Vol. 3 Part 8

The Monthly Journal of the INSTITUTE OF METALS

and

METALLURGICAL ABSTRACTS

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AUGUST 1936

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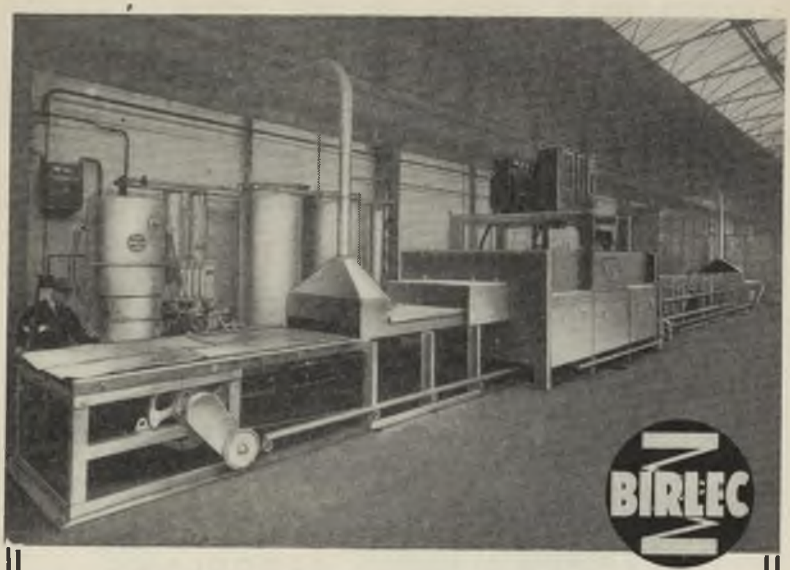
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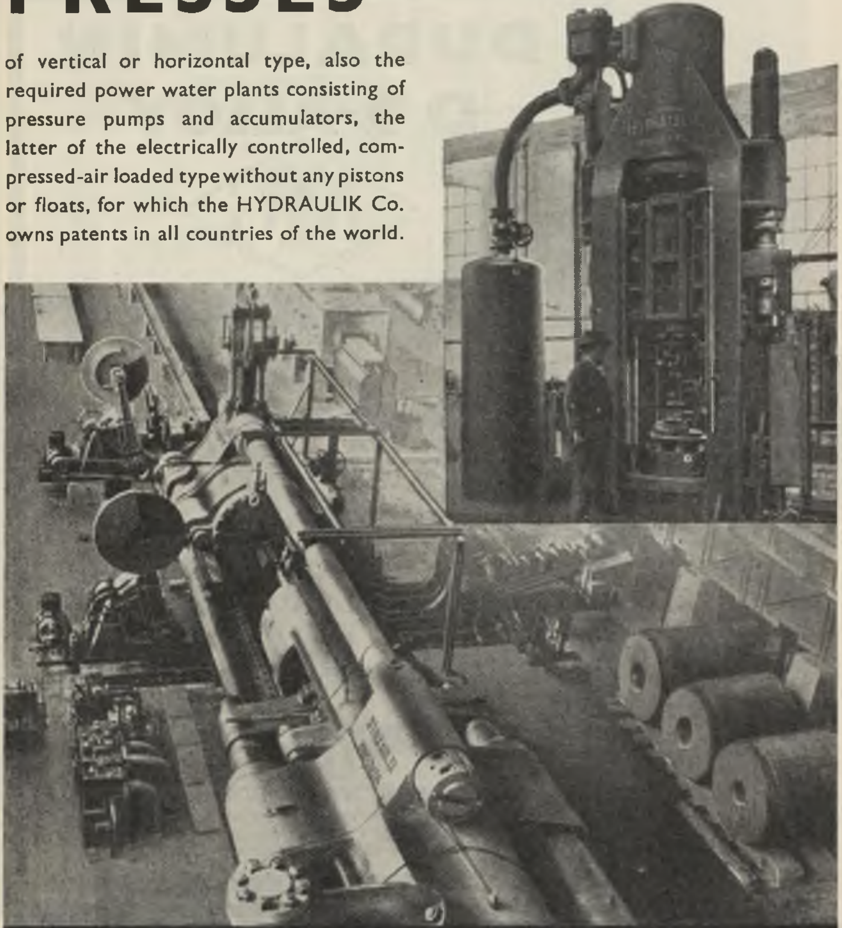

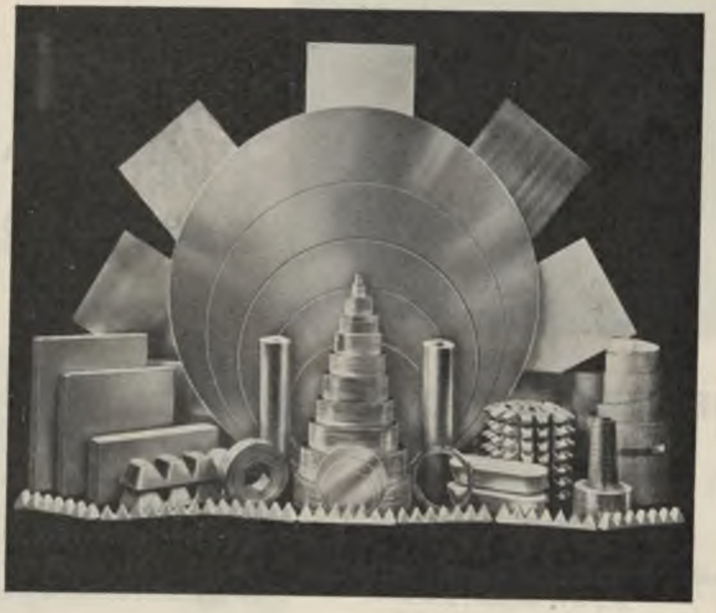

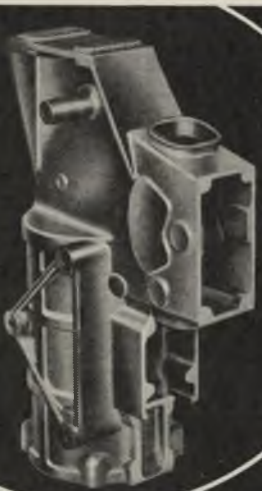

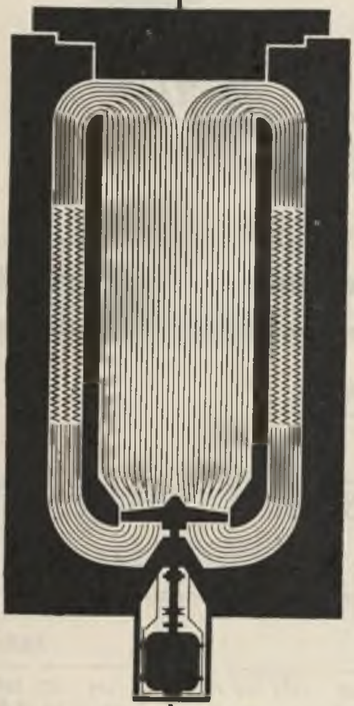

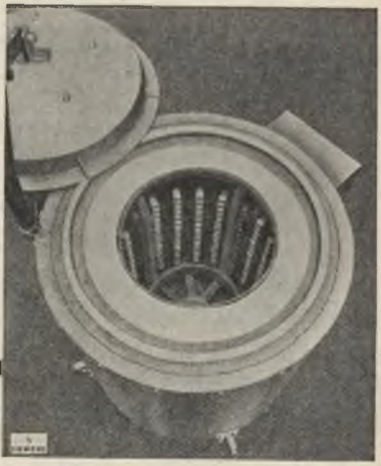

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AUGUST, 1936

HEAT TREATMENT OF MOTOR CAR PARTS

WOLSELEY'S UP-TO-DATE GAS INSTALLATION

(From "The Heat Treatment of Steel")

No requirements for the heat treatment of steel are more exacting than are those for the mass production of motor-car parts. Absolute uniformity and reliability are essential. The desired mechanical and physical properties have to be consistently obtained. A form of heat has, therefore, to be used which can be accurately controlled and which also allows for the control of the furnace atmosphere.

Messrs. Wolseley Motors, Ltd., have found those requirements to be best provided by town gas. Town gas is not the cheapest heat per B.Th.U. but, judging cost on the true basis of the quality and cost of the finished article, town gas has proved to be the most economical. The accuracy and consistency with which the desired conditions can be obtained means fewer rejects. Gas also saves labour, space and plant maintenance and replacement.

Automatic Temperature Control.

The plant consists of a large battery of carburising furnaces of the natural-draught recuperative oven type fitted with automatic temperature and damper control and recording instruments. Charging is also automatic. Small parts are carburised in rotary furnaces.

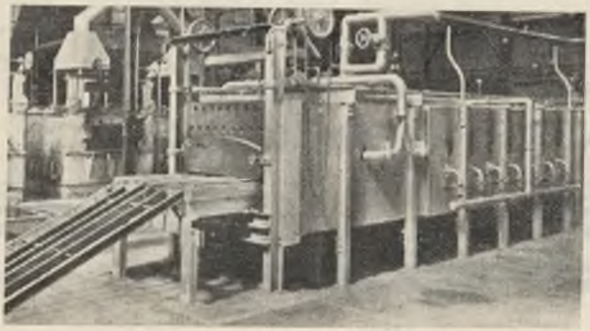
There is a number of reheating furnaces and also two rotating-hearth furnaces which are used for the same purpose. The latter are designed to give a uniform and gradual increase in temperature up to that required for hardening. The total time of reheating is about 45 minutes and the furnace is divided into three zones, preheating, heating and cooking. The temperature in the last zone is automatically controlled.

All normalising requirements are met by a walking-beam normalising furnace which operates with low-pressure gas and air under slight pressure. The work is passed through the furnace in nickel alloy trays.

Case Hardening.

For case hardening three types of steel are employed, a plain carbon steel, a 5 per cent. nickel steel, and a 3½ per cent. nickel chromium steel. In all cases carburising is carried out at 920° C. and the mild steel is then quenched in oil from 900° C., reheated to 720° C., and quenched in oil, water or brine. With the 5 per cent. nickel steel, however, a single quench from 700° C. is sufficient both to refine the core and harden the case.

All interested in the heat treatment of steel should send for the invaluable treatise issued by the British Commercial Gas Association of 28 Grosvenor Gardens, London, S.W.1. It is quite free. Among a mass of information the latest developments in furnace design are explained and, in addition, no less than 23 actual installations are illustrated and described.



All needing expert advice on gas equipment should write to the Association, who will place the enquirer into touch with the body best equipped to assist him.

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Volume 3 AUGUST, 1936 **Part 8**

CONTENTS

METALLURGICAL ABSTRACTS

The monthly issue of *Metallurgical Abstracts* may be cut up for card indexes, as members will receive early in 1937 the year's abstracts in bound form.

INSTITUTE NEWS AND ANNOUNCEMENTS

Autumn Meeting, Paris, September 14–18.

Members are reminded that the Twenty-Eighth Annual Autumn Meeting will be held in Paris from September 14 to 18, in accordance with the printed programme which was sent to all members on July 1. 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 by August 15 if it is proposed to take part in the meeting.

Members attending the meeting should bring with them issues of the *Monthly Journal* containing any of the papers that they intend to discuss at Paris (unless they have subscribed for separate copies of the papers).

Candidates for membership whose applications are in the Secretary's hands by noon on August 27 will be entitled to take part in all the functions connected with the Paris meeting.

The arrangements for the Paris Meeting are being made by a Local Reception Committee constituted as follows :

J. Dalmais : President, Bureau International des Applications de l'Aluminium (*Chairman*).
Professor P. A. J. Chevenard : Corresponding Member to the Council for France.
J. Dhavernas : President, Centre d'Information du Nickel.
J. Dupin : Administrateur-Délégué, L'Aluminium Français.
Professor Léon Guillet : Directeur de l'École Centrale des Arts et Manufactures.
—— Jaudeau : Administrateur-Délégué, Tréfileries et Laminoirs du Havre.
J. Level : President, Cie. des Produits Chimiques et Electrométallurgiques Alais, Froges et Camargue.
L. Marlio : Membre de l'Institut, Vice-President, Union Miniére et Métallurgique.
L. Montupet : Vice-President, Association Technique de Fonderie.
G. J. Painvin : Administrateur-Délégué, Société d'Electrochimie, d'Electro-métallurgie et Aciéries Electriques d'Ugine.
R. Painvin : Administrateur-Délégué, Cie. Générale d'Electrométallurgie.
Professor A. M. Portevin : Past-President, Société des Ingénieurs Civils de France.
J. Vesier : President, Chambre Syndicale des Métaux.
J. S. Douchement : *Honorary Secretary, Local Reception Committee.*

Discussion of Papers at Institute Meetings.

The Publication Committee would ask members who take part in the discussion of papers at Institute meetings whenever possible to let the Editor have a copy of their remarks in writing either before or after the discussion. This will save a great deal of work now involved in editing the shorthand writer's notes and ensure greater accuracy and economy of space in reporting discussions.

Annual Supper-Dance.

The London Local Section, with the co-operation of the Council, is arranging for the third annual Supper-Dance to be held at Thames House, Millbank, Westminster, on November 25.

Particulars of the arrangements will be forwarded to all members of the London Local Section. Members of other Local Sections are cordially invited to the Supper-Dance, a function that has proved increasingly popular since its inauguration.

Next Year's Meetings.

The Twenty-Ninth Annual General Meeting of the Institute will be held in London on March 10–11, 1937, 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 10 the Annual Dinner will be held at the Trocadero Restaurant, Piccadilly Circus.

The Twenty-Seventh Annual May Lecture will be given, also at the Institution of Mechanical Engineers, on May 5, 1937. The name of the lecturer and the subject of the lecture will be announced in due course.

The President's Continental Visits.

Recently Mr. W. R. Barclay, President, visited Sweden and Germany, where he represented the Institute at important meetings. In Stockholm he presented, on behalf of the Institute, an address of congratulation to the Svenska Teknologföreningens on the occasion of the celebration of its Seventy-Fifth Anniversary. The Society, which includes in its membership all branches of engineering, architecture, chemistry, and metallurgy, has a membership of 3600. Delegates were present from Austria, Belgium, Czechoslovakia, France, Germany, Great Britain, Holland, and the Scandinavian countries.

In Germany Mr. Barclay visited Darmstadt to attend the Eightieth Anniversary of the Verein Deutsche Ingenieure, and the Centenary of the Darmstadt Technische Hochschule. The gathering was a very large one, and included representatives of the German Government and the Universities. At Hamburg the President attended the annual meetings of the Deutsche Gesellschaft für Metallkunde. The meetings were held under the Presidency of Dr. W. J. P. Rohn, to whom he conveyed the congratulations of the Council on his appointment as President of the Society. Dr. Rohn for many years has been a valued member of the Institute of Metals, and is a well-known figure at our gatherings both in England and abroad.

International Association for Testing Materials.

By resolution of the Council the Institute has become a Patron of the Congress of the International Association for Testing Materials, to be held in London from April 19 to 24, 1937. The last congress was that held in Zürich in 1931, when the late Dr. W. Rosenhain, F.R.S. (Past-President of the Institute), was elected President of the following Congress, which should have been held in London in 1935, but was postponed owing to economic difficulties.

Annual Subscriptions

All members, except those who pay their subscriptions by means of Banker's 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, 1936, 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." By paying their subscriptions promptly members not only obviate this unnecessary expenditure, but they also ensure the undelayed receipt of their *Journals*.

PERSONAL NOTES

The Editor requests that his attention be directed to items of interest to members that might be included under the "Personal Notes" heading. All contributions for the September issue of the Monthly Journal *should reach him not later than August 25.*

MR. ALAN L. BRADLEY, Assoc.Met., has been appointed chemist to The Steetley Lime & Basic Company, Limited, Worksop, Nottinghamshire.

ENGINEER VICE-ADMIRAL SIR HAROLD BROWN, K.C.B., has been appointed Director-General of Munitions Production to the Army Council. He was a Member of Council from 1934 to 1936.

MR. JOSEPH DHAVERNAS, President of the Centre d'Information du Nickel of Paris, has recently been made an Officer of the Légion d'Honneur.

This is an official and timely recognition of a number of years of service to French metallurgy.

SIR ROBERT MOND, M.A., LL.D., F.R.S. (Ed.), has been presented with the Messel Medal of the Society of Chemical Industry.

MR. FRANK L. SMITH, B.Met., has accepted the position of Works Manager of Messrs. Gilby-Brunton, Limited, of Seamill, Musselburgh, Scotland.

Obituary.

MR. A. V. ATLEY passed away on July 3. He had been a member of the Institute since 1919.

THE CONDUCTIVITY OF SUPER-PURITY ALUMINIUM: THE INFLUENCE OF SMALL METALLIC ADDITIONS.*

743

By GASTON G. GAUTHIER,† MEMBER.

SYNOPSIS.

This paper deals with the effect on the conductivity of super-purity aluminium (exceeding 99·99 per cent.) of additions of those elements which may occur as impurities in commercial aluminium.

It is shown that aluminium follows the universal law that the conductivity and the temperature coefficient of conductivity both increase with the purity: Mathiessen's Law has been confirmed. The data presented in this paper on the effect of small additions on the conductivity of aluminium are of value in that they have been determined under favourable experimental conditions, owing to the extreme purity of the basis metal and the large amount which has been available. This high purity has made it possible to determine, with a stated accuracy, the effect of each one of the added elements in the almost complete absence of other impurities. Further, the figures given for iron and silicon, for these elements with titanium and vanadium, and for magnesium and silicon, make it possible to calculate the conductivity of aluminium of accurately known purity.

Norbury's Law does not appear to hold in the case of aluminium.

INTRODUCTION.

IN employing aluminium for electrical conductors it is necessary to use commercial metal of the highest possible purity. It is essential, therefore, to know accurately the effect on the electrical resistivity of those elements which may be introduced into the metal during its manufacture from the ore stage onwards, and hence to carry out research directed to the elimination of the most harmful of them. Further, accurate curves showing the effect of impurities make it possible to calculate, from the chemical analysis alone, the approximate conductivity which would be expected from a sample of metal which had been given the same thermal and mechanical treatment as those used in establishing the curves.

Numerous investigations have already been carried out on this

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* Manuscript received February 7, 1936.

† Head of the Metallurgical Research Laboratory of the Cie de Produits Chimiques et Electrometallurgiques Alais, Froges et Camargue, France.

Note to Abstractors and Other Readers.—This paper will be published, in permanent form, in the *Journal of the Institute of Metals*, Vol. LIX, 1936. Reference should accordingly be as follows: *J. Inst. Metals*, 1936, 59 (Advance copy).

subject. To attempt to refer to them all would involve the risk of committing the injustice of omitting some; reference will only be made to those in which the conditions of testing were such as to permit comparison with the data now presented: the author apologizes in advance for the omission of any work of which he is ignorant. The majority of previous investigations have been carried out, moreover, on commercial aluminium of which the content of impurities was not negligible: certain of these impurities can combine with the added elements and so modify their influence. Further, in other cases, the amount of element added was too great to allow of any conclusion being reached as to its effect when present merely as an impurity.

The author has been fortunate in having at his disposal super-purity aluminium (of which the purity exceeds 99·99 per cent.) made by the process of the Cie Alais, Froges et Camargue. Additions of other elements were made in amounts comparable with those likely to be met with in practice, and in general not exceeding the limit of solid solubility in the cold. Additions in excess of this amount—which should lead to its accurate determination—will form the subject of further work. Conductivity determinations were made on annealed and on quenched specimens, and precise details will be given below.

The author has thought it advisable to mention some of his data regarding the conductivity and the temperature coefficient of super-purity and of commercial aluminium, since these data appear to afford an explanation of an anomaly found previously in the relationship between purity and conductivity.

Description of Tests.

In preparing the alloys, considerable precautions had to be taken to prevent accidental contamination. Acheson graphite crucibles were used, and in order to ensure that the compositions of the samples conformed as closely as possible with those intended, rich alloys were prepared of suitable composition. These were chill-cast into shallow ingots in order to minimize segregation, and analysis samples were taken by drilling through the ingot. In order to provide sufficient samples, two and sometimes four for each test, and to ensure the greatest accuracy, at least 3 kg. of alloy were prepared each time.

The alloys were cast in small cylindrical billets 64 mm. in diameter, extruded under identical conditions as regards temperature and time of pre-heating, and temperature of extrusion, into rods 10 mm. in diameter; these were cold-drawn to wires 8 mm. in diameter, using a tungsten carbide die in order to ensure a constant and known final thickness (7·975 mm.).

For annealing, the samples were placed, in small quantities at a time, in a large electric furnace of which the temperature was carefully maintained at 320° C. After annealing for 3 hrs., the samples were slowly cooled during 24 hrs. to 100° C., and were then removed, so as to liberate the furnace. For quenching, the samples were placed in the furnace which had previously been heated to 500° C.; after 1 hr. at this temperature they were quenched in cold water.

Frequent checks were carried out by putting billets from the same cast through the whole series of operations, and no abnormal results were obtained. The accuracy of the bridge was checked during each series of measurements against samples of known conductivity serving as standards.

For the measurements a Kelvin double bridge was used, having 4 series of decade resistances. The specimens were about 1·10 m. long, and the resistance was measured over a length of 1 m., at least two and sometimes four specimens being used for each test. All measurements were made at approximately 20° C. in order to reduce to a minimum the necessary correction for temperature, and in order to ensure a constant temperature over the whole length of the specimen, a 70-litre oil-bath was used, of which the temperature was accurately known to 0·1° C. Under these conditions, and having regard to other factors, the maximum relative error was approximately 0·2 per cent.

Using metal cast direct from the refining furnace and analyzing :

	Per Cent.
Iron	0·0011
Silicon . . .	0·0015
Copper . . .	0·0005
Aluminium . . .	99·997 (by difference),

a sample annealed as above at 320° C. gave a resistivity of 2·63 microhms/cm. cube * at 20° C., corresponding with a conductivity of 65·45 per cent. of that of copper. So far as the author is aware, this figure is the highest ever recorded. Edwards [1] quotes 64·6 per cent. of copper for aluminium of 99·971 per cent., and the Bureau of Standards [3] quote 63·4 per cent. for metal of 99·968 per cent. purity. These differences, which cannot be accounted for by the analyses, suggest that the purities were not as high as those stated. The author's figures for aluminium annealed at 320° C. are given in Table I.

TABLE I.

Purity, Per Cent.	Iron, Per Cent.	Silicon, Per Cent.	Copper, Per Cent.	Conductivity, Per Cent. of Copper.
99·997	0·0012	0·0015	0·0003	65·45
99·991	0·0013	0·0037	0·0035	65·35
99·97	0·012	0·008	0·008	64·90

---

* *i.e.* conductivity = 38·0 recip. ohms/m./mm.^{2}.

A sample of metal quenched from 500° C. gave a conductivity of 64·3 per cent. This reduction is evidently due to a structural change during heating.

In order to ascertain whether re-melting introduced any appreciable amount of impurities, several kg. of this metal were re-cast into billets. The analysis was :

	Per Cent.
Iron	0·0023
Silicon	0·0032
Copper	0·0015
Aluminium	99·993 (by difference).

No difference could be detected between the conductivity of this and of the original metal.

In order to verify that this amount of contamination was never exceeded, iron, silicon, and copper were determined on an average sample made up of samples taken from each specimen used in each series. The increase in iron + silicon + copper due to re-melting never exceeded 0·005 per cent.

The effect of introducing a single element was next studied, the intended additions being given in Table II.

TABLE II.

Impurities.	Limit of Solid Solubility at Room Temperature.	Intended Additions, Per Cent.				
Iron	0 ?	0·2	0·4	0·6	0·8	1·0
Silicon	0·05	0·2	0·4	0·6	0·8	1·0
Copper	0·5	0·05	0·10	0·15	0·20	0·25
Zinc	13·5	0·25	0·50	0·75	1·00	1·25
Nickel	0·5	0·05	0·20	0·30	0·40	0·50
Manganese	0·1	0·005	0·01	0·015	0·020	0·025
Magnesium	4	0·25	0·50	0·75	1·00	1·25
Titanium	0·2	0·005	0·010	0·015	0·020	0·025
Vanadium	0·2	0·005	0·010	0·015	0·020	0·025
Chromium	0·03	0·0025	0·005	0·0075	0·010	0·0125

This was followed by an investigation of the effect of adding more than one element at a time : silicon + iron, magnesium + silicon, and silicon, iron, titanium, and vanadium together, and the results were examined to see if the effects were additive or not.

Finally, in order to see if there was any physical law determining the effect of additions, an investigation was made of the effect of elements not usually occurring, namely silver, gold, and gallium.

CONDUCTIVITY OF SUPER-PURITY AND OF COMMERCIALLY PURE ALUMINIUM.

In some previous work, the author had occasion to measure the resistivity and the temperature coefficient of resistivity not only of super-purity aluminium, but also of aluminium of various purities. It was found that, as for other metals, the temperature coefficient of resistivity of aluminium increased with purity. This is contrary to the experience of Holborn.[3]

The author's measurements also confirmed Mathiessen's law, namely that for alloys approximating to pure metals, the product of the temperature coefficient of resistivity at t° into the resistivity at the same temperature is a constant whose value depends on the pure metal in question and on the temperature t° under consideration.

Table III gives the analyses and electrical measurements on specimens annealed for 3 hrs. at 320° C. and slowly cooled.

TABLE III.

Sample.	Analysis, Per Cent.				ρ 20.	α 20.	ρ 20 × α 20.
	Iron.	Silicon.	Titanium.	Vanadium.			
Super-purity aluminium	0·0005	0·0023	...	...	2·620	0·00433	0·01134
Al 99·5%, annealed	0·34	0·10	0·0096	0·0044	2·767	0·0040	0·01107
Al 99%, annealed	0·56	0·32	0·016	0·0039	2·780	0·00413	0·01152
Al 98·5%, annealed	0·96	0·41	0·0168	0·0044	2·835	0·0040	0·01134

The maximum error in the product $\rho\,\alpha$ is of the order of 25/1000, so that, taking a mean value of 0·01135, the experimental values should lie between 0·01164 and 0·01106. The above figures, therefore, confirm Mathiessen's law.

The coefficient α is higher for very pure aluminium than for the ordinary metal. Holborn found the following values for the coefficient α for specimens annealed at 320° C.:

for 0·1 per cent. of impurities, α = 0·00422
0·4 ,, ,, = 0·00443
1·2 ,, ,, = 0·00446
1·6 ,, ,, = 0·00429

It is probable that Holborn's anomalous results are due to impurities other than those usually estimated, as Bosshard has already indicated.[4] Mathiessen's relation shows that those impurities which increase the resistivity the most are those which most reduce the temperature coefficient. A very small content of such impurities as titanium, vanadium, manganese, and chromium would suffice to explain Holborn's anomalous results.

THE EFFECT OF DIFFERENT ELEMENTS.

(1) *Iron.*

A rich alloy containing 8·07 per cent. iron was used. The analyses and conductivity measurements are given in Table IV.

TABLE IV.

Mark.	Intended Iron Content, Per Cent.	Analysis, Per Cent.			Conductivity at 20° C.			
					Annealed.		Quenched.	
		Fe.	Si.	Cu.	m./mm.^{2}.	Cu, Per Cent.	m./mm.^{2}.	Cu, Per Cent.
Fe 1	0·20	0·22	0·0047	on mean sample 0·001	37·18	64·05	36·92	63·65
Fe 2	0·40	0·41	0·0042		36·92	63·65	36·65	63·2
Fe 3	0·60	0·61	0·0037		36·80	63·45	36·60	63·05
Fe 4	0·80	0·82	0·0042		36·72	63·35	36·52	62·95
Fe 5	1·00	0·99	0·0051		36·52	62·95	36·40	62·75

A further point determined for 0·1 per cent. iron gave a conductivity as annealed of 37·55 or 64·8 per cent. of copper. The solid solubility of iron is, therefore, less than 0·1 per cent. at 100° C. All investigators are in agreement that iron is practically insoluble in aluminium. The slope of the curve, indicates, however, a certain small solubility, although part of the difference may be due to a change of crystallization due to the heating before quenching. A similar feature occurs in some of the following curves.

(2) *Silicon.*

A rich alloy containing 10·19 per cent. silicon was used, made from a ferro-silicon containing 98·5 per cent. silicon. The intended compositions, analyses, and conductivity measurements are given in Fig. 1 and in Table V.

It follows that at 100° C., the solid solubility of silicon, in the absence of iron, is approximately 0·06 per cent., in agreement with Dix and Heath,[5] who reported 0·05 per cent. at a temperature of 200° C.

In this series the effect of quenching is very considerable. The curve for the quenched samples is almost a straight line, showing that the solid solubility of silicon at high temperatures is greater than the maximum content investigated.

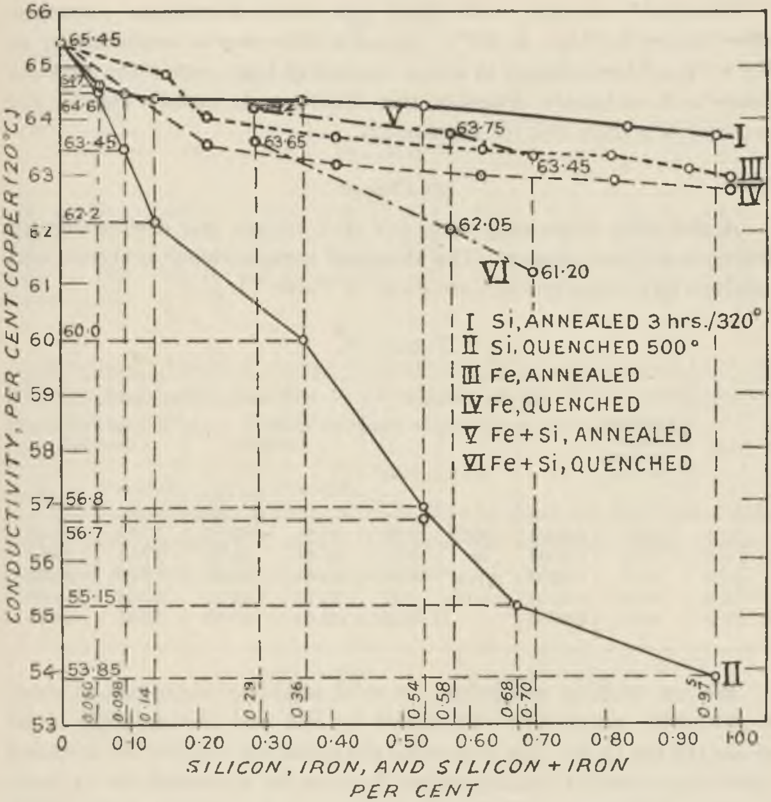

Fig. 1.—Effect of Iron and Silicon and of Iron + Silicon on the Conductivity of Aluminium.

Table V.

Mark.	Intended Silicon Content, Per Cent.	Analysis, Per Cent.			Conductivity at 20° C.			
					Annealed.		Quenched.	
		Fe.	Si.	Cu.	m./mm.².	Cu, Per Cent.	m./mm.².	Cu, Per Cent.
Si 0·5	0·05	on mean sample 0·0027	0·05	on mean sample 0·0011	37·53	64·70	37·49	64·60
Si 1	0·1		0·098		37·42	64·55	36·80	63·45
Si 1·5	0·15		0·142		37·38	64·45	36·12	62·20
Si 3·5	0·35		0·36		37·38	64·45	34·80	60·00
Si 5	0·50		0·54		37·28	64·25	32·85	56·80
Si 7	0·70		0·68		37·18	64·05	32·01	55·15
Si 10	1·00		0·975		36·95	63·70	31·24	53·85

Fraenkel,[6] working with 99·97 per cent. aluminium quenched after heating for 6 hrs. at 450° C., found a difference in conductivity of 8·6 m./mm.^{2} for a change in silicon content of 1 per cent.; the author's figure is 7 m./mm.^{2}. Possibly this difference is mainly due to the presence of a little iron (cf. Section 12).

(3) *Copper.*

A rich alloy containing 49·40 per cent. copper was used, made up from electrolytic copper. The intended compositions, analyses, and conductivity measurements are given in Table VI.

TABLE VI.

Mark.	Intended Copper Content, Per Cent.	Analysis, Per Cent.			Conductivity at 20° C.			
					Annealed.		Quenched.	
		Fe.	Si.	Cu.	m./mm.^{2}.	Cu, Per Cent.	m./mm.^{2}.	Cu, Per Cent.
Cu 1	0·05	0·0004	0·0023 on mean sample	0·06	37·80	65·25	37·78	65·10
Cu 2	0·10	0·0004		0·13	37·65	64·90	37·51	64·65
Cu 3	0·15	0·0004		0·16	37·49	64·60	37·35	64·35
Cu 4	0·20	0·0004		0·21	37·20	64·15	37·16	64·00
Cu 5	0·25	0·0004		0·26	37·01	63·85	36·95	63·70

We are working well below the solid solubility of copper, at room temperature, which was determined by Dix and Richardson[7] to be about 0·5 per cent. The curves for the quenched and for the annealed specimens show no anomaly other than can be accounted for by grain coarsening. Fraenkel,[6], working with a sample of aluminium of 99·97 per cent. purity, of American origin, found a decrease of conductivity of 0·8 m./mm.^{2} per 0·25 per cent. copper added. Bosshard,[4] in his work on binary aluminium alloys, using a specimen of 99·7 per cent. purity, annealed at 300° C. and quenched, found a difference of 1·5 m./mm.^{2} conductivity per 0·35 per cent. copper. These two results are a little different from the author's, one being greater and the other less. It is possible that the explanation lies in small differences in the preparation of the specimens.

(4) *Zinc.*

A rich alloy analyzing 10·44 per cent. zinc was used, made from electrolytic zinc. The intended compositions, analyses, and conductivity measurements are given in Table VII.

As the solid solubility of zinc is far higher than the maximum content studied, the two curves show no abnormalities.

TABLE VII.

Mark.	Intended Zinc Content, Per Cent.	Analysis, Per Cent.				Conductivity at 20° C.			
						Annealed.		Quenched.	
		Fe.	Si.	Cu.	Zn.	m./mm.^{2}.	Cu, Per Cent.	m./mm.^{2}.	Cu, Per Cent.
Zn 1	0·25	0·0022	0·0028 on mean sample	0·0014 on mean sample	0·24	37·70	65·05	37·55	64·80
Zn 2	0·50	0·0012			0·53	37·38	64·45	37·28	64·25
Zn 3	0·75	0·0013			0·78	37·05	63·90	36·97	63·75
Zn 4	1·00	0·0010			1·00	36·78	63·40	36·70	63·30
Zn 5	1·25	0·0010			1·21	36·48	62·90	36·45	62·80

Bosshard[4] found a change of conductivity of 5·5 m./mm.^{2} for an addition of 5 per cent. zinc to aluminium of 99·65 per cent. purity annealed at 240° C. This is roughly what the author finds.

(5) *Nickel.*

Using electrolytic nickel, a rich alloy containing 6·12 per cent. nickel was prepared. Table VIII gives the intended compositions, analyses, and conductivity measurements.

TABLE VIII.

Mark.	Intended Nickel Content. Per Cent.	Analysis, Per Cent.				Conductivity at 20° C.			
						Annealed.		Quenched.	
		Fe.	Si.	Cu.	Ni.	m./mm.^{2}.	Cu, Per Cent.	m./mm.^{2}.	Cu, Per Cent.
Ni 0·5	0·05	0·0020	0·0028 on mean sample	0·0005 on mean sample	0·050	37·93	65·40	37·80	65·25
Ni 2	0·2	0·0012			0·177	37·89	65·35	37·77	65·15
Ni 3	0·3	0·0019			0·27	37·80	65·25	37·69	65·00
Ni 4	0·4	0·0020			0·37	37·77	65·15	37·65	64·90
Ni 5	0·5	0·0020				37·69	65·00	37·64	64·85

Bohner,[8] working on commercial aluminium and a specimen quenched from 300° C., found a change in conductivity of 0·8 m./mm.^{2} on increasing the nickel from 0·1 to 0·5 per cent. This is roughly three times the change found by the author. This is probably due to the formation of complex constituents of nickel, iron, and silicon which increase the lowering of the conductivity.

(6) *Magnesium.*

A rich alloy was used containing 4·25 per cent. magnesium, made from electrolytically refined magnesium. The intended compositions, analyses, and conductivity measurements are given in Table IX.

TABLE IX.

Mark.	Intended Magnesium Content, Per Cent.	Analysis, Per Cent.				Conductivity at 20° C.			
						Annealed.		Quenched.	
		Fe.	Si.	Cu.	Mg.	m./mm.^{2}.	Cu, Per Cent.	m./mm.^{2}.	Cu, Per Cent.
Mg 1	0·25	0·0018	0·0037 on mean sample	0·0025 on mean sample	0·23	35·71	61·50	35·65	61·45
Mg 2	0·50	0·0013			0·54	33·81	58·30	33·75	58·20
Mg 3	0·75	0·0014			0·83	31·67	54·65	31·60	54·50
Mg 4	1·00	0·0014			1·04	30·37	52·35	30·30	52·20
Mg 5	1·25	0·0022			1·40	28·71	49·50	28·68	49·40

In addition, measurements have been carried out on samples containing lower percentages of magnesium. These were prepared from an alloy containing 0·82 per cent. magnesium. It is not easy to analyze such small quantities accurately, and it is only possible to indicate the intended composition (Table X).

TABLE X.

Mark.	Intended Magnesium Content, Per Cent.	Conductivity at 20° C.			
		Annealed.		Quenched.	
		m./mm.^{2}.	Cu, Per Cent.	m./mm.^{2}.	Cu, Per Cent.
Mg 01	0·01	37·80	65·25	37·79	65·20
Mg 02	0·05	37·53	64·70	37·51	64·65
Mg 03	0·1	37·18	64·05	37·10	63·95

All these results are in perfect agreement and show that magnesium exerts a considerable effect on the conductivity of very pure aluminium.

Fraenkel found a decrease of conductivity of 6 m./mm.^{2} per 1 per cent. magnesium working with aluminium of 99·97 per cent. purity. This figure is rather lower than the author's, and the presence of silicon is insufficient to account for the difference.

(7) *Manganese.*

A rich alloy was prepared by the action of potassium permanganate on super-purity aluminium, and analyzed 0·69 per cent. The intended compositions, analyses, and conductivity measurements are given in Table XI.

Rather low manganese contents have been investigated, since no useful comparison could be made with previously published data.

TABLE XI.

Mark.	Intended Manganese Content, Per Cent.	Analysis, Per Cent.				Conductivity at 20° C.			
		Fe.	Si.	Cu.	Mn.	Annealed.		Quenched.	
						m./mm.².	Cu, Per Cent.	m./mm.².	Cu, Per Cent.
Mn 1	0·005	0·0008	0·0014	0·0005	0·0048	37·80	65·25	37·78	65·10
Mn 2	0·010	0·0007	on	on	0·010	37·53	64·70	37·51	64·65
Mn 3	0·015	0·0007	mean	mean	0·016	37·30	64·30	37·28	64·25
Mn 4	0·020	0·0008	sample	sample	0·021	37·05	63·90	36·99	63·80
Mn 5	0·025	0·0008			0·026	36·83	63·50	36·78	63·40

(8) *Vanadium.*

In order to prepare a rich alloy free from impurities, vanadium was introduced by the interaction between vanadic acid and super-purity aluminium. The alloy so obtained analyzed 0·58 per cent. An earlier analysis gave 0·21 per cent.; hence the difference between the intended and the actual compositions. The intended compositions, analyses, and conductivity measurements are given in Table XII.

TABLE XII.

Mark.	Intended Vanadium Content, Per Cent.	Analysis, Per Cent.				Conductivity at 20° C.			
		Fe.	Si.	Cu.	V.	Annealed.		Quenched.	
						m./mm.².	Cu, Per Cent.	m./mm.².	Cu. Per Cent.
V 1	0·005	0·0011	0·0033	0·0018	0·012	37·35	64·35	37·28	64·25
V 2	0·010	0·0011	on	on	0·027	36·62	63·15	36·60	63·05
V 3	0·015	0·0011	mean	mean	0·040	36·03	62·10	35·95	62·00
V 4	0·020	0·0011	sample	sample	0·051	35·24	60·80	35·22	60·75
V 5	0·025	0·0012			0·067	34·85	60·10	34·80	60·00

As we are working well below the limit of solid solubility, the curves show no anomalous features, and there is only a small difference between the quenched and the annealed samples. Here also the author is unaware of any published data dealing with such low contents.

(9) *Titanium.*

A rich alloy was prepared from very pure potassium fluotitanate and analyzed 0·21 per cent. titanium. The intended compositions, analyses, and conductivity measurements are given in Table XIII.

As we are working below the limit of solid solubility, the curves show no anomalous features.

TABLE XIII.

Mark.	Intended Titanium Content, Per Cent.	Analysis, Per Cent.				Conductivity at 20° C.			
		Fe.	Si.	Cu.	Ti.	Annealed.		Quenched.	
						m./mm.^{2}.	Cu, Per Cent.	m./mm.^{2}.	Cu, Per Cent.
Ti 1	0·005	0·001	0·0023 on mean sample	0·0010 on mean sample	0·0056	37·69	65·00	37·67	64·95
Ti 2	0·010	0·0014			0·010	37·53	64·70	37·51	64·65
Ti 3	0·015	0·0014			0·015	37·28	64·25	37·25	64·20
Ti 4	0·020	0·0015			0·022	37·10	63·95	37·05	63·90
Ti 5	0·025	0·0018			0·026	36·84	63·55	36·83	63·50

Working with a sample of aluminium analyzing 99·5 per cent., and annealed at 240° C., Bosshard found a decrease of conductivity of 5·7 m./mm.^{2} on addition of 0·2 per cent. titanium. This figure is almost half that found by the author for the range 0–0·02 per cent. The reason for this is not clear; the limit of solid solubility of titanium is greater than 0·2 per cent., and, as will be shown below, the effect of titanium on conductivity is additive to that exerted by the iron and the silicon.

(10) *Chromium.*

The rich alloy was prepared from refined chromium of 99 per cent. purity, and contained 0·29 per cent. chromium. The intended compositions and conductivity measurements are given in Table XIV.

TABLE XIV.

Mark.	Intended Chromium Content, Per Cent.	Conductivity at 20° C.			
		Annealed.		Quenched.	
		m./mm.^{2}.	Cu, Per Cent.	m./mm.^{2}.	Cu, Per Cent.
Cr 1	0·0025	37·89	65·35	37·79	65·20
Cr 2	0·005	37·77	65·15	37·67	64·95
Cr 3	0·0075	37·65	64·90	37·59	64·75
Cr 4	0·010	37·51	64·65	37·44	64·50
Cr 5	0·0125	37·37	64·40	37·28	64·25

It has not been possible to give analyses for such small quantities of chromium, and the intended compositions have, therefore, been used in preparing the curves. This is permissible by reason of the precautions taken in preparing the specimens, and spectrographic analyses confirm the compositions. Nothing appears to have been published dealing with such low percentages of chromium.

(11) *Silver, Gold, and Gallium.*

Table XV gives the intended compositions and the results of the conductivity measurements. The compositions have been checked spectrographically and conform closely to those intended.

TABLE XV.

Alloy and Mark.	Intended Composition, Per Cent.	Conductivity at 20° .	
		Annealed.	
		m./mm.².	Cu, Per Cent.
Argent Ag 1	Silver 0·2	37·18	64·05
Or Au 1	Gold 0·1	37·93	65·40
Gallium Ga 1	Gallium 0·05	37·93	65·40

As regards silver, Fraenkel, using aluminium of 99·97 per cent. purity quenched from above 500° C., found a change of conductivity of 8·3 m./mm.² corresponding with an addition of 2 per cent. of silver. This is approximately that found by the author.

As regards gallium, the same author found a decrease in conductivity of 2·1 m./mm.² for an addition of 1·28 per cent. of gallium, rather less than that found by the author.

(12) *Effect of Iron and Silicon.*

Having established a curve showing the effect of these two elements, which are invariably present in commercial aluminium, the author prepared a series of synthetic samples of overall purity varying between 99·3 and 99·8 per cent. Rich alloys containing 9·1 per cent. iron and 10·20 per cent. silicon were used, in conjunction with super-purity aluminium, for the work. The analyses and conductivity measurements are given in Table XVI.

TABLE XVI.

Mark.	Analysis, Per Cent.		Purity.	Conductivity at 20° C.			
				Annealed.		Quenched.	
	Fe.	Si.		m./mm.².	Cu, Per Cent.	m./mm.².	Cu, Per Cent.
FES 1	0·21	0·09	99·7	37·25	64·20	36·92	63·65
FES 2	0·23	0·10	99·67	37·16	64·00	...	...
FES 3	0·365	0·21	99·42	36·97	63·75	36·00	62·05
FES 4	0·34	0·23	99·43	36·95	63·70	...	...
FES 5	0·47	0·23	99·3	36·80	63·45	35·55	61·20
FES 6	0·41	0·30	99·29	36·84	63·55	...	...

It is clear—as could have been foreseen—that the effects of these two elements are not additive. This is due to the formation of complex constituents of aluminium, iron, and silicon, whose effect is different from that of the individual elements. To illustrate this, Table XVII gives the conductivity of the preceding samples annealed at 320° C. as measured and as calculated from the curves for iron and silicon (Sections 1 and 2). The difference between the observed and calculated figures is relatively large, and depends essentially on the ratio of iron to silicon contents. In calculating conductivity from the chemical analysis, therefore, due cognisance must be taken of this fact.

TABLE XVII.

Mark.	Conductivity at 20° C.			
	Calculated		Measured.	
	m./mm.².	Cu, Per Cent.	m./mm.².	Cu, Per Cent.
FES 1	36·62	63·15	37·25	64·20
FES 2	36·60	63·05	37·16	64·00
FES 3	36·36	62·65	36·97	63·75
FES 4	36·40	62·75	36·95	63·70
FES 5	36·30	62·55	36·80	63·45
FES 6	36·30	62·55	36·84	63·55

(13) *Effect of Titanium and Vanadium.*

In order to obtain data of practical value, it was considered necessary to study the effect of titanium and of vanadium on aluminium containing iron and silicon in such quantities as occur in the metal normally used for electrical conductors. A basis alloy was, therefore, prepared from iron- and silicon-rich alloys and super-purity aluminium, and analyzed:

	Per Cent.
Iron	0·14
Silicon . . .	0·007

Titanium and vanadium were added, using the bars which had been used for the work on these individual elements, in the ratios of 2 : 1 and of 5 : 1. The results are summarized in Table XVIII.

In Fig. 2 have been included the curves for titanium, for vanadium, and two other curves for ratios $\frac{\mathrm{Ti}}{\mathrm{V}} = 2$ and $\frac{\mathrm{Ti}}{\mathrm{V}} = 5$, respectively. The intended compositions have been used in drawing these curves, since the analyses were not sufficiently accurate: there is a systematic error in the analysis for vanadium.

Contrary to what occurs in the case of iron and silicon together, and in the case of magnesium and silicon together (see below), the effects of

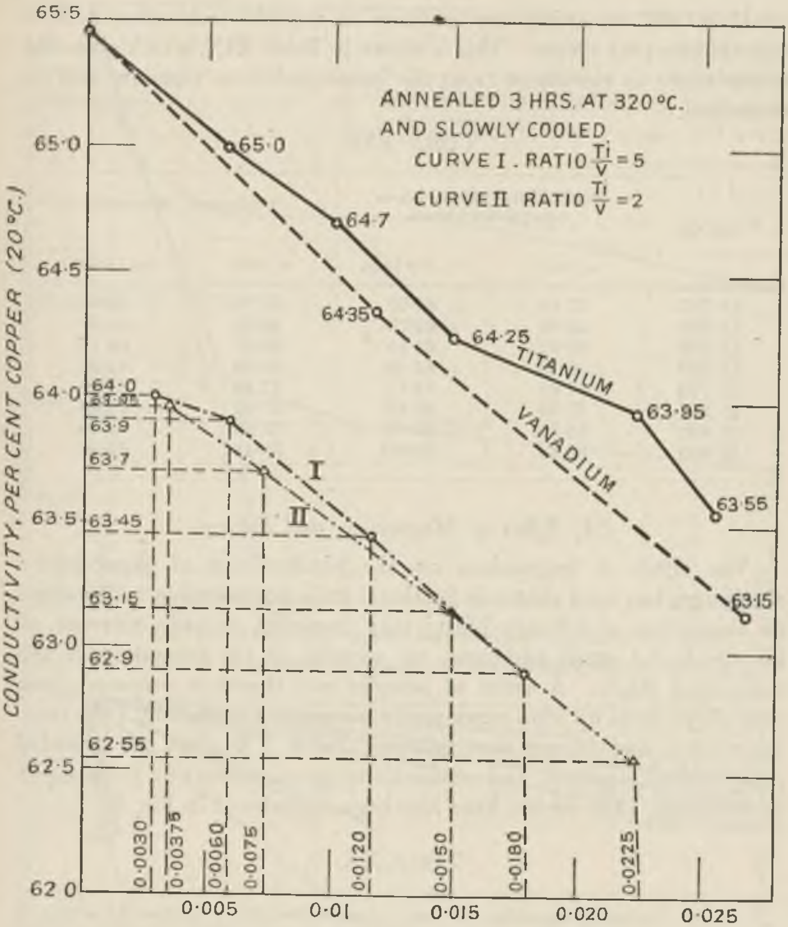

FIG. 2.—Effect of Titanium and Vanadium on the Conductivity of Aluminium.

TABLE XVIII.

Cast No.	Amount Introduced, Per Cent.		Analysis, Per Cent.					Conductivity at 20° C.	
	Ti.	V.	Fe.	Si.	Ti.	V.	Ti + V.	m./mm.².	Cu, Per Cent.
15 787	0·0025	0·00125	0·14	0·070	0·0024	...	0·0024	37·10	63·95
15 788	0·005	0·0025	0·15	0·0655	0·0058	0·0011	0·0069	36·95	63·70
15 789	0·010	0·005	0·15	0·061	0·0108	0·0033	0·0141	36·62	63·15
15 790	0·015	0·0075	0·15	0·056	0·0160	0·0067	0·0227	36·30	62·55
15 794	0·0025	0·0005	0·15	0·07	0·0030	...	0·0030	37·16	64·00
15 801	0·0050	0·001	0·16	0·065	0·0048	0·00055	0·0053	37·05	63·90
15 802	0·010	0·002	0·14	0·061	0·0098	0·0011	0·0109	36·80	63·45
15 803	0·015	0·003	0·17	0·0608	0·0166	...	0·0166	36·48	62·90

titanium and vanadium are additive as regards each other and as regards iron plus silicon. This is shown in Table XIX, which gives the conductivity as calculated from the investigation on titanium and on vanadium.

TABLE XIX.

Cast No.	Conductivity Calculated from Analysis and Curves.		Conductivity Measured.	
	m./mm.².	Cu, Per Cent.	m./mm.².	Cu, Per Cent.
15 787	37·18	64·05	37·10	63·95
15 788	36·97	63·75	36·95	63·70
15 789	36·62	63·15	36·62	63·15
15 790	36·30	62·55	36·30	62·55
15 794	37·22	64·10	37·16	64·00
15 801	37·03	63·85	37·05	63·90
15 802	36·78	63·40	36·80	63·45
15 803	36·48	62·90	36·48	62·90

(14) *Effect of Magnesium and Silicon.*

The effect of magnesium on the conductivity of super-purity aluminium has been shown in Section 6 to be considerable. The effect on aluminium of ordinary purity may, however, be very different, at all events for small additions, on account of the formation of the compound Mg_2Si. A series of samples was therefore prepared from rich alloys made up from super-purity aluminium containing 1 per cent. magnesium and 10 per cent. silicon. Table XX gives the intended compositions, analyses, and conductivity measurements on the samples as annealed. The figures have also been reproduced in Fig. 3.

TABLE XX.

Mark.	Intended Composition, Per Cent.			Analysis, Per Cent		Conductivity at 20° C.	
	Mg.	Si.	Mg_2Si.	Mg.	Si.	m./mm.².	Cu, Per Cent.
M.S. 1	0·0175	0·01	0·0275	...	0·01	37·67	64·95
M.S. 2	0·044	0·025	0·069	0·042	0·018	37·44	64·50
M.S. 3	0·09	0·050	0·140	0·060	0·055	36·87	63·60
M.S. 4	0·175	0·10	0·275	0·166	0·099	36·78	63·40
M.S. 5	0·44	0·25	0·69	0·486	0·235	36·65	63·20

The effect of Mg_2Si is practically that of magnesium within the region of solid solubility. From this work the limit of solubility would appear to be less than 0·14 per cent., whereas Kishino[9] found 0·47 per cent. He did not, however, state the purity of the metal used.

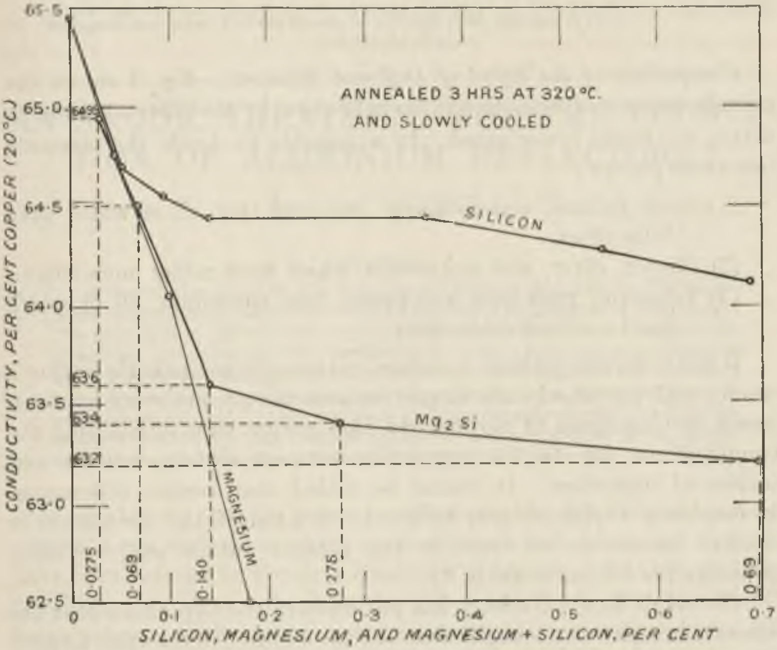

Fig. 3.—Effect of Magnesium and Silicon on the Conductivity of Aluminium.

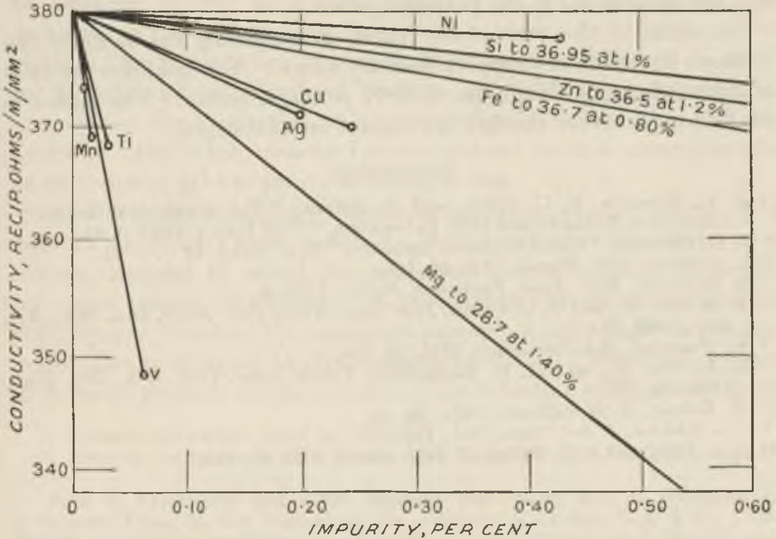

Fig. 4.—Mean Decrease of Conductivity in Alloys of Aluminium as a Function of the Content of Alloying Element Added.

CONCLUSIONS.

Comparison of the Effect of Different Elements.—Fig. 4 shows the average decrease of conductivity brought about by the different elements within the limits investigated. It is possible to divide the elements into three groups :

(1) Gold, gallium, nickel, silicon, iron, and zinc, all of which have little effect.

(2) Copper, silver, and magnesium, which have rather more effect.

(3) Titanium, vanadium, manganese, and chromium, all of which exert a considerable effect.

It has only been possible in certain instances to compare the author's results with published data, largely because the present work has been based on aluminium of particularly high purity, thus eliminating the complications due to the interaction between added elements and incidental impurities. It should be added that certain differences, incompletely explained, may be due to variation in the mechanical or thermal treatment as used by the present author and by other investigators (cf. particularly [10]).

Norbury's Law.—Norbury has put forward the hypothesis that the increase in resistivity brought about by the addition of the same number of atoms is larger, the greater the separation between the added element and the basis metal in the periodic system.

In spite of the precautions taken in preparing his samples the author's figures do not support Norbury's Law. This confirms the view of Fraenkel, using aluminium of 99·97 per cent. purity. The author is considering whether another law cannot be established.

REFERENCES.

[1] J. D. Edwards, F. C. Frary, and Z. Jeffries, "The Aluminium Industry : Aluminium Products and their Fabrication," New York : 1930, p. 44.

[2] J. D. Edwards, "The Aluminium Industry," New York : 19 , p. 43.

[3] L. Holborn, *Ann. Physik*, 1919, **59**, 155.

[4] M. Bosshard, *Bull. Assoc. Electrotech. Suisse*, 1927, **3**.

[5] E. H. Dix, Jr., and A. C. Heath, *Proc. Inst. Metals Div., Amer. Inst. Min. Met. Eng.*, **1928**, 164.

[6] W. Fraenkel, *Metallwirtschaft*, 1933, **12**, 159.

[7] E. H. Dix, Jr., and H. H. Richardson, *Trans. Amer. Inst. Min. Met. Eng.*, 1926, **73**, 560.

[8] H. Bohner, *Z. Metallkunde*, 1934, **26**, 45.

[9] —— Kishino, *J. Soc. Chem. Ind.*, 1932.

[10] A. J. Field and J. H. Dickin, *J. Inst. Metals*, 1933, **51**, 183.

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AN ANODIC TREATMENT FOR THE PRODUCTION OF ALUMINIUM REFLECTORS.* 744

By N. D. PULLEN.†

SYNOPSIS.

A description is given of a dual anodic process designed for the treatment of aluminium surfaces in order to produce a high degree of reflectivity. The first bath in which the electrolytic brightening is produced is a mixture of sodium carbonate and sodium phosphate in the approximate proportions of **3** : 1 having a strongly alkaline reaction. The second bath in which a reinforcing film is produced consists preferably of a strong solution of acid sodium sulphate. Data are given showing the reflectivity of aluminium surfaces treated by this method compared with a standard silver mirror and other surfaces such as chromium plate, nickel plate, &c.

It is well known that the power to reflect incident light is possessed by various metal surfaces to a very varying degree even when such surfaces have been reduced to the same condition so far as possible by grinding, polishing, &c. Not only does the reflectivity vary over the visible range taken as a whole, but it also varies for different wave-lengths and not always in the same manner. The reflectivity of a silver mirror, for instance, is very high when measured on the longer waves, but decreases to almost vanishing point over a narrow band in the ultra-violet. This paper is not concerned, however, with reflectors designed for a particular or specialized purpose, but with an electrochemical method for the production of aluminium surfaces having a high reflectivity value when measured in the normal manner using daylight or an artificial light as source of illumination.

At this point it might be desirable to define what is meant by a reflector as distinct from a mirror. A mirror might be defined as a surface designed to reflect the maximum amount of light with the minimum amount of diffusion. A reflector on the other hand, whilst still required to reflect the maximum amount of light might be, and in many cases is, designed to give maximum diffusion. Since the amount of diffusion depends on the evenness of the reflecting surface, only those

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substances capable of being ground accurately to a predetermined shape and then highly polished without "flowing" or otherwise becoming distorted are suitable for mirrors. This condition, together with the desire for high reflectivity and freedom from liability to tarnish, reduces the choice to a very small number of substances. For reflectors, the production of optically correct surfaces is not required nor is the minimum diffusion of paramount importance. The maximum total reflectivity combined with freedom from tarnishing must, however, still be attained.

It would appear that the above definitions preclude the use of aluminium as a reflecting medium to a very large extent, since in its normal commercial state it is rather too soft to give optical surfaces, its reflectivity is not of the highest order, and it is not free from the liability to tarnish or to acquire a dull surface. The tarnishing trouble has been overcome by the application of anodic oxidation, using various electrolytes producing material which is practically immune to this type of atmospheric corrosion, but the reflectivity of such material is appreciably less than that of the untreated metal and considerably less than the value given by a highly polished specimen. The problem concerning the production of reflectors, therefore, consisted in designing a process which would in the first place increase the reflectivity of a normal aluminium surface to an appreciable extent and then render such surface permanent.

The method of brightening a metal surface by anodic treatment in a suitable electrolyte is not new, as Figour and Jacquet * described a process for copper using orthophosphoric acid and ether solution, whilst more recently a process for aluminium has been patented in America and elsewhere using a hydrofluoric–boric acid mixture.

A still later process † which I shall describe, has a strongly alkaline solution for electrolyte. Its discovery was more or less an accident which happened during an investigation of the possible use of alkaline electrolytes for anodic oxidation in place of the more popular acid type; its development, however, has proceeded along more orthodox lines. This process is divisable into two main parts: (*a*) the production of the brightened highly reflective surface, and (*b*) the application of a protective layer which layer must not reduce the degree of reflectivity already attained.

For the production of brightened surfaces on aluminium, it is essential to remove the thin surface layer consisting of the natural oxide skin and such impurities, dirt, &c., as might be introduced during production; this can only be done by chemical means, using

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* French Patent 707,526.

† British Patent applications.

an acid or alkaline solvent. Without this preliminary treatment improved reflectivity is not obtained. This removal of the oxide skin is carried out without the application of any current, and the time during which solution occurs needs to be carefully controlled. The actual brightening is done under an applied e.m.f. and follows immediately after the chemical treatment in the same bath.

The solution which we use for this part of the process contains a relatively high proportion of alkali plus a smaller proportion of an alkaline phosphate. The actual amounts are not very critical although one particular mixture appears to give rather better results than others. The electrolyte is an aqueous solution containing approximately 15 per cent. sodium carbonate (anhydrous) and 5 per cent. tribasic sodium phosphate, the working temperature being about 80° C.

The material to be treated is immersed in this solution connected to the anode bar, with the current off, and allowed to remain until a vigorous etching action, which starts almost immediately, has persisted for about 20 seconds. Direct current at about 10 v. is then switched on with a current density of about 35 amp./ft.^{2} of anode surface. Within about 30 seconds of switching on, the initial etching of the metal should cease entirely and at the same time the current density should decrease to about half its original value, the voltage being kept within 9–12 v. The anodic treatment is then continued for about 5 minutes, after which the metal is removed from the bath and rapidly washed in clean cold water.

The reflectivity of the surface compared with the original mill finish is now considerably improved, and if the specimen is allowed to dry brilliant interference colours may be seen indicating the presence of an extremely thin transparent film presumably of aluminium oxide. This seems to be confirmed by the fact that the surface is now capable of being dyed by aniline dyes. This film is, however, too thin to withstand much wear and needs to be reinforced, and some difficulty was experienced in finding a suitable type of film for this purpose.

Of the normal electrolytes, chromic acid is useless, as its film is almost opaque; oxalic acid and sulphuric acid are better, particularly the latter, but both films reduce the original reflectivity. By carrying out the second treatment in sodium bisulphate the desired protective film is formed without causing any reduction in the degree of reflectivity obtained in the first process; in fact, in some cases a slight increase has been found. This effect is undoubtedly due to the presence of the sodium ions, since experiments carried out using equivalent solutions of sulphuric acid show a tendency to decrease the reflectivity. For the second part of the process, therefore, an aqueous solution is used containing approximately 20 per cent. sodium bisulphate worked at about 35° C. It is a straightforward anodic treatment using d.c. at 10 v. and a current density of about 5 amp./ft.^{2} anode surface, treatment being continued for 15 minutes.

The working details given above are those which have been found to give the most consistent results. The working, however, is not very critical, the permissible variations being indicated in Table I.

TABLE I.

	Normal.	Permissible Range.
First Treatment.		
Electrolyte :		
Sodium carbonate anhyd., %	15	12–20
Tribasic sodium phosphate, %	5	2·5–7·5
Temperature, ° C.	80–82	75–90
Voltage D.C.	9–12	7–16
Time, minutes	6–9	3–20
Second Treatment.		
Electrolyte :		
Sodium bisulphate, %	20	15–30
Temperature, ° C.	35	30–40
Voltage D.C.	10	8–12
Time, minutes	12–15	10–20

It should be noted, however, that working the process at the extreme limits of the permissible range will not necessarily give good results particularly with the first electrolyte; for instance, a composition of 12 per cent. carbonate and 7·5 per cent. phosphate is not good.

Some care is necessary in the finishing of treated material if a rather unpleasant defect is to be avoided. If a sheet is treated by both processes and finally washed and allowed to dry in air, a very brilliant surface is obtained which remains so until it is rubbed or fingered, when a permanent white streak appears which is rendered worse by further rubbing. This appears to be due to the formation in the first bath, of an extremely thin powdery layer, which is only rendered visible when rubbed in the dry state. The layer can be readily removed, however, without damage to the surface, by light scrubbing using clean water and a rubber sponge; this treatment must be applied before drying.

Several difficulties have arisen in the after-treatment or sealing of these reflector films, as most of the oils, waxes, &c., in general use reduce the reflectivity value, but very good results have been obtained by the application of soap and water. The soap should be applied with a second rubber sponge and worked into a good lather evenly over the reflector surface; this treatment produces a rather greasy effect on rinsing which disappears, however, when the metal is dried by rubbing in hot sawdust. Subsequent cleaning with soap and water and drying with a cloth may be done as often as desired.

Preliminary tests on the corrosion-resistance of the double film produced by the process described above—such as their resistance to dilute alkalis and dilute acids—show that they are at least as good as, and probably better than, anodic films produced by more orthodox means. Additional tests on the effect of atmospheric influences are now being carried out. The effect of heat is worthy of notice, since it is possible to heat metal treated by this process to its melting point without any apparent effect on the total reflectivity. Other tests have been carried out with metal used as reflectors for electric and gas heating elements. A reflector used behind a 1 kw. element after burning for 1500 hrs. showed a decrease in reflectivity of not more than 5 per cent. The element had been burning intermittently over a period of 18 months and the reflector was washed with soap and water as and when the normal accumulation of dirt and dust warranted it. In the case of the gas heaters, the reflector was so arranged that a portion of it was immediately above the heater and therefore subjected to the direct action of the gas fumes. After 1000 hrs. a slight milky haze was noticeable over this portion, the rest of the reflector being unaffected. Even over the hazy portion, however, there was no sign of definite corrosive action.

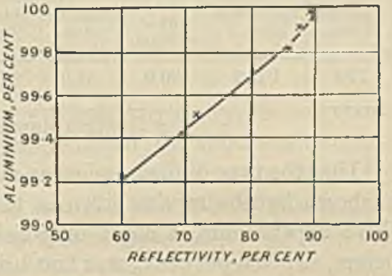

FIG. 1.

The films absorb dye-stuffs very readily, producing very brilliant colours. Here again the effect of the double process is noticeable, since the bisulphate film applied after the first treatment dyes more readily and to a deeper colour than a similar bisulphate film produced under exactly the same conditions but without the first treatment.

That the final results are dependent on the total overall purity of the metal used is shown in Fig. 1, in which reflectivity is plotted against purity. To obtain these results, metal was used varying in purity from 99·2 to 99·992 per cent. The curve is practically a straight line up to 99·8 per cent., after which the increase in reflectivity is less marked. It becomes evident, therefore, that if high results are required high-purity metal must be used.

The reflectivity values for aluminium of 99·8 per cent. purity treated for nickel, silver, and chromium plate, and other materials generally used for mirrors or reflectors. The silver, nickel, and chromium specimens were in the form of plated brass sheet as supplied by manufacturers for reflectors. Each specimen was flat and highly polished. The aluminium specimen was a piece of commercial sheet also polished and electrolytically brightened. The measurements were made in an apparatus using a photoelectric cell, and, since the conditions of each experiment were identical, the results are comparable. The figures represent the percentage of incident light reaching the cell after reflection by the metal surface compared with a standard silvered mirror taken as 100.

TABLE II.

Standard Mirror.	Aluminium Mirror.*	Brightened Aluminium.	Stainless Steel.	Silver Plate.	Nickel Plate.	Chrome Plate.	Plate Glass Mirrors. Thick Plate Glass.	Plate Glass Mirrors. Thin Plate Glass.
100	101·5	86·0	54·0	97·0	72·0	72·0	91·5	95·0

* Distilled aluminium on glass.

That the type of film applied as reinforcement is of major importance is shown by the results given in the first column of Table III. For these experiments, a sheet of polished metal of the same purity as before, *i.e.* 99·8 per cent., was first brightened in the alkaline electrolyte, then cut into a number of smaller pieces each of which was further treated in one of the various electrolytes named, using the normal anodic process for that electrolyte.

In the second column, reflectivity values are given for a further series of specimens treated exactly as those shown in the previous column except that they did not receive the brightening treatment; that is to say, the figures show the comparative reflectivity values for normal good-quality polished and anodized sheet.

TABLE III.

Type of Final Film.	Brightened Metal.	Unbrightened Metal.
Sodium bisulphate . .	84·0	71·0
Sulphuric acid, d.c. . .	78·0	67·0
Oxalic acid, d.c. . .	73·0	66·0
Oxalic acid, a.c. . .	74·0	71·0
Chromic acid . . .	60·0	54·0

Value for plain polished sheet = 85
Standard silver mirror = 100

The measurements were made using a photoelectric cell, as previously mentioned. The general outlay of the apparatus was as follows:

The source of light was a 100 watt projection lamp worked from the 230 v. mains. By means of a condenser, a parallel beam of light from this lamp was thrown on to the reflecting surface arranged at an angle of 30° to the incident beam. In the path of the reflected beam a collimator tube was placed carrying at one end a large lens and at the other a Weston Photronic cell, the length of the tube and position of the lens being such that an image of the illuminated area was thrown on the cell surface. The cell was connected directly to a low-resistance micro-ammeter. Under these conditions the response is linear.

As it is important that the incident illumination shall remain constant, some means of control is necessary. This was obtained by inserting a suitable variable resistance in the mains lead to the lamp. Using the standard silvered mirror and the collimator arranged so that $\angle i = \angle r$, the resistance was adjusted to give a reading on the micro-ammeter of exactly 100. Frequent checks were made during any series of measurements.

Since most metal surfaces give some diffuse reflectivity, the collimator tube was arranged to swing about the reflected ray, and measurements were also taken at various points towards and away from normal. By calculation, therefore, it was possible to arrive at a value indicating the total reflectivity. This arrangement also helped to reduce errors due to a reflecting surface not being optically flat.

The preceding remarks have only dealt with surfaces treated to give high specular reflection and little or no diffusion. The brightening process is equally efficient when applied to surfaces designed to give maximum diffusion. It has also been stated above that for maximum results high-purity metal should be used, but it can also be said that with any normal commercial purity, treatment by this process will result in increased permanent brightness though it may be necessary with metal of the order of 99·2 per cent. purity to increase the electrolyte temperature to 90° C. with a current density of 50 amp./ft.^{2}, or higher.

Although the experimental work described was carried out using pure aluminium sheet, the reaction of a certain number of alloys was also investigated. In a certain number of cases the results were disappointing, but a few alloys have been found with which the results were quite successful. The operation of the process on a scale considerably larger than is possible in a laboratory has already been tested and few difficulties were experienced.

ACKNOWLEDGMENTS.

The author desires to thank Messrs. The British Aluminium Company, Ltd., for permission to publish this paper, the Research Department of Messrs. Metropolitan-Vickers, Ltd., for the loan of the special distilled aluminium mirror, and in particular he wishes to acknowledge the valuable help given by Mr. J. T. Richmond, M.A., B.Sc., who carried out a very large proportion of the experimental work. He also desires to thank Dr. A. G. C. Gwyer for his continued interest throughout the investigation.

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STUDY OF THE FORGEABILITY OF VARIOUS LIGHT AND ULTRA-LIGHT ALLOYS.*

By Professor ALBERT PORTEVIN,† Member, and Dr. PAUL G. BASTIEN,‡ Member.

Synopsis.

The authors have endeavoured to determine, by means of laboratory tests, the optimum conditions for hot-working light and ultra-light alloys. With this in view they have compared the results obtained from static bending and compression tests and dynamic bending and tensile tests. They have indicated the important part played by the rate of deformation, and have shown that the bending test appears to be the most convenient, speedy, and sensitive. The tests have been carried out on aluminium; on copper–aluminium alloys containing 6 and 12 per cent. of copper; on aluminium–magnesium alloys containing 5, 10, and 15 per cent. of magnesium; on magnesium; on magnesium–copper alloys containing 5, 10, and 15 per cent. of copper; and on magnesium–aluminium alloys containing 3, 6, and 9 per cent. of aluminium. The methods of testing employed have made it possible to define the capacity for hot-work of these various alloys.

Introduction.

The study of the mechanical properties of metallic materials at high temperatures is a subject which is very much in the foreground at the present moment, and which has given rise to a number of researches. It can be dealt with under two headings:

(1) Research on materials which are resistant at high temperature; in other words, determination of the temperature up to which deformations and speeds of deformation remain below certain values which are considered to be suitable in industry. The deformations and speeds of deformation must, therefore, remain excessively small. It is necessary on the one hand to carry out very prolonged tests in order to ascertain the law of deformation and on the other hand to make use of very sensitive methods to measure these deformations.

(2) Research on the possibilities and conditions of forming at high temperatures; in other words, the temperatures or ranges of temperature for which the amplitude of deformation and the value of the speed of deformation are large enough to be used industrially, that is to say,

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Note to Abstractors and Other Readers.—This paper will be published, in permanent form, in the *Journal of the Institute of Metals*, Vol. LIX, 1936.

are above certain comparatively large values. The deformations studied, being large under these conditions, do not need to be amplified, and the temperatures are, for the same type of material, higher than those in the preceding case. The tests are very rapid, since industrial forming of materials must be rapid.

It will be seen, then, that in the two cases the ranges of temperature attained for the same metal will be very different and that the choice of tests and methods of measurement also will be very different.

This paper will only deal with the second problem, limiting it to light alloys, *i.e.* alloys rich in aluminium, and ultra-light alloys which are rich in magnesium, and it is proposed to present here results of experiments carried out by mechanical means, ignoring for the moment the structural study of deformations and their consequences.

PART I.

(1) OBJECTS AND METHODS OF THIS STUDY.

The object of this study is to determine by accurate measurements the best conditions for forging two types of light and ultra-light alloys. Work carried out on steels * has shown that the methods of test which are most suited to the study of forgeability are: (*a*) tensile and compression tests; (*b*) static bending and shock tests; and (*c*) torsion tests. In this study torsion tests which give rise to deformations very different from those occurring in forging or rolling, have not been considered.

As it appears that the tendency to fracture at high temperatures is a function not only of the method of deformation but also of the speed of deformation, the authors have been led to study both static and dynamic tests. They have used (*a*) static tests in bending and in compression, the stress–strain diagram being registered at various temperatures; and (*b*) dynamic bending and tensile tests at various temperatures without recording a diagram.

The following metals and alloys have been studied:

(a) *Light Metals and Alloys:* aluminium, copper–aluminium alloys with 6 and 12 per cent. of copper, and magnesium–aluminium alloys with 5, 10, and 15 per cent. of magnesium.

(b) *Ultra-Light Metals and Alloys:* magnesium, copper–magnesium alloys with 5, 10, and 15 per cent. of copper, and aluminium–magnesium alloys with 3, 6, and 9 per cent. of aluminium.

The alloys were prepared from 99·6 per cent. pure aluminium,

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* A. Portevin, E. Pretet, and J. de Lacombe, *Ann. Acad. Sci. Tech. Varsovie*, 1935, 11, 167; *Congrès Internat. Min. Mét. Géol., Section de Métallurgie*, 1935, 1, 339.

99·5 per cent. pure magnesium, and electrolytic copper containing 99·9 per cent. of copper. They were chill-cast in the form of rolling slabs whose dimensions were 320 × 460 × 40 mm. and from which the test-pieces were cut out and machined.

(2) DESCRIPTION OF THE EXPERIMENTAL METHODS EMPLOYED.

A. *Static Tests.*

(1) *Compression Tests.*—These were carried out on an Amsler machine whose maximum load could be varied between 100 kg. and 10 tons. The arrangements for heating and compressing the specimen *e* are shown in Fig. 2. The plungers *C* and *E* are thermally insulated from the machine by porcelain discs *b*, and the temperature is measured by the thermocouple *p*. The dimensions of the specimen are shown in Fig. 1(A). Compression tests for each test-piece were carried out until the specimen broke or until its height was reduced by 50 per cent.; to keep the compression of the specimen to this value it was surrounded by

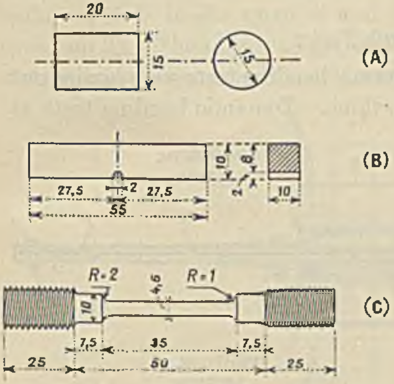

FIG. 1. (All dimensions in mm.)

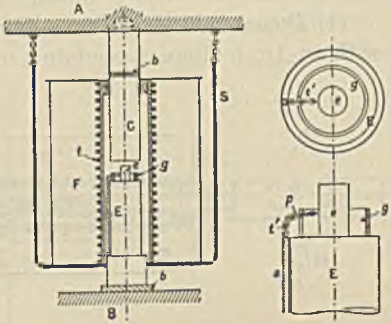

FIG. 2.

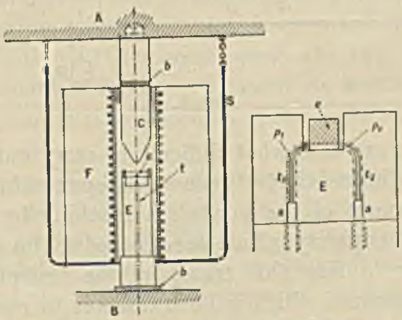

FIG. 3.

For each test the furnace was brought to a steady temperature, and the specimen was put into place by rapidly lowering and raising again the platform of the machine; it was then heated for 15 minutes and the compression test carried out.

(2) *Bending Tests.*—These were carried out in the same machine, the compressing plunger being replaced by a 45° knife edge, the edge having a radius of 5 mm. The arrangement is shown in Fig. 3, and the dimensions of the specimen in Fig. 1(B). The temperature was measured by two thermocouples one on each side of the specimen.

B. *Dynamic Tests.*

(1) *Dynamic Bending Tests.*—Dynamic bending tests were carried out with an Amsler impact pendulum machine. Dynamic bending tests at high temperature are somewhat difficult to carry out with precision: some authors have heated the test-pieces in a separate furnace and carried them to the supports of the pendulum machine by means of tongs having a high heat capacity, which were heated to the same temperature as the specimen; during this transport the test-piece undergoes a decrease of temperature which is both difficult to measure and varies with the temperature of heating and the skill of the operator. Other experimenters have heated the test-piece on the supports of the pendulum by means of an electric current. This method is inconvenient and, furthermore, uniformity of temperature is difficult to attain.

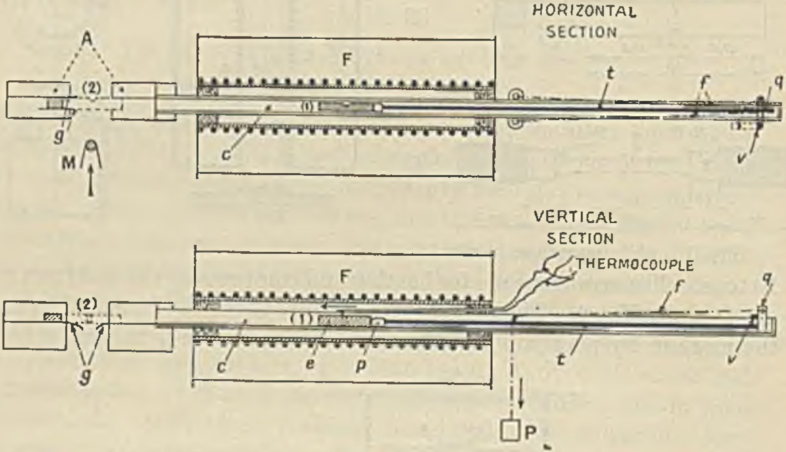

Fig. 4.

The present authors used the arrangement shown in Fig. 4. A Chevenard electric furnace *F*, whose temperature is automatically regulated, is placed perpendicular to the plane of movement of the pendulum M in such a way that its axis is in the prolongation of the straight line joining the centres of the small faces of a Mesnager test-piece placed on the supports of the apparatus. A channel C of mild steel, having a square cross-section, passes axially through the tube of the furnace, and rests on the support of the test-piece which it accurately prolongs. To heat the test-piece, it is placed in the channel in the centre of the furnace (position 1): after 15 minutes of heating the pusher p, which is given a uniformly accelerated movement by the weight P, makes it slide in the channel and puts it into place on the supports (position 2). The object of giving the pusher a uniformly accelerated motion is that the test-piece moves rapidly through the space in which it is out of the furnace. During heating a screw V holds the pusher in its initial position. This screw can be worked from a distance by a flexible joint; a second flexible joint operates on a screw holding the pendulum in its displaced position; the operator works the two flexible joints in succession. The time which elapses between the moment the test-piece leaves the furnace and that at which the hammer hits it is of the order of 0·5 second.

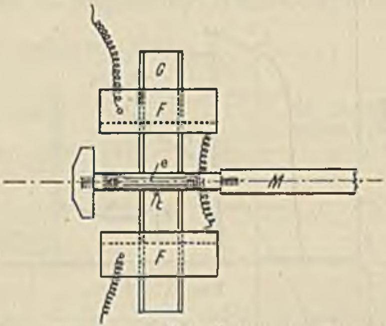

Fig. 5.

(2) *Dynamic Tensile Tests.*—Tensile tests in shock were carried out by a Charpy pendulum of 30 Kgm.; the test-piece is shown in Fig. 1(c). After being fixed on the pendulum M (Fig. 5) it was heated in the displaced position of the pendulum in an electric resistance furnace F. After 15 minutes' heating at the required temperature, the furnace was opened rapidly by displacing the two parts of which it was formed along the rails G, and the pendulum was immediately released.

The first experiments showed that the test-pieces, owing to their small rigidity, bent by reason of inertia effects due to the fall of the pendulum. To overcome this the test-piece was placed inside a had the further advantage of making the temperature more uniform along the specimen.

MEASUREMENTS CARRIED OUT.

A. *Static Tests.*

(1) *Compression Tests.*—The following factors were noted for each test :

(*a*) The rate of compression; in general this was 4 cm. per minute.
(*b*) The temperature.
(*c*) Either the breaking load or the maximum load when any rupture took place. The types of curves obtained are shown in Fig. 6.

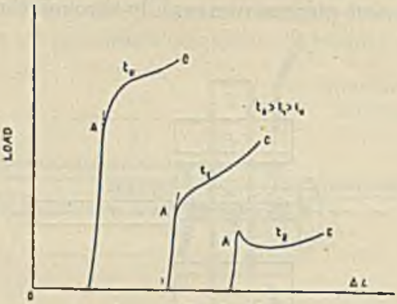

FIG. 6.

(*d*) The amount of flattening at the moment of fracture. When no fracture took place flattening was stopped when the specimen was reduced by 50 per cent.
(*e*) The appearance of the specimen.

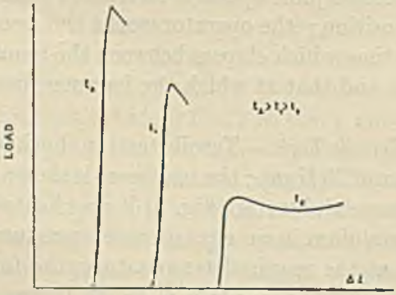

FIG. 7.

(2) *Bending Tests.*—The different types of curves obtained are shown in Fig. 7. The following were noted :

(*a*) The speed of displacement of the knife edge (generally 4 cm. per minute).

(*b*), (*c*), and (*e*) as above.
(*d*) The angle of fracture.

B. *Dynamic Tests.*

The speed of the pendulum, the temperature, and the work absorbed were noted in each case. In addition the angle of fracture or of bending (α) was noted in the case of bending tests and the elongation A on 30 mm. and the reduction in area Σ per cent. on tensile tests.

(3) The Influence of Speed of Deformation.

Experience has shown that the speed of deformation plays an important part in the forgeability of light and ultra-light alloys. The authors have studied the influence of the speed factor on two types of alloys having a low capacity of deformation: magnesium + 15 per cent. aluminium and magnesium + 15 per cent. copper.

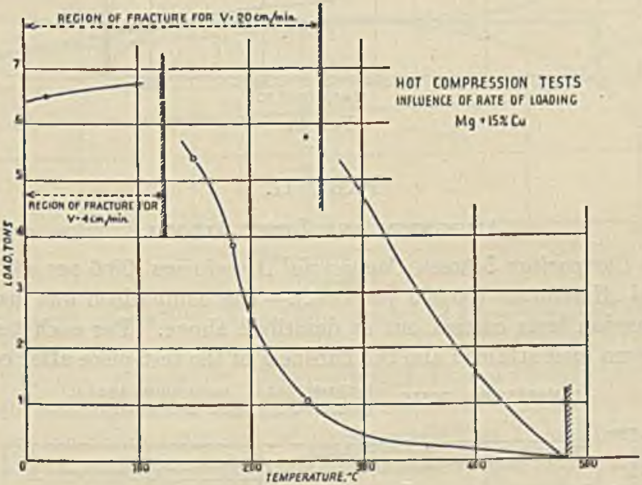

Fig. 8.

Static compression tests at various temperatures were carried out on these two alloys at rates of deformation of 4 and 20 cm. per minute, respectively. Figs. 8 and 9 show (i) the load necessary to cause the rupture of the specimen or its plastic deformation as the speed of deformation increases; (ii) that as the speed of deformation is increased the temperature over which fracture takes place is markedly displaced towards higher temperatures. This explains why in hot working light and ultra-light alloys, slow deformations are adopted (press forging for

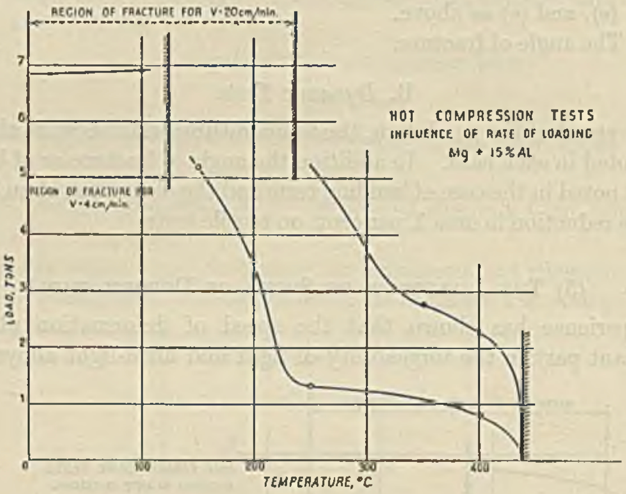

Fig. 9.

PART II.

Aluminium and Light Alloys.

(1) *Comparison between Commercial Aluminium* (99·6 *per cent.*) *and Refined Aluminium* (99·996 *per cent.*).—The comparison was made by compression tests carried out as described above. For each test the maximum load attained and the hardness of the test-piece after cooling

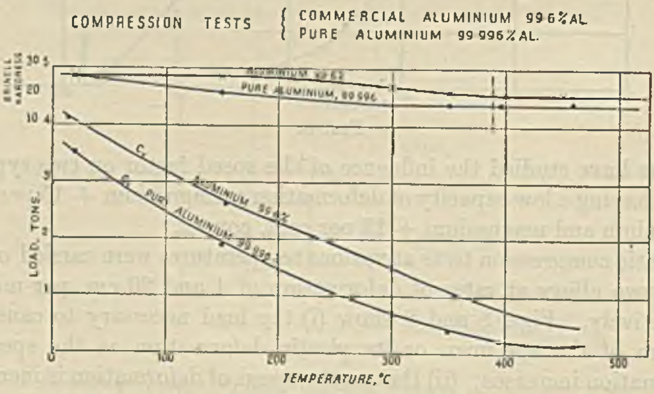

Fig. 10.

were noted. The results, which are given in Fig. 10, show that the loads are higher for commercial than for refined aluminium, and that the hardness after the test is the resultant of the increase in hardness due to working and its reduction by recrystallization. For pure aluminium the influence of the recrystallization comes into play earlier than for commercial aluminium which explains why the hardness of the pure metal remains constant above 300° C. while the same phenomenon does not take place with the commercial metal until 380°–400° C.

Owing to the plasticity of the metal, the compression tests on the aluminium test-pieces do not indicate clearly the existence of a zone of large deformability of fracture. To supplement the preceding results the authors have carried out dynamic tensile tests on commercial aluminium (Fig. 11)* which show the existence of a rapid increase of *A* per cent. and of Σ per cent. above 500° C. and a maximum of these variables at about 600° C.

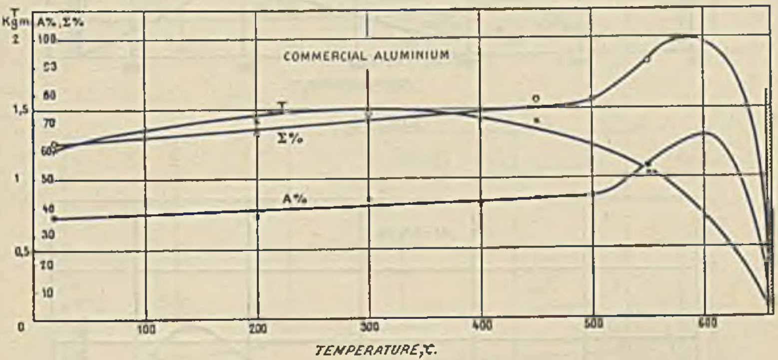

Fig. 11.

(2) *Copper–Aluminium Alloys.*—Figs. 12, 13, and 14 show the results of static bending tests, dynamic bending tests, and dynamic tensile tests on alloys containing 6 per cent. of copper, while Figs. 15 and 16 show the results of the first two tests on the 12 per cent. copper alloys. For this alloy, which is not readily deformed, the dynamic tensile tests do not give accurate results.

Attention is directed to the reduction of the range of high ductility under static bending, and of the maxima in the work and angle of bend curves under dynamic bending, in the 12 per cent. alloy compared with those of the 6 per cent. alloy.

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* *Symbols used in the curves in Figs. 11–45.* The meaning of the symbols used in the curves is given below:

R = maximum load in bending.
F = bend in mm. on a bend test.
ρ = work absorbed in an impact test.
α = angle of bend in an impact test.
T = maximum stress in a dynamic tensile test.

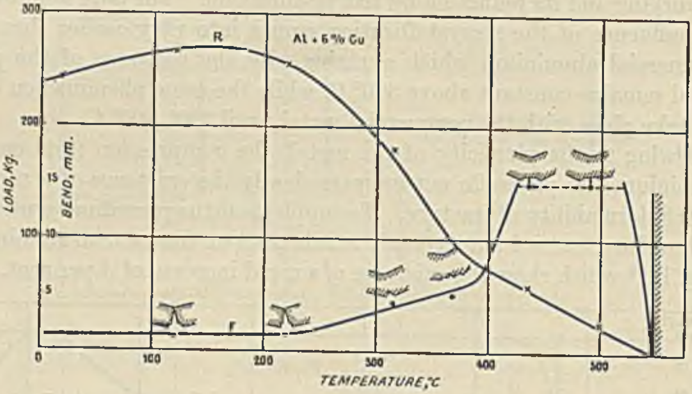


Fig. 12.

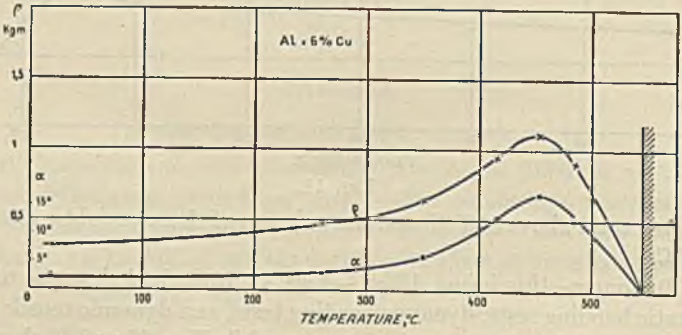


Fig. 13.

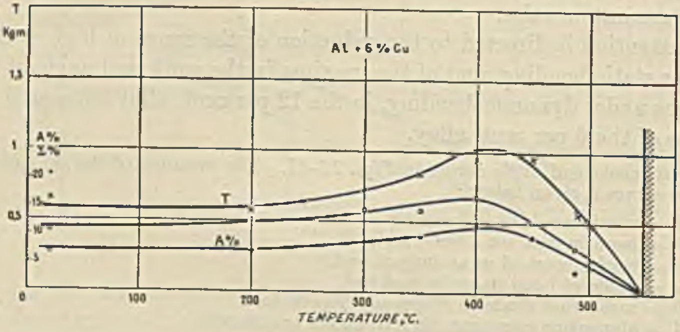


Fig. 14.

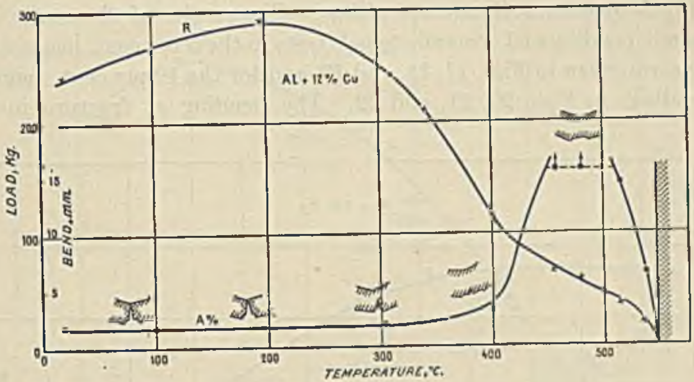

300
200
100
0
LOAD, Kg.
BEND, mm.
15
10
5
0
R
Al + 12% Cu
A%
0
100
200
300
400
500
TEMPERATURE, °C.

FIG. 15.

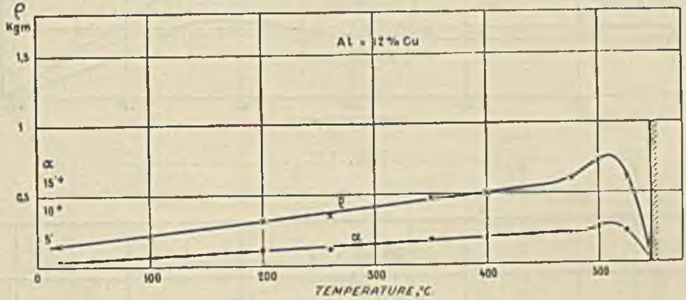
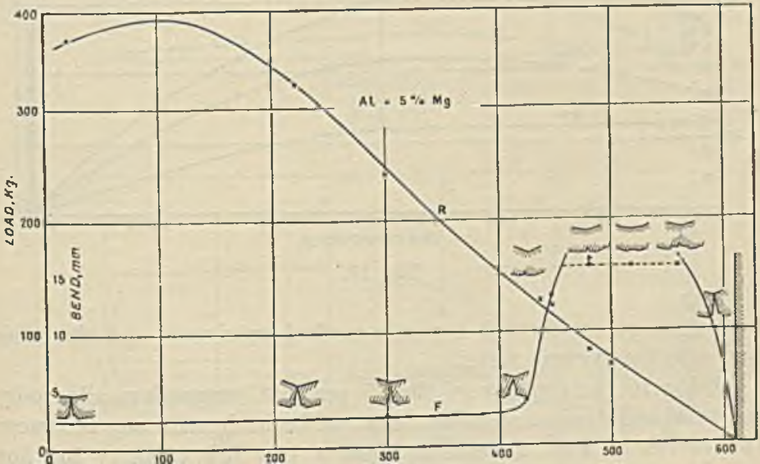

ρ
Kgm
1,5
1
0,5
α
15°
10°
5°
Al + 12% Cu
ρ
α
0
100
200
300
400
500
TEMPERATURE, °C

FIG. 16.


400
300
200
100
0
LOAD, Kg.
BEND, mm
15
10
5
Al + 5% Mg
R
F
0
100
200
300
400
500
600

(3) *Magnesium–Aluminium Alloys.*—The results of the static and dynamic bending and dynamic tensile tests in the 5 per cent. magnesium alloys are given in Figs. 17, 18, and 19, and for the 10 per cent. magnesium alloys in Figs. 20, 21, and 22. The bending at fracture in the static tests passes through a poorly-marked maximum, and the same applies to the dynamic tests.

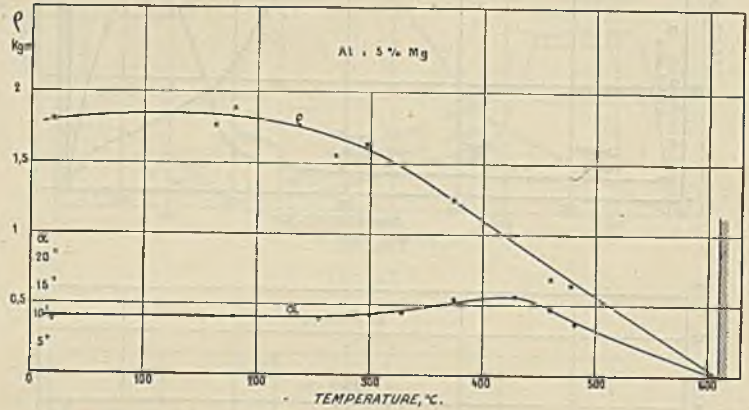


FIG. 18.

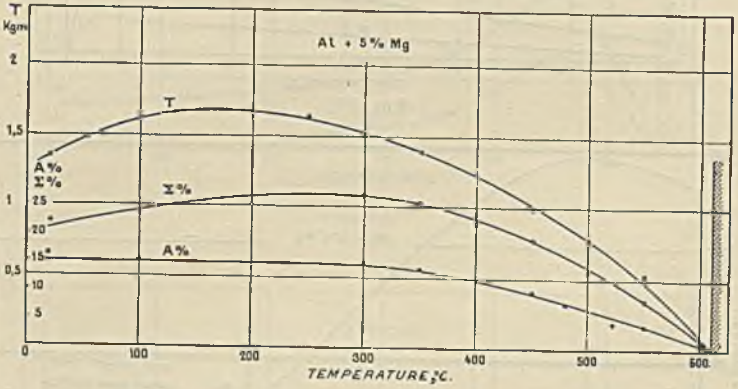


FIG. 19.

Owing to the fragility of the 15 per cent. magnesium alloy only the static and dynamic bending tests can be made with any accuracy. The curves of Figs. 23 and 24 show a very low capacity for hot deformation which gives rise to the non-forgeability of this alloy.

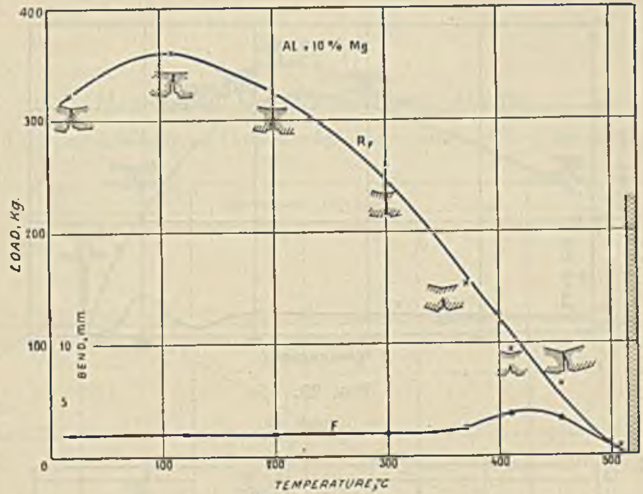

400
300
200
100
0
LOAD, Kg.
10
5
BEND, mm.
AL + 10 % Mg
R_r
F
100
200
300
400
500
TEMPERATURE, °C

FIG. 20.

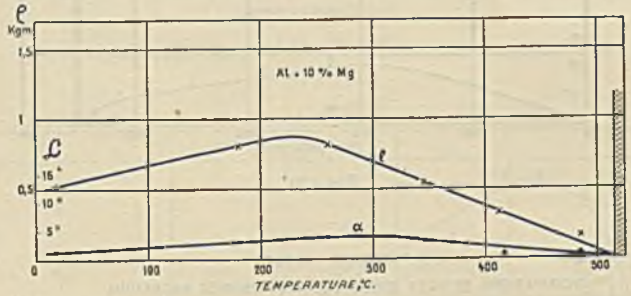
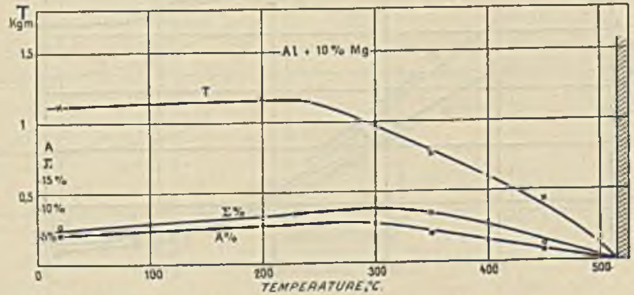

ρ
Kgm
1,5
1
0,5
0
ℒ
15°
10°
5°
AL + 10 % Mg
ρ
α
100
200
300
400
500
TEMPERATURE, °C.

FIG. 21.


T
Kgm
1.5
1
0.5
0
A
Σ
15 %
10 %
5 %
Al + 10 % Mg
T
Σ %
A %
100
200
300
400
500
TEMPERATURE, °C.

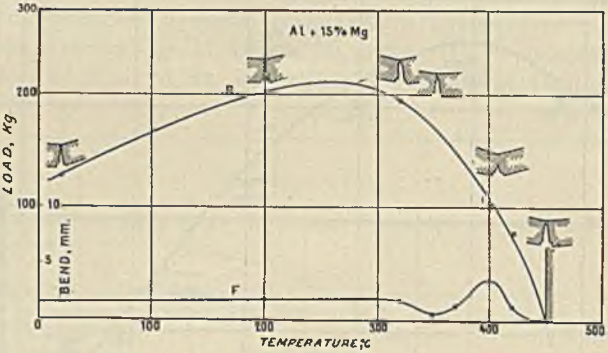


Fig. 23.

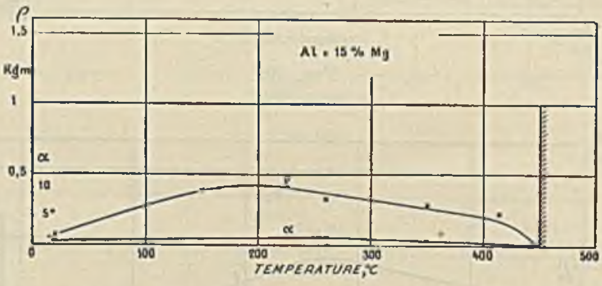


Fig. 24.

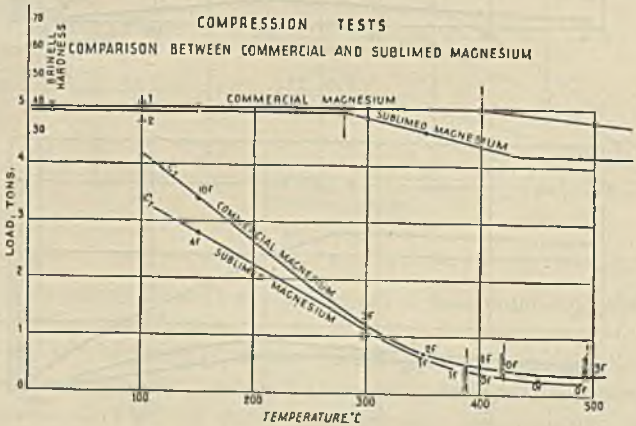


Fig. 25.

PART III.

MAGNESIUM AND ULTRA-LIGHT ALLOYS.

(1) *Comparison between Commercial Magnesium of 99·4 per cent. purity*

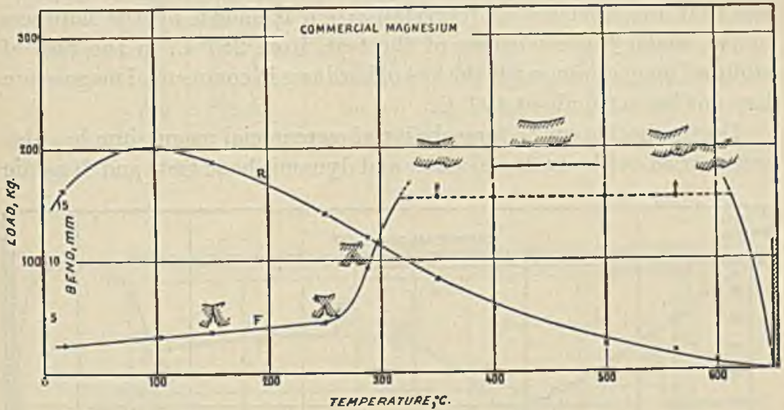


FIG. 26.

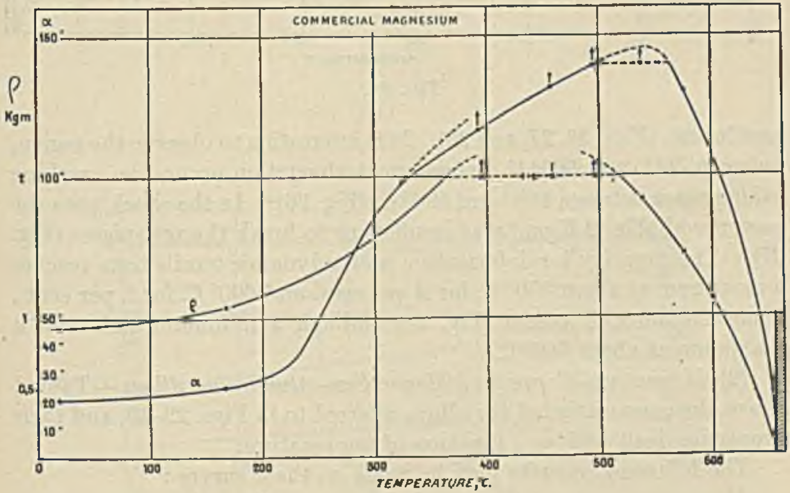


FIG. 27.

and the comparison was made by means of compression tests carried out at a rate of 4 cm./minute.

On each test the following were observed : the maximum load, the hardness of the test-piece on cooling, and the number of cracks visible on the "skin" of the metal (1*f* = one crack, Fig. 25). It is deduced that the loads are slightly higher for commercial than for sublimed magnesium and that the influence of recrystallization is shown by the hardness curves, under the conditions of the test, from 285° C. in the case of sublimed magnesium, while the loss of hardness in commercial magnesium does not begin till about 400° C.

Determination of the forgeability of commercial magnesium has also been carried out by means of static and dynamic bend tests and dynamic tensile tests (Figs. 26, 27, and 28). It is interesting to observe the region, between 300° and 600° C., where great elongation occurs, no cracking taking place between 400° and 550° C. (Fig. 26). In the shock tests the power available (2 Kgm.) was insufficient to break the test-pieces (Fig. 27). The capacity for deformation under dynamic tensile tests reaches a maximum at about 550° C. for *A* per cent. and 600° C. for Σ per cent., while the work *T* passes (Fig. 28) through a minimum and then a maximum at about 560° C.

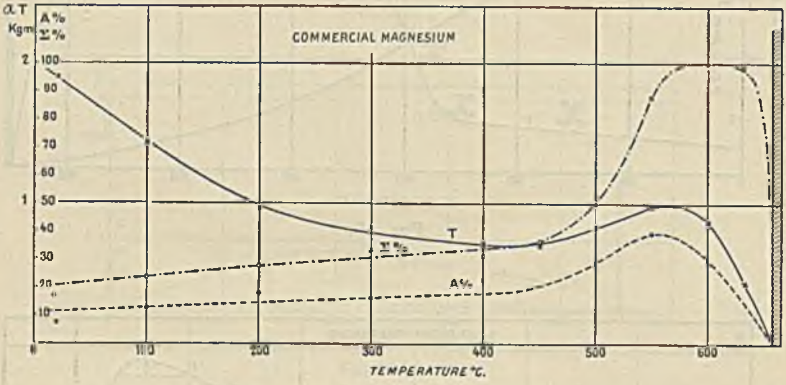


Fig. 28.

(2) *Magnesium–Copper and Magnesium–Aluminium Alloys*.—Table I shows the composition of the alloys referred to in Figs. 29–45, and their properties dealt with as a function of temperature.

The following remarks may be made on these curves :

Magnesium-Copper Alloys.—A maximum exists on the curves showing capacity of deformation; it is more marked on the static tests than on the dynamic ones and on the low-copper alloys than on those of higher

TABLE I.

Alloy.	Static Bending.	Dynamic Bending.	Dynamic Tensile.
Mg + 5% Cu	Fig. 29	Fig. 30	Fig. 31
Mg + 10% Cu	,, 32	,, 33	,, 34
Mg + 15% Cu	,, 35	,, 36	,, 37
Mg + 3% Al	Fig. 38	Fig. 39	Fig. 40
Mg + 6% Al	,, 41	,, 42	,, 43
Mg + 9% Al	,, 44	,, 45	...

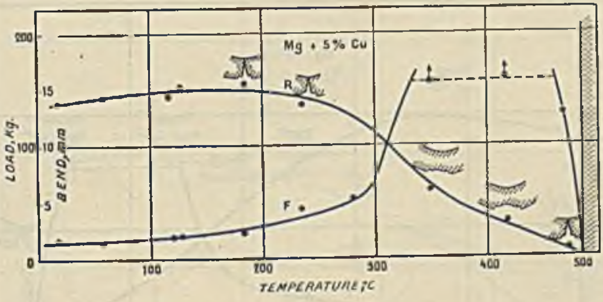


FIG. 29.

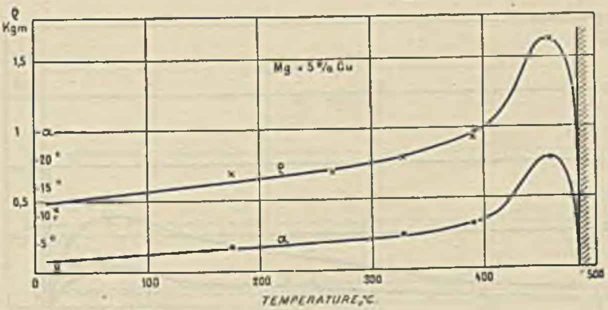


FIG. 30.

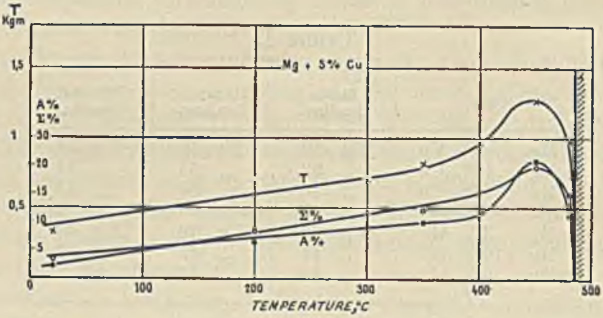


FIG. 31.

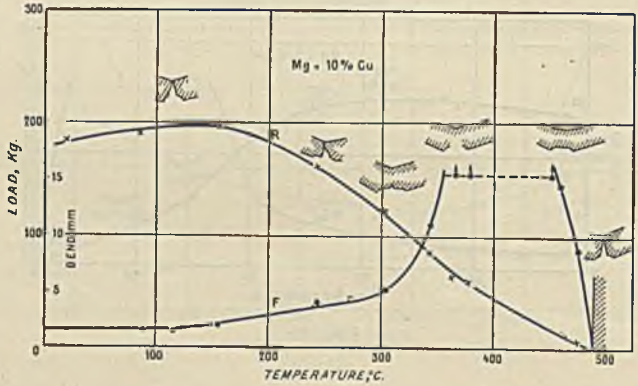


FIG. 32.

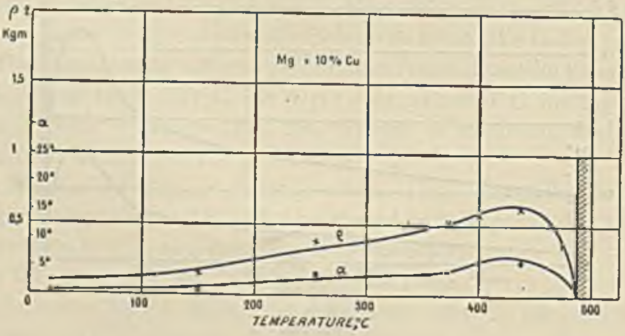


FIG. 33.

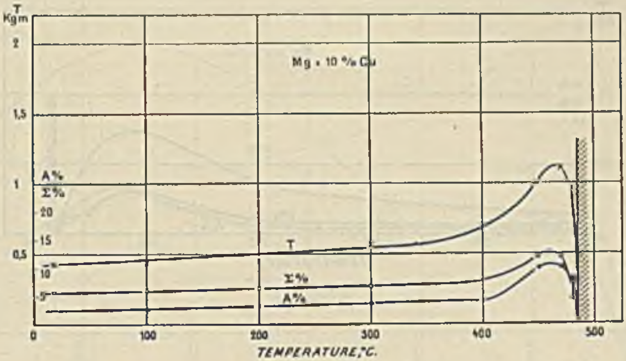


Fig. 34.

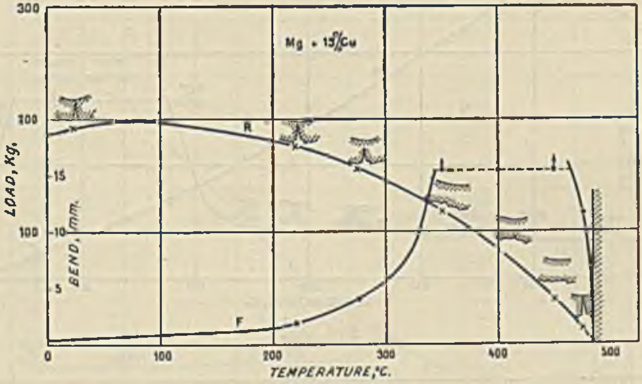


Fig. 35.

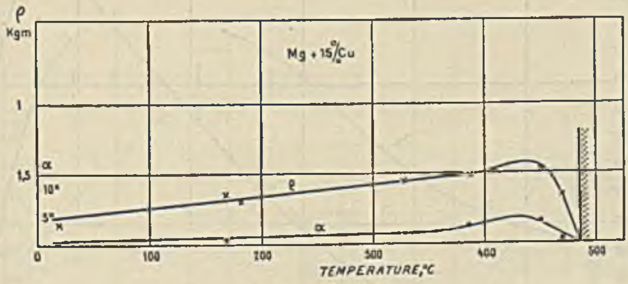


Fig. 36.

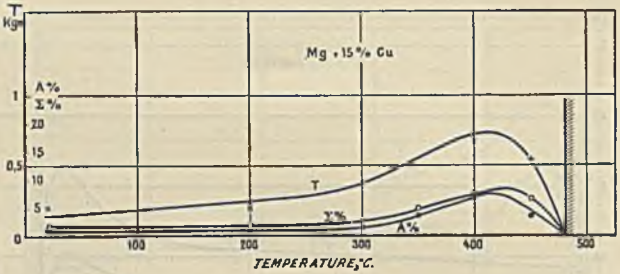


Fig. 37.

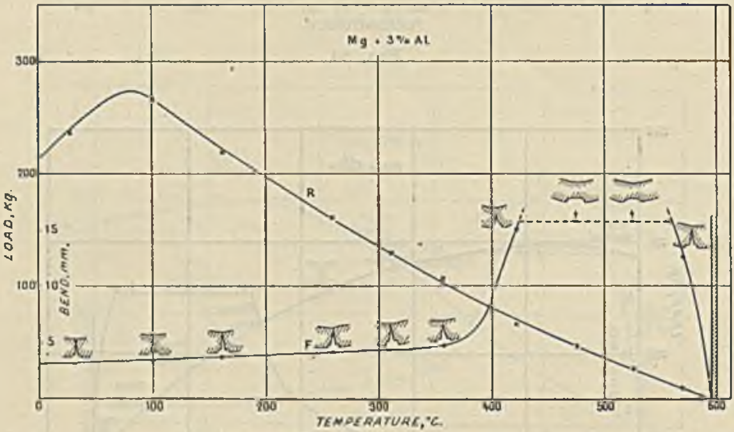


Fig. 38.

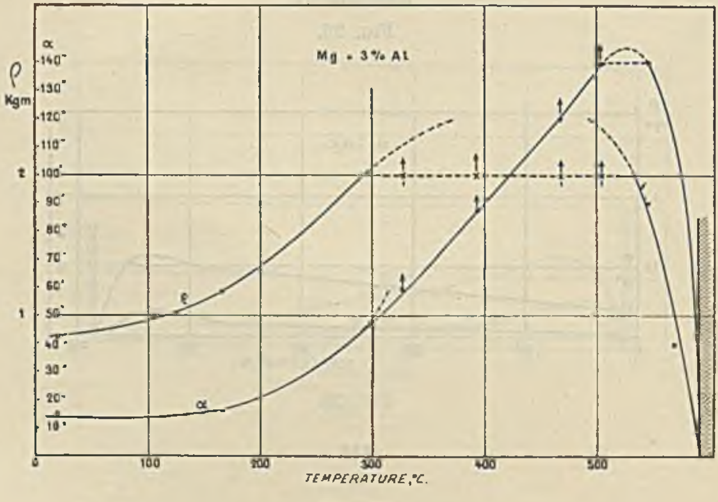


Fig. 39.

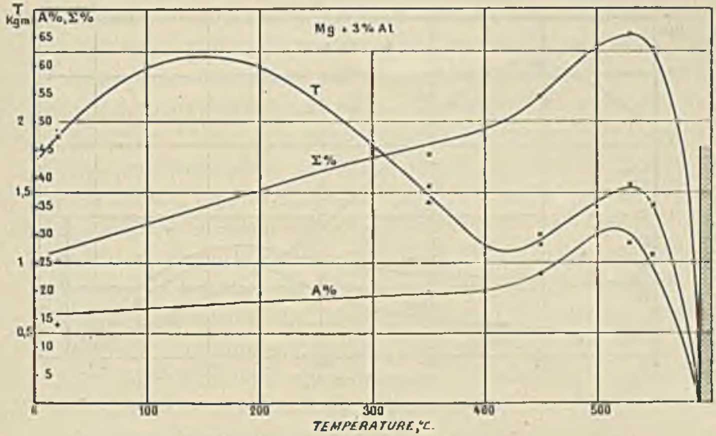

T
Kgm
A%, Σ%
Mg + 3% Al
T
Σ%
A%
65
60
55
50
45
40
35
30
25
20
15
10
5
2
1,5
1
0,5
0
100
200
300
400
500
TEMPERATURE, °C.

FIG. 40.

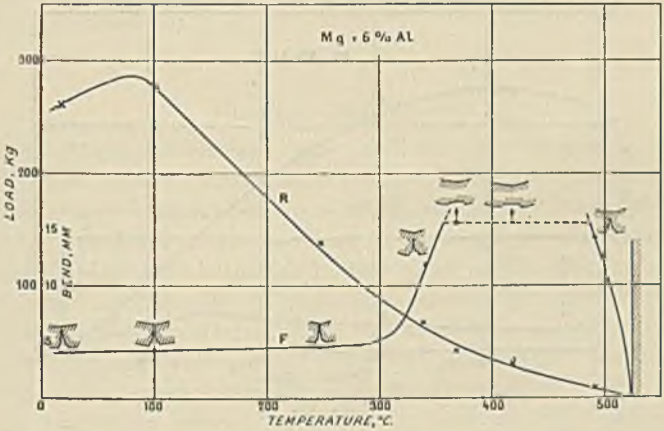
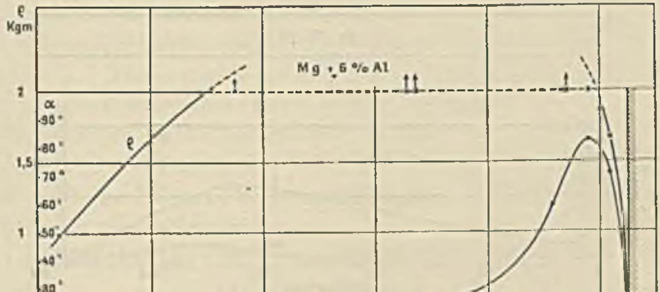

Mg + 6% Al
LOAD, Kg
BEND, MM
300
200
100
15
10
5
R
F
0
100
200
300
400
500
TEMPERATURE, °C.

FIG. 41.


ρ
Kgm
Mg + 6% Al
2
1,5
1
α
90°
80°
70°
60°
50°
40°
30°
ρ

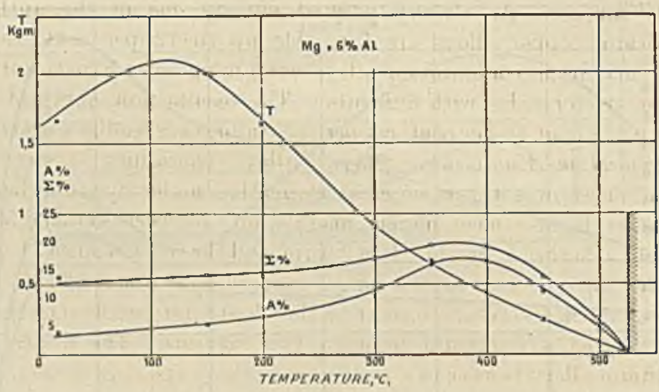


FIG. 43.

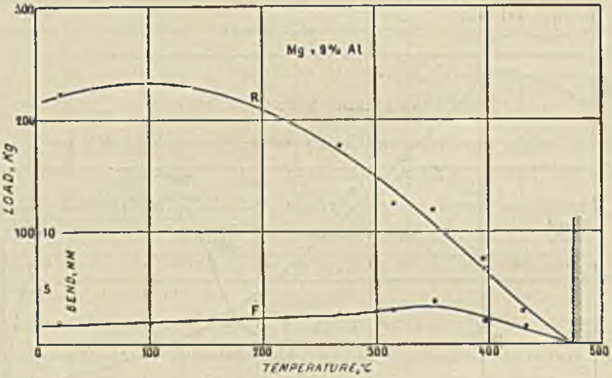


FIG. 44.

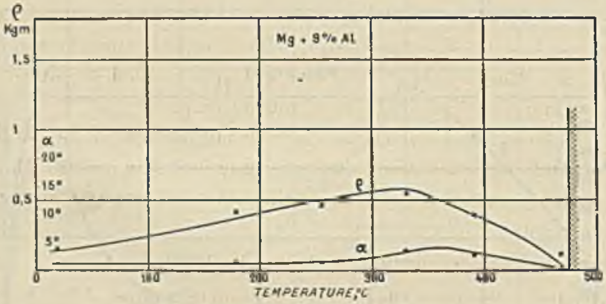


FIG. 45.

copper content. As already pointed out by one of the authors,* magnesium–copper alloys are forgeable up to 12 per cent. copper, whilst magnesium–aluminium alloys containing over 8 per cent. aluminium are forgeable with difficulty. The results now obtained show that up to about 15 per cent. copper these alloys are readily worked hot.

Magnesium–Aluminium Alloys.—Alloys containing 3 per cent. aluminium show a region of great elongation under dynamic bending tests, as is the case in commercial magnesium; between 300° and 530° C. the work absorbed is greater than 2 Kgm. and the test becomes a bending one, the angle of fracture reaching a maximum at about 530° C. The curve of shock fracture is similar to that found for commercial magnesium, having a minimum between two maxima. The 6 per cent. aluminium alloys behave in a similar way, the maxima in general being less marked, but the 9 per cent. aluminium alloys have little capacity for hot-deformation though the curves for F, ρ, and α have a slight maximum towards 350° C. The alloys were too brittle for the dynamic tensile test to be carried out.

GENERAL CONCLUSIONS.

The following conclusions apply to all the alloys studied:

(1) *Static Bending Tests.*—In every case, resistance to static bending passes through a more or less spread out maximum between 100° and 200° C. The bend at the moment of fracture, on the other hand, increases continually with temperature until a sudden decrease takes place at the melting point. Comparative curves follow the same course, the maximum being replaced, in the case of the more plastic alloys, by a fictitious flat, due to the passage of the test-piece between the supports. This flat ends, almost invariably, about 35° C. below the solidus.

(2) *Comparison between Static and Dynamic Bending.*—If capacity of deformation be defined by the bend in static bending and by the angle of fracture in dynamic bending, it is observed that the curves follow the same course and have a maximum, which is very much less marked for the angle α. The capacity for deformation by shock is, therefore, very much less, and sometimes the maximum disappears.

The positions of the maxima on the temperature scale do not agree on static and dynamic tests, being higher on the latter; this is connected with the influence of recrystallization after deformation, which is greater on slow deformation.

It appears that the absence of a maximum on the dynamic curves (or a very small maximum) indicates an alloy which is not practically forgeable, while even a narrow flat on the static curve indicates an alloy which can be forged at slow speeds or rolled.

The curve of variation of work absorbed on shock ρ is in general the same as that of the angle of fracture α and is unaffected by the maximum noted on that of the static load of fracture. In certain cases a maximum angle of fracture occurs without the occurrence of a maximum of work absorbed, at any rate in the same temperature range (*e.g.* aluminium + 5 per cent. magnesium).

(3) *Comparison of the Results obtained on the Different Dynamic Tests.*—This comparison only holds for alloys which are neither too brittle (aluminium + 12–15 per cent. magnesium) or too ductile (pure aluminium).

The curves representing capacity for deformation (those of the angle of fracture α, the elongation A per cent. or the reduction in area Σ per cent.) follow the same course without the maxima always occurring at the same temperature, those of tensile tests being generally lower (magnesium + 6 per cent. aluminium; aluminium + 5 per cent. magnesium or 6 per cent. copper); this is doubtless due to the influence of deformation by compression during bending.

The work absorbed in bending ρ, or in tension T, undergoes the same kind of variation, but T has sometimes a maximum at low temperatures (100°–200° C.), *e.g.* in magnesium + 3 per cent. aluminium and aluminium + 5 per cent. magnesium.

Under the experimental condition employed, the work absorbed on shock, ρ, gives the more sensitive and more economic evaluation; although the work absorbed in tensile shock gives, for the very ductile materials (unalloyed aluminium and magnesium), a value in accord with that of fracture in the region of deformability (which is not the case in bending); this is not of great practical interest, since in any case the thermal region for forging is clearly indicated by the constant value of the flats on the curves.

To sum up, static or dynamic bend tests appear to be the most suitable, convenient, and rapid for studying the forgeability of light and ultra-light alloys; where the metals are difficult to forge these tests make possible a determination of the best temperature range in which to carry out the work.

(4) *Comparison between the Different Alloys Investigated.*—From the results of these tests it would appear that magnesium alloys can be extruded up to about 15 per cent. of copper and about 9 per cent. of aluminium, and can with care be forged up to about 15 per cent. of copper and 7–8 per cent. of aluminium.

As for the aluminium alloys, that containing 12 per cent. copper should be able to be extruded and forged with care; while for those containing magnesium, the limit of forgeability must lie between 5 and 10 per cent. magnesium for metals of the purity employed.

Bibliography.

[1] P. Ludwick, *Z.V.d.I.*, 1915, **59**, 657–664.
[2] W. Rosenhain, S. L. Archbutt, and D. Hanson, "Eleventh Report to the Alloys Research Committee on Some Alloys of Aluminium (Light Alloys)," *Inst. Mech. Eng.*, 1921, pp. 256.
[3] Martin Thomas, *J. Inst. Metals*, 1924, **31**, 121–152.
[4] P. Chevenard and A. Portevin, 5ème. Congrès de Chimie Industrielle, Paris, October 1925; *Chim. et Ind.*, 1926, **16**, 454.
[5] D. H. Ingall, *J. Inst. Metals*, 1925, **34**, 171–182.
[6] A. Portevin, *Rev. Mét.*, 1929, **26**, 435.
[7] J. Cournot, *Rev. Mét.*, 1929, **26**, 326.
[8] A. Portevin and F. Le Chatelier, *Compt. rend.*, 1929, **189**, 248.
[9] W. Schwinning and F. Fischer, *Z. Metallkunde*, 1930, **22**, 1.
[10] H. Sieglerschmidt, *Z. Metallkunde*, 1931, **23**, 26.
[11] R. L. Templin and D. A. Paul, *Symposium on Effect of Temperature on the Properties of Metals. Held at Joint Meeting of Amer. Soc. Mech. Eng. and Amer. Soc. Test. Mat.*, **1931**, 290–313.
[12] D. Hanson and M. A. Wheeler, *J. Inst. Metals*, 1931, **45**, 229–257.
[13] T. Kobayashi, *Mem. Ryojun Coll. Eng.*, 1930, **3**, 145; *Brit. Chem. Abs.*, **1931**, [B], 25.
[14] H. Bohner and R. Vogel, *Z. Metallkunde*, 1932, **24**, 169.
[15] L. Morell and J. Hanawalt, *Phys. Rev.*, 1932, [ii], **40**, 1035.
[16] S. I. Goulkin, *J. Geology*, 1932, **3**, 501–548.
[17] E. Decherf, *Aciers spéciaux*, 1932, **7**, 329–344; 1933, **8**, 102–108, 315–327.
[18] A. E. van Arkel and M. van Bruggen, *Z. Physik*, 1933, **80**, 763–791.
[19] W. Schmidt (with H. Altwicker, A. Beck, H. Bothmann, E. Schmid, W. Schulze, and W. Spitaler), *Z. Metallkunde*, 1933, **25**, 229–236.
[20] R. Streeter, *Trans. Amer. Soc. Mech. Eng.*, 1933, **55**, IS, 55–57, 61–59.
[21] P. Bastien, *Rev. Mét.*, 1933, **30**, 528–542.
[22] A. von Zeerleder, R. Irmann, and E. von Burg, *Schweiz. Arch. angew. Wiss. Tech.*, 1935, **1**, 49–55.
[23] A. von Zeerleder and R. Irmann, *Z. Metallkunde*, 1935, **27**, 145–148.
[24] J. Robinson, *Met. Ind.* (*Lond.*), 1936, **48**, 87–91.
[25] A. Portevin and P. Bastien, *Compt. rend.*, 1936, June 15.

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   - (*b*) First-class reviews of, or accounts of, progress in a particular field;
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AUTHOR INDEX TO ABSTRACTS

Author Index to Abstracts

METALLURGICAL ABSTRACTS

(GENERAL AND NON-FERROUS)

Volume 3 AUGUST 1936 Part 8

I.—PROPERTIES OF METALS

(Continued from pp. 237–245.)

***Experiments on the Influence of the Grain Boundaries on the Deformation of Test-Bars [of Aluminium] Consisting of Many Large Crystals.** Gerhard Seumel (*Z. Krist.*, 1936, **93**, (3/4), 249–284).—[In German.] Cylindrical test-bars of aluminium containing several crystals were prepared by the method of Carpenter and Elam, and their deformation under tension was studied by the measurement of suitable marks. The use of small closed curves drawn by a pair of compasses on the surface of the cylinder is recommended. In general, the deformation of a crystal in the neighbourhood of a grain boundary is of the same nature as that in the main body of the grain, but of smaller magnitude. The grain boundary thus diminishes deformation, but does not destroy it entirely, and does not give rise to slip on new planes. The formation and density of slip-lines was also studied. In the neighbourhood of the grain boundary no new combinations of slip-lines are formed. The slip-lines tend to form "packets," but the density of the fine lines is independent of the amount of deformation, although it is less in the neighbourhood of a grain boundary.—W. H.-R.

***The Deep-Drawing Capacity of Pure Aluminium Sheets of Various Degrees of Hardness.** (Helling.) See p. 322.

***Rate of Crystallization of Aluminium of 99·992% Purity.** J. Czochralski and J. Mikołajczyk (*Wiadomości Instytutu Metalurgji i Metaloznawstwa* (*Warszawa*), 1936, **3**, (2), 106–107).—[In Polish, with French summary.] A single-crystal rod of 99·992% aluminium can be drawn out from a bath of metal maintained at the melting point at a maximum speed of 160 mm./minute; this rate is the same as that previously found for 99·9% metal, hence it appears that the presence of small amounts of impurities has little or no influence on the rate of crystallization of aluminium but only influences the number of centres of crystallization which form during solidification. The diameter of the single crystal formed by this method increases hyperbolically with decrease in the rate of drawing out of the rod.—A. R. P.

***Relation of Electrical Resistance and Grain-Size of Aluminium.** Soji Hori (*Kenkyu Hokoku, Sumitomo Shindokokan Kaisha* (*Res. Rep. Sumitomo Copper and Steel Tube Co.*), 1935, **2**, (3), 239).—[In Japanese.]—S. G.

***Measurement of the Pressure Changes in Aluminium Dust Explosions.** W. Gliwitzky (*Z.V.d.I.*, 1936, **80**, (22), 687–692).—Tests carried out in a specially constructed apparatus at the Chemisch-Technische Reichsanstalt in Berlin show that the pressure developed by the explosion of a definite quantity of the dust in 1 litre of air increases with the fineness of the dust, pressures up to 12·6 atm. being observed.—K. S.

***Plasticity of Bismuth Crystals.** H. J. Gough and H. L. Cox (*Nature*, 1936, **137**, (3469), 701).—Although bismuth single crystals usually deform under alternate compression and tension by twinning and fracture by cleavage parallel to the 0001 plane, under a static compression force applied parallel to the same axis they may deform by slip along the same plane. Photographs of the appearance of the slip-bands are included.—A. R. P.

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* Denotes a paper describing the results of original research.

† Denotes a first-class critical review.

***Recrystallization Diagram of Cadmium.** (Czochralski and Miazga.) See p. 303.

***The Diffusion of Hydrogen Through Copper.** E. O. Braaten and G. F. Clark (*Proc. Roy. Soc.*, 1936, [A], **153**, (880), 504–512).—The rate of diffusion of hydrogen through copper was determined for several temperatures and pressures. The effect of temperature is represented by the usual exponential relation, and an activation energy of 19,700 cal./grm. atom was obtained. The effect of pressure can be nearly represented by $M\alpha p^{\frac{1}{2}}\frac{c_2p}{1 + c_2p}$. The small departure from the above equation which occurs at about 2 mm. pressure is thought to be due partly to the adsorption factor.—S. G.

***The Effect of Annealing on the Length of Cold-Drawn Rods.** (Saito.) See p. 322.

***Thermoelectric and Voltaic Properties of Normal and Abnormal Metallic Films [Gold].** Romolo Deaglio (*Compt. rend.*, 1936, **202**, (10), 831–832).—A very thin film of green gold (of some mμ thickness) is deposited on a glass plate with two electrodes of massive gold (about 1 μ thick) on either side in contact with it. According to Perucca's hypothesis (*Met. Abs.* (*J. Inst. Metals*), 1931, **47**, 71) the film owes its abnormal conductivity to a concentration, C_1, of electrons of a lower conductivity, and the concentration, C_2, of the massive metal. $\frac{C_1}{C_2}$ may be less than 10^{-9}. The arrangement described may be considered as a thermoelectric pile, the film, poorer in electrons, being thermoelectrically negative. If one of the electrodes is heated to 70° C., the other being at 20° C., the e.m.f. of the chain varies between $5 \cdot 10^{-4}$ and $40 \cdot 10^{-4}$ v. for films whose resistance, measured between two opposite sides of a square section, lay between $5 \cdot 10^5$ and 10^9 ω. Thus, two conductors, massive gold and a thin green film of gold, are voltaicly equivalent but thermoelectrically different. This is explained by Perucca's hypothesis.—J. H. W.

***The Solubility of Lanthanum in Mercury from 0° to 50° C.** W. George Parks and Joseph L. Campanella (*J. Physical Chem.*, 1936, **40**, (3), 333–341).—Lanthanum amalgams were made by heating the metal with mercury or by electrolysis of $LaBr_3 \cdot H_2O$ in absolute ethyl alcohol. At 0°–50° C. the solubility is given by $\log N = (-1020/T) - 0{\cdot}4575$, in which N denotes the atomic fraction of lanthanum contained in the saturated amalgam at T° abs. Lanthanum has a high internal pressure, approximately the same as that of bismuth.—J. S. G. T.

***Effect of the Thermal Variations of the Molecular Field on the Curie Constant [Nickel and Cobalt].** L. Néel (*Compt. rend.*, 1936, **202**, (12), 1038–1040).—It is shown that if C = the Curie constant found experimentally, C_0 the atomic Curie constant, and θ the Curie point: $C = C_0(1 + \rho\theta)$. For nickel and cobalt, $\rho\theta$, C, and C_0 are, respectively, $-0{\cdot}140$, 0·323, 0·379, and $+0{\cdot}148$, 1·14, 0·99. The quantum theory shows that for one non-compensated spin per atom, the Curie constant is equal to 0·372, and that for two non-compensated spins to 0·993. These two values are very close to the values of C_0 obtained for nickel and cobalt, respectively, from which it may be inferred that nickel possesses one, and cobalt two, non-compensated spins per atom. Whatever the explanation, even if the conclusions reached are not exactly true, it still remains that for all the paramagnetic materials with a strong molecular field, that which has hitherto been called the Curie constant is not the true one, and must not be interpreted as such. The above equation gives the means for calculating the true value, C_0.—J. H. W.

***Permeability of Palladium to Hydrogen. Loss of Diffusing Power of Pure Palladium under the Action of Temperature. Regeneration of Poisoned Palladium.** Victor Lombard, Charles Eichner, and Maxime Albert (*Compt.

rend., 1936, 202, (21), 1777–1779).—Using special apparatus, the permeability of very pure palladium between 250° and 500° C. was determined. It can be represented by two branches of continuous curves one under the other. The following conclusions were reached: (1) a diaphragm of pure palladium having high permeability to hydrogen loses a considerable part, if not all, its diffusing power on sufficiently prolonged heating above 500°–520° C. in the presence of hydrogen; (2) this loss is progressive and the more rapid the higher the temperature; (3) it is non-reversible; but (4) it can be checked by reducing the temperature to below 450°–500° C.; (5) palladium foil can thus be brought to states of different stable permeability; (6) only the state of maximum permeability would be characteristic of the metal; (7) by heating a diaphragm of diminished permeability to 500° C. in a current of air, cooling in air, and subsequently reducing by hydrogen below 140° C. the superficial film of oxide formed, most or all of the lost diffusing power is restored; (8) oxidation at about 500° C., followed by reduction at the same temperature does not improve the permeability of the foil; (9) the same diaphragm of pure palladium is susceptible to many poisonings and successive regenerations; (10) the process of regeneration recalls the preparation of metal catalysts by hydrogenation; (11) the state of the surface must, therefore, play a very important part in the mechanism of the diffusion of hydrogen through palladium; (12) according to this theory, the loss of diffusing power by elevation of the temperature is the result of a more or less advanced agglomeration of the fine, superficial granules of the diaphragm, causing a diminution in their surface area; (13) the temperature of the beginning of agglomeration is about 500° C. in the case of pure palladium; (14) it will be considerably increased by the presence of certain impurities in commercial palladium, but might be decreased in certain other cases; (15) sufficient data are not yet available to choose between the various theories possible to account for the phenomenon.
—J. H. W.

***The Decomposition of Nitrous Oxide on the Surface of Platinum. II.—The Effect of Foreign Gases.** E. W. R. Steacie and J. W. McCubbin (*Canad. J. Research*, 1936, [B], 14, (3), 84–89).—Further experiments were carried out on the kinetics of the decomposition of nitrous oxide on the surface of platinum. Observations on the effect of foreign gases confirm the previous conclusion that inert gases may exert a surprisingly large retarding effect by hindering the diffusion of the reactant to the more remote parts of a porous catalyst. *Adsorption* measurements were also made, and their bearing on the mechanism of the reaction is discussed.—S. G.

Electrochemistry of Polonium. (Haissinsky.) See p. 311.

***Rate of Crystallization of Sodium. Relation Between the Atomic Heat of Crystallization and the Rate of Crystallization of Some Metals and Non-Metals.** (Czochralski and Garlicka.) See p. 303.

***Theory of the Work-Function. II.—The Surface Double Layer [with Special Reference to Metallic Sodium].** John Bardeen (*Phys. Rev.*, 1936, [ii], 49, (9), 653–663).—Theoretical (cf. Wigner and Bardeen, *Met. Abs.*, this vol., p. 293). The moment of the electrical double layer at the surface of an ideal metal is calculated approximately. It is concluded that the surface barrier is due principally to exchange and polarization forces, and that ordinary electrostatic forces play a minor rôle. An approximate agreement is found between the calculated and experimental values of the work-function of sodium.—W. H.-R.

***The Transformation of β-Tin to α-Tin.** M. Chertok (*Tech. Physics U.S.S.R.*, 1935, 2, (6), 591–597).—[In German.] See *Met. Abs.*, 1935, 2, 661.
—S. G.

***Resilience of Armco Iron, Mild Steel, and Zinc as a Function of the Temperature and Crystal Size.** G. Welter and S. Danielecki (*Wiadomości Instytutu Metalurgji i Metaloznawstwa* (*Warszawa*), 1935, 2, (1), 6–9).—[In Polish, with German summary.] The notched-bar impact resistance of zinc increases from 0·16 at – 50° C. to 2·7 kg.-m./cm.^{2} at 100° C. and, unlike that of Armco iron, is not very different for fine- and coarse-grained structures.—A. R. P.

***Influence of the Rate of Pulling on the Resistance Qualities of Magnesium, Zinc, and Armco Iron as a Function of the Crystal Size.** G. Welter and L. Oknowski (*Wiadomości Instytutu Metalurgji i Metaloznawstwa* (*Warszawa*), 1935, 2, (1), 16–22, 23).—[In Polish, with German summary.] The values obtained for the tensile properties of fine- and coarse-grained magnesium, zinc, and Armco iron with different rates of application of the load are shown in tables and graphs. For magnesium and zinc a noticeable increase in tensile strength is observed with increase in the rate of elongation of the specimen especially at rates between 0·001 and 0·1% elongation/second; for iron the tensile strength and yield-point are considerably affected by the rate of pull. The elongations of magnesium and zinc decrease, whilst that of iron increases, with increase in the rate of pull, but the reduction in area in no case shows any constant relation to this rate. No difference can be observed between the fracture of slowly and that of rapidly pulled specimens.—A. R. P.

Cohesion of Alkali Metals. Paul Gombás (*Nature*, 1936, 137, (3475), 950).—From data referring to the energy of the metal electrons and the simply charged ions, values have been calculated for the heat of evaporation of potassium, rubidium, and cæsium which are in good agreement with the experimental values.—A. R. P.

The Creep of Metals. A. Nadai (*Trans. Amer. Soc. Mech. Eng.*, 1933, 55, APM, 61–77).—A number of idealized cases of plastic flow of a more or less simple nature are discussed with the primary intention of throwing light on how the speed of yielding influences the stresses under which metallic bars are permanently stretched or twisted at normal or elevated temperatures.—S. G.

***An Experimental and Analytical Investigation of Creep in Bending.** Gleason H. MacCullough (*Trans. Amer. Soc. Mech. Eng.* 1933, 55, APM, 55–60).—Describes an experimental and analytical study of the phenomenon of creep as it occurs in bending. Creep tests on a lead beam were carried out to determine the behaviour of originally plane sections during pure bending accompanied by creep. From the results of these tests, and of creep tests in tension and compression, a method is devised whereby the results of the usual tensile creep test may be utilized to predict the rate of creep for transverse sections of the beam. The paper concludes with several analytical examples involving creep as it occurs in pure bending.—S. G.

***A Quantum Mechanical Calculation of the Elastic Constants of Monovalent Metals.** K. Fuchs (*Proc. Roy. Soc.*, 1936, [A], 153, (880), 622–639).—The method developed by Wigner and Seitz for calculating the lattice energy and compressibility of monovalent metals is extended to account for their elastic properties. The elastic constants of lithium, sodium, potassium, and copper are calculated. For copper satisfactory agreement with the observed values is obtained. As the elastic constants of the alkalis have not been measured, the Debye characteristic temperatures of lithium, sodium, and potassium are calculated from the theoretical elastic constants and compared with the values observed at low temperatures. It is shown further that the elastic constants of metals do not obey the Cauchy relations.—S. G.

The Forming Properties of Some Non-Ferrous Sheet Metals. (Gohn.) See p. 302.

The Effects of Service Conditions on the Surface of Metals. Clement Blazey (*Met. Ind.* (*Lond.*), 1936, 48, (10), 300–302; (12), 362–363).—Read before the Australian and New Zealand Association for the Advancement of Science. Discusses metal surfaces in contact, life of wearing parts, shafts in bearings and lubricated surfaces, non-metallic contact and tarnish films, oxidation in brasses, corrosion of condenser tubes, and corrosion-fatigue. 10 references are appended.—J. H. W.

Reactions in the Solid State. Wilhelm Jander (*Z.V.d.I.*, 1936, **80**, (17), 506–510).—Discusses the results of recent work on the origin and course of reactions in the solid state and their importance in metal technology.—K. S.

***Metallic Binding According to the Combined Approximation Procedure.** H. Hellmann and W. Kassatotschkin (*J. Chem. Physics*, 1936, **4**, (5), 324–325).—The combined approximation procedure for the calculation of the chemical interaction between atoms is applied to the problem of metallic binding. The complete work will be published in *Acta Physicochimica U.R.S.S.*—S. G.

***Contribution to the Theory of the Surface Colouring [of Metals].—II.** Carl Wagner (*Z. physikal. Chem.*, 1936, [B], **32**, (6), 447–462).—The equation previously given for the formation of films on metals by treatment with gases (oxygen, halogens) (*Met. Abs.*, 1934, **1**, 132) is modified by introducing factors derived from the theory of errors. The diffusion coefficients for the equalization of concentration of the deviations from the whole number stoicheiometric composition are also calculated.—K. S.

†**On the Vapour Pressure of Metals.** A. Eucken (*Metallwirtschaft*, 1936, **15**, (2), 27–31; (3), 63–68; and (summary) *Light Metals Research*, 1936, **4**, (23), 416–417).—Recent work on the subject is critically reviewed and tables are included showing the most recent values of the various constants in the vapour pressure formulæ for numerous metals. A *bibliography* of 54 references is appended.—A. R. P.

***Theory of the Work-Functions of Monovalent Metals.** E. Wigner and J. Bardeen (*Phys. Rev.*, 1935, [ii], **48**, 84–87).—The factors which determine the work-function of a metal are determined in a qualitative way. The work-function is defined as the difference in energy between a lattice with an equal number of ions and electrons, and the lattice with the same number of ions but with one electron removed. The work-function is then found by first calculating the energy of a lattice with n_i ions and n_e electrons. The final formula gives the work-functions of monovalent metals in terms of the heats of sublimation. The formula is approximate and can claim validity only in a qualitative way as one of the important factors, the electric double layer on the surface, is omitted entirely, and it is assumed that the Fermi energy is as great as if the electrons were entirely free. The values obtained from this formula check very closely with the experimental values for the alkalis, so that it can be concluded that the double layer is probably small for these metals. Finally, the deviations to be expected for other than monovalent metals are considered. A more exact calculation of the work-function of one substance (sodium) will be described later. (See *Met. Abs.*, this vol., p. 291.)—S. G.

***Relation Between Secondary Emission and Work-Function.** L. R. G. Treloar (*Nature*, 1936, **137**, (3466), 579).—The emission from a molybdenum surface contaminated with barium not more than 1 atom thick is related to the work-function by the expression $\log_{10} N = A - bU$, where A and b are constants. The theoretical value of b is 0·070 if U is measured in electron-volts; the experimental value at a primary voltage of 300 was found to be 0·067.—A. R. P.

***The Action Exercised by Ordinary Metals on the Photographic Plate and Electrometrically.** Jean Reboul (*Compt. rend.*, 1936, **202**, (23), 1920–1922).—Russell (*Proc. Roy. Soc.*, 1897, **61**, 424; 1898, **62**, 102) showed that—as well as zinc, magnesium, and cadmium—nickel, aluminium, lead, cobalt, bismuth, and antimony act at a distance on a photographic plate, and explained this effect by the intervention of oxygenated water formed at the contact of the oxidized metals and moist air. This study has been continued, using a more perfect technique than was then available. It was found that with suitable plates, all the metals produced a more or less pronounced photographic action at a distance, and sometimes in conditions when the formation of oxygenated water seemed difficult to explain. The results indicate, without any modification of Russell's explanation, that the ordinary metals emit an X-ray emanation of small quantum, whose coeffs. of absorption by the air can be determined photometrically. The values found varied from 0·4 to 0·8 atm./cm. The study of the ionization of the atmosphere surrounding the ordinary metals (zinc, tin, lead, iron, copper, nickel, and aluminium) confirms the emission of an X-ray emanation of small quantum. The energy corresponding to such ionization would be sufficient to effect a plate after several days' exposure. The metals magnesium, zinc, and cadmium, affect the plate after some hours' exposure, but an electrometric investigation does not indicate any more marked ionization than for the other metals. It is suggested, therefore, that in the case of these three metals, a compound is formed whose action exaggerates the impression on the plate. It is thus considered that Russell's explanation together with that now put forward will account for all the facts observed with regard to the effect of ordinary metals on photographic plates and electrometrically.—J. H. W.

***The Theory of the Surface Photoelectric Effect in Metals.—II.** K. Mitchell (*Proc. Roy. Soc.*, 1936, [A], 153, (880), 513–533).—S. G.

Electrophysics of Solid Bodies. A. Smekal (*Die Physik*, 1936, 4, (1), 17–33; *Sci. Abs.*, 1936, [A], 39, 539).—A critical and historical review of papers dealing with conductivity in solids which have appeared from 1927 to the end of 1935 under the headings: (1) lattice structure, (2) surfaces and structural imperfections in crystals, (3) glasses, (4) ionic conduction in general, (5) dependence of ionic conduction on temperature, (6) dependence of transport properties on temperature, (7) mechanism of ionic conduction, (8) ionic conduction and chemical constitution.—S. G.

***The Electrical Conductivity of Transition Metals.** N. F. Mott (*Proc. Roy. Soc.*, 1936, [A], 153, (880), 699–717).—The quantum theory of electrical conductivity developed by Bloch and others is extended to metals where the conduction electrons occupy more than one Brillouin zone, as is the case for all real metals except the alkalis and noble metals. The theory is applied to the transition metals; certain anomalies in the resistance–temperature curves of the paramagnetic metals palladium, platinum, and tantalum are explained. A theory is presented to account for the fact that the resistance of nickel decreases in a magnetic field, and an expression for the decrease obtained, which is of the same order of magnitude as that observed. Finally, a qualitative discussion is given of the resistance–temperature curves of copper–nickel alloys such as Constantan.—S. G.

***Potential Fluctuations at the Ends of a Metallic Conductor of Very Small Volume Traversed by a Current.** J. Bernamont (*Rev. gén. Élect.*, 1936, 39, (10), 339–346).—Experimental methods used to study the fluctuations of current in very thin films are described, with the results of measurements on one platinum and two tungsten films. No explanation of the effect is at present attempted. The platinum film was 4 millimicrons thick and had a resistivity about 100 times greater than that of massive platinum.—J. C. C.

***Contribution to the Theory of the Influence of Pressure on the Electrical Resistance of Metals.** M. H. Lenssen and A. Michels (*Physica*, 1935, 2, (10), 1091–1107).—[In English.] The influence of pressure on the electrical resistance of metals is discussed, based on the wave-mechanical theory of electrical resistance as developed by Nordheim. This theory permits the separate consideration of the thermal, electrical, and " rest resistance." Special consideration is given to the two limiting cases of practically free and practically bound electrons. The theoretical results are compared with those of other authors. They were also tested by comparison with experimental results published in the literature and with results published in a previous paper, where under certain assumptions it was possible to separate the pressure effect on the thermal, electrical, and " rest resistance."—S. G.

***Thomson Effect at Very Low Temperatures, and Absolute Scale of Thermoelectric Power.** M. Sansoni (*Nuovo cimento*, 1935, **12**, (10), 616–632; *Sci. Abs.*, 1936, [A], **39**, 568).—The e.m.f. E of a wire, with a decrease of temperature along it, is measured at low temperatures and the thermoelectric power $e = dE/dT$ derived; this is plotted for various temperatures against the temperature $T°$ K. from about − 250° to 50° C. The Thomson effect σ is obtained from these curves since $\sigma = Tde/dT$; copper, silver, and gold have positive T Thomson coeffs. at high temperatures, becoming negative and having a minimum at about 80° K. Lead shows a critical point at about 7·5° K., where the thermoelectric power becomes zero. This is the effect of the superconducting state and gives corresponding results when coupled with zinc. Results are given for alloys of various metals containing a small % of other metals, comparison being made with the metals alone. The absolute scale of thermoelectric power is explained and a table given for the values for tin and lead.—S. G.

Magnetic Properties of Colloidal Powders of Metallic Elements. S. R. Rao (*Current Science*, 1936, **4**, 572–575).—A critical account is presented of the investigations on the magnetic properties of colloidal powders of metals. Three types of binding of the valency electrons in metals are contemplated: (1) metallic, (2) homopolar, and (3) Ehrenfest–Raman. The influence of colloidization on the magnetic properties of metals in which these types of binding are present is mentioned. Attention is directed to the experiments by Goetz on the effect of small quantities of foreign metals in bismuth crystals. The close analogy between colloidization and cold-working in the case of metals wherein the metallic type of binding is predominant, is considered in the light of Honda and Shimizu's theory. Brief mention is made of the investigations on nickel powders and films in the light of Heisenberg's theory.—S. G.

II.—PROPERTIES OF ALLOYS

(Continued from pp. 246–250.)

***The Formation of Spherical Eutectic Inclusions in Metal Alloys [Aluminium Alloys].** W. Geller (*Metallwirtschaft*, 1936, **15**, (6), 141–142).—The formation of spherical eutectic inclusions in aluminium and iron alloys is attributed to rapid cooling in the temperature range just above the solidus; the phenomenon is therefore observed in castings only when there is only a small temperature range between the liquidus and solidus.—A. R. P.

***Condition of Al_2O_3 Included in Duralumin.** Soji Hori (*Kenkyu Hokoku, Sumitomo Shindokokan Kaisha* (*Res. Rep. Sumitomo Copper and Steel Tube Co.*), 1934, **2**, (2), 137–145).—[In Japanese.]—S. G.

***On the Thermal Effects Which Appear During the Phenomenon of Ageing Aluminium Alloys.** W. Święctosławski and J. Czochralski (*Wiadomości Instytutu Metalurgji i Metaloznawstwa* (*Warszawa*), 1936, 3, (2), 59–67).—[In Polish, with German summary.] It has long been supposed that heat effects occur during certain transformations which take place during the recrystallization or ageing of light alloys; at high temperatures such effects have already been observed and by the aid of a specially constructed micro-calorimeter similar effects have now been detected during natural ageing at room temperature. The experiments were made on a 580 grm. block of an alloy of aluminium with copper 4·2, iron 0·66, manganese 0·33, silicon 0·54, and magnesium 0·63% after quenching from 510° C. in cold water. After storage for 22 hrs. at room temperature a rapid evolution of heat occurred which gradually decreased with lapse of time but did not entirely cease until 11 days had elapsed; the total heat evolution between the 22nd and 260th hour was 273·3 grm.-cal. equivalent to 0·4712 grm.-cal./grm. of alloy.—A. R. P.

***Age-Hardening of Aluminium Alloys. I.—Aluminium–Copper Alloy.** William L. Fink and Dana W. Smith (*Metals Technology*, 1936, 3, (4), 10 pp.; *A.I.M.M.E. Tech. Publ.* No. 706).—The age-hardening of an aluminium–copper alloy (copper 5·17, silicon 0·01, iron 0·01%) was studied by microscopic examination, and measurements of lattice spacing, yield-strength, and elongation. Precipitation can be observed microscopically before the ageing has progressed far enough to change the yield-strength and elongation appreciably. The lattice parameter as measured by the back-reflection method does not change during the precipitation of minute particles during age-hardening, although it does change during precipitation under equilibrium conditions. The anomalous changes in density can be explained by particle size, or by the precipitation of a transition phase θ' (Wassermann and Weerts, *Met. Abs.*, 1935, 2, 512) which is confirmed. F. and S. consider that the simple precipitation theory is sufficient to explain the facts.—W. H.-R.

Considerations of the Age-Hardening of Duralumin. Tomojiro Tanabe (*Kenkyu Hokoku, Sumitomo Shindokokan Kaisha* (*Res. Rep. Sumitomo Copper and Steel Tube Co.*), 1935, 2, (4), 315–317).—[In Japanese.]—S. G.

***Diffusion of Magnesium and Silicon into Aluminium.** Hertha R. Freche (*Metals Technology*, 1936, 3, (4), 13 pp.; *A.I.M.M.E. Tech. Publ.* No. 714).—The diffusion of magnesium and silicon into pure aluminium was studied with Alclad material consisting of high-purity aluminium coatings rolled on to cores of (*a*) aluminium–magnesium alloy (1·21% magnesium by weight); (*b*) aluminium–silicon alloy (1·95% silicon); (*c*) aluminium–magnesium silicide alloy (1·8% Mg_2Si by weight); (*d*) aluminium–magnesium–silicon alloy containing 1·8% Mg_2Si + 0·71% excess silicon. After annealing at different temperatures, the percentages of magnesium and silicon at increasing depths were determined by a spectroscopic method in which steps at increasing depths were machined in the specimen which was made one electrode of the spark discharge. The coeffs. of diffusion of magnesium and silicon from their respective binary alloys were of the same order of magnitude. The simultaneous presence of both elements affects the rates of diffusion. In the magnesium silicide alloy the elements tend to diffuse in the ratio of Mg_2Si, but the diffusion of magnesium was greatly diminished for the alloy containing Mg_2Si with excess silicon.
—W. H.-R.

***Equilibrium Relations in Aluminium–Magnesium Silicide Alloys Containing Excess Magnesium.** F. Keller and C. M. Craighead (*Metals Technology*, 1936, 3, (4), 9 pp.; *A.I.M.M.E. Tech. Publ.* No. 707).—The solid solubility isothermals of the aluminium-rich solid solution in aluminium–magnesium–silicon alloys at 400°, 440°, 470°, 500°, and 535° C. were determined by the microscopic and quenching method for alloys containing small amounts of magnesium in excess of that required to form the compound Mg_2Si. The effect of excess magnesium is to diminish the solubility of Mg_2Si in aluminium. If age-hardening by precipitation of Mg_2Si is required, no advantage is gained by the addition of excess magnesium, since this excess diminishes the amount of Mg_2Si that can be taken into solution before precipitation.—W. H.-R.

***On the Thermal Conductivity of Some [Aluminium-Base] Piston Alloys at High Temperatures.** F. Bollenrath and W. Bungardt (*Metallwirtschaft*, 1936, **15**, (16), 368–370; and *Light Metals Research*, 1936, **4**, (20), 334–339).—An apparatus is described and illustrated for the accurate measurement of the thermal conductivity of light alloy pistons at temperatures up to 350° C., and the results obtained for 6 alloys with 75–92% aluminium are recorded in tables. The original paper must be consulted for details and results.—A. R. P.

Silumin. —— (*Metallgesellschaft A.G. und Vereinigte Aluminiumwerke A.G.*, **1936**, 56 pp.; *Bull. B.N.F.M.R.A.*, 1936, (89), 6).—An up-to-date summary of the knowledge of alloys of the Silumin class (also known as Alpax), including Silumin (aluminium + 13% silicon), copper–Silumin, Silumin-Beta, and Silumin–Gamma (containing magnesium and manganese), and Lo–Ex (containing copper, magnesium, and nickel). The brochure deals with metallography, mechanical and physical properties, melting and casting, heat-treatment, shrinkage and gassing behaviour, soldering and welding, machining, surface treatment (protection against corrosion, electrodeposited coatings, polishing), and applications (with illustrations). A *bibliography* of recent literature is appended.—S. G.

***Equilibrium Relations in Aluminium–Zinc Alloys of High Purity.—II.** William L. Fink and L. A. Willey (*Metals Technology*, 1936, **3**, (4), 17 pp.; *A.I.M.M.E. Tech. Publ.* No. 705).—The solid solubility of zinc in aluminium was determined by electrical resistance measurements at different temperatures and by microscopic examination of quenched specimens. The solubility increases gradually from 5·4% zinc by weight at 125° C. to 31·6% at 275° C. At this temperature the solid solubility increases suddenly to 77·7% zinc, and between 275° and 353° C. there is a solubility gap, in which alloys consist of two conjugate solid solutions of the same phase but of different compositions. The difference in composition of the conjugate solid solutions diminishes as the temperature increases, and finally vanishes at 353° C. On the zinc side of the solubility gap, the solubility gradually increases from 77·7% zinc at 275° C. to 81·4% at 350° C.—W. H.-R.

***Melting-Points of Eutectics: Lipowitz Alloy and Wood's Metal.** Sidney J. French (*Indust. and Eng. Chem.*, 1936, **28**, (1), 111–113).—A number of cooling and heating curves of 2 quaternary alloys was made, using various cooling and heating rates and various baths. The alloy bismuth 50, lead 27, tin 13, and cadmium 10% approaches the eutectic composition more closely than does the alloy bismuth 50, lead 25, tin 12·5, cadmium 12·5%. The horizontal portions of the curves, for both alloys, coincide and there is a difference of 2° C. between freezing-point (69·7° C.) and melting-point (71·7° C.). It is suggested that the use of the names "Lipowitz alloy" and "Wood's metal" should cease and that the eutectic alloy be called a quaternary eutectic, stating its composition and its melting point–freezing point range.—F. J.

Copper and Copper Alloys. J. T. Kemp (*Tech. Assoc. Pulp Paper Ind. Preprint*, **1936**, 9 pp.; *Bull. B.N.F.M.R.A.*, 1936, (89), 7).—An account is given of the properties and applications of copper, brass, bronze, nickel–brass, and Everdur, with brief notes on the effect of minor addition elements. The corrosion of copper alloys (effect of sulphur dioxide; salt- and acid-spray tests; field tests) and types of corrosion (dezincification, season-cracking) are discussed. To some extent this paper is directed to the needs of the paper industry, but it is of wider interest.—S. G.

***The Influence of Nickel on the Solubility Limits of the α-Phase in Aluminium–Copper Alloys.** V. Gridnew and G. Kurdjumow (*Metallwirtschaft*, 1936, 15, (10), 229–231; (11), 256–259).—Addition of 2% of nickel to aluminium–copper alloys reduces the range of the α-phase field from 9·8 to 8·6% aluminium and displaces the eutectoid horizontal from 570° to 605° C., but produces no change in the solubility of aluminium in copper with temperature below the eutectoid point. The lattice structure of the 11·5–13% aluminium–bronzes containing 2% nickel differs from that of the β′-phase of the nickel-free bronzes quenched from 950° C. Addition of 4% nickel to aluminium–bronze has no further effect on the α-range at the eutectoid temperature than that produced by 2% nickel, but the solubility of aluminium below the eutectoid point is decreased to about 7·8% so that small precipitation-hardening effects can be obtained by appropriate heat-treatment.—A. R. P.

***Temperature of Formation of the Metastable γ′-Phase in Aluminium–Copper Alloys and Its Relation to the Aluminium Content.** V. Gawranek, E. Kaminsky, and G. Kurdjumow (*Metallwirtschaft*, 1936, 15, (16), 370–371).—The γ′-phase produced by quenching aluminium–bronzes containing more than 13% aluminium has a martensitic structure, which is best obtained free from γ and β′ by quenching in oil at 250°–300° C., then air-cooling. Thermal analysis indicates that pure γ′ is formed at 210° C. in the 13·2% aluminium alloy and at 175° C. in the 13·4% alloy. The structures and interrelationships of the β, β′, $β_1$, γ, and γ′ phases are briefly discussed and the mechanism of the various transformations is compared with that of the martensite transformations in steels.—A. R. P.

***Microstructure of the Metastable γ′-Phase of Aluminium–Copper Alloys.** (Gridnew and Kurdjumow.) See p. 303.

***Coefficient of Equivalence of Iron with Respect to Aluminium in Aluminium–Bronze [Constitution of Copper–Aluminium and Copper–Iron–Aluminium Alloys].** J. L. Bray, M. E. Carruthers, and H. R. Heyer (*Metals Technology*, 1936, 3, (4), 10 pp.; *A.I.M.M.E. Tech. Publ.* No. 702).—The phase boundaries of the β-phase area in copper–aluminium alloys in the region 10–15% aluminium were investigated by quenching and microscopic methods using alloys prepared from pure metals. The eutectoid temperature was determined as 568° C., and the phase boundaries displaced in the direction of higher aluminium content by an almost constant amount of 0·51% aluminium compared with the diagram of Stockdale (*J. Inst. Metals*, 1922, 28, 273). The method used was to heat the specimen 100° C. above the expected transformation temperature, and then to cool to this temperature, and hold for 2 hrs. before quenching. In alloys prepared from commercial copper and aluminium, and Armco ingot iron, the addition of up to 4% of iron has little effect on the eutectoid temperature, and the general type of solid solubility relationship is unaltered. Conflicting results were obtained for the coeff. of equivalence of iron which apparently varied with the way in which the metals were melted together.—W. H.-R.

***Rate of Dissolution of Iron, Manganese, and Ferro-Manganese in Molten Copper.** J. Czochralski and T. Beriszwili (*Wiadomości Instytutu Metalurgji i Metaloznawstwa* (*Warszawa*), 1935, 2, (1), 24–26).—[In Polish, with German summary.] At 1150°–1200° C. solid manganese dissolves rapidly and solid iron very slowly in molten copper. The iron in ferro-manganese dissolves much more slowly than pure iron while the manganese dissolves about three times as fast as the iron.—A. R. P.

***The Mechanical Properties of Copper–Tin Alloys.** W. Broniewski and Z. Wawrzynkiewicz (*Rev. Fonderie moderne*, 1936, 30, 147–151).—The effect of prolonged heat-treatment on copper–tin alloys was studied for alloys containing up to 26% tin. The alloys with less than 14% tin were given a preliminary anneal of 25 hrs. at 675° C., those with more than 14% tin, 75 hrs. at 675° C. followed by 75 hrs. at 450° C. The first class was then cold-rolled and drawn with intermediate annealing for 2 hrs. at 675° C. The second class was hot-rolled at 700°–650° C. Both classes were then heated for 75 hrs. at 675° C. followed by 75 hrs. at 450° C., and these alloys are described as annealed. For the tests in the quenched condition, annealed test-pieces were reheated to 720° C., held there for 15 minutes, and quenched in water. Of those studied the 12% tin alloy showed the most marked general improvement in properties, reaching a tensile strength of 50 kg./mm.^{2} with an elongation of 70% and Brinell number over 100, whilst the 22% tin alloy also showed an increase in all properties.—J. E. N.

***On Leaded–Bronzes.** J. Czochralski and H. Łukomski (*Wiadomości Instytutu Metalurgji i Metaloznawstwa* (*Warszawa*), 1936, 3, (2), 69–74).—[In Polish, with German summary.] The uses of leaded-bronzes and the influence of the melting and casting methods, the structure, and the composition on their technological properties are reviewed with reference to the literature. Eight alloys with various lead, nickel, and tin contents were cast in sand and chill moulds and the elastic limit in compression, the Brinell hardness, and the Charpy impact value determined, and the microstructure examined. The results indicate that it is very difficult to prepare completely homogeneous castings, all the properties varying considerably according to the position of the test-piece in the ingot.—A. R. P.

***On Hardenable Bronzes with a Copper–Nickel–Tin Basis. II.—Workable Alloys.** Erich Fetz (*Metallwirtschaft,* 1936, 15, (7), 167–170; (8), 189–191).—The work-hardness of 5–12·5% tin–bronze begins to disappear on heating the cold-worked metal above about 350° C., but is not completely removed until the temperature exceeds 700° C., whereas that of 15–20% nickel–copper alloys begins to disappear at about 500° C. and is completely removed at 600°–650° C. Addition of nickel to tin–bronze increases the recovery temperature and imparts precipitation-hardening properties so that with sufficient nickel it is possible to cause precipitation-hardening to occur before appreciable loss of work-hardness takes place; thus the alloy with 7·5% each of tin and nickel, after 50% reduction by rolling after quenching from the solid solution range, has a Brinell hardness of 250 which is increased to above 400 by reheating at 350° C. for 25 hrs. Cold-work besides increasing the hardness after precipitation also considerably accelerates this process. Nickel–tin–bronzes in the solid solution state are much more easily rolled than plain tin–bronzes of corresponding hardness and strength after heat-treatment, require less intermediate anneals, retain their strength and hardness to higher temperatures, and can be heat-treated to produce greater strength and hardness at lower temperatures than those required for tin–bronzes.—A. R. P.

Non-Ferrous Alloys Available for the Use of Industry (Continued) [Special Bronzes]. —— (*Aluminium and Non-Ferrous Rev.*, 1936, 1, (8), 372).—Lists the properties and uses of a number of special bronzes.—J. C. C.

Bearing Metals with a Copper–Tin–Zinc Basis. F. Hansen (*Z.V.d.I.*, 1936, 80, (26), 807–808).—These special bearing metals are used in lathes, rolls, valves, and toothed wheels; they have a high zinc and low tin content.—K. S.

***The Effect of Annealing on the Length of Cold-Drawn Rods.** (Saito.) See p. 322.

***Internal Stress and Season-Cracking of Brass Tubes.—III.** Tomojiro Tanabe (*Kenkyu Hokoku, Sumitomo Shindokokan Kaisha* (*Res. Rep. Sumitomo Copper and Steel Tube Co.*), 1935, 2, (4), 311–314).—[In Japanese.]—S. G.

***Nature of the Phases Formed by Mutual Diffusion of Cu–Zn and Fe–Zn and the Kinetics of Their Growth.** V. Bugakov and D. Gluskin (*Zhurnal Tehnicheskoy Fiziki* (*J. Tech. Physics*), 1936, 6, (2), 263–289).—[In Russian.] Chemical analysis, micrographic, X-ray, and hardness methods show that in the mutual diffusion of copper and zinc, the β, γ, and ε phases are formed, the γ phase appearing first and having the highest rate of growth. In the iron–zinc system the phases formed are $FeZn_7$ and $Fe_3Zn_{10}(FeZn_3)$. The temperature coeff. of diffusion does not depend on the state of the low-melting metal, the curve showing no inflection at the melting point. The heat of loosening (?) derived from the temperature coeff. of diffusion is almost identical for both systems studied; this coeff. can be derived from the expression $D = Ae^{-Q/kt}$, as is the case for diffusion in solid solutions.—N. A.

***Investigation of the Recrystallization of Copper–Zinc Alloys (with Low Zinc Content).** (Kitaygorodskiy.) See p. 303.

***Orientation in Peritectic Structures [of Zinc–Copper Alloys].** (Greninger.) See p. 303.

***Some Experiments on Oxidation-Resistant Copper Alloy "A.R."** G. Koisho (*Kenkyu Hokoku, Sumitomo Shindokokan Kaisha* (*Res. Rep. Sumitomo Copper and Steel Tube Co.*), 1935, **2**, (4), 294–301).—[In Japanese.]—S. G.

Constitution and Properties of Type Metals. S. Epstein (*Graphic Arts Res. Bur. Preprint*, **1936**, (May), 20 pp.; *Bull. B.N.F.M.R.A.*, 1936, (89), 9).—A simple discussion of the constitution, structure, properties, and behaviour of type metals, as well as of factors such as the effect of impurities, drossing, shrinkage cavities and blow-holes, and castability. Reference is made to the suggested use of zinc–aluminium alloys as type metals. A useful *bibliography* is given.—S. G.

American Magnesium Alloys. P. Mabb (*Machinery* (*Lond.*), 1936, **48**, (1237), 388–391).—The composition and properties of the chief American cast and wrought magnesium alloys are tabulated, together with particulars of the more commonly used British alloys. Notes are added on the casting, machining, forming, and finishing of these materials.—J. C. C.

***The Surface Tension of Calcium Amalgam.** Léon Convers (*Compt. rend.*, 1936, **202**, (4), 289–291).—The surface tension of calcium amalgam was determined by the drop method used in the determination of the surface tension of mercury *in vacuo*. The amalgam was made either by electrolysis of a concentrated solution of pure calcium chloride or by direct combination of mercury with recently broken pieces of pure calcium. The surface tension at 20° C. for various compositions in grm.-% of calcium (given first) are as follows: 0–442; 0·000002–427·8; 0·00002–422; 0·000065–411; 0·00008–409·4; 0·00012–404; 0·00022–396·1; 0·00033–390·8; 0·0005–395; 0·00058–398·4; 0·0006–402·8; 0·0007–403; 0·0033–402·5. The results also show that the surface pressure of the absorbed film increases at first regularly with the concentration of calcium up to 0·00033%, and then diminishes. This may be the effect of oxidation.—J. H. W.

***On the Longitudinal Magnetic-Resistance Effect at Various Temperatures in Nickel–Copper Alloys.** Hakaru Masumoto and Yuki Shirakawa (*Sci. Rep. Tôhoku Imp. Univ.*, 1936, [i], **25**, (1), 104–127).—[In English.] The change of resistance for alloys of the system nickel–copper, at various temperatures from − 195° to 400° C., was measured up to 1600 oersteds by longitudinal magnetic fields, and the intensity of magnetization was measured at − 195° and 0° C. With addition of copper to nickel the change of resistance of nickel increases at first rapidly, and passing through a maximum, then decreases, vanishing at a concentration slightly less than the one at which the alloy changes from a ferromagnetic to a paramagnetic. The intensity of magnetization decreases steadily as the copper content increases.—S. G.

The New Permanent Magnet Alloys [Alnico, Nipermag]. —— (*Electronics*, 1936, **9**, (5), 30–32, 35). **Alnico—a New, Powerful Magnet.** —— (*Power Plant Eng.*, 1936, **40**, (2), 92).—The characteristics of the aluminium–nickel–iron and aluminium–nickel–cobalt–iron alloys used for permanent magnets are reviewed, with special reference to the American patents and to the alloys

" Alnico " and " Nipermag." Typical magnetization and energy curves are given. The alloys suffer practically no loss in magnetism when heated up to 600° (? ° F.) or subjected to mechanical shock.—J. C. C.

***High-Tin Bearing Metals.** [Frhr.] von Göler and H. Pfister (*Metallwirtschaft*, 1936, **15**, (15), 342–348; (16), 365–368).—The mechanical and wearing properties of tin-base bearing metals containing copper 3–10 and antimony 2–12% are shown in tables and graphs and discussed with reference to the literature. Antimony is soluble to the extent of 7–9% in the tin-rich matrix and increases the resistance to deformation and the endurance strength considerably, but reduces the plasticity; a further addition of antimony has no effect on the strength or resistance to deformation but reduces still more the plasticity and increases the rate of wear. Copper has a similar effect to that of antimony but less marked; it unfavourably affects the plasticity probably owing to the production of acicular tin–copper crystals. The rate of wear rapidly decreases with increasing copper content.—A. R. P.

***Zinc–Indium Alloy System.** Curtis L. Wilson and Ettore A. Peretti (*Indust. and Eng. Chem.*, 1936, **28**, (2), 204–205).—An investigation of the alloys of zinc and indium is described. Cooling curves, supplemented by photomicrographs, the eutectic–times interpolation method, and the analysis of " sweat " beads of eutectic were employed in the construction of the freezing-point diagram of the system. The eutectic has a freezing-point of 143·5° C. and consists of an intimate mixture of zinc and indium; its composition is indium 96, zinc 4%. The solid solubility of zinc in indium is approximately nil, that of indium in zinc was not ascertained.—F. J.

Properties of Zinc-Base Die-Cast Alloys. Apex Smelting Co. (*Metalgram*, No. **12**, 4 pp.; *Bull. B.N.F.M.R.A.*, 1936, (89), 13).—Gives the elongation values obtained for the alloy containing aluminium 4·10, copper 1·00, magnesium 0·03%, and balance zinc (99·99+ %). This is described as alloy No. 5. Elongation values are given for the alloy cast at various metal temperatures and die temperatures and pressures, before and after the exposure of the castings to water vapour at 95° C.—S. G.

***Kinetic Differences Between Cast and Worked Metal.** H. Bumm and U. Dehlinger (*Metallwirtschaft*, 1936, **15**, (4), 89–90; and (summary) *Light Metals Research*, 1936, **4**, (17), 278–279).—When a single crystal of copper containing 6% of silver is indented with a cone and annealed at 800° C. to cause all the silver to go into solid solution and the deformed area to recrystallize, then quenched and annealed at 400° C., precipitation of the silver from the supersaturated solid solution can be recognized by etching with alcoholic ammonia only in the deformed zone. After 15 minutes at 400° C. the grain boundaries of the new crystals show that precipitation has commenced there and after 50 hrs. precipitation is complete in the new crystals but is still not detectable in the non-deformed zone. This difference in behaviour between the cast and deformed metal is attributed to the enhanced mosaic structure of the latter. Even on heating the single-crystal supersaturated solution for a long time at 500° C. practically no coagulation of the precipitated silver occurs, whereas such coagulation takes place at 350° C. in the deformed and recrystallized metal. An explanation of this difference based on vapour pressure considerations is suggested.—A. R. P.

***Plasticity of Metal Crystals and Its Importance for the Properties of Materials.** G. Wassermann (*Z.V.d.I.*, 1936, **80**, (10), 283–287).—Two processes are important for the deformation of metals, *viz.* translation and mechanical twinning. Simple laws hold good for the beginning of translation and for the fracture of brittle metals. The properties of polycrystalline technical metals are often dependent on crystallographic conditions. A number of examples are given to show how a knowledge of the properties of single crystals of metals assists in understanding the behaviour of the polycrystalline aggregates which make up metals as used in constructional work.—K. S.

The Forming Properties of Some Non-Ferrous Sheet Metals. G. R. Gohn (*Amer. Soc. Test. Mat. Preprint*, **1936**, 14 pp.).—Reports the continuation of an investigation to obtain information regarding the forming of 90° bends in various non-ferrous sheet materials. The previous paper (Straw, Helfrick, and Fischrupp, *Met. Abs.* (*J. Inst. Metals*), 1931, **47**, 231) described a method by which such forming data might be obtained, and tabulated minimum safe forming radii for 3 brasses, 2 nickel silvers, and 2 phosphor–bronzes. This information proved so valuable in the design and manufacture of telephone apparatus that the investigation was extended. Additional forming data are given for 7 alloys previously studied as well as for other non-ferrous sheet materials (brasses, phosphor–bronzes, nickel silvers, manganese–brass, Everdur, Duronze, Herculoy, copper, beryllium–copper, nickel–beryllium–copper, Monel metal, nickel, Inconel, and aluminium alloys). The method used to determine the minimum safe forming radius is described, and the data so obtained are tabulated.—S. G.

†The Experimental Study of Heterogeneity in Metals and Alloys. Albert Portevin and Pierre Chevenard (*Congrès Internat. Mines Mét. Géol., Section de Métallurgie*, 1935, **1**, 321–338; also *Rev. Mét.*, 1936, **33**, (2), 96–113 and (summary) *Light Metals Research*, 1926, **4**, (23), 421–422).—Heterogeneity in alloys may be inherent, such as is caused by primary segregation, liquation, or the precipitation of a new phase, or it may be produced by such means as cementation, local heat-treatment, and welding. It is emphasized that precipitation of a disperse phase must always be preceded by heterogeneity of the solid solution. In magnetic alloys, heterogeneity is most readily studied by observing the shape of the curve connecting intensity of magnetization with temperature. Examples are given of the application of this method in following changes in two iron–nickel–chromium–carbon alloys after various heat-treatments. In other alloys, it is often possible to observe heterogeneity by mechanical tests on very small test-pieces, using a micro testing machine.—J. C. C.

***Oxide Films of Some Alloys.** Ichirô Iitaka and Shizuo Miyake (*Nature*, 1936, **137**, (3463), 457).—The following facts have been detected by cathode-ray diffraction methods: a thin film of γ-alumina is formed on the surface of aluminium–bronzes containing more than 3% aluminium and a zinc oxide film on 70 : 30 brass at high temperatures, the films acting as a protection against further oxidation. Similar films have been observed on alloys of copper with more than 1% beryllium; no trace of copper oxide is formed on these alloys even at a red heat. The protective film which forms on 80 : 20 Nichrome wire at high temperatures is the chromite $NiCr_2O_4$ (cubic, $a =$ 8·30 A.).—A. R. P.

A Simple Systematic Classification of All Binary, Ternary, and Quaternary Alloys. E. Janecke (*Light Metals Research*, 1936, **4**, (24), 443–444).—Abridged translation from *Z. Elektrochem.*, 1936, **42**, (3), 128; see *Met. Abs.*, this vol., p. 153.—J. C. C.

Topology of the Chemical Diagram of Chemical Equilibrium. N. S. Kurnakow (*Uspehi Khimii* (*Prog. Chemistry*), 1936, **5**, (2), 161–201).—[In Russian.] A theoretical survey of equilibrium diagrams of binary, ternary, and more complex systems from a topological point of view.—N. A.

III.—STRUCTURE

(Metallography; Macrography; Crystal Structure.)

(Continued from pp. 250–256.)

***Microstructure of the Metastable γ'-Phase of Aluminium–Copper Alloys.** V. Gridnew and G. Kurdjumow (*Metallwirtschaft*, 1936, **15**, (19), 437).—The γ'-phase obtained by quenching a 14–14·5% aluminium–copper alloy in 10% sodium hydroxide solution has an acicular structure like that of the β'-phase, but the longer needles are often bisected by twinning lines.—A. R. P.

***Orientation in Peritectic Structures [of Zinc–Copper Alloys].** Alden B. Greninger (*Nature*, 1936, **137**, (3468), 657–658).—An X-ray study of the peritectic reaction $\alpha + \text{liquid} \longrightarrow \beta$ in the zinc–copper system showed that the orientations assumed by the β-phase are definitely related to the orientation of the α-phase. By seeding molten 48 : 52 brass with copper crystals the following sequence of crystallization from the bottom to the top is obtained: copper seed crystal; primary α with the same orientation; large β-grains (2–5 mm.) having a narrow rim of segregated α, the nuclei of the β originating in the peritectic reaction. The orientation of the β grains is within ± 3° as follows: $(110)_\beta$ parallel to $(111)_{\text{copper}}$ and $[1\bar{1}0]_\beta$ parallel to $[11\bar{2}]_{\text{copper}}$.—A. R. P.

***Rate of Crystallization of Sodium. Relation Between the Atomic Heat of Crystallization and the Rate of Crystallization of Some Metals and Non-Metals.** J. Czochralski and W. Garlicka (*Wiadomości Instytutu Metalurgji i Metaloznawstwa* (*Warszawa*), 1936, **3**, (1), 39–44).—[In Polish, with German summary.] The rate of crystallization of sodium was determined by drawing a single crystal of the metal out of a bath of molten metal covered with a thick layer of xylene and maintained as closely as possible at the melting point. The maximum rate of crystallization was found to be 360 mm./minute. When the metal is maintained at 98° C. and the xylene at 82°–88° C., crystal dendrites were obtained at rates below 80 mm./minute, the form of crystallization being obviously dependent on the surface tension and temperature; when the metal bath is at above 98° C. and the xylene is at above 54° C. cylindrical crystals are obtained. Comparison of the results obtained for several metals and for sulphur and phosphorus indicates that the rate of crystallization of the elements is inversely proportionate to the atomic heat of crystallization.—A. R. P.

***Recrystallization Diagram of Cadmium.** J. Czochralski and T. Miazga (*Wiadomości Instytutu Metalurgji i Metaloznawstwa* (*Warszawa*), 1935, **2**, (1), 3–4).—[In Polish, with German summary.] Small cylinders, 6 mm. in diameter and 7 mm. high, of commercial cadmium were annealed at 250° C. for 2 hrs., compressed to 2, 5, 10, 25, 50, 70, and 90% reduction in height and recrystallized at 20°, 50°, 100°, 150°, 200°, 250°, 300°, and 310° C. The resulting grain-size–temperature–reduction diagram is included in the paper; it is similar in all respects to the corresponding diagrams of other metals.—A. R. P.

***Investigation of the Recrystallization of Copper–Zinc Alloys (with Low Zinc Content).** A. I. Kitaygorodskiy (*Zhurnal Tehnicheskoy Fiziki* (*J. Tech. Physics*), 1936, **6**, (2) 290–297).—[In Russian.] By a series of meltings in nitrogen and with a deoxidizer, it was possible to observe separately the effects of zinc and of cuprous oxide on the recrystallization temperature of copper and brass. This temperature for α-brass (with up to 6% zinc) reaches a maximum at 2% zinc. Phosphorus has no effect on the shape of the recrystallization temperature curve, while cuprous oxide has an effect only on that of pure copper, since it is reduced by the zinc present in brass. Experiment and theory indicate that there is no constant ratio between the recrystallization temperature and the melting point.—N. A.

†**The Beilby Layer.** G. I. Finch and A. G. Quarrell (*Nature*, 1936, 137, (3465), 516–519).—A review of recent work on the nature of polish on metals with 27 references.—A. R. P.

***Investigation of the Crystal Structure of Some Beryllium Alloys.** Lore Misch (*Metallwirtschaft*, 1936, 15, (7), 163–166; and (summary) *Light Metals Research*, 1936, 4, (23), 431–432).—A number of intermetallic compounds of beryllium were prepared by melting the constituents *in vacuo* in beryllia crucibles and their crystal structure determined by X-ray analysis. CoBe and PdBe are body-centred cubic with $a = 2{\cdot}606$ and $2{\cdot}813$ A., respectively, two atoms in the unit cell. $AgBe_2$ and $TiBe_2$ have the cubic $MgCu_2$ structure with 12 atoms in the unit cell, $a = 6{\cdot}287$ and $6{\cdot}435$ A., respectively. The following compounds have the hexagonal $MgZn_2$ structure with 12 atoms in the unit cell: $CrBe_2$ $a = 4{\cdot}239$ A., $c/a = 1{\cdot}632$; $MnBe_2$ $a = 4{\cdot}231$ A., $c/a = 1{\cdot}632$; VBe_2 $a = 4{\cdot}385$ A., $c/a = 1{\cdot}629$; $ReBe_2$ $a = 4{\cdot}345$ A., $c/a = 1{\cdot}631$, $MoBe_2$ $a = 4{\cdot}434$ A., $c/a = 1{\cdot}641$; WBe_2 $= 4{\cdot}437$ A., $c/a = 1{\cdot}639$. Compounds with a complicated AB_2 type of structure are formed with rhodium, iridium, ruthenium, and osmium. Only one compound occurs in the beryllium–platinum system; this has a deformed γ-brass structure and gives a similar X-ray pattern to Ni_5Be_{21}. $ZrBe_2$ has a deformed cubic structure, and tetragonal phases are formed in the molybdenum and tungsten systems with a high beryllium content. The beryllium alloys with nickel, cobalt, and palladium do not obey the Hume-Rothery rule in that the cubic AB type of structure occurs when the ratio of atoms in the lattice to valency electrons is 2 : 2 instead of 2 : 3. The hexagonal AB_2 type of structure occurs in beryllium alloys only when the system does not form cubic AB alloys and when the alloying element has a body-centred cubic structure.—A. R. P.

***On the Two Electron Lattices in Iron and Alloys of the Type of β-Brass.** Robert Forrer (*Ann. Physique*, 1936, [xi], 5, 719–756).—Application of the law of melting points to α-iron, β-brass, similar β alloys, and Heusler's alloy indicates that these have two independent electron lattices; one stable at temperatures up to the transformation point in β alloys (or to the Curie point in α-iron), and the other stable up to the melting point (or to the β–γ transformation in iron). The corresponding numbers of electrons in the lattices are, respectively, 3 and 4 for α-iron and $\frac{3}{2}$ and 4 for β-brass.—J. C. C.

***An X-Ray Examination of Atomic Vibrations in Zinc and Cadmium.** G. W. Brindley (*Nature*, 1936, 137, (3460), 315–316).—From the anomalous scattering of X-rays by cadmium and zinc it is concluded that the lattice vibrations are greater along the *c*-axis of the metal crystals than perpendicular thereto, which is in agreement with recent German work on the thermal expansion of these metals.—A. R. P.

Polymorphism from the Point of View of X-Ray Investigations. II.—Polymorphism and the Building of the Atoms of the Elements. Polymorphic Inorganic Compounds. Hugo Stintzing (*Ergebnisse tech. Röntgenkunde*, 1934, 4, 113–129; *Chem. Zentr.*, 1935, 106, (I), 1814; *C. Abs.*, 1936, 30, 4060).—Previous experimental evidence was examined to obtain a general insight into the cause of polymorphism. By " certain " polymorphs are to be understood only those substances for which two solid forms can definitely be differentiated by X-ray crystallographic measurements. The following 20 elements are included in this classification: C, N, O, P, S, Cr, Mn, Fe, Co, Ni, Se, Zr, Ru, Rh, Sn, La, Ce, W, Tl, and U. Possible polymorphism is shown by Si, Ca, Ge, As, Sb, Te, I, Pd, Ir, Pb, and Bi. The following relations were discovered: Elements with special lattice forms (*i.e.* lattices other than face- or body-centred cubic or hexagonal dense packing), of low co-ordination number, and those that follow the Hume-Rothery rule, $K = 8 - N$ (where $K =$ the co-ordination number, N the group number) are pre-eminently polymorphic and are designated as polymorphs of high degree. These include the 18 elements: C, N, O, P, S, Cr, Mn, Se, Sn, W, and U (certain) and Si, Ge, As, Sb, Te, I, and Bi (possible). The remainder of the polymorphic elements show a slight decrease of polymorphism. Polymorphism occurs in general in cases of small atomic distances and slight packing density. If log $d/(n - 1)$ is plotted against log Z (where d is the atomic distance or twice the radius of the atom in the lattice ($n - 1$) the principle quantum number of the last completely filled electron shell, and Z the atomic number of the element) it is seen that: only elements whose value of log $d/(n - 1)$ lies under that for the group of the inert gases are polymorphic, and only those for which this value lies under that for the C group are polymorphic to a high degree. The first polymorphic element, then, appears in any period when the exponential curve log $d(n - 1)$ varies from the linear course corresponding to the " sub-group " law. Polymorphism is therefore conditioned by the electron arrangement. All polymorphic elements, especially those not highly so, are recognized by high values of the atomic binding coeff. In the case of inorganic compounds polymorphism is confined almost entirely to those compounds in which one element is highly polymorphic, especially those containing O or S. The tendency to polymorphism is therefore a specific property of certain elements and based on the presence of anomalies of atomic formation.—S. G.

***On the Mechanism of Transformation of Face-Centred Cubic into Hexagonal Close-Packed Lattice.** Zenji Masumoto (*Sci. Rep. Tôhoku Imp. Univ.*, 1936, [i], 25, (1), 79–93).—[In English.] Cf. *Met. Abs.*, 1935, 2, 101, 514. The mechanism of transformation of the face-centred cubic lattice (γ) into the hexagonal close-packed lattice (h) was studied with an alloy of cobalt containing 30% nickel. It was found that (1) the crystallographic relations between the orientations of crystals of the two modifications are $\gamma(111)//h\,(0001)$ and $\gamma[\bar{2}11]//h[1\bar{1}00]$; (2) the γ crystal can give rise to 4 differently oriented h crystals, all of which in the inverse transformation are brought back to the γ crystals of the original orientation, as if the initial single γ crystal would have reappeared. The results are consistent with H. Shôji's theory of the mechanism of the transformation.—S. G.

***A Classification of Crystal Structures with Defect Lattices.** Lester W. Strock (*Z. Krist.*, 1936, 93, (3/4), 285–311).—[In English.] The ordinary " structure theory " of crystals requires each set of equivalent positions to be occupied and filled by chemically like sorts of particles. Crystal structures which satisfy this condition are called ideal solids. In many actual structures one or more of the different kinds of particles may not satisfy the above condition, and the lattices formed by the particles not arranged in accordance with the structure theory are called " defect lattices." A classification of defect lattices is given based on the way in which one of the lattices differs from that required by the structure theory. The above definition of a defect lattice is very comprehensive, and includes not only structures in which some lattice points are unoccupied, but also interstitial structures in which only some of the " holes " are occupied by small atoms, and some superlattice structures where the relative numbers of the two atoms require one set of equivalent positions to be occupied by two kinds of particles. Many examples of alloy structures are given.—W. H.-R.

***The Effective Radii of Atoms and Ions.** E. Herlinger (*Z. Krist.*, 1936, 93, (5), 399–408).—[In German.] The atomic radii in the crystals of the elements are compared with those of the corresponding kations in salts. The radii of uni-, di-, tri-, and tetravalent kations are usually approximately 0·2, 0·4, 0·6, and 0·8 A. less than those of the same atoms in the crystal of the element.

The difference between the effective radii of atoms in the two types of structure is thus roughly 0·2 A. multiplied by the valency.—W. H.-R.

Precision Lattice Constants from X-Ray Powder Photographs. M. U. Cohen (*Rev. Sci. Instruments*, 1935, [N.S.], 6, (3), 68–74).—A very general method is given for the calculation of lattice constants from powder photographs, in which there is taken into account the various systematic errors inevitable in such photographs, including radius errors, film shrinkage, absorption, eccentricity, and finite slit height. While the solution of the data is made by least squares, it is not at all laborious and is much simpler than the various methods, both analytical and graphical, which have previously been proposed. Examples are given of cubic, hexagonal, and orthorhombic structures solved in this way using data from Debye and focussing cameras, extension to other structures and cameras being made evident. In effect, powder cameras become absolute instruments, independent of calibrating substances, and dependent only on the value of the X-ray wave-length.—S. G.

***The Experimental *versus* the Mathematical Elimination of Errors in the Debye–Scherrer Method [New Debye–Scherrer Camera].** A. Ievins and M. Straumanis (*Z. Krist.*, 1936, **94**, (1), 40–52).—[In German.] Methods for the elimination of errors in precision measurements of lattice constants are reviewed and criticized. The correction formula of Cohen (preceding abstract) is only accurate in a minority of cases. I. and S. describe a new type of camera. In this the break which occurs where the cut ends of the film meet each other is at right angles to the direction of the primary beam, and not, as is usually the case, at the point where the beam enters or leaves the camera. Holes are punched in the film where the beam enters and leaves the camera, and since the reflections are symmetrical about the line of the incident beam, this line can be obtained by measurement of the pairs of reflections corresponding to the same line. In this way a standard angle of 180° on the film is obtained from measurements of the lines themselves, and it is unnecessary to calibrate the camera against a standard substance.—W. H.-R.

New Technique for Obtaining X-Ray Powder Patterns. R. A. Stephen and R. J. Barnes (*Nature*, 1936, **137**, (3465), 532–533).—The authors' technique (*Met. Abs.*, 1935, **2**, 712) for obtaining X-ray powder patterns from flat, polycrystalline specimens and for obtaining an intense monochromatic polarized X-ray beam from a single crystal is simply an application of the principle of foreshortening.—A. R. P.

***On the Preparation of Complete Fibre Diagrams [Faserdiagrammen].** Erwin Sauter (*Z. Krist.*, 1936, **93**, (1/2), 93–106).—[In German.]—W. H.-R.

Determination of Crystal Orientations with the Weissenberg X-Ray Goniometer. J. Palacios, J. Hengstenberg, and J. García de la Cueva (*Anales soc. españ. fis. quim.*, 1933, **31**, 811–821; *C. Abs.*, 1934, **28**, 2994).—An analysis of the problem; the application of the method to wire and rolled foil of aluminium is described.—S. G.

A Graphic Method for Studying Structure by the Weissenberg X-Ray Goniometer. Application of Samples of Sheet Aluminium. J. García de la Cueva and J. Palacios (*Anales soc. españ. fis. quim.*, 1936, **34**, 165–172; *C. Abs.*, 1936, **30**, 4065).—A graphic method of study of crystal structure is described, based on dihedric and stereographic projection; it permits passing easily from the Weissenberg X-ray diagrams to polar figures. The origin of the blank zones in the diagrams (preceding abstract) is attributed simply to a screen effect.
—S. G.

IV.—CORROSION

(Continued from pp. 256–259.)

***On the Corrosion of Refined Aluminium of 99·992% Purity.** J. Czochralski and J. Mikołajczyk (*Wiadomości Instytutu Metalurgji i Metaloznawstwa* (*Warszawa*), 1936, 3, (2), 108–110).—[In Polish, with French summary.] The resistance to corrosion of 99·992% aluminium was determined by the modified Mylius method, the salt-spray method, and by the rate of dissolution in dilute hydrochloric acid. The results are shown in tables and graphs in which the corresponding value for 99·63% commercial aluminium is given for comparison. In the Mylius test the rate of dissolution of the pure metal is about one-third that of the commercial metal, but in hydrochloric acid of 10–25% concentration the pure metal dissolves at first more rapidly and then more slowly than the commercial metal.—A. R. P.

***On the Corrosion of Aluminium in the Presence of Mercury.** J. Czochralski and S. Wajgman (*Wiadomości Instytutu Metalurgji i Metaloznawstwa* (*Warszawa*), 1936, 3, (2), 90–94).—[In Polish, with French summary.] The rates of corrosion of pure and technical aluminium, Duralumin, 12% copper–aluminium, and 4, 7, and 9% zinc–aluminium alloys in hydrochloric acid solutions containing mercuric chloride were determined. The rate of corrosion of pure aluminium is slightly greater than that of the technical metal; alloys containing copper are more resistant than technical aluminium, the surface layers gradually becoming richer in copper. The 4% zinc alloy is attacked about ten times as rapidly as pure aluminium, but the 7 and 8% zinc alloys are much more resistant than the 4% alloy. In 5% hydrochloric acid the rate of corrosion of all the metals increases at first with an increase in the concentration of mercuric chloride and then decreases. The rate of evolution of hydrogen increases to a maximum with technical aluminium in solutions containing 2 grm./litre and with pure aluminium in solutions with 4 grm./litre of mercuric chloride. Cold-work increases the rate of corrosion of all the metals. —A. R. P.

***The Application of Microchemical Methods of Analysis to the Study of the Corrosion of Light Aluminium Alloys.** Henri Fournier (*Compt. rend.*, 1936, 202, (21), 1792–1794).—The corrosion of a Duralumin-type of alloy of the composition: copper 3·8, iron 0·41, silicon 0·35, manganese 0·46, and magnesium 0·91%, and a magnesium–aluminium alloy, containing silicon 0·32, manganese 0·54, and magnesium 8·65%, was studied by means of microchemical analysis in conjunction with a Thyssen and Bourdouxhe apparatus, which gives the loss in weight proportional to the time, when the movement of the liquid is faster than a certain limit, and the concentration of the dissolved products is negligible. Adjustments were made so that the variation of the concentration as a function of the time of attack could be studied, the curve of the loss of weight: time having a logarithmic tendency. The corroding medium was a 10% sodium chloride solution. The results showed the difference in the mechanism of corrosion of the two alloys, and in particular the auto-protection of the magnesium–aluminium alloy. The method is to be applied to other alloys.—J. H. W.

***Corrosion of Copper. Controlling Factors in Unaerated Solutions of Sulphuric Acid.** Glenn H. Damon and Ray C. Cross (*Indust. and Eng. Chem.*, 1936, 28, (2), 231–233).—From experiments on the corrosion of copper in sulphuric acid, which are described, it is concluded that: the rate of corrosion is directly proportional to oxygen-solubility in the acid, up to about 25*N*; above 25*N* the oxidizing character of sulphuric acid affects the corrosion rate. The rate of oxygen diffusion through the air–liquid interface controls the corrosion rate except in those cases where the solution surface area is very large in comparison to the metal surface area. Standard corrosion test methods must specify the solution surface area if reproducible results are to be obtained. The maximum corrosion rate for copper in unaerated 0·2N solutions of sulphuric acid is approximately 40 mg./dm.^{2} per 24 hrs. The same factors should control the corrosion rate of all metals which depend on oxygen depolarization.—F. J.

***Effect of Impurities on Corrosion-Resistance of Solder.** Clifford L. Barber (*Indust. and Eng. Chem.*, 1936, 28, (5), 530–533).—Continuous, intermittent, and short partial-immersion tests were carried out to ascertain the resistances of pure and impure solders to the action of hydrochloric acid solutions. Depending on the strength of acid, time of exposure, access of air, &c., antimony decreases the resistance of solder (tin 38, lead 60, antimony 2%) from 20 to several thousand %. Under certain conditions, in very weak acid, antimonial solders may acquire a protective film of metallic antimony, thus decreasing the rate of corrosion to that of pure solder. Antimony (5%) decreases the resistance of tin to 0·1M hydrochloric acid and air, as also do copper and zinc. In 0·1M citric acid in the presence of air, antimony decreases the corrosion-resistance of solder. Thus antimony, copper, and zinc should be excluded from tin alloys which are required to resist corrosion.—F. J.

***Hot Spring Water at Vienna and Lead Pipes.** Franz X. Mayer (*Abhandl. Gesamtgebiet Hygiene*, 1934, 16, 1; *J. Amer. Water Works Assoc.*, 1935, 27, 793).—Vienna water supply is derived essentially from two high-spring aqueducts; analyses show average total and carbonate hardness, 134 p.p.m.; chloride 0·02 p.p.m.; nitrate 2·5 p.p.m.; and sulphate 12·0 p.p.m.; but no ammonia; p_H is 7·9; the supply contains 1·8 p.p.m. free carbon dioxide and is fully oxygen-saturated. As regards agressivity to lead the water lies on the boundary and exerts a slight, but noticeable, corrosive action. Samples taken from new pipes contain, sporadically, lead in excess of 1 p.p.m.; when drawn from the same pipes 12–18 months later, after 14 hrs.' standing, the permissible limit of 0·3 p.p.m. is not exceeded. Even after approx. 25 years' service, however, old pipe after prolonged content will yield a measurable quantity. According to frequency of use either a very thin greyish-brown coating or a thicker yellow one containing iron, calcium, and silica is observed. In a comparative series of experiments with pipe of ordinary soft smelter lead and of two kinds of light-lead, containing respectively 0·25% cadmium and 0·5% antimony and 0·8% antimony, 0·3% tin, and 0·03% sodium, results indicated that there is no objection to the use of light-lead pipes of these compositions as they do not increase the solubility of lead in local water. No case of lead poisoning has been reported. No solution of antimony took place. Tests on cadmium showed a solubility equivalent at first to 0·25 p.p.m., but decreasing after some weeks to negligible traces of 0·005 p.p.m. Sulphur-treated pipe is not recommended, as in samples from pipe drawn after 14 hrs.' standing after several months in use 0·1 p.p.m. of lead was found. There was no experimental indication that by earthing of radio sets to lead water lines any increased internal corrosion is caused.—S. G.

Corrosion of Lead Cables and Means for Its Prevention. B. M. Domnich (*Russko-germanskiy Vestnick Nauki i Tehniki* (*Deut.-russ. Z. Wiss. Tech.*), 1936, (4), 36–43).—[In Russian.] A review.—N. A.

***Rate of Dissolution of Magnesium in Acids.** I. V. Durdin and A. M. Markovitch (*Zhurnal Obstchei Khimii* (*J. General Chem.*), 1936, 6, (2), 236–249).—[In Russian.] The rate of dissolution of magnesium in hydrochloric acid is proportional to the acid concentration and independent of that of the reaction products; the temperature coeff. decreases with decrease in temperature, being directly proportional to the fluidity of water. Dissolution is thus a diffusion process and therefore accelerated by stirring.—N. A.

***Corrosion of Elektron Alloy A.M. 503 by Leaded Fuels. I.—Mechanism of Attack.** G. D. Bengough and L. Whitby (*J. Roy. Aeronaut. Soc.*, 1935, 39, (300), 1144–1153).—The corrosive effect of T.E.L. fuels on magnesium alloy A.M. 503 is studied. Liquid water is necessary for the attack to proceed, and the attack is probably caused by hydrolysis of the tetra-ethyl lead in presence of ethylene dibromide and water, to form water soluble salts such as lead bromide or ethylated lead bromides which deposit lead on the surface of the alloy and provide low overvoltage cathodes.—H. S.

***Corrosion of Magnesium Alloy Sheet in Salt Water.** I. Igarashi (*Kenkyu Hokoku, Sumitomo Shindokokan Kaisha* (*Res. Rep. Sumitomo Copper and Steel Tube Co.*), 1935, **2**, (4), 302–309).—[In Japanese.]—S. G.

†Texture and Chemical Resistance. C. H. Desch (*Trans. Inst. Chem. Eng.*, 1934, **12**, 198–209).—The distribution of the chemical components of alloys into distinct constituents or phases, and the arrangement of those constituents in space or as it is designated the " texture " is discussed in relation to their chemical resistance. Consideration is given fully to the effect of grain-size; deformation or strain; cold-work (season-cracking in the case of hard-drawn brass); caustic embrittlement; heat-treatment; age-hardening; oxide films with special reference to aluminium alloys, brass condenser tubes, Nichrome alloys, and copper fire-box stays and plates; and to the influence of molecular structure; and it is shown that the effect of these various " textures," as well as the chemical composition, determine the chemical properties of the various materials.—J. W. D.

Researches on Losses of Material [Metal] by Cavitation. H. Schroeter (*Z.V.d.I.*, 1936, **80**, (16), 479–480).—In continuation of earlier work further details are given of the results of cavitation tests on chemically active and relatively inert metals.—K. S.

***Organic Inhibitors of Corrosion. Aliphatic Amines.** Charles A. Mann, Byron E. Lauer, and Clifford T. Hultin (*Indust. and Eng. Chem.*, 1936, **28**, (2), 159–163).—Corrosion tests made in *N*-sulphuric acid on mild steel specimens, with the addition of various inhibitors, are described. The blanketing or protective layer of the aliphatic amine inhibitors is formed by adsorption of inhibitor ions on the metal surface and through the nitrogen atom. Long straight-chain aliphatic di- and tri-amines are excellent acid-corrosion inhibitors. The effect of increase in the number of radicals of the amine on inhibiting properties is shown in a series of graphs. The corrosion of iron in *N*-sulphuric acid is reduced by 97% by adding 0·66% *N*-tributyl amine, 98% by adding 0·34% *N*-diamyl amine, and 99% by adding 0·13% of *N*-triamyl amine.—F. J.

Vacuum Deaeration Combats Cold-Water Corrosion. S. T. Powell and Homer S. Burns (*Chem. and Met. Eng.*, 1936, **43**, (4), 180–184).—The installation of a vacuum deaerator for removal of dissolved oxygen from Mississippi River water is illustrated and described. Results of the operation of this plant for 1 year have demonstrated its effectiveness in inhibiting corrosion of uncoated steel pipe-lines and the practicability of applying corrosion control for large volumes of cold water.—F. J.

***Apparatus and Methods of Corrosion Research Employed at the [Warsaw] Institute of Metallurgy and Metallography.** J. Czochralski, G. Welter, and W. Maruszewska (*Wiadomości Instytutu Metalurgji i Metaloznawstwa* (*Warszawa*), 1936, **3**, (2), 84–88).—[In Polish, with German summary.] The apparatus used in salt-spray and atmospheric exposure tests is described and the precautions taken to obtain reproducible and comparable results are detailed. Tests made on commercial aluminium of good quality and on Duralumin have shown that the former is much more resistant to salt-spray than the latter, the tensile strength undergoing very little deterioration after exposure for 1 year, and the elongation being much less rapidly reduced by corrosion than that of Duralumin.—A. R. P.

Twelfth Report of the Corrosion Committee of the Association Suisse des Électriciens and Associated Societies. J. Landry (*Bull. Assoc. Suisse Élect.*, 1936, 27, (12), 339–340).—A summarized account of the activities of the Committee in 1935.—P. M. C. R.

V.—PROTECTION

(Continued from pp. 259–261.)

Anodic Oxidation. J. W. Rushton (*Aluminium and Non-Ferrous Rev.*, 1936, 1, (8), 380–381).—Applications are briefly discussed.—J. C. C.

***Heat-Treatment and Anodic Oxidation of Duralumin Sheet.** K. Inamura and H. Ohashi (*Kenkyu Hokoku, Sumitomo Shindokokan Kaisha* (*Res. Rep. Sumitomo Copper Steel Tube Co.*), 1934, 2, (1), 67–87).—[In Japanese.]—S. G.

Oxidation of Aluminium Alloys by Chemical Etching. N. S. Klimenko (*Aviopromishlenost* (*Aircraft Ind.*), **1936**, (3), 26–28).—[In Russian.] In etching Duralumin with alkali chromates in nitric acid, water, or sodium carbonate solutions, surface films of oxide are obtained. With a hot solution containing sodium chromate 1·5, carbonate 5, and hydroxide 0·25% a uniform, dense green film of aluminium and chromium oxides, affording good protection against corrosion by sea-water, is obtained in 10 minutes. Impregnation of the film with a drying oil increases the protection. Films obtained from acid or neutral solutions are unsatisfactory in sea-water.—N. A.

Main Causes of Damage of Tubes of Surface Condensers. A. Dorohov (*Sudostroenie* (*Shipbuilding*), **1936**, (3), 203–208).—[In Russian.] Alloys used in condenser tubes, their working conditions and protection from corrosion are examined, chiefly from published data.—N. A.

***Prevention of Corrosion of Magnesium Alloys.—II–IV.** I. Igarashi and N. Nakata (*Kenkyu Hokoku, Sumitomo Shindokokan Kaisha* (*Res. Rep. Sumitomo Copper and Steel Tube Co.*), 1934, **2**, (1), 58–66; 1935, **2**, (3), 161–178; (4), 310).—[In Japanese.]—S. G.

The Constitution of Sprayed Metal.—II. A. Dagory (*Métalliseur*, 1936, **2**, (2), 1–5).—A description is given of the state of sprayed metal during transit between the nozzle and the article. The various theories put forward are discussed, together with some notes on the speed of the particles.—W. E. B.

Metallizing in the Canning Industry. William Hishon (*Metallizer*, 1936, **5**, (3), 7, 12).—Recommendations are given for the sprayed coating of various parts of the machinery used in canning peas and corn; there are also recommendations for the metal spraying of machinery to be used in the preparation of tomato products.—W. E. B.

Aluminium—Plus. J. W. Hishon (*Metallizer*, 1936, **5**, (3), 2, 3, 13).—A description is given of the "M.B.V." treatment for aluminium for the brewing trade. This consists of the treatment of the aluminium with a mixture of sodium chromate, sodium carbonate, and caustic soda. It is suggested that this treatment is suitable for aluminium sprayed coatings. H. also gives the results of some tests on a suitable method of cleaning aluminium tanks from deposits obtained in the brewing trade.—W. E. B.

***Reaction Between Paint Films and Zinc Surfaces.** Henry J. Wing (*Indust. and Eng. Chem.*, 1936, **28**, (2), 242–243).—The failure of paints to adhere properly to zinc or galvanized surfaces may be due to a combination of causes. By studying the reactions between very thin zinc mirrors (deposited on glass by high-vacuum distillation) and varnish films, it is concluded that the compounds, formed as a result of the reaction between zinc and the oxidation products formed in the drying of oil or varnish finishes, are actually present on paint films which peel from galvanized surfaces. Zinc formate has been definitely identified as one of these compounds.—F. J.

VI.—ELECTRODEPOSITION

(Continued from pp. 261–264.)

***Bright Electrodeposition of Cobalt.** A. Chaybany (*Met. Ind.* (*Lond.*), 1936, 48, (26), 721–722).—The factors which affect the brightness of deposited metals were studied. Matt deposits contain traces of hydroxide, while bright deposits are purer metal. Methods were found of suppressing hydroxide precipitation and preventing hydrogen evolution. Bright deposits requiring no further polishing were obtained by the use of hydroquinone and sodium hydrosulphite. Details of operation are given.—J. E. N.

***Electroplating Copper on Plaster of Paris.** Yih-Van Chiang and Chin-Pin Fan (*Indust. Research* (*China*), 1935, **4**, 451–454; *C. Abs.*, 1936, **30**, 2853).—Of several procedures tried, the best was to paint the plaster surface with copper powder (100 mesh) suspended in shellac and then to plate copper from an acid copper sulphate solution at 0·4 amp./in.^{2}.—S. G.

***White and Black Electrolytic Silver.** A. V. Pamfilov and O. S. Fedorova (*Zhurnal Obstchei Khimii* (*J. General Chem.*), 1935, **5**, 1551–1557; *C. Abs.*, 1936, **30**, 2501).—[In Russian.] Experiments on conditions under which white and black modifications of silver are deposited electrolytically and the transformation of one modification into another takes place were carried out with aqueous silver nitrate, between platinum electrodes, with current density 0·01–0·2 amp./cm.^{2} and silver nitrate concentration 0·001*N* and 0·1*N*. The higher the current density the darker the colour of the deposit, in the more dilute solutions, and the slower the change from dark to light colour in the more concentrated solutions. On addition of 0·001% gelatin to the solutions the deposits become darker and the colour more stable.—S. G.

***Experiment in Electroplating Metals in Colour.** P. N. Petrov and M. S. Borozdina (*Zhurnal Prikladnoi Khimii* (*J. Applied Chem.*), 1936, **9**, (2), 229–233).—[In Russian.] Elastic and adherent electrodeposits of a pure green colour slightly olive tinted can be obtained on brass, cadmium, iron, nickel, copper, and zinc from a solution containing copper sulphate crystals 60, zinc sulphate crystals 45, ammonium molybdate 30 grm., 30% sodium bisulphite solution 10–15 ml., and free potassium cyanide 6–8 grm./litre, using a current density of 0·2–0·4 amp./dm.^{2} at 2·5 v. and room temperature. —N. A.

Electrolytic Coating of Metals and Alloys in Molten Salts. N. N. Gratzianskii (*Ukrain. Akad. Nauk. Inst. Khim., Sbornik Trudov Pervoĭ Vsesoyuznoĭ Konferentzii Nevodnuim Rastvoram* (*Proc. First All-Union Conference Non-Aqueous Solutions*), 1935, 213–216).—S. G.

VII.—ELECTROMETALLURGY AND ELECTROCHEMISTRY

(Other than Electrodeposition.)

(Continued from pp. 264–265.)

***The Electromotive Behaviour of a Bismuth Element.** Tauno Kurenniemi (*Ann. Acad. Sci. Fennicæ*, 1935, [A], **44**, (5), 68 pp.; *C. Abs.*, 1936, **30**, 4075).—[In German.] The potential difference of bismuth against $BiCl_3$ solution was determined by measuring the e.m.f. of the cell Bi, Bi_2O_3 (dissolved in HCl)–Hg_2Cl_2, Hg as a function of the concentration of $BiCl_3$ and HCl.—S. G.

Electrochemistry of Polonium. M. Haissinsky (*Electrochem. Soc. Preprint*, 1936, Oct., 29 pp.).—After a review of the physical and chemical properties of polonium, the electrochemical properties of this metal are discussed at length. There is a decided tendency to form complexes, and polonium forms a variety of cations and anions. Further, it is characteristic of polonium to deposit readily, by displacement, on a large variety of basis metals. The electrodeposition of the metal is very dependent on the p_H of the bath and the presence of salts. In the case of polonium, it is not merely the charge and discharge of ions as with ordinary metals such as copper and nickel, but there are complications due to the discharge of α-rays by polonium. In alkaline baths the deposition is largely at the anode, as PoO_3. At times polonium is present in solution not in the ionic form but as a colloid, and may be adsorbed on silica and other bases. In conclusion, a brief summary is given of the various methods for recovering polonium from radio-lead residues and old radium ampules. —S. G.

IX.—ANALYSIS

(Continued from pp. 265–266.)

***The Sensitivity of X-Ray Chemical Analysis. I.—Emission Methods.** Luigi Mazza (*Gazz. chim. ital.*, 1935, **65**, (7), 724–730; *C. Abs.*, 1936, **30**, 2515).—The experiments which are described deal with the sensitivity of emission methods when applied to the rare earths. The experimental technique is described. By means of *K* spectra it is possible to identify with certainty an element in a mixture even when the concentration is less than 1 in 1000. The sensitivity in *L* spectra is considerably greater, and when the substance is fixed on the anticathode in the oxide state it is possible to detect the element at a concentration of only 1 in 25,000. If the samples are in the metallic state the sensitivity is still greater, and an element can be identified at concentrations of about 1 in 50,000. In all the experimental cases studied the sensitivity was limited by the presence of the continuous spectrum, which weakens the definition of the characteristic lines. The influence of the state of the substance under examination was also studied. One of the most serious difficulties in the application of the method, when great sensitivity is required, is the separation of the substance from the anticathode during its exposure. This experimental difficulty was studied in particular and the precautions and technique necessary to eliminate it are described. A sample of highly purified La showed the presence of Ce, Nd, Sm, and Fe, whereas the oxide showed only Nd. Highly purified metallic Ce showed the presence of Nd, Sm, Gd, Tb, and Fe, whereas the oxide showed only Nd, Sm, and Fe.—S. G.

***The Sensitivity of X-Ray Chemical Analysis. II.—Absorption Methods.** Luigi Mazza (*Gazz. chim. ital.*, 1935, **65**, (7), 730–734; *C. Abs.*, 1936, **30**, 2516).—Experiments were carried out to determine the limits of sensitivity of absorption methods of spectrographic analysis with X-rays. The sensitivity of chemical analysis by means of the *K* discontinuity depends on the atomic number of the element to be identified, and it is influenced to different degrees by the presence of excessive proportions of other elements. Light and, therefore, weakly absorbing elements do not diminish the sensitivity to a serious extent, whereas highly absorptive elements render this method of examination only slightly sensitive. The influences of neighbouring elements are discussed, and the significant results of experiments on rare earth elements are described. The diminution in the clearness of the absorption discontinuity with increase in the absorptive power of the elements accompanying the particular element to be identified, and the need for very long times of exposure, limits from a practical point of view the use of X-ray absorption analysis to the investigation of heavy elements in the presence of light elements.—S. G.

***Quantitative Chemical Spectrographic Analysis of Aluminium Alloys.** G. Scheibe and A. Schöntag (*Metallwirtschaft*, 1936, **15**, (6), 139–141).—Suitable comparison lines for the spectrographic determination of Si, Mg, Na, Cu, and Fe in Al are given, and the procedure adopted by the authors in their laboratory is described.—A. R. P.

Detection of Small Quantities of Germanium by a Spot Reaction. A. S. Komarovskiy and N. S. Poluektov (*Zhurnal Prikladnoi Khimii* (*J. Applied Chem.*), 1936, 9, (1), 159–163).—[In Russian.] A drop of the alkaline or feebly acid solution is treated drop by drop with a 15% solution of $(NH_4)_2MoO_4$ in 1 : 1 HNO_3 then with a 0·1% solution of benzidine in $CH_3{\cdot}CO_2H$, followed by $CH_3{\cdot}CO_2Na$ or NH_3 fumes to reduce the acidity; Mo-blue colour indicates the presence of Ge (if SiO_2 and P_2O_5 are absent).—N. A.

Fractional Detection of Zinc and Cadmium. N. A. Tananaev (*Zhurnal Prikladnoi Khimii* (*J. Applied Chem.*), 1936, 9, (2), 367–368).—[In Russian.] The hot ammoniacal solution is treated with KI to remove Ag, then with H_2O_2 to remove Mn; the filtrate is divided, and one-half is treated with excess of KCN, and a few drops of Na_2S solution added to obtain a yellow precipitate of CdS. The second portion is treated with 20% NaOH solution and HCHO to convert the NH_3 into $(CH_2)_6N_4$ and precipitate Cu as metal and Co, Ni, and Cd as hydroxides. Addition of 20% Na_2S solution to the hot filtrate affords a white deposit or turbidity of ZnS.—N. A.

***Analysis of Iron–Nickel Mixtures.** Josef Hanuš and Jaroslav Voříšek (*Chem. Listy*, 1935, 29, 288–295; *C. Abs.*, 1936, 30, 2522).—For separating Fe from Ni the authors used and compared critically the acetate, succinate, and hexamethylenetetramine methods. From a solution having an Fe : Ni ratio greater than 40, the Fe was separated from Ni completely by a single precipitation in all 3 methods. When the Fe : Ni ratio exceeded 40, the Fe was separated from Ni by a double precipitation in the acetate and succinate method, in the hexamethylenetetramine method the Fe precipitated still contained traces of Ni after 2 precipitations. In order to prevent the adsorption of Ni on the precipitated Fe during the separation, the acidity of the acid solution cannot exceed 5 c.c. of *N* AcH per 500 c.c. of solution. The adsorption of Ni on the precipitated Fe is decreased by an addition of NH_4Cl. The ratio of Fe to Ni in the Fe precipitate is always constant for a given procedure. For the second precipitation the Fe should be precipitated by the acetate or succinate method again and not by NH_4OH which, when the Fe : Ni ratio exceeds 2, begins to give Fe precipitations containing large amounts of Ni and demands a third precipitation. In slightly acid solution containing NH_4Cl the acetate and succinate methods were equally accurate and useful. The results obtained by the hexamethylenetetramine method were inferior to those obtained by the acetate or succinate methods but remain better than those obtained by separating Fe from Ni by means of NH_4OH.—S. G.

Spot Colorimetry of Copper. N. A. Tananaev and A. I. Ivanova (*Zhurnal Prikladnoi Khimii* (*J. Applied Chem.*), 1936, 9, (2), 364–366).—[In Russian.] By means of the reaction: $Cu^{\cdot\cdot} + Fe(CN)_6'''' + 2K^{\cdot} = K_2CuFe(CN)_6$ a Cu determination may be made in 10–15 minutes with an accuracy of 3–12%.
—N. A.

Quantitative Determination of Platinum and Its Associates in Ores, Sinters, and Mud by Spectrographic Methods. V. V. Nedler (*Zhurnal Tehnicheskoy Fiziki* (*J. Tech. Physics*), 1936, 6, (3), 553–560).—[In Russian.] The analysis is carried out by comparing photometrically the line intensity of the elements searched for Pt with that of the standard (Ag). By correcting for alteration of the series effect by means of a fixed doublet an accuracy of ± 10%, is attained. Comparison with chemical analysis showed an average divergence of not more than ± 7%. This method is also applicable to alloys.—N. A.

***The Preparation of Substituted Benzene-*o*-dithiols for Use as Specific Reagents for Tin.** R. E. D. Clark (*Tech. Publ. Internat. Tin Res. Develop. Council, Series A*, 1936, (41), 7 pp.).—Directions are given for the laboratory preparation of (*a*) toluene-3 : 4-dithiol from *p*-tolidine *via* the sulphonic acid, the diazonium compound with xanthic acid, Ba toluene-3 : 4-disulphonate, the corresponding Na salt, and the sulphochloride; and (*b*) 1-chlorobenzene-3 : 4-dithiol from *p*-chloroacetanilide *via* similar compounds. The original paper must be consulted for details.—A. R. P.

***Spectrographic Determination of Arsenic, Phosphorus, and Sulphur in Metals, Especially Platinum.** W. Rollwagen and K. Ruthardt (*Metallwirtschaft*, 1936, **15**, (8), 187–189).—Since the presence of even minute amounts of S, As, and P in Pt produces hot-shortness their determination is of considerable practical importance. The most rapid procedure is the spectrographic method using a slightly sputtering arc of 10 amp. at 110 v. with 2 interruptions per second. The most sensitive P lines are 2536 A. and 2553 A. and the most sensitive As line 2349 A.; with the aid of these lines less than 0·005% of As or P can readily be determined. To determine S the specimen must be sparked *in vacuo* in a specially designed tube the construction of which is described and illustrated; the S line 4163 A. can be detected with as little as 0·01% S.—A. R. P.

X.—LABORATORY APPARATUS, INSTRUMENTS, &c.

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

(Continued from pp. 266–267.)

New Methods of Examination in Metal Microscopy. —— (*Machinery (Lond.)*, 1936, **48**, (1229), 133–137; (1230), 163–165).—Describes the use of dark-field illumination and polarized light in a metallurgical microscope, with special reference to the Zeiss "Neophot" equipment.—J. C. C.

***On a New Registering Photomicrometer for the Quantitative Determination of Non-Metallic Inclusions in Metals.** M. Śmiałowski (*Wiadomości Instytutu Metalurgji i Metaloznawstwa* (*Warszawa*), 1936, **3**, (1), 45–55).—[In Polish, with German summary.] The apparatus, which includes a selenium photo-cell, mirror galvanometer, and mechanically operated drum, is described with reference to photographs and diagrams. The metal specimen is moved in a zigzag manner through a field 10 × 10 mm. and with a "wave-length" of 2 mm. and "amplitude" of 5 mm., being illuminated during this movement with a 100-watt lamp through a prism vertical illuminator, the reflected light passing to the photo-cell. In this way differences in the reflective power of various parts of the surface are automatically registered, and from the resulting diagram many quantitative conclusions can be reached on the microstructure of the surface. The use of the apparatus in determining slag inclusions in steel, graphite in cast iron, and the linear dimensions of the crystals in bearing metals is described.—A. R. P.

The Radiographic Study of Microstructures. Alfred Salmony (*Machines*, **1936**, (June), 6–9).—A full description is given of a recently designed apparatus for X-ray photography under works conditions; a note is appended on a smaller apparatus especially suited for the examination of tools and other small parts.—P. M. C. R.

New Type of Powerful Electron X-Ray Tube with a Revolving Anti-Cathode. W. Gorsky and V. Linizkiy (*Zhurnal Tchnicheskoy Fiziki* (*J. Tech. Physics*), 1936, **6**, (3), 514–516).—[In Russian.] Two types are described, in which protection of the high vacuum from the atmosphere is attained by combining with the revolving anti-cathode the functions of a Gede molecular pump.—N. A.

An X-Ray Powder Camera. M. J. Buerger (*Amer. Mineralogist*, 1936, **21**, (1), 11–17).—An illustrated description of an X-ray powder camera for use in conjunction with a Hadding gas tube. The camera is used for the identification of crystalline phases by comparison of films of the unknown and suspected phases, and the diameter is hence small (57 mm.). Full details are given regarding construction, adjustments, preparation of the powder mount, and loading.—P. M. C. R.

***An Apparatus for Conveniently Taking Equi-Inclination Weissenberg Photographs.** M. J. Buerger (*Z. Krist.*, 1936, **94**, (2/3), 87–99).—[In English.] —W. H.-R.

XI.—PHYSICAL AND MECHANICAL TESTING, INSPECTION AND RADIOLOGY

(Continued from pp. 267–269.)

†Mechanical Tests at High Temperatures. Jean Galibourg (*Congrès Internat. Mines Mét. Géol., Section de Métallurgie*, 1935, **1**, 377–383; and *Rev. Mét.*, 1936, **33**, (3), 157–163).—The methods of conducting, plotting, and interpreting creep tests are critically reviewed, and an account given of the procedures adopted by the principal laboratories in England, France, Germany, and the U.S.A. An example of the great need for agreement on test methods is shown by the results of tests on the same alloy steel at 500° C., which yielded values of creep limit varying between 10 and 21 kg./mm.^{2}, according to the procedure followed. A *bibliography* of 21 references is given.—J. C. C.

Castigliano's Principle of Minimum Strain-Energy. R. V. Southwell (*Proc. Roy. Soc.*, 1936, [A], **154**, (881), 4–21).—S. G.

***Contribution to the Study of Forgeability. Search for a Laboratory Test.** Albert Portevin, Etienne Prétet, and Jean de Lacombe (*Congrès Internat. Mines Mét. Géol., Section de Métallurgie*, 1935, **1**, 339–357; also *Rev. Mét.*, 1936, **33**, (2), 114–132; and (abridged) *Light Metals Research*, 1936, **4**, (24), 447–448).—Resistance to deformation can be measured by static or impact compression tests; and both this property and the degree to which the material can be deformed by torsion, notched-bar bending, tensile, or notched-bar impact tests. Results of such tests at elevated temperatures on a number of steels and two brasses are described. A brass containing copper 58·8, lead 1·64, tin 0·52, iron 0·70% showed marked loss of strength at 500° C. in torsion, tension, and notched-bar bending tests. Ductility, as revealed by both static and impact tests, is a maximum at 750°–800° C., decreasing rapidly at higher temperatures. With a brass containing copper 64·9, lead 0·04, tin 0·07, iron 0·06%, bending tests indicated inhomogeneity in the test-bars of cold-rolled material; the central portion, containing $\alpha + \beta$, showing only slight ductility below 850° C., rising steeply at higher temperatures; and the exterior, being mainly β, showing much greater ductility with a maximum at 700° C. Notched bar bending tests, preferably carried out at various speeds, are considered the most valuable since during testing the specimen may be maintained in the furnace and in any desired atmosphere.—J. C. C.

Ductility Testing of Aluminium and Aluminium Alloy Sheet. R. L. Templin (*Amer. Soc. Test. Mat. Preprint*, 1936, 10 pp.).—Because of the great diversion of opinion as to what constitutes ductility of a metal and also as to what measures this same quantity, T. reviews a number of tests which purport to give a measure of this property. Brief reference is made to the known effects of the size and shape of test-specimen and gauge-length on ductility measurements obtained from tension tests. The results of bending tests are discussed from the point of view of comparison with tension test data, with evidence to show that there seems to be no reliable correlation between them. Some results of Erichsen tests are similarly discussed, and data are given to show that here also there is no reliable correlation between Erichsen values and tension test values or bending test values. Results of the Sachs ductility tests are also discussed to point out the difficulties involved in obtaining indices of ductility from this method. Data from about 1500 observations of these various tests are discussed as to whether each type of test might offer some particular information regarding a particular type of forming but no one or any combination of them appears to yield a general quality factor indicating by a single number the quality of the metal in the light of all the varied definitions of ductility.—S. G.

The Elongation Test (on Welds). Experiments and Results. A. Matting (*Elektroschweissung*, 1936, 7, (3), 53–57).—Tensile tests were made on mild steel test-pieces having a longitudinal butt-weld. This form of test is found to give useful information about the ductility of the weld.—H. W. G. H.

Impact Tests of Welded Joints.—A Review of the Literature to Jan. 1, 1936. W. Spraragen and G. E. Claussen (*J. Amer. Weld. Soc.*, 1936, 15, (4), 2–12).—A valuable review, which emphasizes the lack of information on the notch-bar values of non-ferrous welds. 98 references are given, of which 4 are to non-ferrous work.—H. W. G. H.

International Standardization of the Shock Bend Test on Notched-Bars [Resilience].—I–II. Eugene Dupuy, Jacques Mellon, and Pierre Nicolau (*Rev. Mét.*, 1936, **33**, (1), 55–70; (2), 133–139).—(I.—) Details of tests on different steels and with different types of test-piece are described. (II.—) The Copenhagen test-bar is regarded as the most suitable for international standardization until a better one can be found.—H. S.

The Different Hardness Tests. —— Try-Chalons (*Rev. Fonderie moderne*, **1936**, (May), 160–161).—A brief review and comparison of hardness measurements obtained using 15 different scales, including among others Brinell, Vickers, Rockwell, Shore, Herbert, Pendulum, &c. It is shown that no absolute conversion table can be applied to the various methods.—J. E. N.

***Relation of Brinell to Rockwell Hardness.** S. Edé (*Kenkyu Hokoku, Sumitomo Shindokokan Kaisha* (*Research Rep. Sumitomo Copper and Steel Tube Co.*), 1934, **2**, (2), 125–136).—[In Japanese.]—S. G.

***Vickers Hardness Tester and Its Applications.** S. Edé (*Kenkyu Hokoku, Sumitomo Shindokokan Kaisha* (*Res. Rep. Sumitomo Copper and Steel Co.*), 1935, **2**, (3), 227–238).—[In Japanese.]—S. G.

Divergence of Pictures in X-Ray Inspection of Metals. G. V. Davidov (*Zhurnal Tehnicheskoy Fiziki* (*J. Tech. Physics*), 1936, **6**, (2), 257–262).—[In Russian.] The splitting of the electronic beam in an X-ray tube with a hatched focus and its effect on the X-ray examination of metals are considered.—N. A.

XII.—TEMPERATURE MEASUREMENT AND CONTROL

(Continued from pp. 269–270.)

Some Metallurgical Applications of the C–SiC Thermocouple. G. R. Fitterer (*Metals Technology*, 1936, **3**, (4), 14 pp.; *A.I.M.M.E. Tech. Publ.* No. 717).—Examples are given of the use of the C–SiC thermocouple for controlling the temperatures of molten steel and cast iron at different stages of production. The method is often superior to that of optical pyrometry.
—W. H.-R.

Experimental Investigation of the Action of Suction Pyrometers. V. M. Antufiev and K. A. Blinov (*Izvestia Vsesouznogo Teplotehnicheskogo Instituta* (*Bull. Pan-Union Thermotech. Inst.*), **1935**, (11), 40–44).—[In Russian.] From theoretical calculations and experimental curves of the relation of temperature to the rate of gas-flow, the mistakes arising during measurements with suction pyrometers with ceramic shields may for practical purposes be corrected with sufficient accuracy by the same theoretical formulæ as for metallic shields.—N. A.

Ionic Temperature Regulators. U. G. Kornilov (*Tochnaja Industria* (*Präzisions Ind.*), **1936**, (2), 9–12).—[In Russian.] A brief description.—N. A.

***Porcelain Pyrometer Tubes.** S. A. Ruidalchuk (*Keram i Steklo*, 1935, **11**, (11), 22–26; *C. Abs.*, 1936, **30**, 4285).—[In Russian.] Briefly describes experiments to determine mechanical properties, thermal resistance, effect of diameter on thermal resistance, temperature of softening, coeff. of expansion, thermal conductivity and chemical stability.—S. G.

XIII.—FOUNDRY PRACTICE AND APPLIANCES

(Continued from pp. 270–272.)

Casting Industry in Europe and the United States. —— Tanamura (*Imono* (*J. Casting Inst. Japan*), 1935, **7**, (7), 407–420).—[In Japanese.]—S. G.

***Capillarity as a Factor in Foundry Practice.** Albert M. Portevin and Paul G. Bastien (*Met. Ind.* (*Lond.*), 1936, **48**, (25), 683–687; (26), 716–720; and *Found. Trade J.*, 1936, **55**, (1038), 28–34).—French Exchange Paper presented to the Institute of British Foundrymen. Surface tension of molten metals, and the influence of oxide films on this property have received little consideration in connection with foundry practice, although they are of prime importance in the wetting of sand moulds, and the searching and penetration of moulds and cores by metals. The metals available for measuring surface tension of metals melting at moderately high temperatures are discussed in the light of their atomic characteristics, and experimental results are given of the measurement of the strength of the alumina film on molten aluminium. The surface tension of oxidized and unoxidized molten aluminium was determined, and a mathematical treatment of the system aluminium–Cryolite–air is presented. The influence of surface tension on the " life " or castability is analyzed, and the reasons for the " searching " of moulds and cores are fully explained. It is concluded that there is no wetting of sand moulds by unoxidized metal surfaces, but oxide films of certain metals may lead to the formation of silicates, which combination produces wetting. Additions of very small quantities of aluminium produce oxide films which oppose wetting and searching and modify casting properties, but also assert a similar influence on remelting scrap.—J. E. N.

Casting Procedure and Some Regulations.—I, II, III. S. Kusunose (*Imono* (*J. Casting Inst. Japan*), 1935, **7**, (5), 257–275; (6), 330–354; (7), 421–439).—[In Japanese.]—S. G.

The Technical and Economical Aspects of the Production of Aluminium Sand- and Chill-Castings. A. von Zeerleder (*Aluminium and Non-Ferrous Rev.*, 1936, **1**, (8), 365–370).—Discusses design changes necessary when replacing a ferrous casting by one made of a light alloy, tabulates mechanical properties of some typical aluminium alloys in the sand- and chill-cast conditions, and gives details of the relative costs of some specific sand- and chill-castings.—J. C. C.

On the Casting of Aluminium Alloys into Shells. Y. A. Zenter (*Metallurg* (*Metallurgist*), **1936**, (2), 101–104).—[In Russian.] The eutectic Silumin alloy is recommended for castings, cores, and dies for rubber footwear pressure-manufacture. Press-forms are cast at 680°–720° C. into a shell preheated to 350°–400° C., and dies, &c., at 650°–700° C. into a shell at 300°–350° C. Dies, &c., must be cast by the inclined method with smooth rotation of the shell, which must be vertical by the end of pouring.—N. A.

Compound Casting of Pistons. —— (*New Products Digest*, 1936, May 1; and (abstract) *Light Metals Rev.*, 1936, 2, (23), 426).—In the Mahle process, two alloys are used for casting pistons for Diesel engines: "Y" alloy for the centre of the piston-head, and the remainder of an aluminium–silicon alloy with a low-temperature coeff. of expansion and good friction and wearing properties.
—L. A. O.

Methods of Manufacture of Titanium–Aluminium Alloys. S. G. Glazunov and V. A. Ivensen (*Tehnika Vosdushnogo Flota* (*Tech. Aerial Navy*), 1936, (2), 45–65).—[In Russian.] The aluminothermic process for producing titanium–aluminium alloys is described, together with methods of micrographic and chemical analysis of such alloys.—N. A.

Effect of Oxidizing and Reducing Substances on Copper Alloys. K. Sawae (*Imono* (*J. Casting Inst. Japan*), 1935, 7, (9), 576–581).—[In Japanese.]—S. G.

Improvement in Melting Silicon–Copper. Technical Dept., Admiralty (*Imono* (*J. Casting Inst. Japan*), 1935, 7, (1), 1–2).—[In Japanese.]—S. G.

Recommendations for Two Leaded Gun-Metals. Non-Ferrous Sub-Committee of the Technical Committee of the Institute of British Foundrymen (*Found. Trade J.*, 1936, 54, (1034), 456–457, 460; and *Met. Ind.* (*Lond.*), 1936, 48, (24), 660–662).—The aim of the report is to reduce the multiplicity of leaded-bronze compositions now in use to two standard alloys, having nominal analysis and physical properties as follows:

	Copper, %.	Tin, %.	Zinc, %.	Lead, %.	Maximum Stress, Tons/in.².	Elongation, %.	Brinell Hardness No. 1000/10/30.	Density.
G.M.2	87	9	3	1	14	14	65	8·50
G.M.3	85	5	5	5	12	12	60	8·55

The sizes of test-bars, ingates, and risers are recommended, and the results obtained by seven foundries, on two sizes of bars, at three different casting temperatures, in green- and dry-sand, are quoted and presented for criticism and comparison.—J. E. N.

Casting of Lead–Bronze Bearings in a Revolving Magnetic Field. N. M. Tuchkevich and V. S. Rutes (*Tehnika Vosdushnogo Flota* (*Tech. Aerial Navy*), 1936, (4), 62–72; and *Vestnick Elektropromishlenosti* (*Messenger Elect. Ind.*), 1936, (3), 6–10).—[In Russian.] In filling the bearing casings with lead-bronze, it is more convenient to use, instead of the stator of the motor, a specially constructed anchor-type stator placed in the centre of a graphite plug and to create a magnetic field inside the assembly.—N. A.

†**Some Small Phenomena Which Accompany the Melting of Bronze.** —— Dennery (*Bull. Assoc. Tech. Fonderie*, 1936, (3), 78–89; and *Rev. Fonderie moderne*, 1936, May, 163–168).—Every time that bronze is melted it suffers a change. This is due to exposure to air and the products of combustion. Furnace conditions and atmospheres are discussed in detail, and the effects of oxidizing and reducing gases, their solubilities and reactions with the metals are reviewed. The problem is then considered under the headings: (1) lessening of the alteration of the bronze; (2) study of physical or mechanical refining methods; (3) study of chemical refining. Under (1) the type of fuel and furnace, speed of melting, and efficiency of combustion are dealt with. Under (2), 3 methods of degasification are compared, mechanical stirring preferably with a graphite poker, chemical reaction agitation, as by the decomposition of sodium carbonate, or thermal methods such as pre-solidification or slow cooling, or by adding a substance which increases the fluidity and lowers the melting

point. Under (3) chemical refining is examined, and the relative advantages of oxidizing agents, reducing agents, and desulphurizing agents are compared. The use of an oxidizing agent, followed by a reducing agent, is recommended. In the discussion *M. Ballay* recommends that small test-pieces be cast to test the efficacy of the treatment before casting the bulk of the metal. *Lepp* referred to the pre-solidification, inert gas, as well as volatile chlorides methods, and vacuum melting, and recommends a selective oxidation by choice of suitable reagents and temperatures and gave photomicrographs, X-ray photographs, and test results in support of his claims. *Chavy* suggested that certain additions may act by increasing the solid solubility of gases in metals. Other speakers discussed the effect of melting speed on the properties of the alloys. —J. E. N.

Method of Casting Shirugin Bronze. Technical Dept., Admiralty (*Imono* (*J. Casting Inst. Japan*), 1935, 7, (11), 721–725).—[In Japanese.]—S. G.

The Preparation of Graphite-Bearing Alloys for Bushes. R. Thews (*Rev. Fonderie moderne*, **1936**, (Apr.), 124–125).—See *Met. Abs.*, this vol., p. 89. —J. E. N.

***On the Deoxidation of Brasses and Bronzes.** J. Czochralski and Z. Bukowski (*Wiadomości Instytutu Metalurgji i Metaloznawstwa* (*Warszawa*), 1935, 2, (1), 27–30).—[In Polish, with German summary.] The use of phosphorus pentachloride for the deoxidation of 90 : 10-brass and 8% tin–bronze was investigated by making two similar melts side by side and treating one with the chloride vapour just prior to casting, then comparing the tensile properties of castings of the treated and untreated melts. The results show that the pentachloride treatment is more efficient than deoxidation with phosphor–copper and results in a higher strength, ductility, and hardness combined with a more homogeneous and finer-grained structure.—A. R. P.

†**Founding Magnesium Alloys.** John A. Gann and Manley E. Brooks (*Trans. Amer. Found. Assoc.*, 1935, 43, 591–614).—A general review of American practice in the production of magnesium-base alloy sand-castings. This embraces the preparation of the sand, melting, alloying, and fluxing of the molten metal, recommended gating and risering, dressing and machining, heat-treatments and protective coatings. Recovery of scrap and borings is described, the physical properties and uses are discussed, and the economics due to the low sp. gr. are emphasized.—J. E. N.

Casting of Magnesium Alloys. C. Kochi (*Imono* (*J. Casting Inst. Japan*), 1935, 7, (3), 129–139).—[In Japanese.]—S. G.

Foundry Graphite. C. Cibulca (*Fonderia*, 1935, 10, 33–37, 77–82).—The use of graphite in the foundry is dealt with, and the requirements as to properties are discussed.—S. G.

***Composition and Its Effect on the Properties of Mould and Core-Sand Mixtures at Elevated Temperatures.** F. Hudson (*Found. Trade J.*, 1936, 54, (1034), 458–460; (1036), 502–505, 510; and *Met. Ind.* (*Lond.*), 1936, 48, (24), 652–659).—Read before the Institute of British Foundrymen. Many dry-sand mixtures possess good properties at normal temperatures, but frequently have unsuitable characteristics during and after the casting operation. Additions of coal dust effect limited improvements, but with certain disadvantages. Investigation has shown that sawdust may be added instead of coal dust, with more marked advantages and none of the limitations. The compression strength is reduced, the permeability increased, and the expansion at high temperatures (the most fruitful source of " scabs " and " buckles ") reduced to a safe limit. The more important properties at elevated temperatures of a number of compositions are described in detail, and the effects of protective coatings and washes for moulds and cores on the permeability are discussed. An appendix is devoted to the effect of clay additions on the properties of oil-sand at elevated temperatures.—J. E. N.

Natural Bonded Moulding Sands of Canada. Correll H. Freeman (*Canada. Dept. of Mines, Mines Branch,* No. 767, 1936, 144 pp.).—Deals with mode of occurrence and technology, physical properties and methods of testing, the status of the Canadian moulding sand industry, and moulding sand deposits of Canada. An appendix gives mechanical analyses of imported sands, a glossary of foundry terms, and a selected *bibliography* (6 pp.). on moulding sands, testing, and control.—S. G.

Casting Plant. U. Lohse (*Germanskaja Tehnika* (*Z. deut. Technik*), 1936, **15**, (1), 12–15).—[In Russian.] A description of plant exhibited at the 1935 Leipzig Fair.—N. A.

Inserts in Die-Cast Parts. J. Gerber (*Maschinenbau*, 1936, **15**, (11/12), 313–316).—Examples are given of the use of inserts for obtaining special properties, *e.g.* magnetic or electric properties, in die-castings.—K. S.

Die-Casting Practice in the U.S.A. Herbert Chase (*Machinery* (*Lond.*), 1936, **48**, (1231), 185–188).—Some typical zinc-alloy die-castings are illustrated. Production of die-cast radiator grilles for motor-cars has been successfully introduced.—J. C. C.

The Dies Used in Brass Die-Casting. Charles O. Herb (*Machinery* (*N.Y.*), 1936, **42**, (10), 638–640).—A satisfactory steel for brass die-casting dies contains tungsten 10–12, carbon 0·3–0·4, chromium 1·75, and vanadium 0·50%. The dies should be maintained between 300° and 600° F., periodically swabbed with tallow, and polished daily. Some typical dies are illustrated.—J. C. C.

Dust Collection in the Foundry. S. D. Moxley (*Trans. Amer. Found. Assoc.*, 1935, **43**, 191–208). **Methods of Dust Control** (*ibid.*, 209–221). **Dust Control—Discussion** (*ibid.*, 222–227).—S. G.

Industrial Health Hazards and Employer Responsibility. W. J. McConnell (*Trans. Amer. Found. Assoc.*, 1935, **43**, 161–165). **Industrial Health Hazards and Employer Responsibility.** Donald E. Cummings (*ibid.*, 166–179). **Discussion** (*ibid.*, 180–190).—S. G.

XV.—FURNACES AND FUELS

(Continued from p. 273.)

Heat Transfer in Continuous Re-Heating Furnaces.—II. J. E. Eberhardt and H. C. Hottel (*Heat Treat. and Forging*, 1936, **22**, (4), 193–198).—In designing a re-heating furnace for specific requirements certain data are fixed and others can be calculated exactly. A typical example is chosen and a complete thermal balance is deduced making use of the equations given in Part I (*ibid.*, 1936, **22**, (3), 144). Tests on an actual furnace are quoted and analyzed. —J. E. N.

Fuel-Oil for Heat-Treatment. A Comparison of Various Methods. T. F. Unwin (*Wire Industry*, 1936, **3**, (28), 173, 175; (29), 219, 220).—A discussion, primarily from the point of view of the iron and steel trades, of the use of oil-fuel for furnace heating. Advantages claimed are low fuel cost, simplicity of design and low capital cost of furnaces, flexibility, controllability both of temperature and within limits of furnace atmosphere, and the small amount of space required for a given output (cf. following abstract).—W. E. A.

Oil *versus* Electricity. —— (*Wire Industry*, 1936, **3**, (28), 175, 177).—Criticisms made on behalf of makers of electric furnaces of statements and claims advanced in the article referred to in the preceding abstract. —W. E. A.

Industrial Electric Furnaces. R. Boye (*Germanskaja Tehnika* (*Z. deut. Technik*), 1936, **15**, (1), 1–8).—[In Russian.] A description of electric furnaces and their peculiarities, electrical resistance materials, insulation, regulation, and economics. Electric furnaces for the metallurgical (tempering, normalizing with salt-baths, annealing) and other industries are dealt with.—N. A.

Melting Furnace. —— (*Heat-Treating and Forging*, 1936, 22, (2), 96).—A brief description of a resistor type of rocking furnace. To the Detroit rocking furnace mechanism, a resistor element has been adapted by mounting a graphite resistor on the central axis of the furnace, and connecting it to a special transformer. Unusual temperature control and flexibility are available. —J. E. N.

A High-Frequency Furnace with Valve Generator. —— (*Philips Tech. Rev.*, 1936, 1, (2), 53–59).—A furnace is described for melting 200 kg. of steel per hr. The current is supplied by a transmitting valve having a useful output of 250 kw. The principles underlying the design are discussed.—H. W. G. H.

***Kindling Properties of Coke.** C. R. Holmes and J. D. Davis (*Indust. and Eng. Chem.*, 1936, 28, (4), 484–488).—The relation (*a*) between carbonizing temperatures of coal and ignition temperatures of the coke produced therefrom were determined and plotted graphically. Other relationships similarly determined and illustrated were between (*b*) carbonizing temperatures and minimum air-flow necessary to support combustion, (*c*) volatile matter in dry coke and ignition temperatures, (*d*) reactivity in carbon dioxide and ignition temperatures, and (*e*) percentage cell-space and ignition temperatures.—F. J.

XVI.—REFRACTORIES AND FURNACE MATERIALS

(Continued from pp. 273–274.)

Modern Furnace Applications of Refractories and Insulation.—II. J. L. Spence and J. W. Craig (*Iron Steel Canada*, 1936, 19, (2), 5–7).—The requirements of refractory cements for furnace construction are set out, taking into consideration all the working conditions of the furnace. The uses of monolithic and castable refractories are briefly discussed.—J. E. N.

History of Crucibles. Otto Vogel (*Glashütte*, 1935, 65, 722–723).—The production of crucibles in the 17th century is briefly discussed.—S. G.

XVII.—HEAT-TREATMENT

(Continued from p. 274.)

Blister Formation in the Heat-Treatment of Temper-Hardenable Aluminium Alloys. W. Gatzek (*Tech. Hochschule, Breslau, Dissertation*, 1933, 13 pp.; and (abstract) *Light Metals Research*, 1936, 4, (24), 453–454).—Blistering of aluminium alloys is more rapid at 550° C. than at 500° C., and is much more pronounced in specimens heated in a salt-bath than in an air furnace. Blistering is not obtained when heating is carried out in a vacuum or in argon, but occurs in hydrogen, steam, and (on scoured surfaces) in nitrogen. Cold-working decreases the temperature at which blistering occurs. It is concluded that blistering is due primarily to dissolved hydrogen.—J. C. C.

Repeated Thermal Treatment of [Aluminium] "O"-Alloy. N. A. Kalashnikov (*Aviopromishlenost* (*Aircraft Ind.*), 1936, (2), 27–29).—[In Russian.] When a cast aluminium alloy containing copper 1–1·5, silicon 4·5–5·5, magnesium 0·4–0·5, and iron 0·7% is annealed at 535° C. for 15 hrs., quenched in water at 95°–100° C., and aged for 10 hrs. in boiling water, the treatment being repeated two or three times, the hardness and tensile strength are only slightly affected, but the elongation is considerably increased by dissolution of the $CuAl_2$ and homogenization of the solid solution. Intermittent ageing has the same effect as continuous ageing for the same period.

Drying of sections after saturation in oil and varnish causes further improvement of mechanical properties.—N. A.

American Methods of Heat-Treating Scale-Free Metals and Metal Products. V. I. Lalikin (*Amerikanskaja Tehnika i Promishlenost* (*Amer. Eng. and Ind.*), 1935, 12, (11), 528–531).—[In Russian.] A brief description of methods of annealing without oxidation of the metal.—N. A.

Heat-Treated Electrotypes. R. H. Schwarz and J. H. Winkler (*Graphic Arts Res. Bur. Preprint*, **1936**, May, 12 pp.; *Bull. B.N.F.M.R.A.*, 1936, (89), 9).—The hardness of electrotype metal (lead–antimony–tin), used for backing electrotype shells, is said to be increased considerably by heat-treatment for 15 minutes at about 238° C., followed by quenching. Electrotypes can be heat-treated without affecting their printing value, thickness or lateral dimensions, or the hardness of the shell. The treatment is suggested for all cases where increased ruggedness of electrotypes, or resistance to severe service, is desired.—S. G.

***The Effect of Annealing on the Length of Cold-Drawn Rods.** Kisuke Saito (*Sci. Rep. Tôhoku Imp. Univ.*, 1936, [i], 25, (1), 128–140).—[In English.] See abstract from Japanese source, *Met. Abs.*, this vol., p. 55.—S. G.

XVIII.—WORKING

(Continued from pp. 275–276.)

†Advances in the Knowledge of and Procedure in Methods of Plastic Shaping of Metals. II.—Rolling. E. Siebel (*Metallwirtschaft*, 1936, **15**, (5), 103–107; and (abridged) *Light Metals Research*, 1936, **4**, (22), 388–389).—A review of recent work on the mechanics of the rolling process with 37 references to the literature.—A. R. P.

X-Ray Determination of Depth of Cold-Working by Machining. L. Thomassen and D. M. McCutcheon (*Mech. Eng.*, 1934, **56**, 155–157).—See *Met. Abs.*, 1934, **1**, 397.—S. G.

X-Ray Determination of Depth of Cold-Working. J. W. Andrews. O. W. Boston. William G. Praed. L. Thomassen and D. M. McCutcheon (*Mech. Eng.*, 1934, **56**, 306–307).—Correspondence on a paper by T. and M. (see preceding abstract), with the authors' reply.—S. G.

***The Deep-Drawing Capacity of Pure Aluminium Sheets of Various Degrees of Hardness.** Werner Helling (*Metallwirtschaft*, 1936, **15**, (17), 388–394; (18), 409–412).—The deep-drawing capacity of aluminium in various stages of work-hardness prepared by numerous German firms has been determined by the Erichsen bowl-drawing apparatus. The results show that on the average the ¼- and ½-hard sheet behaves better than fully-annealed sheet. Comparison of the results with those of the ordinary Erichsen test shows that a direct conclusion as to the suitability of the sheet for deep-drawing can be drawn from the latter test only when the tensile strength is also known; dead-soft sheets have the maximum deep-drawing capacity only when their strength exceeds 9 kg./mm.^{2}. Cups drawn to a diameter of 66 mm. in the first drawing operation can be re-drawn without an intermediate anneal to 26 mm. diameter with a reduction in wall thickness of 20% irrespective of the degree of work-hardness in the original sheet, the power required in the re-drawing operation increasing only slightly with the degree of original work-hardness.—A. R. P.

***Contribution to the Study of Forgeability. Search for a Laboratory Test.** (Portevin, Prétet, and de Lacombe.) See p. 315.

†The Pressing of Nickel and Its Alloys. W. R. Barclay (*Metallwirtschaft*, 1936, **15**, (11), 253–255).—A description of modern practice.—A. R. P.

Modern Methods of Manufacturing Coins, Medals, and Similar Articles. J. Bertrand (*Prat. Ind. mécaniques*, 1936, **19**, (1), 1–6; (3), 101–106).—A comprehensive survey is given of modern (French) minting practice; a plan shows a typical plant, and the various operations are described in detail. A short note is appended on the application of identical or similar plant to the production of small machine parts.—P. M. C. R.

Wire-Making at Cheadle in the 70's. Interesting Account of the Brindleys. —— (*Wire Industry*, 1936, 3, (29), 187, 189, 191, 193).—Historical. An account, with numerous quotations, from the Order Book (1788–1831) of the Cheadle Brass Company. [*Note by Abstractor:* The title of this article appears to be misleading. The period covered by the Minute Book is from 1788 to 1831, and " . . . in the 70's " seems to be quite indefensible.]—W. E. A.

Soap Containing Colloidal Graphite for Wire-Drawing. —— (*Wire Industry*, 1936, 3, (29), 215, 217).—For non-ferrous wires, the lubricant which requires least power for drawing is a hard soap. Addition of colloidal graphite to drawing oils improves their lubricating properties. It is therefore suggested that a combination of hard soap and colloidal graphite, recently introduced, has potentialities (cf. following abstract).—W. E. A.

A New Lubricant. —— (*Wire Industry*, 1936, 3, (29), 217).—A correspondent reports very favourably on results of tests carried out with a good soap with which a very fine colloidal graphite had been mixed. The metal drawn is not stated. The wire is so well lubricated at the first pass as to allow six or seven further passes without more soap. The graphited soap recovers scraped or scored wire, and is ideal for the drawing of sections, such as square, oval, half-round, &c., from round wire (cf. preceding abstract).—W. E. A.

The Science and Practice of Cold-Working [Machining] Brass. M. Kronenberg (*Russko-germanskiy Vestnick Nauki i Tehniki* (*Deut.-russ. Z. Wiss. Tech.*), **1936**, (1), 3–7).—[In Russian.] See abstract from English source, *Met. Abs.*, this vol., p. 130.—N. A.

***Performance of Cutting Fluids in Drilling Various Metals.** O. W. Boston and C. J. Oxford (*Trans. Amer. Soc. Mech. Eng.*, 1935, **55**, RP, 1–25; discussion, 25–29).—Progress Report No. 4 of the Sub-Committee on Cutting Fluids of the A.S.M.E. Special Research Committee on the Cutting of Metals. Gives the results of a series of drilling tests on 9 different metals using 11 different cutting fluids.—S. G.

XIX.—CLEANING AND FINISHING

(Continued from pp. 276–277.)

Surface Treatment of Iron and Light Metals. Rudolf Klose (*Maschinenbau*, 1936, **15**, (11/12), 317–319).—Modern methods and apparatus for cleaning rusted iron and greasy metal surfaces are described.—K. S.

†Modern Apparatus for the Surface Treatment of Metals. Health Protection in Degreasing Plants and Electroplating Works. J. Klotz (*Maschinenbau*, 1936, **15**, (7/8), 207–210).—Trichlorethylene degreasing plants are described together with precautions to be taken in plating works to safeguard the health of the operatives.—K. S.

Cleaning Before Plating. Terrence A. O'Neil (*Metal Progress*, 1936, **29**, (6), 59–64).—The cleaning of metal parts in preparation for electroplating is performed in three stages—degreasing, the removal of scale and rust and the final removal of insoluble matter left after pickling. The processes described are: solvent degreasing, vapour degreasing, alkaline cleaning (electrolytic and otherwise); electrolytic pickling and cyanide stripping.—P. M. C. R.

***Pickling Solutions for Use in Cleaning of Existing Apparatus.** M. J. van der Wal (*Chem. Weekblad*, 1935, **32**, 709–713; *C. Abs.*, 1936, **30**, 3759).—Four samples of commercial pickling preparations (hydrochloric acid + inhibitor) and pure hydrochloric acid were tested on different metals: iron, zinc, aluminium, copper, brass, bronze, and cast iron in 20, 10, and 3% hydrochloric acid concentration, 15°, 50°, or 80° C., for 1 up to 24 hrs., 100 c.c. solution, 1·5 × 8 cm. plates, 0·5–0·8 mm. thick. The attack was expressed in grm./cm.^{2} surface area. For relatively short periods (up to 8 hrs.) and temperatures below 50° C., the attack by pickling solution is materially less than for straight hydrochloric acid; after 24 hrs. the attack is about equal. The attack of steel by pickling solution was generally at 15° C. after 1–5 hrs. from 0·0037 to 0·0047 grm./cm.^{2}. The pickling solution also worked properly inside old metal pipe. Equally good results were obtained on aluminium, although the action is more rapid. The effect of all solutions on zinc was too fast to be followed properly; on copper, brass, or bronze little action was found and no difference between pure hydrochloric acid and the pickling baths. The inhibitors used were probably vegetable extract in one case, polymerized formaldehyde and hexamethylenetetramine in another. The inhibitor was present in the 24–30% hydrochloric acid solutions in concentrations of about 1 grm./litre.—S. G.

†**Finishing of Die-Castings.** J. C. Fox (*Amer. Soc. Test. Mat. Preprint*, **1936**, 5–15).—Appendix II to the Report of Committee B–6 on Die-Cast Metals and Alloys. A review of the present methods used in finishing zinc and aluminium alloy die-castings. These two types only are considered, since they represent about 90% of all die-castings consumed, the tin- and lead-base alloy die-castings being seldom finished, because in most applications they are used for their corrosion-resistance and not for decorative parts, and the new copper-base and aluminium-base alloy die-castings are not yet of commercial importance. Electroplating including chromium-plating, copper-plating, and nickel-plating is fully discussed, as well as organic finishes and combination of finishes for the zinc alloys, and polishing, acid-dip treatment, enamelling and japanning, and anodic oxidation treatment of the aluminium alloys.—J. W. D.

Chemical Metallic Colorations on Aluminium and the Painting of Aluminium. —— (*Z. Metall- u. Schmuckwarenfabrikation*, 1936, **17**, (5), 12; Special Number: *Surface Treatment of Aluminium and Light Alloys*; and (abstract) *Light Metals Rev.*, 1936, **2**, (23), 429).—In cases where plant for the Eloxal process is not available, it is possible to obtain satisfactory colours on aluminium articles by the M.B.V. or the Jirotka processes, provided that copper-containing alloys are not used. Directions are given for the production of a number of colours, and the available paints and varnishes for coating aluminium are reviewed.—L. A. O.

Colouring of Metals. III.—White Metals. Herbert R. Simonds and C. B. Young (*Iron Age*, 1936, **137**, (25), 30–33, 99).—Describes plating and chemical treatment methods for colouring aluminium, cadmium, chromium, lead, platinum, rhenium, rhodium, and silver. Another method for colouring aluminium is to anodically oxidize the metal by chromic, sulphuric, or oxalic acid groups, and then to colour the oxide so formed, by dipping the part in aqueous solutions of organic dyes. The colouring of cadmium is not of great practical importance. The information on the colouring of chromium is meagre. Rhodium, lead, and silver are seldom coloured. Platinum is usually coloured by alloying, but sometimes chemically.—J. H. W.

Finishing Aluminium with Abrasives. H. K. Work (*Abrasive Ind.*, 1936, **17**, (2), 8–11, 23; and (summary) *Light Metals Rev.*, 1936, **2**, (22), 393–394).—Recommendations are given for the polishing procedures and abrasives to be used in finishing various types of aluminium products.—J. C. C.

Grinding or Scraping? W. Iwascheff (*Machine moderne*, 1936, **30**, (329), 238–240).—The processes of scraping and machine grinding are considered in detail from the standpoints of accuracy, cost, and speed. The mechanical method is considered preferable, especially in the case of large work.—P. R.

XX.—JOINING

(Continued from pp. 277–278.)

Economy in Tin in Soft-Soldering. E. Lueder (*Z.V.d.I.*, 1936, **80**, (21), 655–656).—Economies can be effected by reducing the tin content of the usual solders, by devising new soldering methods, and by developing new alloys. —K. S.

Soldering and Jointing. J. P. Murrough (*Electrician*, 1936, **116**, (3021), 532).—For jointing aluminium conductors, a solder of zinc 60, cadmium 40% is recommended. No flux should be used, but the surfaces should be abraded with a wire brush while covered with the molten solder. Aluminium surfaces in contact with copper should be "tinned" with this solder or separated by a composite sheet of copper and aluminium ("copral") as a safeguard against electrolytic corrosion.—J. C. C.

Gas Welding of Light Metals. M. Maier (*Autogene Metallbearbeitung*, 1936, **29**, (9), 129–134).—"Soft" solders for aluminium do not "tin" the metal readily on account of the protective oxide film. They also have the serious disadvantage of producing joints with very low corrosion-resistance. "Hard" soldering is usually carried out with Silumin rods which have the advantage of a melting point about 80° C. below that of aluminium. This advantage is naturally lost when the aluminium is alloyed to any extent. Successful welding of aluminium and its alloys is dependent on the use of a flux to dissolve the oxide film, and of melting point to suit the alloy to be welded. Such fluxes are hygroscopic, and are liable to set up corrosion if the finished joint is not thoroughly cleaned. If the joint cannot be cleaned, a special non-hygroscopic flux must be used. Cast alloys can usually be welded without flux: in the case of Silumin-Gamma, flux makes the welding more difficult, but it is an advantage for the "German" and "American" alloys. Careful preheating is necessary for welding castings and at the beginning of seams in sheet material. The fuel-gas used has little effect on the quality and corrosion-resistance of welds in light alloys. The ordinary leftward method is used for aluminium and many alloys, but for those which tend to form contraction cracks (*e.g.* Pantal), a special technique is adopted involving an up-and-down as well as a sideways movement of the blowpipe. For such alloys, a 5% silicon filler-rod is often used.—H. W. G. H.

Spot- and Seam-Welding of Stainless Steel and Light Metals. The Use of Special Rectifiers in Resistance Welding Machines. C. Froehmer (*Maschinenbau*, 1936, **15**, (7/8), 201–203).—By the use of special switch gear and new methods of construction of the machines light metals can be satisfactorily welded by the spot or seam method.—K. S.

Some Practical Notes on Working and Joining Sheet Aluminium in Motor-Vehicle Construction. A. J. T. Eyles (*Aluminium and Non-Ferrous Rev.*, 1936, **1**, (7), 324–325; (8), 385–387).—Discusses the operations of beating, polishing, soldering, riveting, and welding aluminium and aluminium-alloy sheet. —J. C. C.

The Welding of Copper. —— (*Soudure et Oxy-Coupage*, 1936, **13**, (72), 283).—Brief hints on technique are given for welding thin sheets (up to 2 mm.), medium thicknesses (3–5 mm.), and heavy material.—H. W. G. H.

Gas-Welding [of Copper Fireboxes] in the Works of the [French] Railway Companies. R. Meslier (*Rev. Soudure Autogène*, 1936, **28**, (265), 2–5).—Some examples of repairs to copper fireboxes are illustrated and described. Double-bead vertical welding is used almost exclusively. A firebox fabricated completely by oxy-acetylene welding is also illustrated.—H. W. G. H.

The Repair by Welding of Cracked Bronze Bells. P. Bräuer (*Autogene Metallbearbeitung*, 1936, **29**, (6), 85–88).—B. considers the repair of bells to be the most difficult of welding tasks and gives a most interesting account of the methods by which the difficulties are overcome. Very careful preheating is carried out by charcoal in a specially built furnace, of which details are given. In the first 2 hrs., the temperature should not exceed 100° C.; at about 500° C. the patina is burned off; and welding is begun when, at the end of 10–12 hrs., 550°–600° C. is reached. 10–20 mm. diam. filler-rods are used, of approximately the same composition as the bell, *viz.* about 75% copper and 20% tin, and most of the many proprietary fluxes on the market are suitable. The blowpipe flame must be kept exactly neutral. Large bells must be supported, mouth downwards, with the rim resting on firebricks, and the repair must always be commenced at the highest point, the rim being the last part to be welded. The actual welding, however, is in an upwards direction, by the "step-back" method. The welding must be completed without interruption, and may take as long as 35 hrs. As much as 80 kg. of filler metal may be required. When welding is complete, the bell is reheated to 600° C., and cooling is retarded to take 3–6 days. It has been found that a properly repaired bell has an even better tone than it had originally.—H. W. G. H.

Welding of Elektron Castings Rejects. A. F. Berzin (*Aviopromishlenost* (*Aircraft Ind.*), 1936, (1), 26–29).—[In Russian.] The welding rods used contained 1% more manganese than the alloy welded, which contained 9–10% aluminium but no zinc. A mixture of barium chloride 40, sodium chloride 27, potassium chloride 13, lithium chloride 8, and sodium fluoride 12% was used as a flux, the castings were preheated to 270°–300° C., a reducing flame was used, and after welding the articles were cooled slowly in an asbestos shroud.—N. A.

Innovations in Welding. R. Granjon and J. Brillié (*Congrès Internat. Mines Mét. Géol., Section de Métallurgie,* 1935, 1, 313–319; and *Rev. Mét.*, 1936, **33**, (2), 89–95).—Deals mainly with factors which influence the strength of welds in ferrous metals. Brief notes are included on the oxy-acetylene welding of copper, brasses, aluminium, light alloys, aluminium–bronzes, and nickel.—J. C. C.

Researches on the Back-Pressure and Velocity of Flow of Flame Gases. M. Maier (*Autogene Metallbearbeitung*, 1936, **29**, (6), 81–85).—The action of a "fierce" blowpipe flame in blowing the molten puddle is well-known to welders. These investigations were carried out to evaluate the various factors influencing this effect. On three blowpipes with oxygen flowing only, measurements were made of the velocity and pressure at various distances from the tip. On two pipes, similar measurements were made on welding flames, neutral, oxidizing, and reducing The pressure at the tip of the inner cone was found to be lower with a neutral flame than with excess oxygen or acetylene, and to increase with increasing velocity of the unburned gases. The effect of excess acetylene in making a flame "soft" is not due to reduced pressure, but to lowered flame temperature.—H. W. G. H.

On a New Method of Electric Arc Welding. S. Akazaki (*J. Zosen Kiokai* (*Soc. Naval Arch. Japan*), 1935, **57**, 15–32).—[In Japanese.] Describes a new method of welding in which the electrode is laid on the weld line of the base metal, and, as soon as the arc is started, the electric current between the tip of the electrode and the weld metal is shorted with a piece of wire. After this the wire is removed, and the arc moves continuously at a constant speed and a constant arc length from the tip of the end, which is connected with the electric terminal wire, until the welding is complete. This method can be used in vertical, horizontal, and overhead welding without difficulty, and just as easily as in downward welding.—J. W. D.

How Does a Welding Electrode Fuse? J. Sack (*Philips Tech. Rev.*, 1936, **1**, (1), 26–29).—A concise, but comprehensive review of published researches on the transfer of weld metal in the arc is given, and the method developed by S. (see *Met. Abs.*, 1935, 2, 730) using an X-ray cine-camera, is briefly described. —H. W. G. H.

The Contraction of Welded Butt Seams. R. Malisius (*Elektroschweissung*, 1936, 7, (1), 1–9).—A formula is developed for the contraction of bars welded end to end, based on the volume of weld metal and Bornefeld's determinations of temperature distribution during welding. The effects of different methods of welding and of clamping the bars rigidly are determined. The calculations are extended to the more complicated case of butt-welded sheets and the values obtained theoretically for the transverse contraction are shown to agree extremely well with experimental results.—H. W. G. H.

Fundamentals of Spot Welding with Particular Reference to Electrode Life. E. I. Larsen (*J. Amer. Weld. Soc.*, 1936, 15, (4), 25–31).—The physical properties of pure copper and two alloys are compared, and tests are described, under definite conditions, of electrode tips made from these materials. The properties required for good service are found to be hardness, high yield-point, and softening temperature, and high heat and electrical conductivity. The tests show the great importance of hardness at high temperature.—H. W. G. H.

Accurate Timing has Greatly Increased the Scope of Spot-Welding. Paul G. Weiller (*Machinery* (*N.Y.*), 1936, 42, (10), 655–656).—J. C. C.

Relay Valves as Timing Devices in Seam-Welding Practice. D. M. Duinker (*Philips Tech. Rev.*, 1936, 1, (1), 11–15).—A time controller for seam-welding must allow the welding current to pass for a given number of cycles, then arrest it for a further number of cycles (not necessarily the same) and repeat the sequence continually. The advantages of valve devices are extreme accuracy, absence of moving parts, and the possibility of obtaining extremely short intervals. The article describes a suitable circuit, using hot-cathode rectifier valves with grid control, which permits wide variation of "on" and "off" times, the lower limit of each being one cycle.—H. W. G. H.

The Present State of Built-Up Welding. W. Berndt (*Metallbörse*, 1934, 24, (58), 921–923; (60), 953–954).—S. G.

Impact Tests of Welded Joints. A Review of the Literature to Jan. 1, 1936. (Spraragen and Claussen.) See p. 316.

The Elongation Test (on Welds). Experiments and Results. (Matting.) See p. 316.

General Training Course for Welding Operators. —— (*Oxy-Acetylene Tips*, 1936, 15, (3), 53–59).—The course is divided into 16 "units," each of which consists of a statement of the objective to be attained and a description of the practical work suggested. Welding of copper, brass, aluminium, nickel, Monel metal, and lead are included, and also bronze-welding, silver soldering, and soft soldering by means of the oxy-acetylene flame.—H. W. G. H.

XXI.—INDUSTRIAL USES AND APPLICATIONS

(Continued from pp. 279–283.)

Aluminium Bells. Harry N. Holmes (*Nature*, 1936, 137, (3470), 745).—A large aluminium bell 3 ft. in diameter and 0·75 in. thick has recently been cast in America in honour of the 50th anniversary of Hall's discovery of the modern process of preparing aluminium; the bell is much flatter than the usual bronze bells, but has a splendid sonorous tone which lasts a long time. —A. R. P.

Steel-Cored Aluminium Conductors. C. H. E. Ridpath (*Elect. Ind.*, 1936, 36, (1838), 994–998).—The strength, electrical resistance and inductance, and corona losses of steel-cored aluminium conductors are discussed. Methods for preventing the vibration of transmission lines strung under high tension are described, and typical clamps and fittings illustrated.—J. C. C.

Fuels for Aircraft Engines [Burning of Light Alloy Pistons]. E. L. Bass (*J. Roy. Aeronaut. Soc.*, 1935, **39**, (298), 879–935; discussion, 936–962).—Reference is made to burning of light alloy pistons and cylinders under detonation conditions in aircraft engines.—H. S.

The Use of Reinforced Aluminium Foil for Insulation for Housing and Other Purposes. —— (*Rep. Ross Inst. Tropical Hygiene* (*L.S.H.T.M.*) *Indust. Advisory Cttee.*, **1935**, Jan.; and (abstract) *Light Metals Rev.*, 1935, **2**, (1), 5–6).—L. A. O.

Metal Foil [Aluminium]. —— (*Boxmakers' J. and Packaging Rev.*, **1935**, Dec.).—L. A. O.

The Future of Beryllium in Automobile and Aeronautical Construction. Maurice Déribéré (*Tech. automobile et aérienne*, 1936, **27**, (173), 63).—A short account is given of the sources, extraction, and uses of beryllium. A table of the prices of beryllium between 1922 and 1934–1935 illustrates the increasing applications and availability of the metal.—P. M. C. R.

†**Copper as a Mould Material.** H. J. Miller (*Met. Ind.* (*Lond.*), 1936, **48**, (26), 705–710).—A review of the development and applications of copper moulds, solid and water-cooled, in the production of ingots and simple shapes in copper, copper alloys, and nickel alloys. More recently complete or part moulds in copper have been used in the aluminium, nickel, and steel industries. —J. E. N.

Cadmium–Copper [Wire] for Power Transmission. G. W. Preston (*Elect. Ind.*, 1936, **36**, (1837), 957–959).—Outlines the advantages of hard-drawn cadmium–copper conductors, containing 0·8% cadmium, for the construction of transmission lines. They can usually be erected with less sag than the corresponding steel-cored aluminium conductors.—J. C. C.

Bronzes Used in Machine-Tool Construction. L. A. Ginzburg and E. D. Spivak (*Stanki i Instrument* (*Machine Tools and Instruments*), **1936**, (2), 24–29).—[In Russian.] Parts of machine-tools made of bronze are enumerated. From a critical examination of the composition of bronzes, the need for substituting special bronzes and brasses for tin–bronzes is indicated.—N. A.

Lead–Bronze Bearings for Diesel Engines. M. Melhuish (*Gas and Oil Power*, 1936, **31**, (369), 151–152).—The increasing explosion pressures and engine loads necessitate the provision of high-duty bearings in Diesel engines, especially as modern design tends to decrease the bearing area. Lead–bronze bearings in steel shells are much used. The alloys employed are either copper–lead alloys (lead 10–40%), or copper–tin–lead bronzes (tin 5–10, lead 10–25%). The advantages and limitations of this type of bearing are considered, and the accompanying modifications in design are described.—P. M. C. R.

Nickel-Containing Bronzes in the Automobile Industry. L. Abbott (*Nickel Bull.*, 1936, **8**, (7), 99).—Describes briefly the application of nickel–bronzes of, for instance, the composition: copper 88, tin 11·2, phosphorus 0·3, and nickel 0·5%, to the manufacture of various parts of motor-cars.—J. H. W.

Sheet Brass for Photoengraving and Etching. B. H. McGar (*Graphic Arts Res. Bur. Preprint*, **1936**, May, 4 pp.; *Bull. B.N.F.M.R.A.*, 1936, (**89**), 7).—A short account of the production of brass sheet, and of the desirable properties of the sheet for photoengraving. Alloys commonly used are "high" brass (66 : 34), "low" brass (80 : 20), "rich low" brass (85 : 15), and commercial bronze (90 : 10); the usual impurities are lead (less than 0·1%) and iron (less than 0·05%).—S. G.

Recent Developments in Condenser Tubes. —— (*Mech. Eng.*, 1934, **56**, 439–440).—Abstract of progress Report No. 7 of the A.S.M.E. Special Research Committee on Condenser Tubes.—S. G.

Impression Lead and Electrotype Foil: Manufacture and Use by the Electrotyper. H. Baker (*Graphic Arts Res. Bur. Preprint*, **1936**, May, 12 pp.; *Bull. B.N.F.M.R.A.*, 1936, (89), 8).—Impression lead is sheet lead used in the production of electrotypes, for making a mould of the subject to be duplicated. Electrotype foil is of solder composition, used for soldering the electrotype shell to its backing of electrotype metal. The composition and desirable properties of these materials, as well as other aspects of electrotyping practice, are discussed.—S. G.

Use of Arsenic–Cadmium Babbitt "B.M." in Motor-Cars and Tractors. M. Hrushev and V. Maslenikov (*Avto-traktornoe Delo* (*Auto-Tractor Practice*), **1936**, (4), 114–120).—[In Russian.] Arsenic–cadmium Babbitt "B.M." is not an entirely satisfactory substitute for tin-base Babbitt for tractor bearings, as it is more liable to crack under working conditions, causes severe wear on the shaft, and requires stricter control of casting.—N. A.

Contributions to the Study of Friction Bearings in High-Speed Combustion Engines. H. Mann (*Automobiltech. Z.*, 1936, **39**, (11), 290–292).—This section of an article on bearing design contains an account of the softer and harder types of bearing alloy; the former include the lead- and tin-base alloys and the soft lead–bronzes, whilst the latter include cast iron, tin–bronzes, and such light alloys as "Y"-alloy, Elektron, and some of the aluminium–silicon series. —P. M. C. R.

Evaluating Bearing Materials. Theodor Rabinovitch (*Petroleum Z.*, 1935, **31**, (41); *Motorenbetrieb u. Maschinenschmierung*, 1935, **8**, (10), 2–5; *C. Abs.*, 1936, **30**, 2892).—Factors important for bearing materials are: molecular-physical properties of the surface and behaviour towards the lubricant; sp. gr., chemical composition, and origin; economic and political situation; thermal properties; optical properties; electrical properties; technological properties which include (*a*) fusibility and castability, shrinkage; (*b*) corrosion-resistance and neutrality towards journal material; (*c*) machinability and surface conditions; (*d*) resistance to repeated impact at operating temperature; (*e*) hardness at operating temperature; (*f*) wear strength at operating temperature; and (*g*) condition of the structure at the operating temperature. The importance of these properties is discussed.—S. G.

Standard Specifications for Magnesium Alloys Recommended by the V.I.A.M. for Supplying U.S.S.R. Industries. J. E. Afanasiev (*Vestnik Standartizazii* (*Messenger of Standardization*), **1935**, (4–5), 35–41).—[In Russian.] Specifications for magnesium alloys for the aircraft industry take into consideration alloys already used in mass production, and also give the composition of alloys tested in practice and by theoretical investigations in the U.S.S.R. and abroad. Trade marks, chemical composition, thermal treatment, mechanical properties, and sp. gr. are given, and the uses indicated.—N. A.

Molybdenum in Automobile and Aero Construction. M. Déribéré (*Tech. automobile et aérienne*, 1936, **27**, (173), 58–60).—An account is given of the occurrence and principal properties of molybdenum, and of its uses as an alloying element in ferrous metallurgy.—P. M. C. R.

The Use of Nickel in Gramophone Record Manufacture. E. A. Ollard (*Nickel Bull.*, 1936, **9**, (6), 121–124).—To produce a nickel face on the master shell of a gramophone record the shell is first drastically cleaned and then plated in a nickel ammonium sulphate solution, containing about 4 oz./gall. of the salt at a $p_{\rm H}$ of about 4·9 and a working temperature of 80° F. (27° C.). Facing may also be done in an ordinary nickel sulphate solution, but the deposit is then rather softer. In general, an ordinary type of warm nickel sulphate solution is used, as follows: nickel sulphate 2 lb., ammonium chloride 2 oz., boric acid 2 oz./gall.; temperature 110° F. (43° C.), $p_{\rm H}$ (quinhydrone) 5·7–5·9. The solution is circulated with a pump and strained through fine muslin, the shell being either hung or rotated half in and half out of the solution at

50–80 r.p.m. For growing in copper, an ordinary acid copper solution is used, containing, say, copper sulphate 32 oz., sulphuric acid 13 oz./gall. The stamper shell used to stamp out commercial records is made from the positive in a manner similar to that which is used to make the positive from the master. —J. H. W.

Nickel Alloys for Low- and High-Temperature Service. Byron B. Morton (*Chem. and Met. Eng.*, 1936, 43, (3), 136–138).—Abstracted from *Oil and Gas J.* See *Met. Abs.*, 1935, 2, 643.—F. J.

The Oligodynamic Action of Metals and Its Practical Application in the Catadyn Process. H. Beger (*Kleine Mitglieder Mitt. Ver. Wasser-, Boden-, Lufthyg.*, 1934, **10**, 182, 339).—A summary is given of existing information on Krause's catadyn process. B. stresses the need for further study. A *bibliography* is appended.—S. G.

Production, Treatment, and Use of Tungsten in the U.S.A. I. M. Krasnopolskiy (*Amerikanskaja Tehnika i Promishlenost* (*Amer. Eng. and Ind.*), 1935, **12**, (11), 508–514).—[In Russian.] The use of tungsten in hard and non-ferrous alloys is indicated.—N. A.

Sheet Zinc for Photoengraving. W. H. Finkeldey (*Graphic Arts Res. Bur. Preprint*, **1936**, May, 15 pp.; *Bull. B.N.F.M.R.A.*, 1936, (89), 12).—Deals with the manufacture, etching—as affected by composition and by structure, respectively—the mechanical properties of sheet zinc of importance to the electroengraver, and dimensional changes in photoengraving plates. For some purposes, a material described as " hard zinc " is mentioned (no composition is given); it has a Rockwell hardness of 85–86 as compared with 73–74 for ordinary zinc.—S. G.

Technical Qualifications (Properties) of Photoengraving Zinc. E. W. Spencer (*Graphic Arts Res. Bur. Preprint*, **1936**, May, 5 pp.; *Bull. B.N.F.M.R.A.*, 1936, (89), 12).—Deals with the desired properties of zinc; the U.S. Government Printing Office specifies zinc 99·2 (minimum), lead 0·4 (maximum), cadmium 0·35 (maximum), and iron 0·016% (maximum). A detailed discussion is given, from a metallographic point of view, of the effect of impurities on behaviour. Pouring and casting, grinding and polishing of photoengravers' zinc are dealt with.—S. G.

Nitric Acid Etching of Photoengravers' Zinc. E. R. Boller (*Graphic Arts Res. Bur. Preprint*, **1936**, May, 16 pp.; *Bull. B.N.F.M.R.A.*, 1936, (89), 11).—An investigation of various phases of the zinc–nitric acid reaction of importance in photoengraving, including a development of a method of measuring the efficiency of a nitric acid etching bath, the determination of the rate of dissolution of zinc in nitric acid, and effects of various impurities and additions (copper, platinum, silver, organic substances).—S. G.

Metallizing with Zinc of Lock Gates for the Saint-Denis Canal. J. Cauchetier (*Métalliseur*, 1936, 2, (2), 6–9).—A description is given of the method of spraying the lock gates with zinc in 1922.—W. E. B.

Valuation of Zinc-Base Alloys. V. S. Prever (*Industria meccanica*, 1936, 18, 128–132; *C. Abs.*, 1936, 30, 4139).—Zinc alloys with copper, aluminium, lead, iron, and tin, particularly when used as bearing alloys, are reviewed from the point of view of Italian industry, which has to economise in their consumption. Several alloys now used in Italy are described, and the literature is cited.—S. G.

Metallurgical Trends of Chemical Engineering Interest. Clyde E. Williams (*Chem. and Met. Eng.*, 1936, **43**, (1), 17–19).—The special applications of heat- and corrosion-resisting alloy steels in chemical engineering work are reviewed. Non-ferrous alloys have also undergone notable changes to meet requirements in this field. The nickel 70, copper 30% alloys to which aluminium (3·5%) or silicon (2·75%) has been added, are used for valves and pumps in handling corrosive solutions at high temperatures and in superheated steam service. The alloy containing aluminium when heat-treated, has a tensile strength at room temperature of 71·5 tons/in.^{2}. The alloy nickel 66, copper 33%, modified by the addition of 2·5–3% silicon, is specially resistant to sulphuric acid. The valuable effects obtained by adding silicon, manganese, or beryllium to copper are discussed. Hand-tools such as chisels, hammers, scrapers, and wrenches are made of beryllium–copper for use in explosive atmospheres. Copper 98, chromium 2%, heat-treated, has high strength with comparatively good conductivity. Mention is also made of the value of joining steel parts by brazing with copper or copper alloy under reducing conditions, of soldering copper tubes with solder containing tin 95, antimony 5% and of new silver solders of greater strength and corrosion-resistance than is obtainable with tin–lead solders.—F. J.

***Materials for Manufacture of Working with Nitroso-Sulphuric Acid Pumps.** V. A. Dunkovich (*Khimicheskoe Mashinostroenie* (*Chem. Machinebuilding*), **1936**, (1), 33–35).—[In Russian.] As shown by experiments, the following materials may be recommended for pumps: steel V2A, silicon–bronze containing copper 93–94, silicon 4·5–5, and iron 0·9–1%. Copper and chromium cast-irons were found to be non-resistant.—N. A.

Non-Ferrous Alloys Used for Aeroplanes in the United States and Europe. Tomojiro Tanabe (*Kenkyu Hokoku, Sumitomo Shindokokan Kaisha* (*Res. Rep. Sumitomo Copper and Steel Tube Co.*), 1934, 2, (2), 147–159).—[In Japanese.]—S. G.

Seals Against Fluid Pressures. —— (*Power Plant Eng.*, 1936, **40**, (5), 280–282; (6), 354–356).—Designs of joints commonly used in piping are illustrated, as are various types of metallic gasket and of rod packing. A list of packing materials includes aluminium, bronze, white metal, copper, lead, nickel, and Monel metal; their special advantages and applications are indicated in each case.—P. M. C. R.

Mogul—The High Production Metallizing Unit. —— (*Metallizer*, 1936, 5, (3), 8, 9).—A description is given of the Mogul high-production metallizing unit.—W. E. B.

XXII.—MISCELLANEOUS

(Continued from p. 283.)

Economics of the Aluminium Industry. Francis C. Frary (*Indust. and Eng. Chem.*, 1936, **28**, (2), 146–152).—The economics of the production of aluminium are discussed, the principal factors involved in the production of the pig metal at the reduction plant being first analyzed: the cost of the materials consumed (aluminium oxide, electrodes, and electrolytic materials), cost of power, repairs and maintenance, labour and overhead charges. Other matters discussed are development of a market, fabrication problems, future of the industry and competition with other metals.—F. J.

50 Years of New Product Development. Francis C. Frary and Junius D. Edwards (*Chem. and Met. Eng.*, 1936, **43**, (2), 64–67).—A review of progress in the development of the aluminium industry.—F. J.

Fifty Years of Industrial Aluminium. Harry N. Holmes (*Sci. Monthly*, 1936, 236–239; *C. Abs.*, 1936, 30, 2851).—An address on the 50th anniversary of Martin Hall's first production of aluminium from the fused cryolite–bauxite electrolyte.—S. G.

Metallurgy of Gold and Platinum Among the Pre-Columbian Indians. Paul Bergsøe (*Nature*, 1936, **137**, (3453), 29).—Half-finished objects made by the Indians of wrought platinum and gold or from plates or wires of these metals have recently been discovered in Ecuador. Some of these objects appear to have been melted on wood charcoal by means of a blowpipe, the platinum grains being joined together by mixing them with grains of native gold and alternately heating and hammering the mass into thin homogeneous plates. —A. R. P.

Lead Smelting in the North Pennines During the 17th and 18th Centuries. A. Raistrick (*Proc. Univ. Durham Phil. Soc.*, 1936, 9, (4), 164–179).—S. G.

Fire Risks on Magnesium Alloys. Brigade Tests and Remedies. —— (*Aluminium and Non-Ferrous Rev.*, 1936, 1, (8), 373–375).—The report of a provincial Fire Brigade on experiments with ignited Elektron swarf is reproduced and criticized. Notes are given on the fire hazard when machining this alloy. Tools should be kept sharp, and a special dust extraction plant used. In case of fire, water or liquid extinguishers should not be used, but the fire smothered with an asbestos cloth, dry sand or graphite, or heavy cast-iron turnings.—J. C. C.

Advances in the Field of Hard Metals. Karl Becker (*Metallwirtschaft*, 1936, 15, (5), 110; (15), 349–350).—A number of recent patents are briefly reviewed. —A. R. P.

The Zinc Industry in France. —— (*Écho Mines Mét.*, 1936, 64, 154–157).—S. G.

Electricity in Metallurgy as Disclosed by the Proceedings of the International Congress of Mines, Metallurgy, and Applied Geology (Paris, October 20–26, 1935). L. Descroix (*Rev. gén. Élect.*, 1936, 39, (17), 617–626; (18), 661–667). An abstract-review.—J. C. C.

Report on the Department of Metallurgy and Metallurgical Chemistry [of the National Physical Laboratory] for the Year 1935. C. H. Desch (*Nat. Phys. Lab. Rep.*, 1935, 157–169).—The report covers *inter alia* work done on the following: oxidation of solid and liquid metals and alloys at high temperatures, the age-hardening of aluminium alloys, gases in aluminium, oxide films on aluminium, magnesium alloys for use up to 150° C., effect of age-hardening on the creep of a nickel–silicon–copper alloy, dental alloys and amalgams. —A. R. P.

Report on the Engineering Department [of the National Physical Laboratory] for the Year 1935. H. J. Gough (*Nat. Phys. Lab. Rep.*, 1935, 134–156).—Work on the following subjects is recorded: resistance of metals to wear, methods of testing thin sheet metal, fatigue in relation to crystalline structure, effect of orientation on the resistance of single crystals of aluminium to alternating torsional stresses, and other work on the fatigue of aluminium, creep and cracking of metals at high temperatures, lubrication of metals, corrosion and fatigue of plated metals.—A. R. P.

Report on the Physics Department [of the National Physical Laboratory] for the Year 1935. G. W. C. Kaye (*Nat. Phys. Lab. Rep.*, 1935, 26–56).—Among the subjects of non-ferrous interest dealt with are determinations of the thermal and electrical conductivity and specific and latent heats of metals and alloys at high temperatures, and of the melting point of palladium, and the application of X-rays to the study of the structural changes produced by cold-working metals and of the structure of electrodeposited metal coatings. —A. R. P.

Report on the Electricity Department [of the National Physical Laboratory] for the Year 1935. E. H. Rayner (*Nat. Phys. Lab. Rep.*, 1935, 57–87).—The report covers a great deal of work on precision measuring apparatus, including standard resistance coils of platinum and work on the stability of Manganin resistances and the use of chromium–gold alloys for resistances.—A. R. P.

XXIV.—BOOK REVIEWS

(Continued from pp. 286–288.)

Der Aufbau der Zweistofflegierungen. Ein Kritische Zusammenfassung. Von M. Hansen. Med. 8vo. Pp. xv + 1100, with 456 illustrations. 1936. Berlin: Julius Springer. (Geb., R.M. 87.)

For the skill and patience shown by Dr. Hansen in compiling this monumental critical review of the constitution of binary alloys no praise can be too high. This is a book which nobody interested in the constitution of alloys can possibly afford to be without. It is a "Guia" brought up to date, extended, and crammed full of modern knowledge, and the work is only less important to the ferrous metallurgist than it is to the non-ferrous man. There is no longer any need to spend hours looking for a reference. All the relevant references are there. It is claimed that the literature up to the autumn of 1935 has been examined, and indeed we find that work published in Volume 57, 1935, of this *Journal* has been considered. In all, 824 binary systems, including 50 containing copper and another element and 54 containing iron and another element, are reviewed. True, some of these systems are dismissed in a line or two, but the grand total of references must be astonishing.

It would perhaps be most useful to illustrate Dr. Hansen's method by considering some typical systems. Let us take copper–zinc, chromium–iron, and tungsten–zirconium. There are 17 pages and 100 references devoted to brass. There is first an introductory page with some mention of Bauer and Hansen's monograph on these alloys and references to the earlier work, with some indication of the experimental methods used and the relative importance of the papers. Then a short paragraph on the liquidus is followed by a considerable discussion on the solidus. A table is given in which the collected results of no less than 17 workers on the positions of the 5 peritectic lines and the one eutectoid line are set out, together with the most probable results from which a diagram has been constructed. A glance at this diagram gives the temperatures of these reactions; a glance at the table gives the solubility limits at these temperatures. Next follows a description of work on the α-phase boundary, in which that of Genders and Bailey takes pride of place, with that of Gayler and Owen and Pickup not far behind. The other boundaries are similarly treated, and a diagram showing the collected results in the α, β, γ-region is given. There follow 3 pages on the β–β' transformation, one on crystal structure, and a short paragraph on the "finer" physical properties, with some 14 references. One learns at once, for example, where to find information on the electrode potentials of the alloys. Lastly, a page of additional entries giving summaries of four recent papers.

The treatment of the chromium–iron system is somewhat different, but just as satisfactory. First there is an historical survey, occupying some 6 pages, with short abstracts of 33 papers. This is followed by a short critical summary dealing with the liquidus and solidus, the γ-loop, FeCr, and the magnetic change point. There are two diagrams; the first gives the γ-loop as found by Adcock and the magnetic change points by 6 investigators; the second is the probable diagram. The author thinks that the positions of the liquidus and solidus (Adcock), of the γ-loop and of the upper part of the magnetic line can be regarded as settled, while the lower part of this line, the nature and range of the ϵ-phase, and the freezing-point of chromium must be regarded as doubtful. Finally, three more references and a note on Eriksson's work on the ϵ-phase. (*Met Abs.*, 1935, 2, 343.)

Under tungsten–zirconium, an example of an unfamiliar system, we find only that the production of these alloys has been repeatedly described (4 references), that Claassen and Burgers have proved with certainty the existence of the compound W_2Zr (19·86 per cent. Zr) and have examined its crystal structure (cubic with 8 molecules of W_2Zr in the unit cell), and that W_2Zr forms a solid solution with Zr.

It is almost impossible that a work of this size should be free from mistakes. Such as we have noticed have been trifling and obvious—the omission of a decimal point, a reference in the text omitted in the list of references (but nevertheless a broad trail left to the original paper). For all its thousand pages the volume is not unduly bulky. The print is excellent. The diagrams, through the co-operation of author and publisher, are clear. An author index would have been impossible; the given system index is unnecessary. One finds one's way about without any difficulty at all. But the book's greatest value lies in the criticisms of the relative accuracy of various workers. This appears to be very sound, just, and free from all bias.

This is the best book on the constitution of alloys which has ever been published. The sooner we have an English translation the better.—D. STOCKDALE.

A Comprehensive Treatise on Inorganic and Theoretical Chemistry. By J. W. Mellor. Volume XV.—**Ni, Ru, Rh, Pd, Os, Ir,** Med. 8vo. Pp. viii + 816, with 423 illustrations. 1936. London: Longmans, Green and Co., Ltd. (63*s.* net.)

Nearly two-thirds of the present volume is devoted to nickel and the remainder to the metals of the platinum group other than platinum itself, which will be covered in the sixteenth and final volume of the treatise. It seems a pity that the metals of the platinum group were not all included in one volume.

This treatise contains more to interest the metallurgist than one would infer from the title. The section on the physical properties of nickel, which includes mechanical properties, is comprehensive and occupies about one-fifth of the space devoted to this metal and as two-fifths are also given to intermetallic compounds and alloys of nickel, more than half of the nickel section is of direct interest to metallurgists.

There are, however, surprising omissions; for instance stainless steel is not mentioned under the uses of nickel. In these days of information bureaux it would have been easy to get exhaustive information about uses.

The section on extraction is not so good. The author states that reliable statistics for the world's production of nickel are not available. He could have obtained up-to-date and accurate statistics of both production and prices by referring to the current issue of the *Mineral Industry*, whereas he gives nothing more recent than 1920 for productions and 1922 for prices.

The section on the extraction of nickel is not up to date. For instance, flotation methods *are* in general use for treating the Sudbury ores (W. T. MacDonald, *Eng. and Min. World*, **1930**, pp. 615–622) and a much more recent description of the Orford process could have been given (R. L. Peck, *Eng. and Min. World*, **1930**, pp. 636–638); also although Hybinette's electrolytic process is mentioned (p. 25) there is no indication that in a modified form and linked with the Orford process it has developed into the leading process for refining nickel (R. L. Peck, *loc. cit.*). Consequently it is not surprising that there is no mention of the Port Colborne electrolytic nickel refinery of the International Nickel Company where 80 million pounds of electrolytic nickel were produced in 1935, nor of the Christiansand refinery of Falconbridge where 10,750,000 lb. of electrolytic nickel were produced in the same year.

The author has given names to intermetallic compounds, *e.g.* nickel pentitahenicosizincide, Ni_5Zn_{21} (p. 207) and nickel pentitahenicosicadmide, Ni_5Cd_4 (p. 222) from which one may deduce that " henicosi " = heck of a lot.

The sections on the metals of the platinum group are on similar lines to the nickel section, and likewise are comprehensive rather than critical.

The references throughout the book are copious and well arranged and there are numerous illustrations.

There are a number of misprints and minor mistakes which, although they are unlikely to mislead the expert, will puzzle the general reader and tend to detract from one's estimate of this monumental work.—R. H. Atkinson.

Les Métaux légers et leurs Alliages. Aluminium, Magnésium, Glucinium, Métaux alcalins et alcalino-terreux. Tome 1.—**Historique, Métallurgie, Propriétés, Situations économiques.** Par Léon Guillet, 16 × 25 cm. Pp. xiii + 429, with 267 illustrations. 1936. Paris: Dunod. (Broché, 138 francs; relié, 148 francs.)

This volume deals with the occurrence, preparation, properties, and statistics of the light metals aluminium, magnesium, and beryllium, together with the alkali and alkaline-earth groups. A second volume, dealing with the alloys of these metals, is in preparation in collaboration with M. Jean Cournot.

In his foreword, the author deplores the fact that, in spite of the large part played by French scientists in the discovery and development of the light metals, no comprehensive book on the subject has previously been published in the French language. It is not surprising, therefore, that in the present book the author tends to stress French industrial developments and researches.

The first 278 pages are devoted to aluminium. The subject is dealt with thoroughly, and recent developments receive their fair share of attention, information being given which is not readily accessible elsewhere. The next section (50 pages) deals with magnesium, and is followed by a shorter section dealing with beryllium. The remainder of the book deals with the alkali and alkaline earth metals. Here the arrangement is changed: the methods employed for the extraction of all these metals are considered in one chapter, and their properties in a second. Each section concludes with a bibliography, supplementing the references given in the text.

The book is written primarily for engineers and users of the light metals, and as such may be warmly commended.—H. W. L. Phillips.

Hartmetallwerkzeuge. Wirkungsweise, Behandlung, Konstruktion und Anwendung. Von Karl Becker. 15 × 21 cm. Pp. 215, with 100 illustrations. 1935. Berlin: Verlag Chemie G.m.b.H. (Geb., R.M. 18; ausl. Preis, R.M. 13.50.)

Dr. Becker has compiled a comprehensive work on the use of hard-cutting alloys in tool construction. The volume is well illustrated, and contains valuable data in the form of graphs and tables.

The contents include an account of the selection and preparation of tools for various purposes, the applications and economics of hard metals, the theory and practice of cutting processes, the application of cutting tools to metals (drilling, turning, milling, tapping, reaming, sawing, &c.), to non-metals (insulating materials, glass, ceramics, brickwork, &c), to mining, to wire-drawing, and to many other technical processes. The book includes a list of patents and a bibliography, but no alphabetical index.

This work should commend itself unreservedly to all engaged in engineering practice and especially to those for whom a thorough knowledge of modern high-duty tools is essential. An English translation would be very welcome.—W. D. JONES.

Metallkeramik. Die Herstellung von Metallkörpern aus Metallpulvern. (Metallurgie der Metallpulver.) Nachtrag: Fortschritte seit dem Erscheinen des Hauptwerkes. Von Franz Skaupy. Med. 8vo. Pp. 10. 1935. Berlin: Verlag Chemie G.m.b.H. (R.M. 1.)

Since the appearance of Dr. Skaupy's monograph "Metallkeramik" some five years ago, considerable advances have been made in the metallurgy of metal powders. This appendix is intended to bring the monograph to date, and is arranged so that each section may be referred immediately to the corresponding section in the main work. It is an admirable condensation of the recent work on the manufacture of metal powders and their use in the preparation of sintered metal bodies.

The booklet contains a good selection, but by no means a complete list, of references to patents and scientific papers. In fact a fuller bibliography would have done much to enhance its value.—W. D. JONES.

Formerei und Giesserei. Von A. Velten. (Spanlose Formung der Metalle in Maschinenfabriken durch Giessen, Schmieden, Schweissen und Harten, Band I.) Elfte, völlig neu bearbeitete Auflage. 15 × 21 cm. Pp. xiv + 148, with 254 illustrations. 1936. Leipzig: Max Jänecke. (R.M. 3.20.)

That this is its eleventh edition, shows the value of this little book. Although only 7 pages (about 4½ per cent. of the whole) are devoted specifically to non-ferrous work, the concise and comprehensive description of plant and practice for iron and steel contains much that will interest the non-ferrous foundryman. A disadvantage of the book is the extreme brevity of some sections. The many diagrams are clear and informative.—H. W. G. HIGNETT.

An Introduction to the Theory of Elasticity for Engineers and Physicists. By R. V. Southwell. (Oxford Engineering Series.) Med. 8vo. Pp. ix + 509, with 120 illustrations. 1936. Oxford: Oxford University Press (Humphrey Milford). (30*s*. net.)

This book is designed to meet the requirements of a student for an honours degree in engineering science, and to enable him, subsequently, to study the more advanced treatises of Love and of Rayleigh. Such a book has been much wanted, and here is *the* book to fill a very obvious gap in English mathematics. The author, now Professor of Engineering Science at Oxford, and formerly Head of the Aeronautics Department of the National Physical Laboratory, has provided a volume which will at once take its place as the standard text-book on the subject, and which will serve as a useful reference book to those engineers who may have forgotten part of what they learnt as students.

The book deals with the strength of materials and can be thoroughly mastered by any one familiar with the elements of differential and integral calculus and having some acquaintance with partial differential equations. The problems, to which answers are provided, are of a fairly practical type, and a few worked examples are given. The contents of the book may be briefly summarized thus: Hooke's law and examples, Castigliano's theorems and Saint-Venant's principle, elementary theory and general analysis of stress and strain, torsion, deflection of girders, two-dimensional stress systems, and elastic stability. All are well done. The book is well printed on good paper, is substantially bound, and is provided with adequate name and subject indexes. Its price is very reasonable.—J. S. G. THOMAS.

Reports on Progress in Physics. Volume II. General Editor: Allan Ferguson. 7 × 10 in. Pp. iv + 370, illustrated. 1936. London: The Physical Society, 1 Lowther Gardens, S.W.7. (21*s*. net, post free.)

This second volume of "Annual Reports" of the Physical Society is better even than the first. The same main subjects of physics—classical physics, quantum theory, atomic physics, sound, heat, electrical and magnetic measurements, X-rays, spectroscopy and optics—are reviewed, and special articles are contributed on geophysical prospecting, radio exploration of upper-atmospheric ionization, the value of *e*, and electron tubes. All the contributions are by experts, all are authoritative and thorough. Some of the reports make difficult reading, and are obviously intended for experts only; others, more especially those on sound and heat, can be read and enjoyed by the non-expert.

The sections most likely to interest metallurgists are those devoted to heat, to X-rays, and to the electron microscope. Here, so far as I know, is the first full account in English, of the theory, the design and an account of applications of the electron microscope. The ideas underlying the instrument were put forward by Busch in 1926, and already the device has found numerous applications in metallurgical science, *e.g.* in the investigation of centres of electron emission in incandescent bodies. The important fact about the instrument is that its limit of resolution is about $0{\cdot}27 \times 10^{-7}$ mm., while the resolving power of a microscope objective of N.A. 1·40 is only about $0{\cdot}2 \times 10^{-3}$ mm. for sodium light. Most of the work with the electron microscope has hitherto been done in Germany. The section of the Report devoted to the electron-diffraction camera is of great importance to metallurgists interested in the physics of metal surfaces.

The venture of the Physical Society in undertaking the publication of a series of Annual Reports on Physics would appear now to be assured of success: the extremely high quality of the separate contributions and the fact that the Reports are printed by the Cambridge University Press ensure that. This Report will find its way into every scientific library, and will be eagerly read by all research workers in physics and chemistry. I especially recommend it to students preparing for an Honours degree in physics, and to their examiners.

—J. S. G. Thomas.

Handbuch der anorganischen Chemie. Herausgegeben von R. Abegg, Fr. Auerbach, und I. Koppel. In vier Bänden. Vierter Band, dritte Abteilung, Dritte Teil. **Kobalt und seine Verbindungen.** Sup. Roy. 8vo. Pp. xv–xxvi + 627–848, with 23 illustrations. 1935. Leipzig: S. Hirzel. (Geh., R.M. 30.)

The present section of this famous book completes the treatment of the chemistry of cobalt. The whole section is devoted to a very complete account of the ammine derivatives of this metal in the tervalent state. The section opens with a general survey of these compounds, which includes the history, general methods of preparation, constitution, isomerism, spatial isomerism, and the determination of the configuration of the compounds. The relationship between the properties and the composition is next dealt with in connection with density and volume, magnetic properties, electroconductivity, solubility, and optical properties. The various ammines are then dealt with systematically under the sub-headings, mono to hexa-nuclear derivatives. The ammonia derivatives include the compounds with a large number of substituted ammonia compounds, some 30 organic bases, hydroxylamine derivatives, &c., being included here. The acido derivatives of the complex cations are described in the order of the groups of the periodic system in which the typical element of the acido group occurs, commencing with group 7 and going down to group 3. The salts are considered according to the same plan.

The book contains a very large amount of useful material, which is carefully and intelligently arranged. The numerical data are profuse and accurate. The work is an extremely valuable one and it can be recommended with confidence.—James F. Spencer.


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