definite crystallographic directions, the paths being limited by a secondary structure in the crystal, and the break in the magneto-resistance curve occurring when the thickness of the film equals the unit of the secondary structure.—W. H.-R.

Two New Phenomena at Very High Pressure [Allotropy of Bismuth and Phosphorus]. P. W. Bridgman (*Phys. Rev.*, 1934, [ii], **45**, (11), 844–845).—A note. At room temperature with pressures above 25,000 kg./cm.^{2} bismuth is transformed into a new modification with a volume decrease of about 9%. Extrapolation of the curve for the liquid indicates that the new allotrope at a higher temperature would melt with an expansion of the order 4%, in contrast to the abnormal contraction which takes place when the ordinary modification melts. The change from white to black phosphorus has also been studied.—W. H.-R.

The Longitudinal Thermoelectric Effect: (I.) Copper. P. C. Feng and William Band (*Proc. Phys. Soc.*, 1934, **46**, 515–522).—F. and B. show that the e.m.f. can be regarded as of like nature with the Thomson potential as defined by Sommerfeld and Frank. The potential gradient in copper is not a linear function of the temperature gradient but requires quadratic and cubic terms for its expression. The linear term is retained for the Thomson effect,

* Denotes a paper describing the results of original research.

† Denotes a first-class critical review.

which is thus distinguished from the e.m.f. which arises in asymmetrical states.—J. S. G. T.

The Absorption and Reflection of Gold Between 380 A. and 1400 A. I. B. Liben and H. M. O'Bryan (*Phys. Rev.*, 1933, [ii], **44**, 952).—Abstract of a paper read before the American Physical Society. With a one-meter vacuum spectrograph and a "hot-spark" between Carboloy electrodes, the reflection from gold mirrors at various angles of incidence, and transmission of thin gold films have been determined. Sputtered gold mirrors gave more reproducible reflecting powers than evaporated surfaces. At normal incidence 12% of 1000 A. is reflected with a gradual decrease to less than 1% of 400 A. The absorbing films were evaporated on celluloid films about 10^{-6} cm. thick. The gold films appeared green by transmitted light and from their absorption in the region 2500–6000 A. are estimated to be from 10^{-6} cm. to 3×10^{-6} cm. thick. The absorption coeff. is about 5×10^5 per cm., showing that gold is almost as transparent as celluloid from 1000 to 400 A. Films of silver and selenium show quite different absorption in this region. Preliminary calculation by means of Fresnel's equations from the reflection data give values of the extinction coeff. which agree in order of magnitude with those from direct absorption. The oil-coated plates used were tested for reciprocity failure in the near ultra-violet and in the extreme ultra-violet gave parallel characteristic curves indicating no failure of this law over an intensity range of 30. The magnitude of the absorption in this region accounts for 3 electrons per atom of gold. This includes some of the O, IV, V electrons as well as the conduction electron.—S. G.

On Insects which Perforate the Lead Sheathing of Aerial Cables. Walter Horn (*Arch. Post Telegr.*, **1933** (July), and *Ann. Postes Télég. Téléph.*, 1934, **23**, 559–573).—Damage by insects to cable sheathing is of widespread occurrence. Several typical cases are described and illustrated. General features are the cessation of insect attack when the inner (paper) sheathing is reached, the presence of pulverulent lead and lead compounds outside the borings, the absence of deformation or of preferential intercrystalline attack (thus disposing of certain previously suggested causes of failure) and the location of attack in the neighbourhood of cable suspensions. Protective measures have not so far proved of universal value: they include the use of arsenical lead for sheathing, an additional protective coating of rubber or copper (cost prohibitive), a tallow coating (temperate climates only), organic coatings of poisonous character (apt to deteriorate and to facilitate rather than inhibit attack). H. suggests the use of a modified suspension, of a light surface oxidation of the sheathing, and a closer attention to the surface condition of cables, as well as certain methods of entomological investigation.—P. M. C. R.

Manganese. M. Déribéré (*Métaux et Machines*, 1934, **18**, 163–167).—A detailed review of the sources, production, properties, principal ferrous and non-ferrous alloys, and industrial applications of manganese. A *bibliography* of each section is given.—P. M. C. R.

***The Specific Heat of Nickel and of Some Nickel–Copper Alloys.** K. E. Grew (*Proc. Roy. Soc.*, 1934, [A], **145**, 509–522).—The specific heats of pure nickel and alloys of copper with 94·0%, 87·2%, and 78·8% of nickel have been determined over the temperature range −180° to 450° C. Values of the specific heat, S_1, due to intrinsic magnetization and of the excess specific heat, S, over the "normal" value for a substance without intrinsic magnetization but otherwise similar are deduced. S_1 accounts for a part only of S; the existence of a second term, S_1, having a common origin with the ferromagnetism, is necessary to account for the total excess S.—J. S. G. T.

Adsorption of Hydrogen by Palladium Black under High Pressure. V. Ipatieff, Jr., and W. G. Tronow (*J. Physical Chem.*, 1934, **38**, 623–633).—The

solubility of hydrogen in palladium black at 15°, 25°, 100°, 150°, 200°, and 300° C. at pressures of from 1 to 27 atm. is investigated.—J. S. G. T.

The Reaction of Sodium with Dry Oxygen. B. L. Herrington (*J. Physical Chem.*, 1934, **38**, 675–682).—Sodium amalgams exposed to oxygen dried over phosphorus pentoxide for more than a year were found to be instantly covered with a protecting film which prevented further action. Sodium will react with dry oxygen at room temperature with the emission of light, but the reaction ceases unless water vapour is present to prevent the formation of protective films. It remains to be proved that oxygen can be made so dry that it will not react with sodium.—J. S. G. T.

***The Mechanism of Plastic Deformation of Crystals. I.—Theoretical. II.—Comparison with Observations.** G. I. Taylor (*Proc. Roy. Soc.*, 1934, [A], **145**, 362–387 and 388–404).—The fact that the macroscopic distortion of metal crystals is a shear parallel to a crystal plane and in a crystal direction, and the fact that this remains true even when the distortion is large, show that the plastic strain must be due chiefly to the sliding of one plane of atoms over its immediate neighbour in such a way that the perfect crystal structure is re-formed after each atomic jump. Slipping occurs over limited lengths, L, of the slip-plane, and it is shown that this type of plastic strain gives rise to elastic stresses near the two dislocations which occur at the two ends of each of these lengths L. The assumption that such dislocations will migrate through the crystal, owing, possibly, to temperature agitation, then leads to a definite picture of the mechanics of plastic distortion. This theory of strain-hardening gives a parabolic relationship between stress and plastic strain which agrees well with results obtained with metals crystallizing in the cubic system. L is found to be of the order 10^{-4} cm., agreeing with the order of magnitude of faults found in metals and rock-salt. The system of faulting or mosaic structure limits the free motion of centres of dislocation. The actual strain occurs inside the " blocks " of the mosaic structure, and the crystallographic nature of the faults is immaterial from the point of view of the theory.—J. S. G. T.

Scattering of X-Rays by Cold-Worked and Annealed Beryllium [Theory of Cold-Worked Metals]. James E. Boyd (*Phys. Rev.*, 1934, [ii], **45**, 832–834).—Geiss and —— van Liempt (*Z. anorg. Chem.*, 1924, **133**, 107; 1925, **143**, 259) suggested that the charge distribution in the atoms of a cold-worked metal differs from that of the atoms of the same metal in annealed crystals, and if so a change in the atomic structure factor (F) curve is to be expected. B. has investigated the intensities of reflection from different planes of powdered beryllium crystals before and after annealing, and the atomic structure factors derived from these results show no change with annealing. The beryllium was of 99·5% purity, and was brittle [*Note by abstractor:* pure beryllium is ductile], but some flattening of the particles occurred on grinding.—W. H.-R.

***Comparative Studies on Creep of Metals [Iron, Nickel, Cobalt, Silver, Iron–Chromium–Nickel Alloy, and Iron–Chromium–Silicon Alloy] Using a Modified Rohn Test.** C. R. Austin and J. R. Gier (*Metals Technology*, **1934**, (Feb.), *A.I.M.M.E. Tech. Publ.* No. 544, 1–21).—A modification of the Rohn test has been used to investigate the creep properties of iron (99·967%), nickel (98·78%), cobalt (99·32%), fine silver, and some ferrous alloys. The effect of the method of application of the load on test results is examined. At the higher temperatures the effects of minute amounts of plastic deformation on resistance to further creep become of less importance. Methods for obtaining derived curves which show the results more clearly are described, and the advantages of the method are emphasized.—W. H.-R.

***Elastic Behaviour and Creep.** M. F. Sayre (*Amer. Soc. Mech. Eng., Preprint*, **1933.**)—No clear-cut differentiation appears to exist between creep effects which occur below the elastic limit and the more pronounced plastic yield which occurs at higher stresses. One apparently merges gradually into

the other. In general, the amount of creep and hysteresis seems to be definitely related (*a*) to the temperature of the metals and (*b*) to its state of internal stress.—W. P. R.

†**Hooke's Law Amended [Elastic Phenomena in Instrument Springs].** R. W. Carson (*Instruments*, 1934, **7**, 109–112).—In designing instrument springs, account must be taken of elastic ageing (a slow permanent change in elastic properties) and elastic lag. Ageing is caused by internal stresses and can be prevented by suitable heat-treatment. Lag is of two types—"statical hysteresis" or "elastic back-lash" which is nearly independent of time, and "hereditary hysteresis" or "time lag" which is similar to creep, is influenced by internal stresses, and can be controlled by heat-treatment. A critical survey of these phenomena is given, together with a *bibliography* of 21 references.—J. C. C.

An Elementary Discussion of Ferromagnetism. Francis Bitter (*Proc. Roy. Soc.*, 1934, [A], **145**, 629–644).—The statistical theory of spontaneous magnetization, based on a model consisting of a geometrical array of magnetic elements, of which only the nearest neighbours interact, is discussed. An attempt is made to show quantitatively that discrepancies between the magnetization curves predicted by the theory and experimental curves for iron and nickel crystals in weak fields are due to crystal imperfections.

—J. S. G. T.

II.—PROPERTIES OF ALLOYS

(Continued from pp. 340–346.)

***Internal Stresses in Quenched Aluminium and Some Aluminium Alloys.** L. W. Kempf, H. L. Hopkins, and E. V. Ivanso (*Metals Technology*, **1934**, (Feb.), *A.I.M.M.E. Tech. Publ.* No. 535, 1–23).—Cylindrical bars of pure (99·97%) aluminium, and of 5 ternary or quaternary aluminium-rich alloys were cast and machined to form cylinders of from 5 to 7 cm. in diameter, and 26–29 cm. in length, which were annealed at 343° C. to remove casting and machining stresses. The specimens were heated at different temperatures up to 538° C., and then quenched in (*a*) ice-water, (*b*) oil at 25° C., or (*c*) boiling water in order to give 3 different rates of cooling. The resulting internal stresses were then determined by (1) machining off successive layers of the metal and measuring the change in length of the cylinder (Heyn, *J. Inst. Metals*, 1914, **12**, 3), or (2) by boring out the cores of the cylinders, and measuring the variations in length and diameter (Sachs, *Z. Metallkunde*, 1927, **19**, 352). The latter method permits the determination of the longitudinal, transverse, and radial stresses. The internal stresses increase with the rate of cooling, and under extreme conditions may reach values of the order 10,000–30,000 lb./in.^{2}, the outside of the cylinders being in compression, and the centre in tension. The details of stress-distribution are illustrated graphically. It is concluded that in castings or forgings of smaller size quenched or heat-treated under commercial conditions internal stresses will not lead to trouble, particularly if the quenching is in hot water. Internal stress can be removed in a short time only by heating above 260° C.—W. H.-R.

Some Peculiarities in the Physical Properties of Iron–Aluminium Alloys. C. Sykes and H. Evans (*Proc. Roy. Soc.*, 1934, [A], **145**, 529–539).—The electrical resistivity at room temperature of iron–aluminium alloys containing from 11 to 16% of aluminium by weight, is shown to depend on the rate of cooling of the specimens from about 600° C. Alloys in this range consist of a single solid solution at all temperatures concerned. Rearrangement of atoms takes place in the alloys under slow cooling conditions, and the more regular atomic arrangement so produced leads to a decrease in resistance. Atomic rearrangement occurs over a considerable temperature range even under conditions of very slow cooling.—J. S. G. T.

Special Alpax Alloys. P. Barrand (*Rev. Aluminium*, 1934, **11**, 2421–2423).—The mechanical properties and limitations of Alpax (Silumin) are summarized and the work that has been done on the effects of adding manganese, copper, magnesium, zinc, cobalt, and nickel to the alloy is reviewed. The results of Petit's experiments on the alloys containing manganese 0·3–0·5 and magnesium 0·2–0·3% are briefly described. Of these alloys, the one containing manganese 0·5 and magnesium 0·3% (silicon 12–13%) is recommended for an alloy having the highest elastic limit, but by reducing the manganese to 0·3%, a higher percentage elongation is obtained. The alloys are usually quenched and tempered, but even tempering alone gives an alloy with better mechanical properties, especially the elastic limit, than ordinary Alpax.—J. H. W.

***Dimensional Changes in Die-Casting Alloys. Metastable Beta Phase in Aluminium–Zinc Alloys.—II.** R. G. Kennedy (*Metals and Alloys*, 1934, **5**, 124–126).—Cf. *Met. Abs.*, this volume, p. 346. The hardness of the 78·3% zinc alloy quenched in ice-water increases to a maximum of 120 (Baby Brinell) in 40 minutes, then decreases rapidly; for the 83% zinc alloy under the same conditions the maximum hardness of 100 is reached in 6 minutes. In both cases no change in hardness occurs on prolonged storage at — 70° C., but on warming to 0° C. after this treatment the same changes occur as though the alloy were quenched in ice directly. The contraction which occurs during the hardening is almost completely suppressed by addition of 0·21% of magnesium, although X-ray examination shows that the transformation of β to $\alpha + \gamma$ is not affected by this addition. Apparently the contraction is compensated for by the precipitation of a magnesium-rich phase during ageing.—A. R. P.

***Solubility of Oxygen in Solid Copper.** F. N. Rhines and C. H. Mathewson (*Metals Technology*, **1934**, (April), *A.I.M.M.E. Tech. Publ.* No. 534, 1–17).—The solid solubility of oxygen in copper has been measured between 600° and 1050° C. by exposing copper of purity greater than 99·99% to the action of air at different temperatures for long periods, removing the scale, and then determining the composition of the inner saturated portion by analysis. The solubility increases from 0·007% oxygen at 600° C. to about 0·015% at 1050° C., in fair agreement with the results of Hanson, Marryat, and Ford (*J. Inst. Metals*, 1923, **30**, 197), but in contradiction to those of Vogel and Pocher (*Z. Metallkunde*, 1929, **21**, 333, 368). Age-hardening could not be observed, but evidence was obtained of the precipitation of cuprous oxide on re-annealing at low temperatures. Oxygen can be removed from solid copper by heating at high temperatures *in vacuo* without the use of reducing agents, whilst cuprous oxide also decomposes on heating at low pressures. The pressure–temperature diagram of the system copper–cuprous oxide is discussed. —W. H.-R.

New Requirements for Copper Alloy Tubes. D. K. Crampton (*Metal Progress*, 1934, **25**, (66), 20–24).—The need for higher quality and greater durability in copper alloy tubing has been intensified by severer service conditions, the increased use of softened water, the installation of circulating systems in hot-water lines, and the earthing of electrical circuits on water pipes. Modifications in design and in production equipment are described for tubes of hard and soft temper copper. The development of the sweated joint has resulted in an increased use of copper tubing in water and compound air systems. The Admiralty alloy for condenser tubing has serious competitors in aluminium–brass (copper 76, zinc 22, aluminium 2%), cupro–nickel, and copper–nickel–aluminium–bronze (92 : 4 : 4%). The treatment of copper intended for refrigeration tubing is fully described.—P. M. C. R.

***Contribution to Our Knowledge of the System Copper–Lead–Sulphur.** W. Guertler and G. Landau (*Metall u. Erz*, 1934, **31**, 169–179).—All alloys in the lead–lead sulphide system are two-phase and show a strong tendency to

segregation; 51 alloys in the ternary system lead–copper–sulphur have been investigated, and the results are shown in a ternary diagram. Alloys having a composition near the quasi-binary system lead–cuprous sulphide separate into three layers on cooling, the middle layer consisting of a little cuprous sulphide in lead and appearing to be formed by the reaction of lead sulphide in the top layer with the copper in the lower layer during cooling from 942° to 600° C. The results show that two-layer copper–lead alloys used for bearing metals can be made practically homogeneous by addition of 0·67–1·6% of sulphur, and casting from above 960° C., followed by slow cooling.—A. R. P.

***Action of Hydrogen Sulphide on Copper–Lead–Sulphur Alloys.** W. Guertler and G. Landau (*Metall u. Erz*, 1934, **31**, 269–272).—Passage of hydrogen sulphide through molten lead–copper–sulphur alloys first sulphidizes the copper, forming an upper eutectic layer of cuprous sulphide and lead sulphide; later a middle layer of cuprous sulphide in lead forms. The bottom layer consists of cuprous sulphide and copper in lead. Below 942° C. the reaction ceases.—A. R. P.

Mechanical Properties of Standard Ingot Bronzes. E. Moustacas (*Cuivre et Bronze*, **1932**, (31), 17–25; (32), 19–25; (33), 23–27).—A general discussion of the relative mechanical properties of certain standard railway bronzes made from new metals, partly of new metal, or wholly of reclaimed metal. Some details of the tolerances allowed, and of the qualities demanded in bronzes used on French railways are included. A *résumé* of the discussion is given. The general conclusion appears to be that a certain amount of twice-melted metal is preferable in a casting, but that comparative tests are likely to be misleading unless the test-pieces are taken from identically similar positions in the moulding boxes or on the castings.—W. A. C. N.

Bronzes. M. Godfroid (*Rev. Fonderie moderne*, 1934, **28**, 141–145, 163–165).—The definition of a bronze is discussed, and the melting, properties and applications of ordinary bronze, "aluminium–bronzes," and special bronzes containing phosphorus, lead, zinc, and nickel are described.—J. H. W.

†**Studies on Cast Red Brass for the Estimation of a Basic Classification of Non-Ferrous Ingot Metals for Specification Purposes.** C. M. Saeger, Jr. (*Met. Ind.* (*Lond.*), 1934, **44**, 607–609; and *Found. Trade J.*, 1934, **50**, 359–361, 370, 395–398).—Read before the Institute of British Foundrymen. An investigation has been made for purposes of classification of the tensile strength, Brinell hardness, electrical resistance, and density of alloys having the nominal composition: copper 85, tin, zinc, and lead each 5%. The alloys were made from virgin and remelted metal, and were poured at 1040°–1260° C. They were classified as: (1) bars from chill ingots; (2) bars from "immersed-crucible" ingots, and (3) sand-cast bars. The addition of 0·1% sulphur lowers the physical properties less than higher casting temperatures. The addition of up to 0·6% of iron improved the physical properties, but raised the electrical resistivity. A number of references are given.—J. H. W.

***Electrical Conductivity and Equilibrium of Binary Alloys. XII.—The Lithium–Bismuth System.** G. Grube, H. Vosskühler, and H. Schlecht (*Z. Elektrochem.*, 1934, **40**, 270–274).—The equilibrium diagram of the lithium–bismuth system has been constructed from the results of thermal analysis and electrical resistance determinations. The compound, Li_3Bi, melting at 1145° C., is formed, and the compound, LiBi, is formed by the peritectic reaction at 415° C. This latter exists in 2 polymorphic forms, the transformation temperature being 400° C. The solid solution range of the system cannot be determined.—J. H. W.

***The Lithium–Magnesium Equilibrium Diagram.** Otto H. Henry and Hugo V. Cordiano (*Metals Technology*, **1934**, (Feb.), *A.I.M.M.E. Tech. Publ.* No. 536, 1–14).—The constitution of the magnesium–lithium system has been investigated by thermal and microscopic methods. Cooling curves were

taken using a closed steel crucible for all except the magnesium-rich alloys, which were melted under flux. The solid solubility curves were investigated by annealing for a few hours only. The two metals are completely miscible in the liquid state, and partly miscible in the solid state to form 2 primary solid solutions separated by a 2-phase area. The magnesium-rich solid solution extends to approximately 4·9% lithium by weight at 550° C., and the solubility limit probably increases with temperature up to 591° C. At this temperature a peritectic reaction takes place, and the solid solution in lithium is formed, the solubility limit at the peritectic temperature being approximately 90·2% magnesium by weight. The solid solubility of magnesium in lithium decreases with temperature, and is estimated tentatively as about 88% magnesium at room temperature.—W. H.-R.

***The Mechanism of the Oxidation of Magnesium Alloys at High Temperatures.** R. Delavault (*Compt. rend.*, 1934, **198**, 1929–1932).—The mechanism of the oxidation of solid magnesium and magnesium alloys at high temperatures has been investigated. The specimens consisted of commercially pure magnesium and its alloys with 0·2–10% of sodium, thallium, calcium, zinc, cadmium, aluminium, lead, tin, bismuth, silicon, copper, and silver in the form of small cubes with one polished face, and were heated in an electric furnace in contact with air. Micro-examination in oblique light showed that: (1) all parts of the specimen which exhibited protuberances had started partial fusion, with two distinct appearances according as to whether the expansion due to the partial fusion had or had not been compensated by deformation of the rest of the metal; (2) the protuberances nearly always appeared between the crystals and in those places which first showed signs of fusion. Thus when magnesium contains 10% or less of a foreign metal, oxidation begins through the medium of a liquid phase on which are formed protuberances which offer a large surface in contact with air. A recent study of calcium shows that this phenomenon is not confined to magnesium.—J. H. W.

Nickel-Chromium. I.—Nickel Alloys Resistant to Corrosion. Nickel Informationsbüro G.m.b.H. (*Nickel-Handbuch*, **1934**, 60 pp.).—A very brief summary is given of the nature of corrosion, the factors which are instrumental in promoting it, and the chemical and physical reactions involved. The following points are dealt with: the effect of nickel and chromium in raising the resistance of iron to corrosion; the relevant portion of the ternary diagram in relation to the corrosion properties of the various alloys, among which are included nickel–chromium, nickel–chromium–iron, nickel–iron (containing also molybdenum, copper, silicon, &c.), austenitic chromium steels, pearlitic and martensitic chromium–nickel steels, nickel cast-iron. Numerous tables indicate the resistance of these materials to the action of various industrial chemicals. A review is given of factors to be borne in mind when choosing an alloy for use in corrosion conditions with a list of parts commonly used in the food, building, sanitation, chemical, ceramic, glass, engineering, railway, shipping, and metallurgical industries in which nickel-bearing alloys may be used. Brief instructions are added for the working of the alloys—forging, annealing, hardening, deep-drawing, welding, soldering, polishing, sand-blasting, and etching.—W. A. C. N.

Electrical Properties of Copper-Nickel Resistance Alloys. S. Kimura and T. Aizawa (*Japan Nickel Rev.*, 1933, **1**, 391).—[In English and Japanese.] Abstracted from *Res. Electro-tech. Lab.* (*Tokyo*), 1926, No. **171**, 1–10. See *J. Inst. Metals*, 1926, **36**, 447.—W. A. C. N.

III.—STRUCTURE

(Metallography; Macrography; Crystal Structure.)

(Continued from pp. 347–348.)

***The Beilby Layer.** G. I. Finch, A. G. Quarrel, and J. S. Roebuck (*Proc. Roy. Soc.*, 1934, [A], **145**, 676–681).—From observations made on metal films deposited on polished and etched surfaces, employing an electron diffraction camera, it is concluded that the existence of the Beilby layer has been raised from the realm of hypothesis to that of established fact.—J. S. G. T.

Studies upon the Widmanstätten Structure. VI.—Iron-Rich Alloys of Iron and Nitrogen and of Iron and Phosphorus. Robert F. Mehl, Charles S. Barrett, and H. S. Jerabek (*Metals Technology*, **1934**, (April), *A.I.M.M.E. Tech. Publ.* No. 539, 1–18).—W. H.-R.

***Multiple Laue Spots from Aluminium Crystals.** A. Komar and W. Obukhoff (*Phys. Rev.*, 1934, [ii], **45**, 646).—A note. See *Met. Abs.*, this volume, p. 347.—W. H.-R.

***Disintegration of Sputtered Deposits [of Metallic Films of Bismuth, Antimony, and Gold].** Ellis A. Johnson and Louis Harris (*Phys. Rev.*, 1934, [ii], **45**, 630–634).—Factors affecting the deposition and disintegration of metallic films by cathodic sputtering are investigated, and the results discussed.—W. H.-R.

***The Crystal Structure of Mercury.** C. Hermann and M. Ruhemann (*Z. Krist.*, 1932, **83**, 136–140; *C. Abs.*, 1932, **26**, 5467).—Single crystal measurements were made on an unoriented crystal of mercury at -50° C. The data secured were successfully interpreted in accordance with the structure proposed by McKeehan and Cioffi (*Phys. Rev.*, 1922, [ii], **19**, 444) on the basis of powder photographs, thus confirming their results.—S. G.

***The Effect of Thermal Agitation on Atomic Arrangement in Alloys.** W. L. Bragg and E. J. Williams (*Proc. Roy. Soc.*, 1934, [A], **145**, 699–730).—Equilibrium states of an alloy are considered and the degree of order of the structure as a function of temperature is calculated. The ordered structure has a lower potential energy than the disordered structure, but thermal agitation promotes disorder. Above a critical temperature the structure is completely random. As the temperature is lowered, order sets in abruptly at the critical temperature and, at first, increases rapidly. It becomes complete only as absolute zero is approached. This characteristic sudden onset of order causes a sharp inflection in curves showing the variation of resistivity, lattice spacing, and specific heat with temperature. These inflections simulate a phase-change, but actually there is no such change. A general law for the dependence of rate of relaxation on temperature is derived, and this enables the effects of annealing and quenching to be predicted. The rate of relaxation depends on the "activation energy" required to surmount a potential barrier when two atoms exchange position. An alloy is a system of dynamical equilibrium; it receives its character at a point in its history when the temperature is just sufficiently high for interchange to occur. Maxima and minima in physical properties do not imply the existence of compounds; they are statistical effects.—J. S. G. T.

About the Origin of the Mosaic Structure in Metal Crystals. A. Goetz (*Phys. Rev.*, 1934, [ii], **45**, 138).—Abstract of a paper read before the American Physical Society. In order to explain the periodicities of higher orders (secondary or mosaic structures) it is suggested that an aggregation of groups takes place during an interval of temperature of a few degrees *above* the melting point. These aggregates ("groups") are of approximately equal size and their existence is essential for the formation of a solid crystal. If their formation is prevented, undercooling results down to a temperature at which

the group formation is more probable. The support for this hypothesis is found partly in experiments by G. concerning the "survival" of crystalline qualities of single crystals beyond the melting point; partly in Webster's experiments on the phenomena of undercooling as a function of previous heating; partly by the fact that the X-ray analysis of liquid metals whose structure in the solid state deviates much from close-packed arrangements does not give an indication of a statistical distribution of the molecules in the liquid. It is suggested that the mosaic structure in solids is caused by the slight structural deformation which the molecules at the surface of the groups possess in the moment of the transition into the solid state. The variation in the size of these groups as well as slight inaccuracies of their packing may serve to explain the failure to observe diffraction patterns of such structures and also the dependence of such structures on the methods of growth of the crystal.—S. G.

The X-Ray Investigation of Microstructure. W. E. Schmid (*Arch. tech. Messen*, 1934, **3**, (35), T62).—See also *Met. Abs.*, this volume, p. 348. Important applications of X-ray examination are enumerated and described, notably the determination of (*a*) the crystalline or amorphous nature of the sample examined; (*b*) grain-size in crystalline materials, and (*c*) crystal orientation.—P. M. C. R.

Practical Auxiliaries in the Evaluation of Atomic Structural Investigations. Maximilian v. Schwarz and Oskar Summa (*Forschungsarb. Metallkunde u. Röntgenmetallographie*, 1932, (**6**), 40 pp.; *C. Abs.*, 1933, **27**, 3390).—Mathematical formulæ, methods, graphic aids, tables, curves, &c., useful in the evaluation of X-ray analysis data, are presented.—S. G.

IV.—CORROSION

(Continued from pp. 348–351.)

Contribution to the Question of the Influence of the Heat-Treatment of Hardenable Aluminium Rolling Alloys on Their Resistance to Corrosion by Sea-Water. Oskar Summa (*Korrosion u. Metallschutz*, 1934, **10**, 57–58).—A theoretical discussion of the part played by the structural constituents of aluminium alloys in the corrosion of the alloys by sea-water and the effect of heat-treatment on the electrochemical behaviour of the constituents.

—A. R. P.

***Action of Acids on Iron and Copper [Corrosion of Sugar Factory Apparatus].** J. Zamaron (*Bull. assoc. chim. sucr. dist.*, 1933, **50**, 108–113; *C. Abs.*, 1934, **28**, 3932).—Abnormal corrosion of diffusion-battery steel calorizator tubes in a beet-sugar factory, involving a loss of 44% of the metal in 4 campaigns, is attributed to the acids in the raw juice. No such corrosion occurred in the tubes of the carbonated juice heater. Pieces of ordinary steel immersed for 7 hrs. in 0·04–0·16% sulphuric acid at 90° C. lost 0·4–1·4% in weight; in acetic acid of the same range of concentration under similar conditions losses of 1·2–1·5% were observed. Similar experiments with copper showed losses only about one-tenth as great in sulphuric acid and much less in acetic acid.

—S. G.

On the Resistance to Corrosion of Bronzes. O. Dahl (*Korrosion. Bericht über die III. Korrosionstagung, Berlin*, **1933**, 23–34; discussion, 35–36).—A review of recent work on the resistance of tin, tin–zinc, nickel, aluminium, and beryllium–bronzes to corrosion, especially by sea-water. 19 references are given.—A. R. P.

***Influence of the Annealing Treatment on the Resistance to Corrosion of Condenser Tubes.** E. Schumann (*Korrosion. Bericht über die III. Korrosionstagung, Berlin*, **1933**, 47–57; discussion, 58–60).—The tests were made on

tubes of an alloy containing copper 70·43, tin 0·87, iron 0·02, aluminium 0·05, lead 0·03, and zinc 28·6% in hard tap-water and in salt-water (about 1·2% sodium chloride). The resistance to corrosion was found to depend chiefly on the internal stress, the best resistance being obtained with annealed tubes having a medium-size grain. This structure was obtained by annealing at 400° C.; with increasing annealing temperature the grain-size became coarser and the corrosion-resistance fell to a minimum at 650° C., whereas with a lower annealing temperature than 400° C. the protective film first formed tended to break owing to residual stress in the metal. Removal of the skin produced in annealing considerably reduced the resistance to corrosion. A laboratory apparatus for testing the behaviour of condenser tubes in corrosive media is described.—A. R. P.

***Corrosion of Brass in Water Subjected to p_H Correction.** Edward W. Moore (*J. New England Water Works Assoc.*, 1934, **48**, 47–58; *C. Abs.*, 1934, **28**, 3818).—Dezincification seems to decrease from p_H 6·0 to a minimum at p_H 10·0 and then to increase slightly. This condition appears to be reversed for copper. The tests covered a p_H range from 6·0 to 11·0. Discussion emphasizes the importance of salts in solution and suggests that p_H control will not solve the problem.—S. G.

Zinc in Drinking Water. August G. Nolte and Warren A. Kramer (*Amer. City*, 1934, **49**, (4), 63–64; *C. Abs.*, 1934, **28**, 3816).—Tap-water in contact with galvanized piping reacts with the zinc to form a basic zinc carbonate. The highest concentration found from any much-used tap was 5 p.p.m. The presence of dissolved carbon dioxide hastens the solution of zinc, whilst dissolved sulphates retard solution. It is concluded that zinc in concentrations found in drinking water has no harmful physiological effects.—S. G.

Prevention of Corrosion [in Tannery Liquors]. M. P. Balfe (*Leather World*, 1933, **25**, 1217; *J. Amer. Leather Chem. Assoc.*, 1934, **29**, 171; *C. Abs.*, 1934, **28**, 3935).—Applied protective coatings are unsatisfactory for metals in contact with moving tanning liquors. Suitable alloys are: for acid pickle and chrome tan liquors—Monel metal; for lime liquors—iron, because oxide film forms; for tan liquors—copper-alloys (oxide film); for bleach liquors—aluminium–brass (Al_2O_3 film).—S. G.

***The Corrosive Properties of Dichloroethane and Trichloroethylene.** S. S. Drozdov and N. S. Drozdov (*J. Chem. Ind. (Moscow)*, **1934**, (2), 53–54; *C. Abs.*, 1934, **28**, 3704).—[In Russian.] Iron, lead, and copper are appreciably corroded by these solvents, but less so by their vapours. Extraction of the metals in a Soxhlet apparatus causes greater corrosion than mere standing in the solvents. The presence of water increases the corrosion. In all cases the iron is the most strongly corroded and the copper the least. Trichloroethylene acts more strongly than dichloroethane. Free chlorine ion is always found in the solvents after their action on the metals.—S. G.

***Experiments on the Newton Water and Treatments for the Control of Corrosion.** F. Wellington Gilcreas (*J. New England Water Works Assoc.*, 1934, **48**, 105–116; *C. Abs.*, 1934, **28**, 3818).—An effort was made to duplicate domestic conditions—12 hrs. of movement and 12 hrs. of rest. Untreated and aerated water, without and with soda ash to give p_H 8·2, was used. Dissolved oxygen, carbon dioxide, and p_H were determined. Corrosion losses on wrought iron, galvanized iron, brass pipe, and copper tubing are shown. The treatment adopted did not include aeration, but corrected the p_H with soda ash to between 7·6 and 8·0. The treatment started in December 1931 and the results are considered to be satisfactory.—S. G.

Corrosion Studies in Steam Heating Systems. R. R. Seeber, F. A. Rohrman, and G. E. Smedberg (*Heating, Piping, Air-Conditioning*, 1934, **6**, 124–126; *C. Abs.*, 1934, **28**, 3704).—Progress made to date is reported on the investi-

gation of the relationship of oxygen, carbon dioxide, p_H value, and method of operation on the corrosive properties of condensate in steam heating systems. —S. G.

***Corrosion and Fatigue.** K. Laute (*Korrosion. Bericht über die III. Korrosionstagung, Berlin*, **1933**, 1–10; discussion, 10–11).—Under alternating compression–tension stresses (100 million cycles) the endurance limit of electrolytic copper in water is the same as in air; this applies to the hard-drawn metal, annealed metal, and coarsely crystalline annealed metal. Welding and brazing reduces the endurance limit to the same extent in air and water. Values are also given for various steels showing a big reduction in the endurance limit under water.—A. R. P.

Effect of Corrosion on Fatigue Limit. H. Ochs (*Schriften Hess. Hochschulen*, 1932, (**4**), 55–59).—S. G.

Influence of Volta Effect on Corrosion. R. J. Piersol (*Metal Cleaning and Finishing*, 1934, **6**, 109–114; *C. Abs.*, 1934, **28**, 3704).—A discussion. Methods for determining electrode potentials are given.—S. G.

On the Influence of Surface Films on Corrosion [of Metals].—I. Willy Machu [with W. J. Müller] (*Oesterr. Chem.-Zeit.*, 1934, **37**, 46–50).—The detection and properties of protective films on metals are discussed and methods of producing such films are described briefly, with especial reference to the formation of sulphate films on lead.—A. R. P.

Outline of Stray Current Electrolysis. Ira D. Van Giesen (*J. Amer. Water Works Assoc.*, 1934, **26**, 653–671).—A general review dealing with the action of stray currents in causing corrosion of underground structures, methods of reducing leakage currents, and the preparation of electrolytic surveys.—J. C. C.

10th Report of the Corrosion Committee of the Association Suisse des Électriciens and Three Associated Societies. J. Landry and others (*Bull. Assoc. Suisse Élect.*, 1934, **12**, 322–324).—The work undertaken by the Committee in 1933 includes: (1) experiments on corrosion of metallic objects by soil electrolysis, using a controlled current of known strength; (2) periodical inspection of most of the federal and municipal railways and tramways, with a view especially to investigating the corrosion of welded joints and the effects of short circuits in supply cables; (3) corrosion tests on lead, light alloys, and various types of ferrous materials, some galvanized, in 3 different soils, with variable and reversible current, reproducing the conditions of subterranean conductors in the neighbourhood of tramways or electric rails. Reports on the soil-corrosion of pipes were received.—P. M. C. R.

Gold as a Corrosion Resistant. P. Steen and O. P. van Steewen (*Werkstoffe u. Korrosion*, 1933, **8**, 37–39; *C. Abs.*, 1934, **28**, 3043).—Gold in the form of plating has the advantages of being resistant to oxidation, acids, and alkalis; it has low heat radiation coeff., small grain-size and other advantages, which are discussed.—S. G.

V.—PROTECTION

(Other than Electrodeposition.)

(Continued from pp. 351–352.)

Electrolytic Oxidation of Aluminium by the Eloxal Process. E. Herrmann (*Schweiz. Tech. Z.*, **1933**, (46), 695).—The electrolyte consists of a 3–10% aqueous solution of oxalic acid containing 0·1% chromic acid, and is used at a temperature of 15°–30° C. D.c. or a.c. may be employed. For thin films that are afterwards to be coloured only 1–2 kw.-hr. per in.^{2} are required. For denser films it is necessary to have 10–12 kw.-hr. per in.^{2}. In general, agitation of the baths is not undertaken.—W. A. C. N.

Application of Aluminium to Reaction Chambers Prevents Metal Loss. H. R. Leland (*Nat. Petroleum News*, 1934, **26**, (15), 25–26).—Read before the

(U.S.) Western Refiners' Association. An account of the performance of metallized aluminium coatings on the interior walls of refinery reaction chambers. The coating gave satisfactory service in coke chambers, a flash tower, a Dow surge pot, and boiler tubes. Metallizing with 18–8 has been successfully applied to worn plungers. Methods of application and inspection are described in some detail.—P. M. C. R.

New Methods of Protection from Corrosion. R. Doczekal (*Sparwirt.*, 1933, **11**, (1), 20–22; *Build. Sci. Abs.*, **6**, 165; *C. Abs.*, 1934, **28**, 3367).—The Parker process is described. Variations of weight are shown which were observed with test-specimens of steel exposed to various reagents after Parkerizing, Sherardizing, coating with tin, nickel, zinc, or painting. Results are given of an accelerated corrosion test in which steel protected by various methods, including the Parker process, was sprayed with a corrosive solution and observation was made of time required for rust to appear. Reference is made to the Parkolite spray process, the Bonderite process, the Protal process for aluminium, and also to the Udylite process for the electrodeposition of cadmium.—S. G.

The Varying Behaviour of Zinc Protection Plates in the Boilers of Railway Ferryboats. R. Kühnel (*Korrosion. Bericht über die III. Korrosionstagung, Berlin*, **1933**, 42–46).—Wide variations in the life of protective plates of zinc in boilers have been investigated; the zinc contained 1–1·7% lead and minor amounts of iron, but no relation was found between the composition and the rate of corrosion. Hard plates behaved much better than soft ones the best life being obtained when the Brinell hardness exceeded 46.—A. R. P.

Painted, Lacquered, and Pickled Surfaces and Their Resistance to Corrosion. P. Steen and O. P. van Steewen (*Bauing.*, 1933, **14**, 160–162; *Build. Sci. Abs.*, **6**, 127; *Sci. Abs.*, 1934, **28**, 3367).—The corrosion-resistance of steel, copper, and aluminium surfaces which have not been galvanized, but are protected by coatings of oil paint or lacquer, the properties of oils and lacquers which are essential to the prevention of corrosion beneath the paint, and methods of pickling, which, besides affording protection, also produce definite colours are discussed.—S. G.

***Study of the Anticorrosion Power of Paints on Tinned Cans.** A. Vila (*Recherches et Inventions*, 1933, **14**, 308–318; *C. Abs.*, 1934, **28**, 3915).—Comparative tests were carried out on 4 laboratory-prepared paints and 22 commercial paints and 6 commercial varnishes, which were applied to tins (over 1000 altogether) and exposed to the atmosphere for about 1 year. Four paints, all of which contained only or largely ferric oxide as pigment, in various oils, showed little or no change at the end of the test; but it should be noted that the colour of these paints (red in all cases) does not lend itself readily to observations of small changes in appearance.—S. G.

Tests Carried Out on Anticorrosion Paints. A. Vila (*Recherches et Inventions*, 1933, **14**, 318–321; *C. Abs.*, 1934, **28**, 3915).—A brief discussion showing the difficulties of obtaining a satisfactory rapid test for evaluating the quality of anticorrosion paints and that no satisfactory artificial ageing test has as yet been devised. The quality of anticorrosion paints is due essentially to their impermeability to agents exerting a destructive action on the surface to be protected. So far, the most satisfactory test devised is the mercuric chloride–sodium chloride test (see following abstract).—S. G.

The Permeability of Anticorrosion Paints. A. Vila (*Recherches et Inventions*, 1933, **14**, 328–331; *C. Abs.*, 1934, **28**, 3915).—The mercuric chloride–sodium chloride test is described. When the test was applied to a number of paints that had been subjected to exposure to the weather over a prolonged period, the results were in agreement with those of the exposure tests.—S. G.

Anticorrosion Paints. Study of the Anticorrosive Power of Commercial Paints. A. Vila (*Recherches et Inventions*, 1933, **14**, 290–303; *C. Abs.*, 1934, **28**, 3915).—A more detailed description of the tests comparing white lead and

aluminium paints on the one hand with lead-free paints, both commercial and prepared in the laboratory, on the other.—S. G.

***Tests on Anticorrosion Paints.** A. Vila (*Recherches et Inventions*, 1933, **14**, 303–308; *C. Abs.*, 1934, **28**, 3915).—A description of the tests carried out (on 8 steels) on 28 different paints under 4 sets of conditions (over 1000 test strips). —S. G.

VI.—ELECTRODEPOSITION

(Continued from pp. 352–354.)

The Preparation of Silver Baths by Anodic Dissolution of Fine Silver. K. W. Fröhlich (*Mitt. Forschungsinst. Edelmetalle*, 1934, **8**).—Silver-plating baths can be prepared by electrolysis using large sheet silver anodes and small copper-rod cathodes in a cyanide solution containing 50–75 grm. of potassium cyanide per litre. The cathode is preferably surrounded by a porous clay diaphragm, and current is supplied at 3 v. to give an anode current density of 0·4 amp./dm.^{2} with a cathode current density of 200 amp./dm.^{2}. About 50 grm./litre of silver can be dissolved in this way in about 6 hrs. with the deposition of less than 1 grm. of silver on the cathode.—A. R. P.

***The Electrodeposition of Tantalum from Aqueous Solutions.** N. Isgarischew and A. F. Prede (*Z. Elektrochem.*, 1934, **40**, 295–297).—Different types of solutions for the electrodeposition of tantalum have been investigated, especially those containing glucose, potassium salicilate or resorcinol. Cathodic deposition is possible from all 3 solutions. In the case of the first two, metallic deposition ceased a short time after the beginning of the test, the initial current efficiency being very low; this, however, was not observed in the case of the resorcinol solution.—J. H. W.

A Method for Measuring the Adherence of Electrodeposits. P. Jacquet (*Compt. rend.*, 1934, **198**, 1313–1315).—A method for measuring the adherence of electrodeposits depends on the fact that a deposit can be separated from its base if one of its extremities is detachable. For instance, a strip is marked out with varnish in the middle of one face of a (nickel-plated steel) sheet and part of the sheet immersed in a 0·5 grm./l. aqueous solution of peptone. The whole sheet is then made the cathode in a copper-plating bath. By filing the edges, the coating is raised from the peptoned part of the sheet, and a tongue is cut from the coating thus raised in line with the marked strip. The sheet is then clamped in a horizontal position and the strip is detached by means of weights or a compound lever attached to the other end of the tongue. Experimental errors are not more than 20%, which is sufficiently accurate for a systematic study of the adherence of the deposits. Cf. *J. Inst. Metals*, 1933, **53**, 313.—J. H. W.

IX.—ANALYSIS

(Continued from pp. 355–358.)

Micro-Analysis. J. Gordon Pearson (*Chem. Eng. Min. Rev.*, 1934, **26**, 279–283).—A list of the reagents and strength of the solutions required, and details of tests for the micro-analysis of Ba, Ca, Sr, Mg, Ag, Cu, Hg, Bi, As, Sb, Fe, Cr, Mn, Ni, Co, Al, Na, K, and dioxide and 17 acid radicles, all vouched for by P. are described, and references for each test are given.—J. H. W.

Notes on the Analysis of Alkaline Tin Plating Solutions. M. R. Thompson (*Monthly Rev. Amer. Electroplaters' Soc.*, 1934, **20**, (10), 16–22).—Total Sn is determined by acidifying the solution with HCl, oxidizing any $SnCl_2$ with Br-water, adding 4 grm. of $NH_2OH{\cdot}HCl$ and electrolyzing at 35° C. with 2 amp.; it may also be determined volumetrically with $FeCl_3$ in the usual way. Stannous Sn is determined by acidifying with HCl and titrating the hot solution

directly with $FeCl_3$. Free NaOH is determined by removing the Sn with an excess of $SrCl_2$ solution and titrating the filtrate with standard acid; carbonate can be determined only by acidifying and collecting the CO_2 in KOH.—A. R. P.

***Simplifications in the Method of Separation of Metals by Graded Potential.** A. J. Lindsey and H. J. S. Sand (*Analyst*, 1934, **59**, 328–335).—Lassieur's work is critically reviewed; the values given by L. for the potential at which the various metals are deposited are not generally applicable owing to polarization of the auxiliary electrode and its back-resistance. A modified auxiliary electrode is described, together with a potentiometer arrangement for determining the correction required for direct readings from this electrode.—A. R. P.

***The Determination of Bismuth in Copper.** E. W. Colbeck, S. W. Craven, and W. Murray (*Analyst*, 1934, **59**, 395–399).—Bi may be quantitatively removed from Cu by heating fine turnings of the metal for 1 hr. in H_2 at 1060° C., the Bi being deposited as a mirror on the cool parts of the tube. The deposit is dissolved in HNO_3 and the Bi determined colorimetrically by the iodide method. Sb and As are removed from the Cu by the same method, but do not interfere in the Bi determination.—A. R. P.

***An Indirect Method for the Determination of Cobalt.** P. Spacu (*Z. anal. Chem.*, 1934, **97**, 192–193).—The Co is precipitated as $Co(C_5H_5N)_4(SCN)_2$ and the excess of KCNS titrated potentiometrically with $AgNO_3$.—A. R. P.

***An Indirect Method for the Potentiometric Determination of Copper.** G. Spacu and P. Spacu (*Z. anal. Chem.*, 1934, **97**, 99–102).—The Cu is precipitated with C_5H_5N and a measured volume of 0·1*N*-KCNS, and the excess of the latter is titrated potentiometrically with $AgNO_3$.—A. R. P.

***On the Potentiometric Determination of Copper.** W. Hiltner and W. Grundmann (*Z. anal. Chem.*, 1934, **97**, 172–179).—The HNO_3 solution of the metal is diluted to 150 c.c., neutralized with NaOH, made just acid with HNO_3, treated with 20 c.c. of 2*N*-$CH_3{\cdot}CO_2Na$, 5 grm. of glucose, and a slight excess of 0·1*N*-KCNS, boiled, cooled, and filtered. The filtrate is acidified with 15 c.c. of 2*N*-H_2SO_4 and 20 c.c. of 2*N*-$CH_3{\cdot}CO_2H$, and the excess of KCNS is titrated potentiometrically with $AgNO_3$ using a AgI indicator electrode.—A. R. P.

***On the Determination of Copper, Cadmium, and Nickel as New Complex Compounds.** Alfred Taurinš (*Z. anal. Chem.*, 1934, **97**, 27–36).—In the presence of an excess of NH_4NO_3, Cu is precipitated from ammoniacal solution by a 10% solution of K_2HgI_4, free from excess of KI, as the complex compound $Cu(NH_3)_4(HgI_3)_2$ (4·91% Cu). From 2*N*-NH_4OH containing 4% of KI Cd gives a similar compound (8·29% Cd) with K_2HgI_4; under the same conditions Ni gives the compound $Ni(NH_3)_6(HgI_3)_2$ (4·43% Ni). Since Co also gives a precipitate like Ni, it should first be oxidized in ammoniacal solution to $[ClCo(NH_3)_5]Cl_2$ by boiling with H_2O_2. All the complex precipitates can be weighed after washing first with a saturated alcoholic solution of the compound, then with $(C_2H_5)_2O$, and drying *in vacuo*.—A. R. P.

Conditions for the Potentiometric Titration of Copper with Sodium Sulphide Using a Platinum Electrode. Jang Bahadur Iha (*J. Indian Chem. Soc.*, 1933, **10**, 643–647).—Cu may be determined potentiometrically in sulphate solution containing a little $CH_3{\cdot}CO_2H$ by titration with Na_2S solution using a Pt indicator electrode.—A. R. P.

***The Determination of Zinc in Large Quantities with Particular Reference to the Analysis of Brass.** L. C. Nickolls and J. G. N. Gaskin (*Analyst*, 1934, **59**, 391–395).—The brass (2 grm.) is dissolved in 7 c.c. of HCl with the aid of the minimum amount of HNO_3 and the solution is evaporated to dryness on the water-bath. The residue is dissolved in hot water containing 5 grm. of Na_2SO_4 and the Cu is removed by boiling for 1 hr. with a strip of Al sheet. The solution is then poured into an excess of 50% NaOH solution to dissolve the $Al(OH)_3$ and $Zn(OH)_2$ first precipitated, and the resulting solution is elec-

trolyzed at 0° C. with a rotating gilt Pt cathode using 3·5 amp./dm.². About 1½ hrs. are required to deposit 1 grm. of Zn as a firm, closely-adherent plate, which is washed with acetone, and dried in a steam oven for 1 minute before weighing. Small amounts of Pb, Sn, Ni, or Mg do not interfere, Fe and Mn are removed by the NaOH treatment, As and Sn are precipitated with the Cu as well as large amounts of Ni, and large amounts of Pb are precipitated by the Na_2SO_4.—A. R. P.

X.—LABORATORY APPARATUS, INSTRUMENTS, &c.

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

(Continued from p. 358.)

***The Apparatus and Technique for Growing Large Specimens of Single-Crystal Zinc.** C. A. Cinnamon (*Rev. Sci. Instruments*, 1934, [N.S.], **5**, 187–190).—A modification of Kapitza's method (*Proc. Roy. Soc.*, 1929, [A], **119**, 358), is described, and has been applied to prepare a set of large zinc crystals which should be strain-free, of uniform cross-section (about 1·2 cm.²), about 35 cm. long, and of any desired orientation. A polycrystalline casting of the desired size and shape made in a horizontal mould is melted and then re-crystallized after inoculation with a small single-crystal nucleus, set so as to determine the orientation of the growing crystal. A gross mosaic structure which may occur during the initial stages of growth of the crystal can be eliminated by a steep temperature gradient. The ratio of the temperature gradient in the stem of the mould to the rate of growth must approximate to a certain favourable, but not necessarily the same, value for each orientation. —J. S. G. T.

***Apparatus for Measuring Thermal Conductivity of Metals up to 600° C. [Conductivity of Pure Zinc, Pure and Commercial Nickel and Nickel–Chromium Alloys].** M. S. Van Dusen and S. M. Shelton (*U.S. Bur. Stand. J. Research*, 1934, **12**, 429–440; *Research Paper* No. **668**).—Apparatus for measuring the thermal conductivity of metals up to 600° C. is described. The method employed consists in comparing the conductivity of a metal, either directly or indirectly, with that of lead. Lead was selected as the standard, since previous measurements have established its conductivity within fairly close limits. Determinations are made by measuring the axial temperature gradients in two cylindrical bars soldered together end to end, one end of the system being heated and the other cooled, and the convex surfaces protected from heat loss by a surrounding guard tube. Data are given for the conductivity of commercial nickel, high-purity zinc, high-purity nickel, and several commercial nickel–chromium and other alloys widely used for heating elements and thermocouples.—S. G.

A Convenient Apparatus for Distilling Metals. R. V. Jones (*J. Sci. Instruments*, 1934, **11**, 167–168).—A note. A glass apparatus is described for coating small articles (*e.g.* mirrors) with metals by evaporation. High melting-point metals are evaporated from a tungsten helix, and low melting-point metals from a small Alundum crucible heated by tungsten wire. The feature of the apparatus is that it can be opened easily and quickly. It is suitable for coating articles of which the dimensions do not exceed 5 cm.—W. H.-R.

The Photoelectric Cell and Its Use for Measuring the Polish and Colour of Metals. René Toussaint (*Rev. Aluminium*, 1934, **11**, 2403–2414).—A description is given of various forms of the photoelectric cell and its accessory apparatus, and its use in determining the degree of polish of metals and the colour tints of various metallic surfaces.—J. H. W.

The Measurement of Welds. R. Cajar (*T.Z. prakt. Metallbearbeitung*, 1934, **44**, 197–200).—An instrument in the nature of a special caliper, used both

for the predetermination of the thickness of welds, especially at angles, and for their measurement after production, is described. Various types of instruments are illustrated and described.—W. A. C. N.

Two Variations of the Powder Method of X-Ray Analysis of Crystals. J. P. Blewett (*J. Sci. Instruments*, 1934, **11**, 148–150).—Two "focussing" methods are described for X-ray crystal analysis by the powder method, one using a parallel, and the other a convergent beam of X-rays. Diffraction at angles of almost zero degrees can be observed, and the intensity is increased.

—W. H.-R.

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

(Continued from pp. 358–362.)

Acceptance–Rejection Requirements in Specifications. H. F. Dodge (*Amer. Soc. Test. Mat. Preprint*, **1934**, June, 1–14).—Specifications for quality materials and finished products impose requirements for individual quality characteristics to distinguish between what may be satisfactory for a given purpose and what may not. For many characteristics 100% inspection or testing is not feasible, hence reliance must be placed on sampling a part of the whole. Under these conditions, 100% conformity with requirements cannot be achieved with certainty, and errors arising from sampling fluctuations cannot be avoided. The sampling clauses included in specifications often provide criteria for the acceptance or rejection of lots of a product. These clauses constitute interpretations of the intent of the basic quality requirements and serve as a basis for action. With sampling, certain risks are assumed by the consumer and by the producer. One type of risk is discussed, and the relationship between (1) the distribution of such risks between consumer and producer, and (2) the choice of acceptance criteria and sample size, is indicated for certain conditions.—S. G.

Internal Pressure Stress in Lead Pipes. Heinz Bablik and J. Krystof (*Met. Ind.* (*Lond.*), 1934, **45**, 3–6).—An investigation into the best specifications for B.N.F. lead pipes has lead to the following conclusions: (1) the critical hydraulic pressure which lead tubes must withstand is the pressure of the repulsion plus the static water pressure; (2) for correct testing the hydraulic pressure which causes an increase of 0·2% in the internal diameter must be determined, and not the ultimate bursting pressure; (3) an increase in the hydraulic resistance is possible practically only by increasing the wall thickness so that its ratio to the internal diameter is unity, but it would not be commercially economical to raise this ratio above 0·6; (4) further increase in the hydraulic resistance can be effected only by raising the mechanical strength of the lead by alloying and heat-treating; (5) the B.N.F. alloy No. 1 gives a 64% higher yield-stress than pure lead.—J. H. W.

***Investigating the Importance of Bearing Metals.** J. R. Connelly (*Amer. Soc. Mech. Eng. Preprint*, **1933**).—Describes a new test machine which reproduces wear under service conditions and gives variation in rate of wear with unit pressure. The essential elements of the new machine are a block of bearing metal with one side machined to a plane surface and a cylinder. The block is held by a constant-force tangent to the cylinder. The cylinder rotates in a bath of lubricant, and a depression is worn in the bearing metal. The test is run until there is no measurable increase in the depth of the depression with continued operation.—W. P. R.

***Concerning the Effect of Notches and Laws of Similitude in Material Testing.** A. Nadai and C. W. MacGregor (*Amer. Soc. Test. Mat. Preprint*, **1934**, June, 1–13).—In a number of recent investigations on the various effects of stress concentration produced by notches, size effects, and other discrepancies have

been observed. Some of these cases are briefly analyzed, and an attempt is made to include in the comparison factors such as the speed of deformation, geometrical and mechanical similitude. A few tests made with notched bars of steel and aluminium, in which the influence of the speed of plastic deformations was considered, and photoelastic tests with notched bars, are reported. —S. G.

Transverse Bars Breaking Out of Centre. F. Bacon (*Bull. Brit. Cast-Iron Res. Assoc.*, 1934, **3**, 291).—A note. Sometimes a transverse bar breaks out of centre—that is, away from the point immediately underneath the load—when central loading is used. If a load W is applied at the centre, O, of a bar supported over a span L, and the bar breaks at P, distance x from O, then the section at P is weaker than the section at O, and if the weakness had occurred at O the bar would have broken under a smaller load W_1. This can be calculated by the equation $W_1 = W \cdot \frac{(L - 2x)}{L}$.—W. H.-R.

***The Creep of Wires at High Temperatures.** W. O. Richmond (*Physics*, 1934, **5**, 131–134).—Apparatus designed to make creep tests on wires *in vacuo* at high temperatures up to 1000° C. is described. Results of creep tests made on the alloy Konal at temperatures 800°–1000° C. show that Ludwik's logarithmic law connecting rate of deformation and stress holds for the higher creep rates and stresses, but certainly does not hold for the lower creep rates and stresses. A linear relation best expresses the variation of the minimum creep rate with temperature. The method used is readily adapted for making short-time creep tests.—J. S. G. T.

The Strength of Materials at High Temperatures. H. J. Tapsell (*Métaux et Machines*, 1934, **18**, (245), 168–174).—The National Physical Laboratory method of determining limiting creep stress is described and contrasted with the method in general use in the U.S.A., and with that recently proposed by the American Society for Testing Materials. The representation of results is discussed. T. considers that the assumption of a constant rate of flow during a "secondary period" is untenable; that creep-test results are not representative without amplification by a study of flow under prolonged loading sufficient to produce fracture; and that only under certain conditions does the logarithmic time–elongation curve become a straight line. Short-time testing methods based on "plastic flow" characteristics are described and criticized. T. prefers tests to be made over an extended period, as allowing for structural changes, if any, as indicating both primary and secondary flow properties, as registering more accurately the total deformation, and as wiping out initial differences in testing conditions which might vitiate short-time tests.—P. M. C. R.

The Strength and Behaviour of Steels at High Temperatures [High Temperature Testing Apparatus]. W. H. Hatfield (*Proc. Inst. Mech. Eng.*, 1932, **123**, 773–791).—A general lecture, including diagrams of high-temperature testing apparatus.—W. H.-R.

Method of Testing Individually the Even Distribution of Hardness on Specimens. C. Benedicks and C. F. Mets (*Arkiv Mat. Astron. Fysik*, 1934, **24A**, (15), 14 pp.; and *Tomkontorets Ann.*, 1934, **114**, 4–22; *C. Abs.*, 1934, **28**, 3039).—A fine grating is produced automatically by parallel scratches with a diamond point. Microscopic examination of the scratches reveals local discrepancies of hardness, especially those caused by local work-hardening which cannot be detected by other methods.—S. G.

***Influence of Speed of Testing on the Result of the Tensile Test.** F. Fettweis (*Arch. Eisenhüttenwesen*, 1932, **6**, 149–154; and (abstracts) *Metallurgist* (Suppt. to *Engineer*), 1932, **8**, 179–180; *J. Iron and Steel Inst.*, 1933, **127**, 660).—Experiments confirm the observations of previous investigators, that not only the elastic limit and yield-point, but the elongation and reduction

of area are all increased in different proportions by the carrying out of the tensile test at high speed.—S. G.

***Time Effect in Testing Metals.** H. Quinney (*Engineer*, 1934, **157**, 332–334).—Describes a testing machine designed so that a tensile test can be carried out at a fixed rate of extension. Experiments carried out with the machine show that the yield stress obtained from tests made at normal speeds is largely influenced by the temperature reached in annealing and that the softer specimens with lower yield stress are more susceptible to the rate of extensions than those in the harder condition. Although Q. deals with mild steel and iron, the results are of general interest.—W. P. R.

Concerning the Effect of Strain and Rate of Strain on Tensile Tests at Normal and Elevated Temperatures. R. Beeuwkes (*Physics*, 1934, **5**, 135–139).—Idealized cases of plastic flow are analyzed to ascertain the influence of constant coeff. of work-hardening and pure viscosity on tensile tests made at normal and elevated temperatures. The results indicate that more emphasis should be placed by experimenters on the changes in yield-stress (in the hardness) that occur in materials even without stress under exposure to time and high temperatures.—J. S. G. T.

The Tensile Test of Welded Joints. —— Czternasty (*Elektroschweissung*, 1934, **5**, 56).—A test-piece is recommended having a short gauge-length. Typical dimensions are tabulated.—H. W. G. H.

***Studies in Photoelastic Stress Determination.** E. E. Weibel (*Amer. Soc. Mech. Eng. Preprint*, **1933**).—Describes results on the determination of stress distribution in Bakelite models using the monochromatic fringe method. Another section of the paper describes an application of the membrane analogy in conjunction with the photoelastic fringe method to obtain a complete solution of a two-dimensional stress problem.—W. P. R.

***Stress Concentration Produced by Holes and Notches.** A. M. Wahl (*Amer. Soc. Mech. Eng. Preprint*, **1933**).—The results of photoelastic tests on Bakelite models are plotted in the form of curves showing the relationship between the concentration factor K and the ratio d/w where d = diam. of hole or notch and w = width of specimen, and the two following empirical equations have been obtained: $k = 3 - 3{\cdot}13d/w + 3{\cdot}76(d)^2/w - 1{\cdot}71(d)^3/w$ for a bar with a hole under tension or compression and $k = 2{\cdot}75 - 2{\cdot}75d/w + 0{\cdot}32(d^2)/w + 0{\cdot}68(d)^3/w$ for a bar with two semi-circular notches.—W. P. R.

***Membrane Analogy Supplementing Photoelasticity.** J. G. McGivern and H. L. Supper (*Amer. Soc. Mech. Eng. Preprint*, **1933**).—W. P. R.

XIII.—FOUNDRY PRACTICE AND APPLIANCES

(Continued from pp. 363–364.)

Chill-Casting of Non-Ferrous Metals. R. C. Stockton (*Met. Ind.* (*Lond.*), 1934, **44**, 651–653, 658).—Chill-casting in the brass foundry is resorted to for: (1) economic production; (2) the improvement of certain physical properties, or (3) the prevention of drawn castings in work of widely varying sections. The application of the process for the attainment of each of these three objectives is discussed, and the process of centrifugal casting is briefly described. —J. H. W.

Fluxes in Brass Melting. Erich Weiss (*Met. Ind.* (*Lond.*), 1934, **44**, 665).—In a letter commenting on a paper by T. Tyrie on "Fluxes and Slags in Brass Foundry Melting Practice" (see *Met. Abs.*, this volume, p. 363), W. recommends the automatic filling of copper cartridges with the deoxidizing material, closing these cartridges at both ends and introducing them into the liquid metal with special tongs. For the removal of aluminium from brass he recom-

mends an alternative method to the barium sulphate; the latter involves overheating the metal to 1320° C.—J. H. W.

Melting and Casting of Special Brass Alloys. Leo S. Ivanoff (*Met. Ind.* (*Lond.*), 1934, **45**, 7–10).—The calculation of the required composition of special brasses containing 1–3% each of manganese, iron, nickel, aluminium, and tin on the basis of the "zinc equivalent" of these metals, the use and production of "hardeners" for melting, the addition of secondary material, loss of zinc, and the pouring of these alloys are discussed.—J. H. W.

Pressure Casting. M. Kessler (*Rev. Fonderie moderne*, 1934, **28**, 157–161; discussion, 161–162).—Read before the Association Amicale et Mutuelle de Fonderie. The requirements for pressure casting and the alloys for which this process is suitable are described. Moulding machines and the composition and preparation of the moulds and the metal are described.—J. H. W.

Difficulties of Die-Casting Pure Aluminium. Anon. (*Met. Ind.* (*Lond.*), 1934, **44**, 627–630).—The chief difficulties in die-casting pure aluminium are its hot-shortness and the absence of a freezing range, which prevents feeding. To overcome these some addition of other metals is made to the aluminium and the permissible departure from absolute purity is laid down. The method of die-casting the resulting metal is described in some detail, and pressure casting and slush casting are more briefly discussed.—J. H. W.

Cleaning Castings by Sand-Blasting. W. E. Warner (*Met. Ind.* (*Lond.*), 1934, **45**, 35).—A brief discussion of the form of abrasive, air pressure, and nozzle wear in sand-blasting castings and forgings.—J. H. W.

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

(Continued from pp. 364–365.)

***Recovery of Crude Copper from Scrap Brass by an Oxidizing Blast in a Basic Converter.** Gotthard E. Lenk (*Metall u. Erz*, 1934, **31**, 244–251).—Scrap brass containing copper 58, iron 7, zinc 30, lead 4, and tin 1% can be converted into 97·5–98·5% copper by blowing in a basic-lined converter provided that the iron is increased to 10% by addition of scrap; 2% of lime and 1·5–2% of quartz is all the flux necessary. The recovery of copper is about 85%, and the product can be readily refined by electrolysis. The remaining copper and all the iron pass into the slag, which contains about 15% copper and 20% zinc. The flue dust contains most of the lead and zinc as oxides and assays 80% zinc.—A. R. P.

XV.—FURNACES AND FUELS

(Continued from pp. 365–366.)

Possibilities of Application of Heating by Induction without Iron Core. Wilhelm Fischer (*Elektrowärme*, 1934, **4**, 77–82; *C. Abs.*, 1934, **28**, 3663).—The principle is explained and curves are given from which the minimum frequency required for any material can be taken; the frequency must be higher the lower the electrical conductivity and the smaller the diameter of the material to be heated. Whilst up to 10,000-cycle generators can be used for producing the current, spark gaps are used for frequencies above 10,000 cycles per second. Advantages and applications in the chemical industry, melting of metals, &c., are discussed. The highest temperature obtainable depends only on the heat losses, no account being taken of the material in the crucible. The question of regulation of frequency is not simple with spark

generators, since capacity and self-induction of the circuit determine the frequency; valve generators are more flexible.—S. G.

High-Frequency Induction Furnaces. W. S. Gifford (*Met. Ind.* (*Lond.*), 1934, **44**, 411–414).—The construction, method of operation, and applications of high-frequency induction furnaces of sizes up to 4-ton capacity are described. —J. H. W.

The Construction of Electric Resistance Furnaces. G. W. Ashton (*Machinery* (*Lond.*), 1934, **44**, 97–99).—The construction of a simple wire-wound muffle furnace with outside windings is described.—J. C. C.

Technique and Control of Temperature Gradient. Max Lang (*Elektrowärme*, 1934, **4**, 83–86; *C. Abs.*, 1934, **28**, 3670).—The problem and methods of temperature regulation of large industrial furnaces are discussed, and formulæ for proper regulation are developed.—S. G.

XVI.—REFRACTORIES AND FURNACE MATERIALS

(Continued from p. 366.)

How Can I Increase the Life of a Graphite Crucible? Max Schied (*Z. ges. Giesserei-Praxis: Das Metall*, 1934, **55**, 187–191, 205–208).—The construction, constituents, and shape of graphite crucibles for metal melting are described, and the precautions to be taken as regards first heating, flame impingement, use of slags, seating, charging, and handling so as to increase the life of the crucible are discussed.—J. H. W.

XVII.—HEAT-TREATMENT

(Continued from pp. 366–367.)

Bright-Annealing of Fine Copper Wire in the Continuous Furnace. Neil H. Knowlton and Theo. B. Bechtel (*Wire and Wire Products*, 1934, **9**, 142–143, 156–157).—The equipment and process for the production of uniformly annealed fine spooled copper wire are described.—J. H. W.

Heating or Annealing in Controlled Atmospheres. R. J. Cowan (*Metal Progress*, 1934, **25**, 35–39, (1), 52).—Controlled flue-gas atmospheres have been successfully utilized in the annealing of a variety of non-ferrous and ferrous materials; certain atmospheres, not consistent with direct combustion, necessitate the use of a muffle, the material of which may itself act catalytically. The bright-annealing of copper–zinc alloys is especially noticed, staining, even in oxidizing atmospheres, being inhibited by the presence of small amounts of methanol vapour. A continuous belt-type muffle is illustrated and briefly described, as especially adapted for this process.—P. M. C. R.

XVIII.—WORKING

(Continued from p. 367.)

Concerning the Distribution of Stress in a Laterally Compressed Strip. C. W. MacGregor (*Physics*, 1934, **5**, 140–145).—Photoelastic tests, in which the contact pressure distribution in a strip of Bakelite compressed between rollers is determined, are described. Results obtained by Siebel and Lueg (*Mitt. K.-W. Inst. Eisenforschung*, 1933, **15**, 1) relating to tests of the contact pressure distribution in a copper strip rolled under service conditions in a rolling mill are briefly referred to.—J. S. G. T.

A New Shrinkage Process; Expansion Fitting. Marc Rivière (*Technique automobile et aérienne*, 1934, **25**, Part 2, (165), 42–45).—Parts to be fitted are

immersed immediately before erection in liquid nitrogen at a temperature of — 196° C., their subsequent expansion ensuring a satisfactory fit. Tables give specific gravities, coeffs. of thermal expansion and contraction, weight of metal effectively cooled by 1 litre of liquid nitrogen, and volume of liquid nitrogen needed to cool 1 kg. of metal, for steel, cast iron, copper, brass, bronze, aluminium, and nickel. Suitable vessels for transport and for chilling are illustrated, and some erection processes are described in detail.—P. M. C. R.

Laboratory for Machine Tools and Works Methods in the Technical High School, Aachen. A. Wallichs (*T.Z. prakt. Metallbearbeitung*, 1934, **44**, 1–4).—A description of the lay-out and plant of this laboratory.—W. A. C. N.

***Use of X-Rays on Depth of Cold-Work by Machining.** L. Thomassen and D. M. McCutcheon (*Amer. Soc. Mech. Eng. Preprint*, **1933**).—By directing a beam of X-rays containing the molybdenum doublet against a flat piece of metal under an angle of 10° and recording the diffracted rays, a surface layer of thickness less than 0·0001 in. will produce practically all the diffracted rays. This gives a method of investigating the structure of thin films, and T. and McC. have used it to determine the depth of cold-work produced by various machining operations.—W. P. R.

XIX.—CLEANING AND FINISHING

(Continued from p. 367.)

Detergents for Metal Cleaning. M. B. Peterson (*Metal Cleaning and Finishing*, 1934, **6**, 127–130; *C. Abs.*, 1934, **28**, 3700).—A general discussion of the use and action of detergents in cleaning baths. The recently developed hymolal salts, consisting of salts of high-mol. alcohols, are recommended. The sodium salt known as " orvus " has new and distinctive properties making it indispensable for some types of metal cleaning work.—S. G.

The Use of Bituminous Compositions in Metal Finishing. J. Mitchell Fain (*Metal Cleaning and Finishing*, 1934, **6**, 99–104, 130; *C. Abs.*, 1934, **28**, 3700).—Various types of bituminous coating materials, their pigmentation and application to metal products are discussed.—S. G.

***Rapid Development of Patina on Copper After Installation.** John R. Freeman, Jr., and Philip H. Kirby (*Metals and Alloys*, 1934, **5**, 67–70).—For the development of a green patina on copper roofs and other installations the following solution is prepared : 90 lb. of ammonium sulphate and 3 lb. of copper sulphate crystals are dissolved in 100 gall. of water and 1 lb. 3 oz. of ammonia solution (*d* 0·90) are added, thus giving 110 gall. of solution. The copper is washed by spraying first with alkali solution, then with clean water, allowed to weather for a few days to develop a brown tarnish, and then sprayed with the above solution, which should fall on the metal is such a way as to cover it with minute droplets which do not run together. After complete drying the spraying is repeated ; usually five sprayings with intermediate dryings are required. The resulting green patina adheres well and improves in adherence and beauty with ageing. Moisture, *e.g.* dew at night assists greatly in the development of the best effects. Examples of the use of the process for colouring a church spire and house roofs are described.—A. R. P.

Surface Treatment of Objects Made of Zinc Sheet or of Cast Zinc. Anon. (*Illust. Z. Blechindustrie*, 1934, **63**, 591–592, 614–615).—The popularity of zinc as a protective medium can be appreciably increased by improving its appearance. The process of colouring, with the essential preliminaries of cleaning and de-greasing, is described, and the compositions of the solutions employed are given, with precautions as to handling. Zinc surfaces may be dyed, copper-plated, or given a brass or Tombak finish. Compositions are

given for these, and for brown, bronze, gold, yellow, orange, red, pink, green, blue and black finishes, and suitable wax emulsions are recommended for the final treatment of the coloured surfaces.—P. M. C. R.

XX.—JOINING

(Continued from pp. 367–369.)

Resistance Welding of Aluminium and Its Alloys. D. I. Bohn (*J. Amer. Weld. Soc.*, 1934, **13**, (4), 4–7).—Successful spot and seam welding of aluminium alloys depends on establishing a very high thermal gradient from the point of weld to the electrode contact. The use of synchronous control is, therefore, highly desirable. With suitable technique, the strength of spot welds in the strong aluminium alloys should keep within 90 and 110% of the average strength. Spot welds in "Alclad" are practically as resistant to corrosion as the parent metal. No success has been obtained with flash-welding, but butt-welding has a limited field of application, mainly for architectural work.
—H. W. G. H.

The Welding of Aluminium Castings. W. Johag (*T.Z. prakt. Metallbearbeitung*, 1933, **43**, 365).—A general description of the methods by which aluminium castings may be welded, the means of testing, and the efficiency of the process. The difficulties of rapid oxidation and the use of fluxes are discussed.—W. A. C. N.

Tests of Welds in Electrolytic Copper. W. J. Chaffee (*Welding Eng.*, 1934, **19**, (5), 17–19).—Tensile tests on welds made by the "long-arc" method show that a phosphor-bronze rod of high tin content gives the best results. De-oxidized copper welding rod gives very poor results on material above $\frac{1}{8}$ in. thick.—H. W. G. H.

Hard-Facing. E. Lewis (*Indust. Gases*, 1934, **15**, (1), 42–44).—Three classes of hard-facing materials are described—the iron-base alloys (Stoodite), non-ferrous alloys (Stellite), and the tungsten-carbide group (Borium). Their properties, sphere of application, and recommended methods of deposition by the blow-pipe, are discussed.—H. W. G. H.

Welding Torch or Electric Arc. E. Stursberg (*T.Z. prakt. Metallbearbeitung*, 1933, **43**, 394–397).—A discussion of the comparative advantages of these two methods of welding. Questions of cost, utility, and special applications are introduced.—W. A. C. N.

Studying Structural Stresses with the Aid of the Polariscope. E. W. P. Smith (*Welding Eng.*, 1934, **19**, (4), 17–19).—The construction of a simple polariscope is explained and its use, in studying the distribution of stress in welded joints, is described.—H. W. G. H.

XXI.—INDUSTRIAL USES AND APPLICATIONS

(Continued from pp. 369–370.)

†**Piston Material and Design.** H. J. Maybrey (*Diesel Engine Users Assoc.*, **1934**, 20 pp.).—The development of piston materials is reviewed and the design of pistons considered in so far as design has taken advantage of the specially selected alloys. The relative suitability of piston materials as regards thermal conductivity, density, and coeff. of linear expansion are determined by a formula. The materials compared are cast iron, "2.L.8." to "3.L.11." types of aluminium alloys, "Y"-alloy, and hyper-silicon aluminium alloys, and the relative values obtained for these alloys are 151, 585, 610, and 860 $\times$ 10^3. The latter class of alloys are binary aluminium–silicon alloys containing more

than 14% silicon, and it is stated that large quantities of pistons are turned out in alloys containing 20 and 25% silicon, and that very interesting results are obtained with a specially treated alloy of 35% silicon. Reference is also made to the "anodic" treatment of aluminium–silicon pistons and the advantages which might be obtained from it. An interesting discussion dealing with composition, treatment, design, and use of aluminium pistons is also included.—J. W. D.

Beer Scale on Aluminium Vessels. H. Schnegg. Richard Seligman (*Z. ges. Brauw.*, 1934, **57**, 13–18, 21–27).—3·7 and 1·85% solutions of hydrochloric acid required 30 and 90 minutes, respectively, to enable the scale to be easily scraped off, and without appreciable corrosion of the metal. With periods longer than 4 hrs. the solubility of the metal continued to increase progressively. The addition of colloidal resinous substances did not reduce the solubility of the scale, but greatly inhibited the attack on the metal. Under these conditions, the use of 3·7% hydrochloric acid was recommended, and the results obtained compared favourably with those from 10% nitric acid. In a written communication in *J. Inst. Brewing*, 1934, **40**, 228, R. S. criticizes the proposed use of hydrochloric acid as likely to cause damage to vessels which have been in use for any length of time.—H. W. G. H.

Aluminium at the "Deutsches Volk–Deutsche Arbeit" Exhibition. —— Buschlinger (*Werkstatt u. Betrieb*, 1934, **67**, (11/12), 217–218).—Exhibits at the above exhibition are enumerated and described: important items are: Alfol heat-insulation, aluminium alloy cables of high resistance to vibration stresses, damping apparatus for minimizing cable vibrations, and applications of the high reflectivity of aluminium and of certain alloys.—P. M. C. R.

The Future of Beryllium in Automobile and Aero Construction. Maurice Déribéré (*Technique automobile et aérienne*, 1934, **25**, Part 2, (165), 58–61).—An account, with *bibliography*, of the sources, chemical and physical properties, manufacture and present uses of beryllium. A description is given of the alloys of this metal with copper, nickel, tin, and iron; brief notes are appended on light alloys containing beryllium.—P. M. C. R.

Copper Tanks for the Hydrolysis of Fats. Rob Heublyum (*Mat. grasses*, 1934, **26**, 10072–10073; *C. Abs.*, 1934, **28**, 3921).—A copper tank has been in continuous use since 1929 at the Krasnodar (U.S.S.R.) plant for the hydrolysis of fats by the Twitchell process without giving rise to any trouble. Definite cost figures cannot be obtained until the tank fails in service.

—S. G.

Springs for Measuring Instruments. G. Keinath (*Arch. tech. Messen*, 1934, **3**, (35), T64–T65).—Some useful data are given for calculations relating to flat spiral springs. The relationships between tempering temperature and external diameter, hardness and elongation are shown graphically. The corrodibility and magnetic properties of steel have led to its partial replacement by non-magnetic copper alloys, the choice of which is influenced by working conditions. Specific resistances are quoted for copper–silicon–bronze, phosphor–bronze, and nickel–silver, with elastic moduli for the first 2 of the foregoing and for steel. The effect of temperature on the elastic modulus of Elinvar is comparatively slight, and certain light alloys of similar properties are being developed. The advantages of bimetal springs are considered, and the residual effects of working, loading and heat-treatment are discussed.

—P. M. C. R.

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[Supersedes B.S.S. No. 485—Part 1—1933.]

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XXIV.—BOOK REVIEWS

(Continued from pp. 335–336.)

Pressen von Nichteisenmetallen. Von W. Brunnckow. Demy 8vo. Pp. 20, with 13 plates. 1934. Berlin : VDI-Verlag G.m.b.H. (R.M. 1.60 ; to VDI members, R.M. 1.45.)

This is a short brochure on a subject which sooner or later will warrant a considerably more ambitious treatment, preferably from both an engineering and metallurgical point of view. The hot-stamping and hot-pressing of non-ferrous metals have, during recent years, become increasingly important, particularly when linked up with developments in die-casting. The author of the present volume has sought to do little more than introduce the subject, and as an " introduction " it may be commended to the attention of workers in this field. The text itself occupies only about 20 pages, and the greater part of the volume is occupied by illustrations and diagrams of machinery. The latter are useful to the English reader as illustrating the type of plant developed in Germany for die-casting, hot-pressing, stamping, and extrusion.

In his foreword the author emphasizes that his object is to promote a more intelligent understanding between the producer of hot-worked material and the ultimate user, an object which is always to be commended.—W. R. Barclay.

Handbuch der anorganischen Chemie. Herausgegeben von R. Abegg, Fr. Auerbach und I. Koppel. In vier bänden. **Kobalt und seine Verbindungen.** Vierter Band. Dritte Abteilung, Lieferung I. Pp. xvi + 626, with 170 illustrations. 1934. Leipzig, Hirzel. (R.M. 58.)

The volume under review deals with the element cobalt, and commences with an account of the determination of the atomic weight, compiled by J. Meyer. The structure of the cobalt atom is then considered by E. Rabinowitsch. In this chapter the spectral and magnetic relationships are very fully considered and the data concerning the dimensions of the atom collected. The occurrence and history of the metal are treated in the following chapter by A. Kurtenacker, the distribution and the nature of the minerals are fully described, and the main sources of the metal and the production in various countries indicated. The technical production of cobalt and its separation from nickel by a large number of processes is described. The method of preparation and the applications of the metal are detailed. The same author contributes the following two chapters on the physical and chemical properties of metallic cobalt. This chapter is particularly complete, and includes a vast amount of numerical data. The chapters dealing with the divalent compounds of cobalt, the ammines of divalent cobalt, and the tervalent cobalt compounds follow, and are all written by A. Kurtenacker. These are very full, and have been put together with care and discretion. The chapter following on the alloys and compounds of cobalt with non-metals and with the metal of groups 1–6 has been written by J. Holluta; here we find compounds such as the nitrides, carbides, sulphides, borides, and phosphides, together with binary and ternary metallic alloys fully described. The concluding chapter, written by I. Koppel, deals with the colloidal chemistry of cobalt.

The book is excellently put together, is clearly written, and is accurate in its descriptions and in the numerical data it presents. A notable feature would appear to be the introduction of a very large amount of fundamental physical chemical data. The references, which are inserted after each chapter, are a valuable feature of the volume. They are numerous, some 3100 being included.

The volume is one which will find many to welcome it, and it may be recommended very warmly.—James F. Spencer.

Metallgiesserei. Von Hans Steger. Lieferung 1. Pp. 30. Lieferung 2. Pp. 31–54. Lieferung 3. Pp. 55–84. Illustrated. Potsdam: Boness u. Hachfeld. (R.M. 0.90.)

These are the first three parts of an elementary primer on foundry methods intended for home study. In each "lesson" are given a lecturette, a *résumé* of important facts and conclusions, revision in the form of question and answer, questions on the subject-matter to be answered, and a subject for an essay. The principal items dealt with are general consideration of metals and alloys used in foundries, separation of scrap metals, moulding, melting methods, types of furnaces, and die-casting. At the end a table of alloys in common use is given. The information given is neither comprehensive nor up-to-date. Presumably the aim is to deal with fundamental processes using, for the purpose, diagrams and illustrations that apply principally to ancient methods. The books would be extremely useful to those wishing to acquire an elementary knowledge of German metallurgical terms.—W. A. C. Newman.

A Comprehensive Treatise on Inorganic and Theoretical Chemistry. By J. W. Mellor. Volume XIII.–Fe (Part II). Med. 8vo. Pp. ix + 948, with 381 illustrations. 1934. London: Longmans, Green and Co. (63*s.* net.)

The present volume of this excellent text-book continues the treatment of the chemistry of iron, which was started in Volume XII. The mechanical properties of iron and iron–carbon alloys are dealt with in the first 18 pages, whilst the succeeding 110 pages give an account of the thermal properties of the same materials. The optical, electrical, and magnetic properties are considered in the following sections. The chemical properties are next dealt with, and after this follows a very informative account of the corrosion of iron and steel, which occupies rather less than 100 pages. A consideration of the valency and atomic weight of iron constitutes the next section, and the treatment of the properties of iron is completed by an account of the passivity of the metal. The next 168 pages are devoted to a description of the alloys and intermetallic compounds of iron. Here not only the technically important alloys are considered, but also binary and ternary alloys and binary intermetallic compounds, with practically the whole of the metallic elements. The remaining pages of the volume, about 200, are devoted to a consideration of the oxides and hydroxides of iron and the ferrites and ferrates.

The present volume is written in the careful and clear manner which has come to be expected of the author. The material is very full and accurate, and an exhaustive bibliography is appended to each section. The volume presents a very full account of the chemistry of the materials with which it deals, and in all respects it is admirable and to be recommended without reserve.—James F. Spencer.

Die Metallurgie des Eisens. Von R. Durrer. (Aus Gmelins Handbuch der anorganischen Chemie. Achte völlig, neubearbeitete Auflage. Herausgegeben von der Deutschen Chemischen Gesellschaft.) Med. 8vo. Pp. vii + 423–1166, with 410 illustrations. 1934. Berlin: Verlag Chemie G.m.b.H. (Steif Kartoniert, R.M. 32; geb., R.M. 36, post free inland.)

The present work is identical in every respect with System nummer 59, Teil A, Lieferungen 3–5 of Gmelin's handbook. This portion of the handbook is published separately under the above title, with the object of providing a text-book on the metallurgy of iron and steel for those interested in the subject, without the large amount of purely chemical data which is found in the text-book itself. The portions of the text-book concerned have already been reviewed in the *Journal of the Institute of Metals*, and the remarks made there apply to the present work.—James F. Spencer.

Der Einfluss von Drehschwingungsbeanspruchungen auf die Festigkeit und Dämpfungsfähigkeit von Metallen besonders von Aluminium Legierungen. Von Hans Frankenberg. (Mitteilungen des Wöhler Instituts, Braunschweig. Heft 16.) Demy 8vo. Pp. iv + 55, with 62 illustrations. 1933. Berlin: NEM-Verlag G.m.b.H., Schöneberger Ufer 34. (R.M. 3.60.)

The work described in this publication is based on that undertaken by Bankwitz and published in Heft 11 of the Wöhler Institute journals. There are four sections, of which the first serves as an introduction and a review of previous work, and the last is a summary of the conclusions. The second section is devoted to standard static calibration curves of various ferrous and non-ferrous materials, the third to "Werkstoffdämpfung" (defined as "that work per unit volume which in every change of loading is converted into heat") and rate of oscillation, and the fourth to the mechanical properties of the materials under test. The object of the research is to supply answers to the following questions (1) What is the course of the "Dämpfung" curve when alternations between 0 and 200 per minute are employed? (2) Does the "Dämpfung" of a material vary when the latter is maintained under constant stress for a lengthy period? (3) What influence have impurities in aluminium on the form of the alternating stress diagram? (4) Is there a reliable relationship between an alteration in the rate of alternations and the "Dämpfung"? (5) Is a greater or lesser number of small changes of form more potent in raising the plastic limit? (6) What is the effect of continued application of stress on the plastic limit? (7) What relationships exist between the "Dämpfung," rate of alternations, and fatigue-strength?—W. A. C. Newman.

Dauerfestigkeit von Schrauben, ihre Beeinflussung durch Form, Herstellung und Werkstoff. Von Wilhelm Staedel (Mitteilungen der Materialprüfungsanstalt an der Technischen Hochschule, Darmstadt. Herausgegeben von A. Thum. Heft 4.) Demy 8vo. Pp. vi + 102, with 106 illustrations. 1933. Berlin: VDI-Verlag G.m.b.H. (R.M. 8.)

The fatigue-strength of screws is a matter that affects all, in different ways, and many will welcome the appearance of this small volume, written in a readable style and well illustrated with diagrams and excellent photographs of fractures. The author makes no attempt to summarize present knowledge of the subject, but succeeds admirably in giving a serviceable account of two years' experimental research carried out at Darmstadt. The outstanding feature of the investigation is the use of a novel type of repeated-impact machine, rationally designed for testing bolts and screws with measured blows causing longitudinal tension. By using a relatively heavy weight and small drop, it was found possible to work at speeds up to 380 blows per minute, *i.e.* four times as fast as had been employed in an earlier machine, although still only one-eighth of the speed of modern fatigue-testing machines working with harmonic cycles of stress. Eight of these new machines were maintained in operation during the course of the investigation. The results are plotted in diagrams with energy of blow as ordinate on a base representing the endurance to fracture; and the limiting safe value of the impact energy can be recognized before the endurance reaches two million blows. The results for different materials and different forms of bolt are compared with data for Wöhler and other tests. Bolts with reduced diameter of shank naturally, on account of their greater elastic elongation under the limited resistance of the screw, require blows with greater energy to cause fracture. The practical application of the results is discussed in an interesting manner, and the photographs of fractures—excellently reproduced—show the origin and progress of the cracks formed in a great variety of cases.

—B. P. Haigh.

Copper Welding by the Acetylene Process. By H. Martin. Demy 8vo. Pp. 46, with 34 illustrations. 1932. London: The Welding Journal, 30 Red Lion Sq., W.C.1. (2*s.* net.)

Here we are given full information "straight from the horse's mouth" about the welding of copper. The authors of almost every existing text-book on welding should read this little

book. The first chapter describes the development and properties of deoxidized copper, the second deals with technique, and the last two are devoted to design and repair work. The photomicrographs might be much better: they fail to illustrate clearly the points they are intended to emphasize. The test results, given at the end, would be more useful if the methods of measuring yield-point and elongation were indicated. The tensile figures, however, are very illuminating.—H. W. G. HIGNETT.

The British Industrial Gases Manual of Oxy-Acetylene Welding and Cutting. The British Industrial Gases, Ltd. Post 8vo. Pp. 128, with 95 illustrations. London: British Industrial Gases, Ltd., 34, Victoria St., S.W.1. (1*s.* 6*d.* net.)

The equipment for high- and low-pressure welding is described, and the principles of the respective blowpipes are explained. Details of preparation and technique for welding various metals are then given, with full instructions for minimising troubles due to expansion and contraction. The non-ferrous metals dealt with are aluminium, copper, brass, bronze, nickel, and lead. Simple weld tests, defects, and "dont's" complete the information on welding, and the remaining 36 pages are devoted to cutting and miscellaneous tables. This booklet may be highly recommended to practical welders. Only one small criticism can be made: the serviceability of the book would be improved by a better binding, for which a small increase in price would be money well spent.—H. W. G. HIGNETT.

Störungen beim Betrieb von Azetylenapparaten und ihre Beseitigung. Von Gottfried Lottner. Cr. 8vo. Pp. 63, with 19 illustrations. 1934. Halle a. S.: Carl Marhold. (Kart. R.M. 1.70.)

Into small space, the author compresses the results of a long and wide experience in the testing of acetylene plant. The various types of generator on the German market are classified, and the most popular examples are briefly described with diagrammatic illustrations which omit unnecessary details, but show clearly the important features. Recommendations for diagnosing troubles and putting them right are given in tabular form. Purifiers, hydraulic valves, and blowpipes are also dealt with, but more briefly and without classifying into types. This is an excellent little book, which should be useful to all interested in the generation and supply of acetylene.—H. W. G. HIGNETT.

Encyclopædia of Oxy-Acetylene Welding. Vol. IV.—Welding Non-Ferrous Metals. The International Advisory Committee for Carbide and Welding Technique. $8\frac{1}{4}$ in. × $11\frac{3}{4}$ in. Pp. xvi + 80, illustrated. [1934.] London: The Acetylene and Welding Consulting Bureau, Ltd., 637–638 Grand Buildings, Trafalgar Sq., W.C.2. (10*s.*)

Volumes I and II of this Encyclopædia were reviewed in *J. Inst. Metals*, 1933, **53**, 430. The third volume is similarly arranged, a preliminary discussion on technique being followed by illustrations of welded plant, with brief descriptions in English, French, German, Italian, and Spanish. The illustrations are excellent, and give impressive evidence of the scope of non-ferrous welding. For this reason, the book is of great value. To one or two points, however, exception must be taken. The statement made in the foreword: "Oxy-acetylene welding is at present the one and only process by means of which non-ferrous metals can be joined homogeneously . . ." is definitely incorrect. The development of oxy-acetylene welding is hindered rather than helped by such statements. The metallurgy of modern copper welding receives no attention, and the strength figures of 7·5–7·8 tons/in.^{2}, given for copper welds, are consequently very significant. On p. 61 Elektron is described as an aluminium alloy. This does not do justice to a wonderful piece of work, if the tanks illustrated are of magnesium alloy.—H. W. G. HIGNETT.

Electric Arc and Oxy-Acetylene Welding. By E. Arthur Atkins. A Practical Handbook for Works Managers, Welding Operators and Students. Second edition. Cr. 8vo. Pp. vii + 350, with 151 illustrations. 1934. London: Sir Isaac Pitman & Sons, Ltd. (7*s.* 6*d.* net.)

After a preliminary chapter comparing the various methods of jointing metals, five chapters are devoted to arc and five to acetylene welding. Further chapters deal with welding gases; cutting; expansion and contraction; weld testing; filler rods, electrodes, and fluxes; metallography of steel; welding wrought iron, cast iron, copper, and aluminium; and the testing of welders. Finally, the composition and properties of metals and alloys are tabulated, safety regulations and standard specifications are abstracted, and selected examination papers are reprinted. Considering the price and size of the book, one can expect only a brief account of each item, and there is clearly no room for wordiness, or repetition, or such vague recommendations as "hammer at a good heat" (p. 56). The space devoted to purely metallographic matters might have been reduced, with advantage, in favour of more adequate treatment of weld testing and the non-ferrous metals. The latter are almost ignored: the welding of copper

is discussed without mention of the deoxidized material! Of aluminium, we are merely told that it " can, of course, be perfectly welded by a welder who is blessed with sufficient intelligence and experience " (p. 218). Much information is given about obsolete plant and methods, but none is forthcoming concerning such processes as atomic hydrogen welding, or recent advances in the technique of blowpipe welding. That " Cyc-Arc " welding is " perhaps the most recent of all methods of welding " (p. 218) is an astonishing statement in a 1934 publication.

—H. W. G. Hignett.

The Thermodynamics of Electrical Phenomena in Metals. By P. W. Bridgman. Med. 8vo. Pp. vi + 200, with 33 illustrations. 1934. New York: The Macmillan Company ($3.75.); London: Macmillan and Co. (16*s.* net).

Professor Bridgman's name is perhaps more familiar as an investigator of the properties of materials under extremely high pressures than as a physicist concerned with the electrical properties of metals. During the last ten years he has contributed, principally to the *Physical Review*, a number of papers dealing with inter-relations of a thermodynamic character between various electrical properties of metals. These papers are here consolidated into a coherent whole, and some extensions and new relations are added. Professor Bridgman is sufficiently prominent a physicist to be able to admit that one of the relations deduced between the four transverse galvanomagnetic effects turns out to be erroneous. The subjects treated may be briefly indicated. They comprise thermoelectric and thermionic phenomena, the Volta effect, transverse galvanomagnetic and thermomagnetic effects, electron theory, and the photo-electric properties of metals. The treatment is necessarily mathematical in character, but does not make inordinate demands on the reader's mathematical equipment. A knowledge of thermodynamics and partial differentiation to about pass B.Sc. standard is necessary. Dr. Bridgman's treatment is logical, critical, and extremely careful. Nothing is accepted without full inquiry. He is doubtful concerning the existence of the Benedicks homogeneous thermoelectric effect, which, so far as my opinion may be worth anything, I saw beautifully and unequivocally demonstrated by Professor Benedicks at the May Lecture of the Institute of Metals in 1920 (*J. Inst. Metals*, 1920, **24**, 7–55). A very brief account of Professor Bridgman's work on this subject is given, for the first time, as a footnote on p. 40. The book is nicely printed on good paper; it is provided with a brief bibliography and an index; it will appeal principally to the specialist. Its price is quite reasonable.—J. S. G. Thomas.

The Adsorption of Gases by Solids. By S. J. Gregg. Fcap. 8vo. Pp. viii + 120, with 15 illustrations. 1934. London: Methuen & Co., Ltd. (2*s.* 6*d.* net.)

This handy little pocket-book reviews briefly and efficiently the whole field of the adsorption of gases on solids. What is meant by adsorption? Briefly, as stated in the opening words of this booklet, " wherever we have an interface between a solid and a gas or vapour, the concentration of the gas is higher in the immediate vicinity of the solid than it is in the free space beyond. The gas is said to be adsorbed on the solid." That, I think, puts the matter very clearly. Is the subject of importance to metallurgists? Most assuredly it is. Gases are adsorbed by metals, and the phenomenon in these cases is complicated by questions of solubility. Thus, by way of example, to quote from p. 15: hydrogen is taken up by copper (above 400° C.), iron (400°–600° C.), nickel (above 200° C.), platinum (slight at 580° C., appreciable above 1340° C.), tungsten (1500° C.). Can this little booklet be recommended to metallurgists? Yes, unreservedly to those interested more especially in the theoretical aspects of the subjects. Here they will find references to all important papers on this subject.—J. S. G. Thomas.

(1) **Elements of Industrial Heat.** By John A. Randall and J. Warren Gillon. Volume I. Med. 8vo. Pp. vii + 261 with 94 illustrations in the text and 1 folding diagram. 1933. New York: John Wiley & Sons, Inc. ($2.75.); London: Chapman and Hall, Ltd. (18*s.* 6*d.* net).

(2) **Industrial Heat Transfer.** By Alfred Schack. Translated from the German by Hans Goldschmidt and Everett P. Partridge. Med. 8vo. Pp. xxii + 371, with 40 illustrations. 1933. New York: John Wiley & Sons, Inc. ($5.00); London: Chapman & Hall, Ltd. (31*s.* net).

These two books can be very well reviewed together, as each is concerned with what is termed " industrial heat," and let me at once confess that after reading many works on so-called " industrial heat," the significance of the expression has quite escaped me. In recent years the stream of books dealing with " industrial heat " has been in full spate, and my acquaintance with them will amply justify my contention that, with one exception only, they will render very little assistance to those concerned with the *practical* aspects of industrial heating. The books are altogether too theoretical in character to serve this purpose. If it be contended that the practical man concerned with industrial heating needs a fair modicum of theory in his make-up, I

will agree, provided that it be understood that this theory is to be provided in a thorough manner by a systematic course of study devised with no special professional application in view. The books on industrial heat to which I have referred attempt to teach the essentially practical man the theory of his job where it is too late. I am certain that such procedure is foredoomed to failure. Let us consider the first of these books. It contains practically nothing of a practical character. Its contents comprise calorimetry, expansion, the three states of matter, conduction, convection and radiation, fuels and combustion, properties of air and its moisture content, energy diagrams. None of these matters is treated even theoretically with the precision that characterizes a course of study in heat for, say, the Inter B.Sc. examination of an English University. I could illustrate this from almost any page of the book. Let one or two examples, taken haphazard, suffice. On pp. 52, 53 we read, " A vacuum is said to exist in a container when no gas particles are present : thus if the pressure in a container is reduced from atmospheric pressure to 0 lb. per sq. in. a *perfect vacuum* is said to exist." On p. 209 there commences a series of questions. The first reads, " How many Centigrade degrees are there between the freezing and boiling points ? " I put this question to ten practical men who had attended courses in theory of the type outlined in this book. Each answered, " One hundred degrees "; not one spotted that the question was meaningless without reference to the material concerned. On p. 241 we find " $\pi = 3{\cdot}1416 = 22/7 =$ circumference/diameter." No reference is made to a circle. My complaint about this kind of book is that it contains too much information of this type which, for lack of a better term, may be called " Zip-fastener " information. This, I think, is characteristic of these post-war years.

Now with regard to the second of these books. In the translators' preface it is emphasized that the translators have kept the requirements of the engineer engaged in practical work in view. Well, I must say that I have not met many engineers who could read with profit more than a very little part of this book. It can be appreciated only by those equipped with mathematical knowledge far beyond that of the ordinary practical engineer. He will get on quite well without knowledge of the contents of this book. These include the three mechanisms of heat transfer, heat exchanges, heat transfer in industrial furnaces, equations, and physical constants for heat transfer. The translators' task has been no light one, for throughout they have converted the metric units of the original to the English system of units.

Summing up, then, I would say that each book attempts the impossible—*viz.* to supply the essentially practical man with a knowledge of the theory of his craft when it is too late. The store of knowledge is a vast one, but contains no bargain basement. One can ascend from ground to top floor by a slowly ascending lift. These books attempt to make a rapid descent to the non-existent bargain floor. I think that puts the matter fairly. There may be some who deem this possible; I am of the contrary opinion.

Both books are well got up, are well printed on good paper, and well bound. Neither is unreasonable in price.—J. S. G. Thomas.

The Design and Construction of High-Pressure Chemical Plant. By Harold Tongue. Med. 8vo. Pp. ix + 420, with 306 illustrations. 1934. London: Chapman and Hall, Ltd. (30*s.* net.)

Mr. Tongue has endeavoured to compress within about 400 well-illustrated pages the results and experience of hundreds of technical workers in Europe and America during the last decade. He has succeeded to a remarkable degree in compiling a book of reference of great value to all interested in this new technique of high-pressure work, which has been one of the most outstanding industrial developments of recent times. The author writes with authority from our National Chemical Laboratory, and is clearly well acquainted with the details of the methods developed in Great Britain, Germany, Holland, U.S.A., and elsewhere. Much of the information has not been published before, and certainly we have not seen elsewhere, between two covers, such a fund of useful and interesting information on this subject.

Members of the Institute of Metals will be most interested in the chapters on " Materials for Service in High-Pressure Plant when Exposed to High and Low Temperatures," " The Design and Construction of the Chemical Autoclave," and " Manufacture of Large Pressure Vessels for High Temperatures."

The use of published creep data is described, and there is an excellent survey of corrosion and hydrogen penetration and embrittlement of steels under stress at high temperatures. Here we should have liked a fuller account of the use of bronze, aluminium, and other non-ferrous metals as linings, and for internal fittings of H.P. converters. The limiting creep stresses for copper, nickel–copper, and nickel–chrome alloys at high temperatures are given, and some very recent work—November, 1933—on the behaviour of these and other non-ferrous metals and alloys at low temperatures is summarized.

The author raises an important question in regard to the safety of fusion and other types of welding for the construction of high-pressure vessels. As Mr. Tongue points out, this matter should now be reviewed officially in the light of the rapid development and experience which has been gained abroad with these methods of manufacture.

It is interesting to note that the early chemical pressure vessels of Papin (1680) and Frankland

(1855) were constructed of bronze and wrought copper, respectively. Also that Mr. Tongue recommends the use of solid drawn seamless copper tube for H.P. piping up to 550 atmospheres, with bronze fittings. This is, of course, only economic for small-scale experimental plant.

The book is not complete, as it does not include treatments of some very important sections of industrial high-pressure plant, *e.g.*, scrubbing towers and absorbers, liquid injection pumps, internal electric heaters—usually of non-ferrous metal—rotary type pumps, gas compressors and circulators and coolers. In regard to the last, we should have liked some account of the effect of coating steel tubes with non-ferrous metals to protect against corrosion.

A valuable feature of the book is the patent abstracts given at the end of each chapter.

—A. F. B.

How to Use a Large Library. By Eric John Dingwall. Pp. 63. Second Edition. 1933. Cambridge: Bowes and Bowes. (2*s.* 6*d.*)

This useful little book is intended to aid readers to trace references in some of the great libraries in Europe and America, *e.g.*, the British Museum Library, the Cambridge University Library, the Bodleian Library, the Bibliothèque Nationale in Paris, the Library of Congress in Washington, and the Prussian State Library in Berlin. General notes are given on the methods of cataloguing books and periodicals in these libraries, together with hints on the best way of consulting these catalogues with reference to specific examples. Having found the reference, details are given of the procedure to be adopted in obtaining access to the book or periodical required. Another useful feature of the book is a list of bibliographies in various languages, which is particularly valuable for tracing very old books. To all who are unacquainted with the use of large libraries this work should prove indispensable.—A. R. Powell.