Vol. 3 Part 5

The Monthly Journal of the INSTITUTE OF METALS

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MAY 1936

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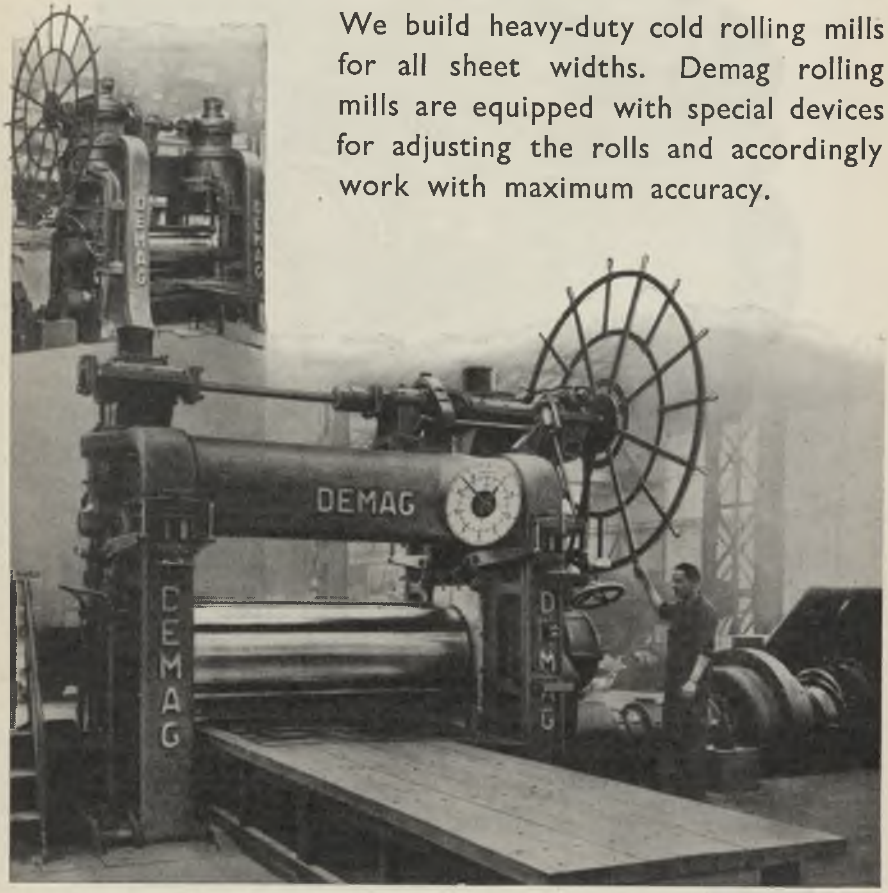
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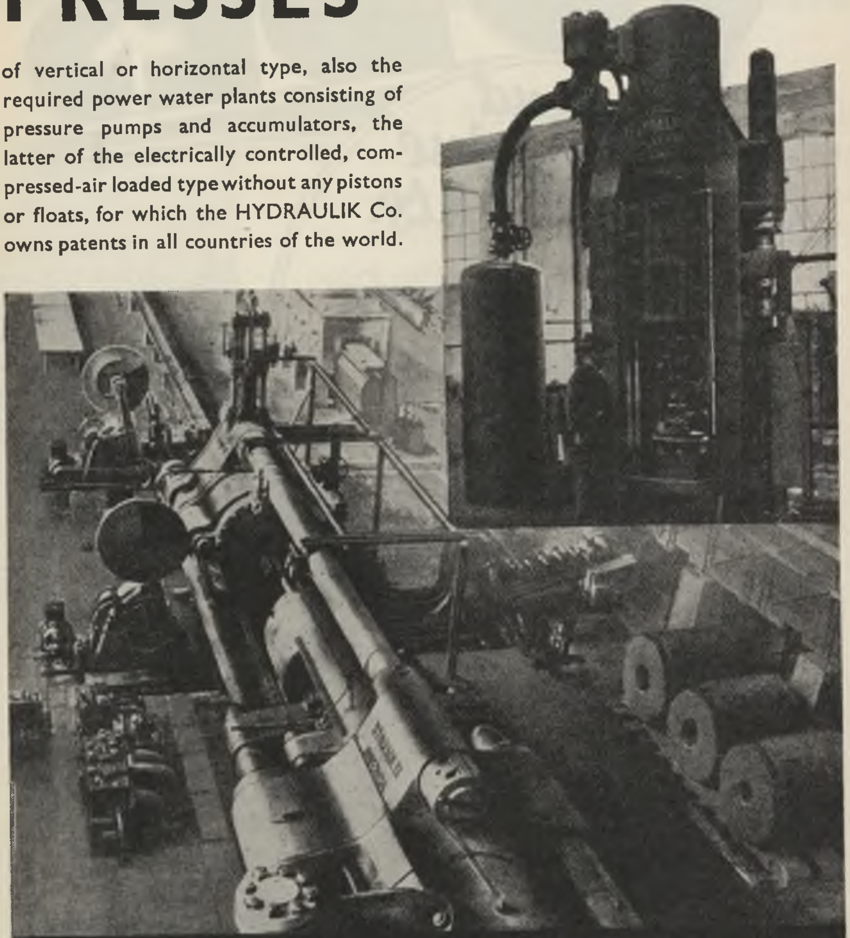

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CONTENTS:

1. INTRODUCTION.
2. THEORY OF HEAT TREATMENT.
   (a) Plain Carbon Steels.
   (b) Mass Effect and Volume Changes.
   (c) Effect of Alloying Elements Summary Table of Definitions.
3. HEAT TREATMENT PROCESSES.
   (a) Normalizing.
   (b) Annealing.
   (c) Hardening.
   (d) Tempering.
   (e) Case Hardening.
4. SPECIFICATIONS AND TESTING.
5. FURNACE REQUIREMENTS AND ADVANTAGES OF TOWN GAS.
6. TYPES OF FURNACE.
   (a) General.
   (b) Continuous and Special Type Furnaces.
7. FURNACE PRACTICE.
   (a) General.
   (b) Case Hardening.
   (c) Tool Steels.
   (d) High Speed Steels.
   (e) Bright Annealing.
   (f) Tin Plate and Sheet Mills.
8. TEMPERATURE CONTROL.
9. INSTALLATIONS.

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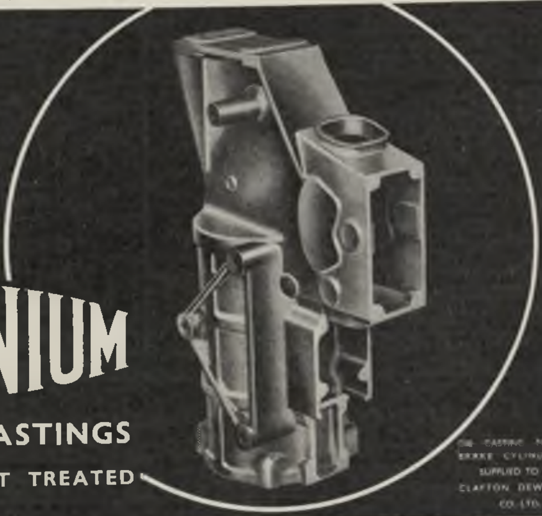

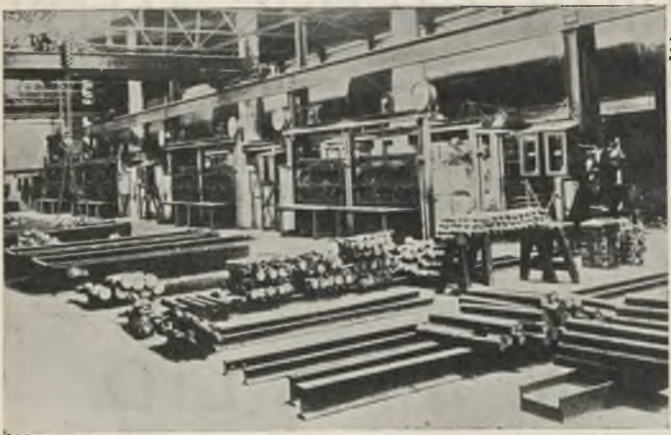

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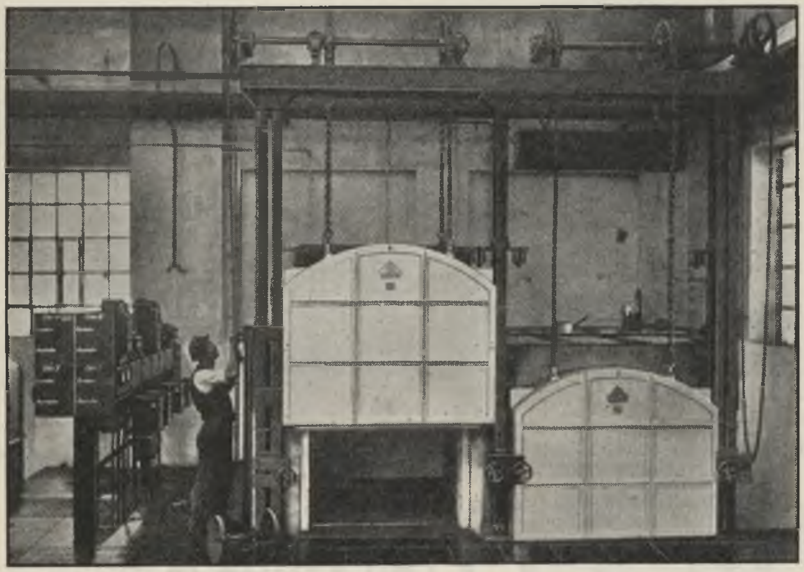


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INDEX TO ADVERTISERS

MAY, 1936

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Volume 3 **MAY, 1936** **Part 5**

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.

Norton Boron Carbide as it comes from the electric furnace (uncrushed)

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INSTITUTE NEWS AND ANNOUNCEMENTS

Council Nominations for 1937–1938.

At the Autumn Meeting to be held in Paris from September 14 to 18, the Council will present, on September 15, a list of names of persons nominated for office in the year 1937–1938. It is hoped to publish this list in an early issue of the *Monthly Journal*.

In accordance with the Rules, "Any ten members may also, at or before such ordinary general meeting, nominate in writing, with the written consent to act if elected of the person nominated, any duly qualified person other than one of those nominated by the Council. . ."

Alteration of Articles.

Copies of the Special Resolution altering Articles 19 and 21 of the Institute's Articles of Association, as passed at the Extraordinary General Meeting held on March 10, 1936, are now available and can be supplied to any member on request being made to the Secretary.

The prints are of the same size as a *Journal* page and have a gummed edge, so that they may be affixed in existing copies of the Articles of Association. Members should see that their copies are brought up to date by the addition of the newly-printed page.

Paris Autumn Meeting.

The Secretary visited Paris early this month to discuss with the Institute's hosts the local arrangements for the meeting which is to be held in that city from September 14 to 18.

Judging by the number of replies already received from members who expect to take part in the Paris meeting, this first gathering of the Institute in France should be largely attended by members from all parts of the world.

A detailed programme, supplementing the information already given in the April issue of the *Monthly Journal*, is now in preparation. A copy will be posted shortly to every member.

May Lecture.

At a General Meeting of the Institute held in the Hall of the Institution of Mechanical Engineers, London, on May 6, Mr. C. C. Paterson, O.B.E., Member, delivered the Twenty-Sixth Annual May Lecture on "The Escape of Electricity from Metals: Its Practical Consequences." The lecture was given before a large audience, and afterwards members met for light refreshments and conversation.

Prior to the lecture Mr. Paterson was entertained to dinner by the Council.

As the lecture was largely experimental, the record of it that will appear in the forthcoming bound volume of the *Journal* (Vol. LVIII) will be of a briefer character than is usual in the case of the majority of May Lectures.

Membership Additions.

The following were elected on May 6, 1936:—

As Members.

Aldridge, Denis William, Prescot.
Christiansen, Vilhelm, Finspong, Sweden.
Clotworthy, Stanley Edward, B.Sc., London.
Cunliffe, The Hon. Geoffrey, London.
Douchement, Jacques S., Paris, France.
Gibbons, Alfred Charles, M.C., Bristol.
Gilbert, Walter Villa, London.
Goss, Norman P., M.Sc., Youngstown, O., U.S.A.
Hardwick, John Vinor, Rugby.
Hindle, Clifford, Horsforth, near Leeds.
James, Desmond, M.A., London.
McLean, Hector Murray, Birmingham.
Parry, Robert Morgan, London.
Platt, Edward Cecil, Birmingham.
Schoeller, Victor, Dr.-Ing., Köln-Mulheim, Germany.
Shepley, James, Dukinfield, Cheshire.
Standring, Joseph Robert, Beckenham.
Teindl, Joseph, Povazská Bystrica, Czechoslovakia.

As Student Members.

Dunsmore, Alexander Carmichael, Stirling.

Messner, Otto Hans Caspar, Zurich, Switzerland.

Price, Laurence Ernest, B.A., Cambridge.

Tai, Li Chi, B.Sc., London.

Annual Subscriptions.

Will members, particularly those residing overseas, be good enough to note that the amount of their subscriptions (£3 3*s*. in the case of members; £1 1*s*. in the case of student members) should be remitted in time to be received on or before July 1, when subscriptions for the next financial year become due? Only by remitting their subscriptions promptly can members ensure the continued receipt of the *Monthly Journal*, "Proceedings" volumes, and other publications of the Institute. *Prompt payment of subscriptions means a substantial saving to the Institute in postage, bank charges, and discounts.*

Visit to Fuel Research Station.

Members who were unable to participate in the Institute's visit last March to the Fuel Research Station, East Greenwich, S.E.10, have yet another opportunity to inspect the laboratories and large-scale experimental plants and to obtain a general insight into the whole range of the fuel research activities of the Department of Scientific and Industrial Research, for a Visiting Day has been arranged for Tuesday, June 9 (2–6 p.m.). An invitation card can be obtained by any member from Mr. G. Shaw Scott, The Institute of Metals, 36 Victoria St., London, S.W.1.

Members travelling by rail from Charing Cross, Cannon Street, or London Bridge to Maze Hill Station, will find a free service of motor coaches operating between the railway station and the Fuel Research Station.

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 June issue of the Monthly Journal *should reach him not later than May 25.*

Sir Herbert Austin, K.B.E., has made a gift of £250,000 to Cambridge University for scientific research. The money will be used for the extension and further endowment of the Cavendish Laboratory.

Professor Sir Harold Carpenter, F.R.S., Past-President and Fellow, received the Honorary Degree of Doctor of Metallurgy at a Degree Congregation of Sheffield University held on May 2, 1936.

Mr. G. H. M. Farley, B.Sc., has opened an office at 39 Victoria Street, London, S.W.1, for research into statistics and economic surveys of the metal and other industries.

Herr Eugen L. H. Illg has taken over the agency of the Hydraulik G.m.b.H., Duisburg, for South Germany.

Mr. F. C. Mannox has been appointed as Works Manager of the I.C.I. Metals, Ltd., Landore, South Wales.

Dr. Paul D. Merica, B.A., formerly Assistant to the President of the International Nickel Company, has been appointed Vice-President. Dr. Merica recently visited London.

Professor Gustav Tammann, Honorary Member, was awarded the honour of the Eagle Shield of the German Reich on April 20 on the occasion of the birthday of Herr Hitler.

Marriage.

van Someren—Dolby. At King's Norton Congregational Church, on April 18, 1936, Ernest van Someren, B.Sc. (Lond.), to Kathleen, younger daughter of Mr. and Mrs. Frank C. Dolby, King's Norton, Birmingham.

Obituary.

M. Lucien G. Jannin, Ingénieur Arts et Métiers, Chevalier Legion d'honneur, died at Menden (Seine et Oise). He was consulting engineer at the Usines Renault, and had been a member of the Institute since 1933.

PAPER No. 734. This paper is copyright. It may be reprinted, wholly or in part, in the Press (with due acknowledgment) after the Annual Autumn Meeting of the Institute to be held in Paris from September 14 to 18, 1936. The Institute as a body is not responsible for the statements or opinions expressed in this paper, on which written discussion may be sent to the Secretary not later than October 1, 1936.

METALS OF THE PLATINUM GROUP.*

ORES, RECOVERY AND REFINING, FABRICATION AND USES, AND PROPERTIES.

By R. H. ATKINSON,† M.A., MEMBER, and A. R. RAPER,‡ M.A., MEMBER.‡

SYNOPSIS.

An attempt is made to present up-to-date metallurgical information about the six metals of the platinum group. After a brief description of the discovery of the metals and an account of the ores, particular attention is devoted to the recovery and refining of the metals produced from the Canadian nickel industry. This is followed by a full description of the methods of fabrication of the metals and their alloys. It is shown that the two ductile metals of the group platinum and palladium are readily worked, while rhodium and iridium are worked with much greater difficulty. The two metals osmium and ruthenium, belonging to the hexagonal system, have not up to the present been thoroughly investigated. Finally, an account is given of the properties of the metals and their uses.

THE metals which comprise the platinum group are platinum, palladium, iridium, rhodium, osmium, and ruthenium.

DISCOVERY.

Platina (Spanish for small silver), a strange metal from the New World, was noted by European travellers as early as 1538, but it was not until 1741 that samples were brought to England. Watson and Brownrigg gave the first scientific description of the metal in 1751.

Wollaston discovered palladium and rhodium in 1804, and in the same year Smithson Tennant proved the existence in platinum residues of two new metals to which he gave the names osmium and iridium. Ruthenium, the sixth metal of the group, was discovered by Claus in 1845.

ORES.

Platinum usually occurs in nature as native metal alloyed with one or more of its allied metals in the form of very fine grains more

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* Modified form of paper read before the London Local Section of the Institute of Metals on January 9, 1936. Manuscript received March 17, 1936.

† Assistant Manager, Precious Metals Refinery and Research Laboratory, Mond Nickel Company, Ltd., Acton.

‡ Metallurgist, Precious Metals Research and Development Department, Mond Nickel Company, Ltd., Acton.

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).

or less flattened; sometimes in the form of irregular nuggets; and occasionally, though rarely, in small cubic crystals. It is sometimes coated with a black layer of iron oxide, which may be magnetic, in which case it is not easily recognizable. When unrefined it is referred to as " crude " platinum.

Up to 1915 more than 95 per cent. of the whole supply of platinum metals was derived from alluvial deposits; the remainder was obtained from the refining of copper and gold bullion, particularly from the copper–nickel deposits of Sudbury, Ontario.

The first commercially important discovery of native platinum in a primary deposit was made at the Onverwacht mine, Lydenburg, South Africa, which yielded approximately 30,000 oz. during the years 1926–1930.

The principal alluvial deposits of crude platinum at the present time in order of importance are found in the Ural Mountains, Colombia, and Abyssinia. Typical analyses of Ural, Colombian, and Onverwacht platinum are given in Table I.

TABLE I.

	Platinum, Per Cent.	Iron, Per Cent.	Palladium, Per Cent.	Rhodium, Ruthenium, Osmium, Iridium, Per Cent.
Ural platinum	73–86	8–17	0·3–1·8	2·5–7·7
Onverwacht platinum	80–84	11	0·4	0·5–1·0
Colombian platinum	84–86	5–8	0·5–1·0	3–6

There are also very extensive primary deposits of platinum metals in sulphide-bearing norite in the Potgietersrust and Rustenburg districts of the Transvaal. These deposits contain about 10 dwt. of platinum metals per ton; platinum and palladium are present in about equal proportions, with subordinate amounts of the other platinum metals. The platinum metals in the concentrates prepared from this ore are said to be in combination, mostly with sulphur.[1] Two new minerals, cooperite, PtS, and braggite, (Pd, Pt, Ni)S, have been discovered in these deposits. Copper and nickel sulphides are present in the ores but not in sufficient quantities to pay working costs, which consequently fall almost entirely on the platinum metals.

Platinum is also found mostly in combination with arsenic as sperrylite in the well-known copper- and nickel-bearing deposits of the Sudbury district of Ontario, Canada. Palladium, in about the same amount as platinum, and subordinate amounts of other platinum metals are also present.

The main sulphide mineral is pyrrhotite or magnetic pyrites (Fe_3S_4). With this is associated the copper mineral chalcopyrite or copper pyrites ($CuFeS_2$) and the nickel mineral pentlandite (NiS).

Although the amount of the platinum metals per ton of these deposits is very small, yet owing to the fact that big tonnages of ore (over 1,800,000 tons in 1934) are treated for the recovery of the main products, copper and nickel, very substantial amounts of platinum metals are produced as by-products. For instance, during the period 1928–1934 the production of platinum metals from these deposits corresponded to 1·7 oz. for every ton (2000 lb.) of nickel.

The principal source of palladium is the above-mentioned Sudbury copper–nickel ores, and there is a small amount from the South African sulphide norite deposits.

Rhodium, ruthenium, osmium, and iridium accompany platinum in all the deposits which have been mentioned, and are recovered when the platinum is refined.

The principal source of osmium and iridium is the mineral osmiridium, which is now recovered as a by-product of gold mining operations on the Witwatersrand. The composition of this mineral is variable: osmium from 23 to 40, iridium from 21 to 35, ruthenium + rhodium from 9 to 15, and platinum from 5 to 15 per cent. There is also a fluctuating production of this mineral, depending on the market price, from alluvial deposits in Tasmania.

PROPERTIES OF THE METALS OF THE PLATINUM GROUP WHICH AFFECT THEIR REFINING.

The six metals of the platinum group are white in colour and are permanent in air under normal atmospheric conditions when in compact metallic form. As would be expected from their position in the Periodic Table, their chemical properties are similar. For instance, rhodium, ruthenium, and iridium are not attacked by *aqua regia*; platinum is dissolved by *aqua regia* but is not attacked by any single acid; palladium is easily soluble in *aqua regia*, and it is also attacked by hot concentrated sulphuric acid and to a less degree by nitric acid, but with these exceptions it is resistant to the common acids. The metals in the finely divided state are less resistant to chemical attack than the compact metals; for instance, osmium black dissolves in nitric acid and rhodium black is attacked by hot concentrated sulphuric acid.

In solution the metals readily form very stable complex salts, many of which are isomorphous. For this reason clean separations of the metals are rarely accomplished.

It will be obvious from this brief reference to the chemical properties, that the refining of the platinum metals is likely to be a complicated chemical process. Electrolytic refining methods which are so helpful in the case of many other metals cannot be used because palladium is the only one of the group which easily dissolves anodically in an aqueous electrolyte. Further, all the metals have relatively high melting points ranging from 1550° C. for palladium to 2700° C.* for osmium; consequently it is customary to market the metals in the form of sponge or meal and they are not melted until required for fabrication.

RECOVERY AND REFINING.

Native platinum is recovered from alluvial deposits by gravity concentration methods which yield a concentrate (for typical analyses see Table I) rich enough for refining.

The essential steps in the refining of native platinum are probably the same now as when described by Wollaston in his Bakerian Lecture to the Royal Society in 1828.[2] The crude platinum is dissolved in hot concentrated *aqua regia*; ammonium chloride is added to the filtered solution to precipitate ammonium chloroplatinate which is filtered off, washed, dried, and ignited to convert it into platinum sponge. If a purer metal is required the operations are repeated as often as may be necessary.

McDonald[1] has described an alternative refining process based on the recrystallization of sodium chloroplatinate.

If the platinum metals present in a deposit cannot be concentrated by gravity methods, lengthy and costly treatments may be necessary to prepare a concentrate rich enough for *aqua regia* treatment unless the metals are recovered as the by-products of the recovery and refining of some other metal. In the case of the Sudbury copper–nickel deposits, the platinum metals follow the nickel through the various operations; finally, when the nickel is separated in a pure form the platinum metals remain behind as a residue which at very little additional expense can be concentrated sufficiently for refining by the *aqua regia* process.

In view of the growing importance of by-product platinum metals, a brief outline will be given of the treatment of the Sudbury copper–nickel ores.

The ore after concentration and partial roasting is smelted either in blast furnaces or in reverberatory furnaces to give a furnace matte or sulphide of iron, nickel, and copper which acts as a collector of platinum metals. This matte is blown in converters to remove the

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* This temperature is not known accurately.

iron, yielding a Bessemer matte having the approximate composition copper 35, nickel 46, iron 0·8, and sulphur 17 per cent. The subsequent treatment of this matte depends on whether electrolytic metal or Mond pellets are to be produced; in the latter case, the matte is shipped to the refinery of the Mond Nickel Co., Ltd., at Clydach, South Wales.[3]

The matte as it is received is ground in ball mills and then calcined to convert the nickel and copper sulphides into the corresponding oxides:

$$(Cu,Ni)S + 2O_2 = CuO + NiO + SO_2.$$

The copper oxide is then leached out by treatment with 12 per cent. sulphuric acid:

$$NiO + CuO + H_2SO_4 = NiO + CuSO_4 + H_2O.$$

After drying, the copper-extracted matte is reduced by treatment with water-gas in a special reducer at a temperature of 330°–350° C.:

$$NiO + H_2 + CO = Ni + H_2O + CO.$$

The reduced nickel is submitted to the action of carbon monoxide in volatilizers at a temperature of about 50° C., when the following reaction takes place:

$$Ni + 4CO = Ni(CO)_4.$$

The nickel carbonyl from the volatilizers is blown by fans into the decomposers where, at a temperature of about 180°–200° C., the nickel carbonyl decomposes according to the equation:

$$Ni(CO)_4 = Ni + 4CO.$$

As the reactions are incomplete, it is in practice found necessary to pass the material through the plant three times to get good yields of nickel and copper. After the third pass, the residue is roasted and then leached with sulphuric acid to remove most of the residual copper and nickel. According to Langer and Johnson [4] an analysis of a typical leached residue gave: platinum 1·85, palladium 1·91, rhodium 0·20, ruthenium 0·16, iridium 0·04, gold 0·56, and silver 15·42 per cent.

For the production of electrolytic nickel,[5] the treatment of the ore is the same as already described as far as the Bessemer matte stage. The nickel sulphide is then separated from the copper sulphide by the Orford process, also known as "tops and bottoms" process. For this purpose the Bessemer matte is mixed with coke and sodium bisulphate and smelted in blast furnaces, as a result of which the charge separates into two layers—the "tops" which consist of a double sulphide of sodium and copper, and "bottoms" which consist of nickel sulphide. In this process the platinum metals mainly go with the nickel, whereas the silver and gold follow the copper. As the separation is not clean, it is necessary in practice to repeat the operation separately with the " tops and bottoms " portions. The final " tops " are blown in converters whereby the sodium sulphide is oxidized to sodium sulphate and the copper sulphide is converted into blister copper which is shipped to a copper refinery for electrolytic purification. Nickel sulphide " bottoms " are crushed, leached, and then roasted on Dwight-Lloyd sintering machines. The oxide thus obtained is reduced to metal in reverberatory furnaces, and the resulting metal (containing about 2 per cent. of copper and some iron) cast into anodes for electrolytic treatment. The first anode slimes, which, of course, contain the precious metals, are roasted and then smelted to give secondary or P.M. anodes (containing about 24 per cent. copper and 73 per cent nickel). Secondary slime contains about 2 per cent. of platinum group metals and is concentrated by acid treatment to a product containing about 50 per cent. platinum group metals.

Powell and Deering have patented a modified nickel extraction process for the treatment of low-grade sulphide flotation concentrates.[6] The modification consists in generating a small proportion of iron-nickel metallics in the body of the molten matte which act as collectors of the platinum metals. The metallics are subsequently separated by gravity or magnetic treatment and smelted to give a nickel matte sufficiently rich to be treated economically either by a wet chemical or electrochemical process for the recovery of the metals of the platinum group.

Operations at the Acton Refinery of the Mond Nickel Company.

The Acton Refinery receives residues from the Clydach nickel refinery besides concentrates from the electrolytic nickel refinery and a smaller amount of concentrates from the electrolytic copper refinery which treats the Company's blister copper.

The residues from the Clydach refinery require further concentration before the platinum can be extracted economically with *aqua regia.* For this reason the residues are smelted with litharge, fluxes, and charcoal in small basic-lined tilting furnaces to collect the precious metals in lead and at the same time to slag off silica and base metals. Subsequent cupellation of the ingots in similar furnaces removes the excess of lead as litharge (which is used again in further smelting charges) and yields a silver-rich precious metal alloy about four times richer than the Clydach residue. This alloy is parted with boiling concentrated sulphuric acid, which removes most of the silver and about one-third of the palladium as sulphates. The residue contains the platinum, gold, and the rest of the palladium in a form particularly suitable for extraction with *aqua regia* which is the next operation. From the solution of chlorides thus obtained, the gold is precipitated as brown gold by means of ferrous sulphate, and then the platinum as ammonium chloroplatinate by the addition of ammonium chloride, and lastly, the palladium is precipitated as palladosammine chloride. The only one of these operations which calls for special comment is the precipitation of palladosammine chloride. The palladium present as chloride is converted into soluble tetrammino-palladous chloride by the addition of excess ammonia solution according to the equation

$$PdCl_2 + 4NH_3 = [Pd(NH_3)_4]Cl_2.$$

When excess of hydrochloric acid is added, the sparingly soluble yellow compound known as palladosammine chloride is precipitated according to the equation

$$[Pd(NH_3)_4]Cl_2 + 2HCl = [Pd(NH_3)_2Cl_2] + 2NH_4Cl.$$

The impure platinum salt is converted into metal by ignition, dissolved in *aqua regia* and re-precipitated as pure ammonium chloroplatinate, which, on ignition, yields pure platinum sponge. The impure palladosammine chloride is purified by dissolving in ammonia and reprecipitating with hydrochloric acid; the pure salt is converted into sponge by igniting.

The silver and the gold are purified electrolytically, by the Moebius and Wohlwill processes, respectively, special attention being given to the recovery of small amounts of platinum metals.

The final insolubles and reduction residues from the above wet process treatment are smelted to concentrate the rhodium, ruthenium, and iridium (which are known as by-metals). From the precious metal alloy thus obtained, the individual metals are separated and refined by chemical processes.

Refining of the richer concentrates from the nickel and copper refineries which contain more than 50 per cent. platinum metals and very little silver, commences with the *aqua regia* treatment.

In precious metals refining, the order of operations depends on the ratio in which the precious metals are present. The order which is here described is followed because it has been found to be the most suitable for these by-product concentrates, although it is realized that other sequences of operations might be more suitable for other types of material.

The average purities of the metals recovered from these concentrates are: platinum 99·93, palladium 99·94, iridium 99·7, rhodium 99·7, ruthenium 99·7, gold 99·97, and silver 99·97 per cent.

The high intrinsic value of the materials treated makes it imperative to reduce working losses to a minimum and to obtain the maximum yield as quickly and directly as possible. In practice, not more than 0·25 per cent. of the platinum metals contained in the concentrates is lost, while 1·25 per cent. is temporarily retained in furnace slags which are returned to the nickel refinery for re-treatment. The remaining 98·5 per cent. is produced directly as refined metal. The losses occurring in the processes of extracting the nickel and copper are also very small, and it is estimated that 90 per cent. of the precious metals contained in the ore is ultimately recovered.

FABRICATION.

PLATINUM.

Historical Review.

The history of the development of methods of fabricating platinum is of considerable metallurgical interest. The early chemists soon found that they were unable to melt platinum in any quantity with the means then at their disposal, and realizing the value of the metal to aid them in their experimental work, they sought other means of converting the spongy metal into foil and wire.

One of the first processes for working the metal depended on the observation of Scheffer[7] that platinum could be fused with the help of arsenic and the later observation of Achard[8] that this alloy on ignition leaves a residue of malleable platinum. Janetty in Paris was celebrated for his platinum work and was able to make crucibles, &c., of the low melting point arsenic alloy, subsequently removing the arsenic by volatilization. This process and also one involving the use of mercury must have been particularly poisonous, and the methods were not successful in the hands of British experimenters.

At the beginning of the nineteenth century several workers in this country attempted to solve the problem of rendering platinum sponge malleable by mechanical means, and interesting papers were published by Richard Knight[9] in 1800, by Alexander Tilloch[10] in 1805, and by W. H. Wollaston[2] in 1828. In the course of this work they laid the foundations of powder metallurgy. The method described by Wollaston is in essentials still used in this country and will be described in a later section of the paper.

A further stage of progress in the metallurgy of the platinum metals became possible with the invention of the oxy-hydrogen blowpipe by Robert Hare, who showed[11] in 1847 that it was possible to melt large quantities of platinum and small amounts of rhodium and iridium.

Prior to this only very small quantities of platinum had been fused, although as early as 1758 Macquer and Baumé[12] had succeeded in melting the metal with the aid of a powerful burning glass. A further significant advance was made by Deville and Debray[13] in 1859 when they recommended the use of lime as a refractory hearth for platinum melting, and designed an excellent type of furnace.

In more recent years the chief advance has been in the use of the high-frequency induction furnace.

Powder Method.

The description of Wollaston's process is given in the 1828 Bakerian Lecture to the Royal Society,[2] and he remarked that it was so successful that he did not see any occasion to wish for further improvement.

In order to prepare platinum powder, pure ammonium platinichloride was heated with the utmost caution, with so low a heat as just to expel the whole of the ammonium chloride and so that the particles of platinum cohered as little as possible, for on this depende the ultimate ductility of the product. The grey powder was then rubbed between the hands of the operator to obtain by the gentlest means a powder which passed through a fine lawn sieve. The coarser particles were ground in a wooden bowl with a wooden pestle and, in the later stages of grinding, water was added and the finer portions of platinum removed as soon as they were suspended. In this way Wollaston obtained a uniform mud or pulp. The next stage was to compress the wet mud, which was carefully packed in a tapered brass barrel of about 1 in. internal diameter. After compression, the cake was heated first on a charcoal fire to drive off moisture and grease and to give it a firmer degree of cohesion, and finally heated in a wind furnace to a very high temperature. The ingot was forged while hot and afterwards either rolled down or drawn into wire.

The following figures quoted by Wollaston illustrate the gradual bonding of the particles as the process proceeds :

Specific gravity of cake of metal mud = 4·3
,, ,, after pressing = 10
,, ,, after wind furnace = 17–17·7
,, ,, after forging = 21·25
,, ,, of drawn rods = 21·4

The process described above is, in main essentials, still used in this country. A purer grade of metal is undoubtedly produced by modern chemical methods, and the fine powder is now compressed dry instead of in the wet state.[1] The dry powder is subjected to a pressure of 5 tons/in.^{2} in an iron mould. The pressed ingot so obtained is heated gradually to a temperature of 1500° C. and then forged.

It will be convenient here to make a few general remarks about this process, and to compare it with the melting and casting process to be described later. The powder method obviates gas contamination and the picking up of impurities from refractories such as occur during melting, and it is, therefore, an important process where it is necessary to maintain the metal in the highest state of purity. It is not so convenient, however, as oxy-hydrogen blowpipe melting for general work, nor is the process suitable for dealing with scrap. For the production of alloys, also, the fusion method is more convenient.

A very thorough forging of sponge ingots above 1000° C. is necessary in order to get rid of porosity.[14] If this is not done the resultant sheet shows blisters. To give such a thorough forging, bars of large cross-section are necessary. If an attempt is made to produce too large a bar, the friction at the side of the mould becomes important, and the bar so produced is of varying density and either warps or fractures when heated or shows shrinkage holes at the least dense points, resulting in large blisters or double stock. The amount of metal, therefore, which can be accommodated in one ingot is restricted and is less than the amount which can be dealt with by melting methods.

It is said [1] that the sponge ingots, provided that they have been made from pure platinum handled in a proper manner, and have been sufficiently annealed, are physically and metallurgically superior to the usual unalloyed melted metal, and can be drawn or rolled perfectly satisfactorily. Under ordinary commercial working conditions the melted metal is found to be slightly harder than the pressed metal. The Brinell hardness figure (10 mm. ball : 500 kg. load) for annealed pressed sheet is 38–42, whereas for annealed cast sheet it is 40–44.

Blowpipe Melting and Casting.

In this process an oxy-hydrogen or oxy-coal-gas blowpipe is used for melting (the freezing point of platinum is 1773° C.). The nozzle of the blowpipe is made of platinum or platinum–iridium alloy, and the blowpipe may be water-cooled. The design of furnace is the familiar one suggested by Delville and Debray [13] shown in Fig. 1. It consists of two well-fitting lime blocks pressed within a supporting casing of sheet iron. The top is bored centrally to take the nozzle of the blowpipe while the bottom is scooped out to form a hearth. A slanting groove is made in the bottom half for the exit of the products of combustion during melting and is subsequently used for casting. The furnace is arranged to tilt in such a way that the position of the lip *D* does not alter, by having the lip in line with the two hinges *LL*. This is necessary because the dazzling whiteness of the stream of molten platinum makes it impossible to see the mould. The shape of the furnace can be easily modified to a rectangular or elliptical section if it is required to use more than one blowpipe for large quantities of metal.

Using the furnace shown in Fig. 1, Deville and Debray melted 11·6 kg. of platinum in 42 minutes, by means of oxygen and coal-gas. The consumption of oxygen was 1200 litres, and the loss of weight in metal (after allowing for a mechanical loss) was approximately 0·5 per cent. which corresponded closely to the amount of impurity present in the platinum.

During melting, volatile metals were removed and other impurities such as silicon were oxidized and absorbed by the lime hearth. There is always this refining action during melting on lime, and the metal is kept molten until the refining action is completed. If highly pure metal is being melted, the gas consumption is less, and about 60 litres of oxygen are required for each kg. of platinum. Overheating of the metal should be avoided, since there is a sensible volatilization at very high temperatures. The metal is usually cast into a graphite mould. Care is taken not to have the mould too hot, since platinum readily takes up carbon, rendering the metal very brittle. Silica moulds may also be used,[14] particularly if a high gas content is suspected, since the slow cooling enables some gas to be liberated. The slow rate of cooling leads to the formation of large grains and more care is needed in working the ingot.

Fig. 1.—Deville and Debray's Furnace for Melting and Casting Platinum.

The process described above is still used to a considerable extent, and charges of up to 600 oz. troy (18·6 kg.) can be dealt with at one time. The blowpipe flame is kept slightly oxidizing to remove impurities and to prevent the platinum becoming contaminated with calcium, which would be produced at the very high temperature under reducing conditions. Under the usual working conditions very little calcium finds its way into the melt, and only traces can be found in the finished metal. The need for highly pure lime is apparent, and for melting the highest purity platinum by this method Heraeus has used calcium oxide made by igniting marble.[15]

Other types of refractory can be used for making small melts, but particular care must be taken in the case of magnesium oxide and alumina to keep the conditions oxidizing. These and other refractories will be discussed in the next section.

In preparing alloys by this method the added metals may be introduced just before casting. This is particularly desirable if the alloying constituents are volatile at the melting point of platinum or if they are readily oxidized.

Melting in the High-Frequency Induction Furnace.

Considerable attention has been given during recent years to melting in the high-frequency induction furnace. This process is commercially attractive because melting losses are low. In addition, there are the usual technical advantages such as ease of control of atmosphere above the melt and control of composition coupled with good mixing of alloys.

The choice of refractory depends on a number of factors such as the purity of product required and the conditions of melting.[16] Crucibles made of fused thoria are the most satisfactory for melting very highly pure metals and also for dealing with the highest melting point alloys. For general work, magnesia, alumina, zirconia, zirconium silicate, and lime are satisfactory. In the case of these latter materials very little contamination occurs if melting is done under oxidizing conditions, but under reducing conditions or *in vacuo* appreciable quantities of impurities may be picked up.

Some time ago Reeve [17] published a very interesting account of the melting and casting of platinum *in vacuo*. He used an alundum crucible lined with zirconia, and melted the platinum under a vacuum of 0·1–0·01 mm. of mercury. The mould made of graphite or nickel, was situated in a side arm of the apparatus just above the level of the top of the crucible, and the metal was cast *in vacuo* by tilting the furnace. Reeve found that ingots produced by this method were extremely sound and free from cavities. As an example, he mentioned that ingots of 0·5 in. in diameter and weighing 500 grm. could readily be drawn to 0·003 in.-diameter wire in one continuous length without breaking.

Arc melting is unsuitable for the platinum metals because of the ease with which carbon is picked up, and for the same reason the Arsem type of furnace cannot be used. Attempts to use the atomic hydrogen torch have also been unsatisfactory, no workable piece of metal having been produced by this method.[14]

Rolling and Drawing.

The pure metal is both soft and ductile, and ingots can be rolled down cold. It is usual, however, to commence by working hot at about 800° C., a rapid reduction being possible. The alloys also are worked hot, but the reductions are smaller. During this treatment the surface picks up iron, but this is readily removed by boiling hydrochloric acid.

Cold-working of sheet is carried out by 5–10 per cent. reductions in thickness per pass, the total reduction between annealings being determined by the nature of the material. The annealing temperature also varies with the nature of the alloy.

The temperatures recommended for short 5-minute anneals by Wise and Eash[18] are: chemically pure platinum 900°–1000° C.; 5 per cent. iridium alloy 1100°–1200° C.; 10 per cent. rhodium alloy 1100°–1200° C.; 20 per cent. iridium alloy 1200°–1400° C.

The ordinary wire-drawing operations do not require special comment, and by careful work platinum can be bare drawn down to 0·005 in. in diameter. To obtain finer wires it is necessary to resort to Wollaston's method.[19] Wollaston took a wire of 0·01 in. diameter fixed it centrally in a cylindrical mould $\frac{1}{3}$ in. in diameter, and cast molten silver round it. The ingot and core were then treated as a single rod and drawn down to the required size, when the silver could be removed by nitric acid. In this way Wollaston produced wires down to 0·00003 in. in diameter. The fine wire is not usually in one continuous length if the diameter is reduced beyond 0·0001 in.

Miscellaneous Operations.

Platinum sheet can be formed to various shapes by the usual cold-forming operations such as spinning, stamping, &c. Seamless tubing is made by forming a circular blank into a cup and then drawing this on a mandrel through dies to the required finished dimensions.

The pure metal is difficult to work on a lathe or punch press since the metal tends to drag. The iridium alloys are better in this respect.

The metal is joined either by welding or soldering. Hammer welding is possible at quite low temperatures. Pure gold is a very satisfactory solder, but for platinum jewellery where white solders are necessary a number of white alloys, containing palladium, gold and smaller amounts of platinum, silver, and copper, are used.

PALLADIUM.

Palladium is a very malleable and ductile metal and can be readily fused, cast, and mechanically worked by the methods already described for platinum.

Wollaston, the discoverer of palladium, was the first to describe a method for converting sponge into a malleable piece of metal.[2] In principle the method consisted of making a low melting point fusible mass by the addition of sulphur, just as arsenic was used in the case of platinum. The sulphur was roasted off in a series of stages and the ingot gradually consolidated. In the light of modern knowledge this process could not give highly ductile or highly pure metal.

With the development of the oxy-hydrogen blowpipe it became quite easy to melt palladium in quantity since the melting point is 1553° C., some 220° C. below that of platinum. Palladium is usually melted on a lime hearth and cast into graphite moulds. Various precautions are necessary to prevent gas absorption. Palladium is usually regarded as a metal with a high affinity for hydrogen, and, while this is true at low temperatures, in a state of fusion it readily dissolves oxygen. This gas is largely liberated during solidification and the metal may swell to twice its original volume. As in the case of silver, no oxide phase can be detected microscopically in the solidified metal. By suitable control of flame composition, oxygen absorption can be largely eliminated. During melting there may be an appreciable loss by volatilization, so that quite apart from other considerations the metal should not be overheated.

Palladium can be readily melted with an oxy-coal-gas flame, but there is a definite danger that sulphur contamination will occur. In this respect palladium is more sensitive than platinum. A very small content of sulphur leads to the formation of a brittle compound $Pd_{[illegible]}S$[20] which usually separates along the grain boundaries. This compound is insoluble in palladium and melts at 785° C. Even 0·02 per cent. of sulphur leads to hot-shortness and at room temperatures reduces the ductility of the metal.[21]

For melting in the high-frequency induction furnace, the refractories mentioned in the case of platinum give good service. Graphite crucibles cannot be used since carbon is so readily picked up.

Palladium and its alloys are worked by methods analogous to those described for platinum, and do not call for detailed description. The pure metal tends to work-harden rather more rapidly than platinum. The extraordinary ductility of pure palladium is demonstrated by the fact that it can be beaten out into leaf in the same way as gold.

A satisfactory annealing treatment for pure palladium consists in heating in air to 800°–900° C. for 5 minutes.[18] Annealing at temperatures above 1000° C. results in a pronounced decrease in elongation owing to the onset of marked selective grain-growth. Below 1000° C. the grain-size remains very uniform. A slight surface discolouration occurs during cooling owing to the formation of a thin palladium oxide film. If this is objected to, the metal may be heated and cooled in nitrogen.

Palladium alloyed with other metals of the platinum group, *e.g.* rhodium and ruthenium, requires a higher annealing temperature. With 5 per cent. of added metals the annealing temperature is increased to 1000°–1100° C.[18]

RHODIUM.

Deville and Debray [13] melted rhodium on a lime hearth with an oxy-hydrogen blowpipe and found its density to be 12·1. When very pure they found it malleable and ductile.

At various times rhodium has been melted, cast, and mechanically worked. For instance, Grüneisen [22] measured the density of a rod of rhodium 27 cm. long and 1·6 cm. in diameter, which had been cast by Heraeus.

Rose [23] measured the density of a piece of rhodium, made by Messrs. Johnson, Matthey and Company, which had been forged from sponge and not melted.

It is clear from the above references that rhodium may be worked starting either with sintered sponge or a cast ingot.

More recently Swanger [24] and Sivil [14] have described more systematically the problems involved in the mechanical working of melted rhodium. High-purity rhodium is essential for ease of working. The melting point of rhodium (1966° C.) is considerably higher than that of platinum (1773° C.), which makes it somewhat more difficult to melt with the oxy-hydrogen flame. The rhodium meal is compressed into pellets in a steel mould before melting, and the pellets are melted with a "hard" (oxygen-rich) flame. During melting, oxygen is absorbed in considerable quantity, and the metal tends to spit and sprout during solidification. If, however, the supply of oxygen to the torch is reduced when the metal is molten, spitting can be largely obviated, and the metal made to freeze with a fairly smooth surface.

Rhodium can be melted readily in the high-frequency induction furnace. Thorium oxide crucibles are the most satisfactory though with care zirconium oxide crucibles can be used.

Melting in air leads to the same troubles due to dissolution of oxygen as in oxy-hydrogen melting, but if the metal is frozen slowly forgeable ingots are obtained. If melted *in vacuo* (about 1 mm. of mercury pressure) a smooth silver-white surface is obtained. In the case of small vacuum-fused ingots, large shrinkage cavities make forging difficult, hence it may be necessary to remelt on a lime hearth.

It should be noted that molten rhodium has a considerable affinity for carbon, a property shared by the other metals of the group. Rhodium melted in an Acheson graphite crucible increased in weight by 1·8 per cent.[24] The button was very hard and brittle and could not be forged either hot or cold. The colour of the metal was noticeably darker than that of pure rhodium.

The forging or swaging of rhodium ingots does not present any unusual difficulties. They cannot be forged at room temperature, but become quite malleable above a red heat.

For the production of wire the ingots may be hand-forged at about 1100° C. to bars of a suitable size for swaging. The bars are heated in an oxy-coal-gas or oxy-hydrogen flame and enter the swaging dies at a temperature of about 1000° C. Wire produced by swaging above 800° C. is not ductile at room temperature, the metal having a coarse-grained, equiaxed structure. By drawing through tungsten carbide dies at gradually decreasing temperatures, a fibrous structure is developed until the metal can eventually be drawn at room temperature. In this way wire down to 0·004 in. diameter has been made.

Rhodium sheet is made by hot-rolling to a thickness of about 0·030 in. at which size it becomes sufficiently ductile for cold-rolling.[14] During the cold-work frequent annealings at high temperatures (about 1200° C.) are necessary. The annealed material hardens rapidly, and by far the greatest reduction occurs during the first pass. Foil has been produced in sheets 10 in. × 24 in. × 0·001 in.

After annealing at 1200° C., the Brinell hardness of rhodium is 101.[24] The metal does not machine readily, however. Great difficulty was experienced in drilling sight holes in specimens used for melting point determinations.

IRIDIUM.

No systematic account of the working of iridium has been given in the literature. The metal is, in normal circumstances, so rare and valuable that only the precious metal refiners have had opportunities to investigate its properties.

Early attempts to fuse iridium were unsuccessful, but from 1837 onwards it was known that a fusible product could be obtained by adding phosphorus to very hot iridium sponge.[25] This recalls the early use of arsenic in the metallurgy of platinum and of sulphur in the metallurgy of palladium. The phosphorus process was later elaborated by Holland for the manufacture of iridium alloy grains suitable for tipping fountain pens.[26] The fusible alloy contains about 7 per cent. of phosphorus, and can be cast into thin plates, which are very brittle.

Deville and Debray [13] melted iridium with an oxy-hydrogen blowpipe. The operation was not easy, and they used 200–300 litres of oxygen in melting 25 grm. of metal. They were unable to melt iridium with the oxy-coal-gas blowpipe. At room temperature the ingot broke under impact, disclosing a rather coarse, crystalline structure, but at a white heat they were able to forge it.

In a letter [25] to *The Chemical News* in 1885, Messrs. Johnson, Matthey and Company stated that for many years they had succeeded in fusing and working pure iridium into rods and wires, and in 1908 Crookes described [27] the use of pure iridium crucibles for analytical work.

Sivil [14] states that iridium can be worked in a way similar to the working of rhodium, but with greater difficulty. Cold-working is quite impossible, the material crumbling to small fragments after a very small reduction. This limited workability is attained only by iridium of high purity, the presence of minute amounts of other metals, including platinum metals, reducing the malleability to zero.

It is clear that iridium can best be worked at a white heat. As a starting point either sintered sponge or fused metal may be used. In connection with the melting of iridium it should be noted that the melting point (2454° C.) [28] is very close to the maximum temperature of the oxy-hydrogen flame. Iridium can be more readily melted with the oxy-acetylene blowpipe and, provided that care is taken to adjust the flame composition, the ingot so produced is quite malleable at a white heat. The dissolution of carbon and oxygen during melting should be avoided as in the case of the other metals of the group.

The high-frequency induction furnace was used by Henning and Wensel [28] for melting iridium during the determination of the freezing point of pure iridium. Fused thoria crucibles were used, and were found to be quite satisfactory. These authors mentioned that iridium is very difficult to machine. Tungsten carbide tipped drills were used for making a slight hole in the ingot, but even so it was very laborious work.

The annealing temperature of iridium has not been determined. In determining the lattice parameter, using filings, Owen and Yates [29] found that after 240 hrs. at 600° C. some of the lines were well enough resolved for measurement.

Very little information is available about the working of iridium-rich alloys. Heraeus [30] states that the addition of more than 10 per cent. rhodium has a beneficial effect on the working properties of iridium. Swanger [31] records the use of a 72 per cent. iridium : 28 per cent. platinum alloy crucible for the study of phase equilibria of oxide systems at 2000° C.

RUTHENIUM AND OSMIUM.

The four metals previously described all belong to the cubic system and can be worked under suitable conditions. Ruthenium and osmium possess the hexagonal structure, and very little indeed is known about their working properties. They are inherently more difficult to fabricate than those metals of the group having a cubic structure, they have higher freezing points, and possess the undesirable property of forming very volatile oxides, that of osmium being very poisonous. These factors coupled with the rareness of the metals are responsible for the present lack of knowledge concerning them.

The freezing points of the metals are not known, but the difficulty of melting the metals with a blowpipe indicates that ruthenium melts at a somewhat higher temperature than iridium, while osmium is the most infusible metal of the group. Deville and Debray [13] melted very small quantities of ruthenium with an oxy-hydrogen torch, but were unable to fuse osmium. During the melting of ruthenium there was a considerable loss of metal as ruthenium dioxide and tetroxide and on freezing it spitted like rhodium. It was very hard and brittle. Osmium sintered on heating to a temperature estimated to be equivalent to the melting point of rhodium (1966° C.), and the metal had a pronounced metallic lustre showing a bluish tinge.

On melting ruthenium in a graphite crucible in a high-frequency induction furnace, it dissolves about 1·2 per cent. of carbon, thus conforming to the general behaviour of the platinum metals.

There seems no definite reason to exclude the possibility of working these metals, and it is thought that an attempt using modern powder methods might prove successful, provided that working was done at a sufficiently high temperature. There are indications that sintered ruthenium powder is forgeable at very high temperatures.

As regards the annealing temperatures of these metals, we have the evidence of Owen, Pickup, and Roberts [32] that annealing at 800° C.

for 6 hrs. failed to remove the distortion from ruthenium, but after 4 hrs. at 1000° C. it gave quite satisfactory X-ray photographs. Osmium which had been crushed and ground in an agate mortar required 5 hrs.' annealing at 1000° C. before well-defined lines were recorded. The annealing temperatures in the accepted sense are probably above 1000° C.

Osmium filaments which were at one time used in incandescent lamps were formed from powdered osmium held together with a bonding material which was burnt out before the lamp was used. This method gave very fragile filaments.

Some Properties and Uses.

Physical Properties.

The physical properties of the platinum metals are, as might be expected, very dependent on purity; consequently those uses of the metals which depend on specific physical properties demand products of extremely high purity.

In Germany an attempt has been made to draw up specifications for the various grades of platinum used in industry. Five grades of purity are recognized, as follows :

Platinum A. Physically pure platinum with a minimum standard of purity of 99·99 per cent. Used for thermocouples and resistance pyrometers.

Platinum B. Chemically pure platinum with a minimum standard of purity of 99·90 per cent. Used for electrodes.

Platinum C. Utensil platinum containing up to 0·3 per cent. iridium, other metals not exceeding 0·1 per cent. Minimum platinum content 99·7 per cent.

Platinum D. Technically pure platinum containing at least 99 per cent. platinum and not less than 99·5 per cent. of platinum metals.

Platinum E. Jewellery platinum containing not less than 95 per cent. platinum.

It should be noted that the highest quality of platinum is designated "physically pure" platinum, and is used where specific electrical properties are required. The purity of this grade of platinum is best determined either by a thermoelectric method or by measurement of the temperature coefficient of resistance. The thermoelectric method is stated to be more sensitive even than spectroscopic tests.[33]

At the Bureau of Standards (U.S.A.) each batch of material is tested against a special standard (Pt 27) which contains less than 1 part in 10^6 of impurity. In some cases the thermal e.m.f. against the standard Pt 27 has been found to be as much as 50 microvolts at 1200° C. when spectroscopic tests failed to show any impurity. The smallest amount of impurity which has been detected spectroscopically corresponds to a change in thermal e.m.f. at 1200° C. of about 20 microvolts. In general, small amounts of impurity make it positive thermoelectrically to pure platinum.

Dissolved gases as well as metallic impurities have a marked effect on the thermoelectric properties. Sivil [14] records the case of a sample containing dissolved oxygen whose thermal e.m.f. was reduced from 4 microvolts to 1 microvolt by heating *in vacuo*. He also states that platinum melted in the atomic hydrogen torch gave at 1200° C. an e.m.f. of 750 microvolts against a platinum standard.

The temperature coefficient of resistance between 0° and 100° C. is also a sensitive indication of purity. Physically pure platinum should have a value of the ratio $\frac{R_{100^\circ}}{R_{0^\circ}}$ of at least 1·390. The presence of 0·1 per cent. palladium will lower the value of this ratio to about 1·379 while 0·1 per cent. iron lowers it to 1·355.[34] Gerlach [15] has shown that the purest form of platinum prepared by Heraeus has a residual resistance between 4° and 1·35° A. scarcely 0·0003 of the resistance at 0° C.

In the determination of the freezing point of platinum at the National Physical Laboratory, using fused thoria crucibles, Schofield [35] measured the value of $\frac{R_{100^\circ}}{R_{0^\circ}}$ before and after the freezing point determinations. In one example given the value decreased from 1·3919 to 1·3911, showing that very little contamination occurred.

Physical methods for testing the purity of the other platinum metals are not so well developed.

Some of the more important physical properties are given in Table II, and the most reliable data given for each metal.

Platinum on account of its permanence and stability has been proved to be the ideal material for constructing standards of mass and length. For instance, in Great Britain we have to-day two legal standards of mass, the pound avoirdupois which is the mass of a certain piece of platinum marked "P.S. 1844 lb." and the kilogram which is the mass of a certain lump of platinum, preserved in Paris, called the "Kilogram des Archives." The inconsistencies of base metal standards such as brass and gun-metal were clearly shown when it became necessary

TABLE II.—*Physical Properties of the Metals of the Platinum Group.*

Property.	Platinum.	Iridium.	Osmium.	Palladium.	Rhodium.	Ruthenium.	Units.
Atomic number	78	77	76	46	45	44	
Atomic weight	195·23	193·1	191·5	106·7	102·91	101·7	0 = 16
Specific gravity	21·40	22·42	22·48	12·16	12·41	12·20	Grms. per c.c. at 20° C.
Melting point	1773·5° ± 1°	2454° ± 3°	Higher than ruthenium	1553° ± 2°	1966° ± 3°	Higher than iridium	° C.
Boiling point	4300°	>4800°	>5300°	2200°	>2500°	>2700°	° C.
Specific heat :							
0° C.	0·0316	...	...	0·0584	...	...	Calories per grm.
0°–100° C.	0·0319	0·032	0·031	0·0590	0·058	0·061	
Temperature coeff. of linear expansion :							
20° C.	8·9	6·5	...	11·7	...	...	× 10^{-6} per ° C.
40° C.	8·99	...	6·6	...	8·5	9·6	
Thermal conductivity : 18° C.	0·166	0·141	...	0·168	0·210	...	Calories cm.$^{-1}$ sec.$^{-1}$ temp.$^{-1}$
Specific resistance, annealed :							
0° C.	9·97	5·33	9·5	10·78	4·3	14·47	ohm-cm. × 10^{-6}
Temperature coeff. of resistance :							
Hard	0·003917	...	...	0·0037	...	...	0°–100° C. per ° C.
Annealed	0·003923	...	...	...	0·00457	...	
Young's modulus	16·8	51·5	...	11·3	27·5	...	Dynes per sq. cm. × 10^{11}
Structure type	Face-centred cubic	Face-centred cubic	Hexagonal close-packed	Face-centred cubic	Face-centred cubic	Hexagonal close-packed	
Unit cell :							
a_0	3·9158	3·8312	2·7304	3·8824	3·7957	2·6987	Angstrom nnits
c_0/a_0	...	...	1·5785	...	...	1·5833	

to replace the brass standard pound lost in the Houses of Parliament fire in 1834, and since that time platinum has been used.[36]

The permanence of platinum has also been shown [37] in a remarkable way by the constancy of the B.A. Standards of resistance made of this metal, over the period 1865–1932. The temperature coefficient of resistance of the standard platinum coils is low (308×10^{-5}) compared with the value of modern high-purity platinum (392×10^{-5}), yet these coils have remained absolutely constant.

The high-temperature properties of the platinum metals are of some general interest. For most high-temperature uses it is important that they should remain either of constant weight or of constant composition, and mechanical strength is usually a secondary consideration.

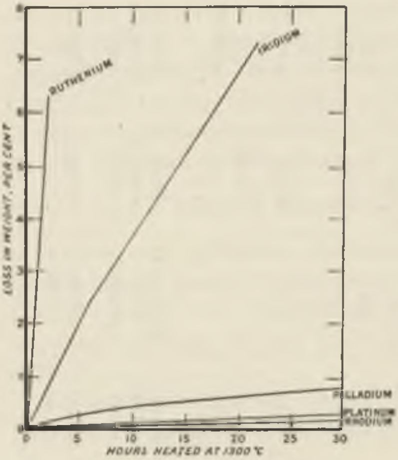

Fig. 2.—Volatility of Platinum Metals in Air at 1300° C. Results of Sir William Crookes.

Crookes [38] carried out some experiments on the loss in weight of the pure platinum metals when heated in air at 900° and 1300° C. His results for 1300° C. are shown in Fig. 2. The least loss in weight is shown by rhodium, and this is closely followed by platinum. Palladium shows somewhat higher losses, while iridium and ruthenium lose weight very rapidly. Osmium was not included, presumably because of the poisonous nature of the volatile tetroxide, but it would have given by far the highest weight loss. At 900° C. rhodium and platinum showed practically no weight loss even after prolonged heating, but palladium lost 0·18 per cent. in 30 hrs. and iridium 0·09 per cent. in 22 hrs.

Carter [39] has indicated that weight losses for wires heated electrically are greater than for wires heated externally, and that rhodium is more volatile than platinum at temperatures above 1300° C.

In analytical work the constancy in weight of platinum crucibles after ignition is essential, and this point has been carefully examined by the Bureau of Standards.[40, 41]

Platinum crucibles are not often made of "physically pure" metal, and there may be present small amounts of iridium and rhodium and traces of iron. Below 900° C. the loss of weight on heating in all cases is negligible, and at lower temperatures there may even be a slight gain in weight due to the iron content diffusing to the surface and oxidizing. At higher temperatures there is a definite loss in all cases as shown in Table III.

TABLE III.—*Approximate Loss in Weight mg./100 cm.^{2}/hr. for Platinum Nearly Free from Iron.*

Temperature, ° C.	Platinum containing:			
	Pure Platinum.	1% Iridium.	2·5% Iridium.	8% Rhodium.
900 or less	0	0	0	0
1000	0·08	0·30	0·57	0·07
1200	0·81	1·2	2·5	0·54

Above 900° C., the loss in weight for iridium-containing platinum is very much greater than that of pure platinum, and increases with the iridium content and with temperature. Rhodium-containing material shows lower weight losses than pure platinum at all temperatures above 900° C. These observations indicate the desirability of using platinum free from all metals other than rhodium. The addition of rhodium is beneficial in that it lowers weight losses and moreover gives a more robust material. For general laboratory use the Bureau of Standards recommends a rhodium content of 3–3·5 per cent. A further example may be taken from the use of the 10 per cent. rhodium–platinum alloy gauzes for the catalytic oxidation of ammonia, where weight losses are again lower than for the pure platinum gauzes.

In thermocouple work constancy of composition is important and the above remarks indicate why the platinum–rhodium alloys are superior to the platinum–iridium alloys.

The losses in weight of the platinum metals (other than palladium) on heating in air are probably due to the formation of volatile oxides. The evidence in the case of osmium, ruthenium, and iridium is quite definite, but it has often been doubted that the loss in weight of platinum and rhodium is due to the formation of volatile oxides. In the case of these two latter metals there is a negligible loss *in vacuo* or in hydrogen and nitrogen, and in an oxygen atmosphere the loss is proportional to the partial pressure of oxygen. This seems to be decisive evidence against a true volatilization loss, and in favour of the view that volatile oxides are formed. Palladium shows a definite weight loss *in vacuo* and in the case of this metal true volatilization probably occurs.

The use of platinum for the resistance windings of high-temperature laboratory furnaces is well known. Pure platinum has some disadvantages, but it has been found that the alloy 80 per cent. platinum : 20 per cent. rhodium is much more satisfactory.[31] This alloy has a higher melting point than platinum, a higher specific resistance, lower temperature coefficient of resistance, lower density, lower rate of volatilization, and less tendency to become brittle due to crystal growth.

Other physical properties of the metals have led to important uses, some of which will be mentioned briefly. The high reflectivity and silvery-white appearance of rhodium coupled with its nobility has led to the use of thin rhodium electrodeposits for the protection against tarnish of sterling silver ware, reflectors, and a multitude of trinkets made by the jewellery trade. The high density of platinum and platinum–iridium alloys coupled with high corrosion-resistance and good workability makes them suitable materials for constructing radium needles and tubes for the medical profession. Finally, the similar thermal expansion coefficients of platinum and glass led to the widespread use of platinum as a lead-in material.

Mechanical Properties.

The mechanical properties of the two very ductile metals of the group, platinum and palladium, are known fairly completely, but information about the other four metals is incomplete. Such data as is available is presented in Table IV.

TABLE IV.—*Mechanical Properties of Platinum Metals.*

	Platinum.	Iridium.	Osmium.	Palladium.	Rhodium.	Ruthenium.	Units.
Ultimate strength :							
Hard * . .	16·0	...	...	20·9	...	...	Tons/in.^{2}
Annealed . .	9·8–10·7	...	...	13·4	...	...	0·05 in. wire
Proportional limit :							
Hard * . .	12·0	...	...	14·2	...	...	Tons/in.^{2}
Annealed . .	2·4–4·5	...	...	2·2	...	...	0·05 in. wire
Elongation :							
Hard * . .	2·5	...	...	1·5	...	...	Per cent. in 2 in.
Annealed . .	24–34	...	...	39–41	...	...	0·05 in. wire
Reduction of area :							
Hard * . .	95	...	...	91·5	...	...	Per cent.
Annealed . .	92	...	...	89–92	...	...	0·05 in. wire
Erichsen ductility :							
Hard . .	7·8	...	...	7·6	...	...	mm.
Annealed . .	12·2	...	...	12·0	...	...	
Hardness :							
Cast . .	50	172	350	52	101	220	H 2/30/120 except Osmium which is a Vickers number.
Hard . .	97	...	...	109	...	...	
Annealed . .	47	...	...	49	101	...	

* 50 per cent. reduction after annealing.

Attention is drawn to the great hardness of osmium and ruthenium.

The most important platinum alloys are those used for the manufacture of fine jewellery. Owing to the difficulties of assay of platinum alloys, it has not yet been found possible to evolve a scheme for hall-marking platinum jewellery, and at the present time most manufacturers adhere to a 950 standard which has been agreed to by all the important European countries. Iridium counts as platinum in this 950 standard. Base metals may be present in amounts up to 5 per cent. and two commonly used alloys contain 3 per cent. and 4·5 per cent. of copper, respectively. These two alloys have adequate hardness and strength for most purposes, and have good working properties. The use of copper for hardening platinum follows the long-established trade custom of hardening the two precious metals gold and silver. In the case of platinum the use of base metals is quite unnecessary, since the quality of platinum goods could best be maintained by the use of alloys hardened solely with the other platinum metals such as iridium, rhodium, and ruthenium. These alloys are superior in several respects to the copper-containing alloys. The highest-quality platinum jewellery is made from 5 per cent. and 10 per cent. iridio-platinum. Other very high-grade alloys can be made with the addition of 5 per cent. rhodium plus ruthenium, the ruthenium content being varied according to the hardness required.

A general idea of the properties of the various platinum alloys can be obtained from Table V, which records the Brinell hardness values of the fully-annealed materials.

TABLE V.—*Brinell Hardness of Annealed Platinum Alloys.*

	Weight Percentage of Alloying Metal.			
	5 Per Cent.	10 Per Cent.	15 Per Cent.	20 Per Cent.
Iridium	80	105	140	175
Rhodium	80	85	88	91
Ruthenium	105	158	Alloy unworkable	Alloy unworkable
Palladium	65	70	73	75
Copper	110	135	142	145

More detailed information concerning certain important alloys is given in Table VI.

A similar range of palladium alloys may be prepared with similar strength characteristics. Iridium, rhodium, and ruthenium harden palladium to a rather less extent than they harden platinum for equivalent additions. Palladium alloys were largely used for jewellery purposes during the Great War when platinum was scarce. In more normal times this use has largely disappeared, though on account of appearance and working properties they are much superior to " white gold " alloys.

TABLE VI.—*Mechanical Properties of Platinum Alloys Cold-Drawn (50 Per Cent. Reduction) and after Annealing.*[18]

Material.	Condition of Alloy.	Proportional Limit. Tons/in.^{2}.	Ultimate Strength. Tons/in.^{2}.	Elongation, Per Cent. on 2 in.	Reduction of Area, Per Cent.
5% Ir : 95% Pt	Hard	23·9	30·8	2·0	92
	Annealed	8·0–10·3	17·4–18·5	22–32	95
10% Ir : 90% Pt	Hard	24·2	36·8	2·5	94
	Annealed	13·4–16·1	23·7–24·6	25–27	95
20% Ir : 80% Pt	Hard	44·95	62·6	2·5	85
	Annealed	26·4–27·7	41·5–45·5	20–21	89
10% Rh : 90% Pt	Hard	24·8	37·6	3·0	90
	Annealed	7·6–9·8	21·0–21·9	25–37	94
4% Ru : 1% Rh : 95% Pt	Hard	22·6	38·0	3·5	87
	Annealed	8·0–12·5	26·8–27·7	19–33	93
5% Ni : 95% Pt	Hard	31·2	46·0	2·0	84
	Annealed	14·7	29·0	23·5	93
3% Cu : 95% Pt	Hard	21·6	36·1	2·5	84
	Annealed	7·6–9·8	23·7–25·9	26–34	91
4·5% Cu : 95·5% Pt	Hard	24·2	40·9	2·5	64
	Annealed	9·4–11·2	27·7–30·4	24–28	86

After jewellery the next most important group of alloys are those used in dentistry, and here platinum and palladium are alloyed with the metals of the coinage group. A sub-division of the alloys into wrought and casting alloys is convenient. The wrought alloys are used in the form of circular blanks for swaged plates and in the form of wire and thin bands for correcting malformations of the mouth. Two of the most useful alloys for swaged plates are " dental alloy " of the composition platinum 30 : silver 70 per cent. and the alloy palladium 50 : silver 50 per cent. The high-strength wires and bands used for correcting malformations of the mouth are of complex and varied composition and may contain up to 30 per cent. of platinum and/or palladium, the remainder being gold, silver, and copper. These alloys are very responsive to heat-treatment, as shown by the comprehensive work of Wise, Crowell, and Eash.[42, 43] The transformations responsible for hardening are similar to those occurring in the systems gold–copper, palladium–copper, and platinum–copper in the neighbourhood of the 50 atomic per cent. alloys. In the fully heat-treated condition such alloys may show ultimate strength values of 65–80 tons/in.^{2}.

Dental casting alloys should not have a melting point greater than

1050° C., hence the amount of platinum and/or palladium which may be added is restricted. Alloys in the 18 carat range may contain up to 12–15 per cent. platinum and/or palladium, but cheaper alloys of approximately 9 carat quality may contain up to 25 per cent. of palladium. The addition of the platinum metals increases the response to heat-treatment, and the alloys are white in colour and are, therefore, inconspicuous in the mouth. Most of the casting alloys can be hardened by simple heat-treatment, and in this state regularly develop an ultimate strength [44] of 45–50 tons/in.^{2}.

Various other special platinum metal containing alloys are fabricated to meet the special needs of industry. The alloy platinum 95 : nickel 5 per cent. is particularly suitable for the filaments used in amplifying tubes in communication systems. A large variety of platinum metal contact alloys are used where conditions are severe or where great reliability is required. Aeroplane and automobile magneto contacts, for instance, are made of 15–25 per cent. iridio-platinum. File-hard alloys containing relatively large amounts of the " by-metals " are used on relays where contact pressures are very low. The alloy palladium 60 : copper 40 per cent. is finding many uses among which may be mentioned telegraph relays. A brief reference should also be made to the very hard alloys containing varying proportions of iridium, osmium, and ruthenium for fountain pen points.

Chemical Properties.

The catalytic and corrosion-resistance properties of the platinum metals lead to their extensive use in the chemical industries.

As regards catalytic reactions brief mention might be made of the use of gauzes of the alloy rhodium 10 : platinum 90 per cent. for the oxidation of ammonia in the production of nitric acid, and the use of finely divided platinum on a suitable carrier for the contact process of sulphuric acid manufacture.

The corrosion-resistance of the platinum metals is made use of in chemical processes where the conditions are severe. As examples there may be mentioned spinnerets used in the artificial silk industry and anodes used for the manufacture of per-salts and oxidizing agents.

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THE SOLID SOLUTIONS OF INDIUM AND LEAD.*

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SYNOPSIS.

The constitutional diagram of the alloys of indium and lead has been modified as a result of new data obtained by means of X-ray examination and thermal analysis. The diagram shows that the alloys have limited solid solubility and a peritectic transformation. The physical properties of the alloys are in agreement with this diagram.

INTRODUCTION.

THE constitutional diagram of the indium–lead alloys has been examined by N. S. Kurnakow and N. A. Puschin,[1] who found by thermal analysis that the metals were soluble in each other in all proportions. Electrical resistivity measurements and extrusion pressure measurements made by N. S. Kurnakow and S. F. Schemtschushny [2] showed that the change of properties with composition was such as would occur in the case of a continuous series of solid solutions.

W. Meissner, H. Franz, and H. Westerhoff [3] investigated the alloys in connection with a systematic study of superconductivity. The temperature of the transition point and the isothermal curves of electrical resistance at 77·7° and 20·4° K. change continually with composition as they must for solid solutions.

C. Benedicks [4] referred to the possibility of coreing in solid solutions of indium and lead, and corrected the transition points of the diagram of W. Meissner, H. Franz, and H. Westerhoff in accordance with this heterogeneity.

The crystal structure analysis made by A. W. Hull and W. P. Davey [5] shows that indium has a face-centred tetragonal lattice with $a = 4{\cdot}58$ A., $c = 4{\cdot}86$ A., and $c/a = 1{\cdot}06$. F. P. J. Dwyer and D. P. Mellor [6] confirmed the tetragonal lattice of indium and gave the lattice constants as $a = 4{\cdot}588$ A., $c = 4{\cdot}946$ A., $c/a = 1{\cdot}078$. Goniometric measurements of a crystal of indium, made by E. Zintl and S. Neumayr,[7] agreed with the results previously obtained and gave $a = 4{\cdot}583$ A., $c = 4{\cdot}936$ A., $c/a = 1{\cdot}077$.

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It is well known that lead has a face-centred cubic lattice [8] with a parameter $a = 4{\cdot}942_1$ A. Measurements made in our laboratory agree with this.[9]

Experimental evidence has shown that a continuous series of solid solutions can only exist when the constituent metals have a similar crystal lattice. From these references it will be observed that while indium and lead have different crystal lattices they form a continuous series of solid solutions. This, if true, is unique, and in order to investigate it the experiments described below were carried out.

X-Ray Investigation.

For X-ray analysis alloys were prepared by melting together indium and lead (Kahlbaum) in porcelain crucibles under paraffin oil. Specimens 1 mm. in diameter were obtained by sucking liquid alloys into the thin glass tube. After the specimens had been removed from the glass tube, they were rolled between two glass plates and annealed at 25° C. for 10 days. Powder photograms of the alloys were obtained with a Hadding tube using copper radiation ($CuK_\alpha = 1{\cdot}539$ A.; $CuK_\beta = 1{\cdot}389$ A.). The X-ray camera was calibrated against pure lead, the lattice parameter of which was taken as $4{\cdot}942_1$ A.[9] The results obtained are shown in Table I.

Table I.—*Structure and Parameters of the Indium–Lead Alloys.*

Lead, Atoms Per Cent.	Lattice.	Parameters.			Parameter.
		a.	c.	c/a.	a.
0	α (tetragonal)	4·635	4·997	1·079	...
5	α	4·622	4·965	1·074	...
10	α	4·567	4·933	1·080	...
20	$\alpha + \beta$	4·500	4·824	1·072	4·793
30	$\alpha + \beta$	4·500	4·824	1·072	4·775
35	$\alpha + \beta$	4·515	4·867	1·077	4·792
40	β	...	...	...	4·792
50	β	...	...	...	4·854
100	β (cubic)	...	...	...	4·942

Fig. 1 (Plate I) shows an example of the type of photogram obtained and Fig. 2 shows the change of parameter with composition.

Table I and Fig. 2 indicate that alloys with 5 and 10 per cent. of lead have a lattice similar to that of indium, the parameter and axial ratio changing continuously. Alloys from 40 per cent. of lead to pure lead have a cubic face-centred lattice with varying parameter, while in

PLATE I.

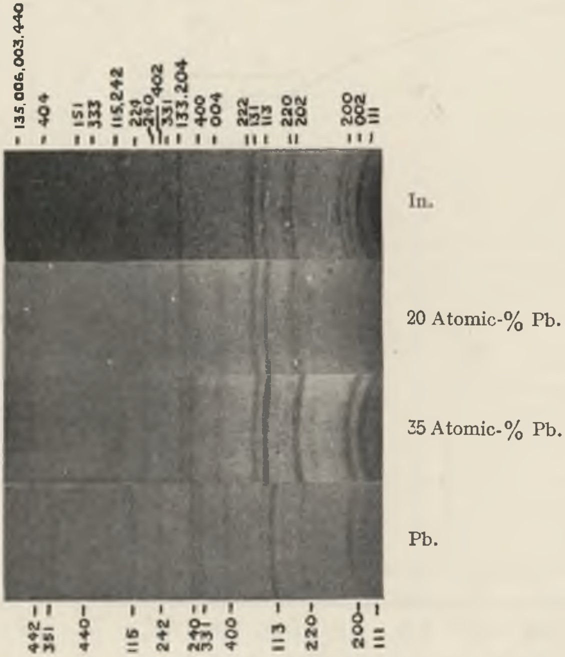

Fig. 1.—Powder Photograms of Indium–Lead Alloys.

the interval from 20 to 35 per cent. of lead the alloys show both lattices with an approximately constant parameter.

It will be seen, therefore, that the investigation shows the presence of a two-phase range between 20 and 40 atomic per cent. of lead. This result differs considerably from the previously published data, and further investigation by thermal analysis was undertaken to check this.

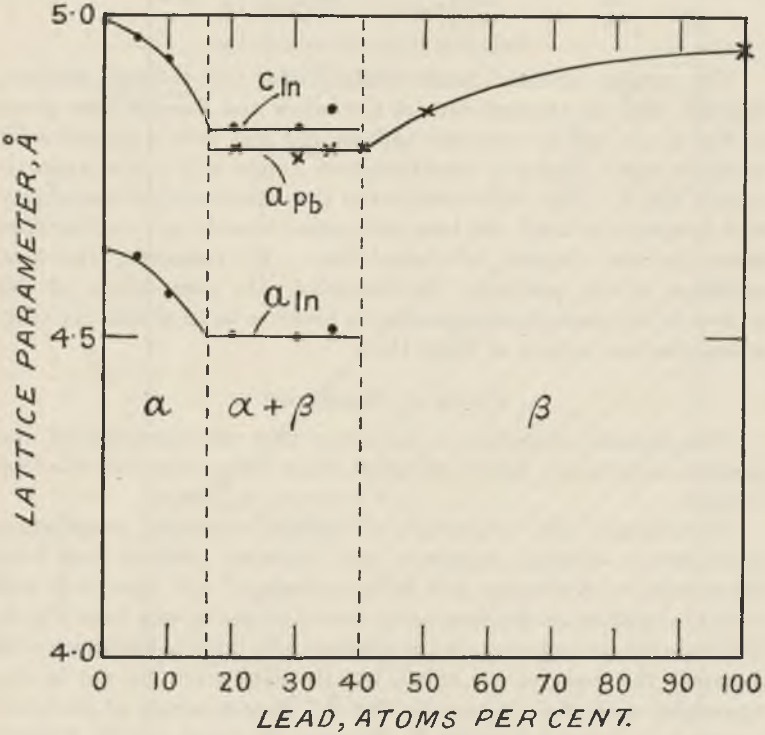

Fig. 2.—Lattice Parameters of the Indium–Lead Alloys.

Thermal Analysis.

The investigation by N. S. Kurnakow and N. A. Puschin [1] was not carried out over the whole range of the alloys. A blank was left at the range of composition from 30 to 60 atomic per cent. of lead, *i.e.* the interval where the X-ray evidence indicates occurrence of duplex structure. To fill up this gap thermal curves were taken of alloys in the range 30–40 atomic per cent. lead. The thermal curves were recorded by means of Kurnakow's self-registering pyrometer.[10] The specimens weighed 4–5 grm. The calibration was made with pure tin and water. The data obtained are given in Table II.

TABLE II.—*Thermal Analysis of Indium–Lead Alloys.*

Lead, Atoms Per Cent.	First Arrest, ° C.	Second Arrest, ° C.	Heat Evolution at Second Arrest.
30	189·3	154	small
32	194·3	154	largest
35	199·0	154·5	large
38	207·1	154	small
40	208·9	...	...

The present authors' results from X-ray and thermal analysis, together with the thermal data of Kurnakow and Puschin,[1] are given in Fig. 3. It will be seen that indium and lead have a limited solid solubility and a peritectic transformation Liquid $+ \beta = \alpha$ at approximately 154° C. Part of the solidus and the variation of solid solubility with temperature have not been determined exactly and are therefore shown on the diagram by dotted lines. By measuring the heat evolution at the peritectic transformation, the composition of the α-phase at the peritectic temperature is found to be 32 atomic per cent. of lead (see last column of Table II).

PHYSICAL PROPERTIES.

The physical properties of the alloys were not measured by the present authors, the results discussed below being obtained by other workers.

The changes with composition of electrical resistivity, temperature coefficient of electrical resistance, and extrusion pressure have been determined by Kurnakow and Schemtschushny,[2] and agree very well with the equilibrium diagram given above, as can be seen from Fig. 4. There are not enough points in the heterogeneity range to determine with certainty the shape of the curve, but the data given are not in disagreement with the diagram in Fig. 3. Measurements of electrical resistance in liquid helium by W. Meissner, H. Franz, and H. Westerhoff [3] also give results in the two-phase range which are not in disagreement with Fig. 3. According to Benedicks,[4] the temperature of a transition point must alter as it passes through the two-phase range. The values given in the paper by W. Meissner, H. Franz, and H. Westerhoff [3] can be plotted so as to show a change of temperature of the transition point of superconductivity in the α and β range.

CONCLUSIONS.

The equilibrium diagram of indium–lead alloys has been modified as a result of X-ray and thermal analyses. The new diagram differs considerably from the earlier one.

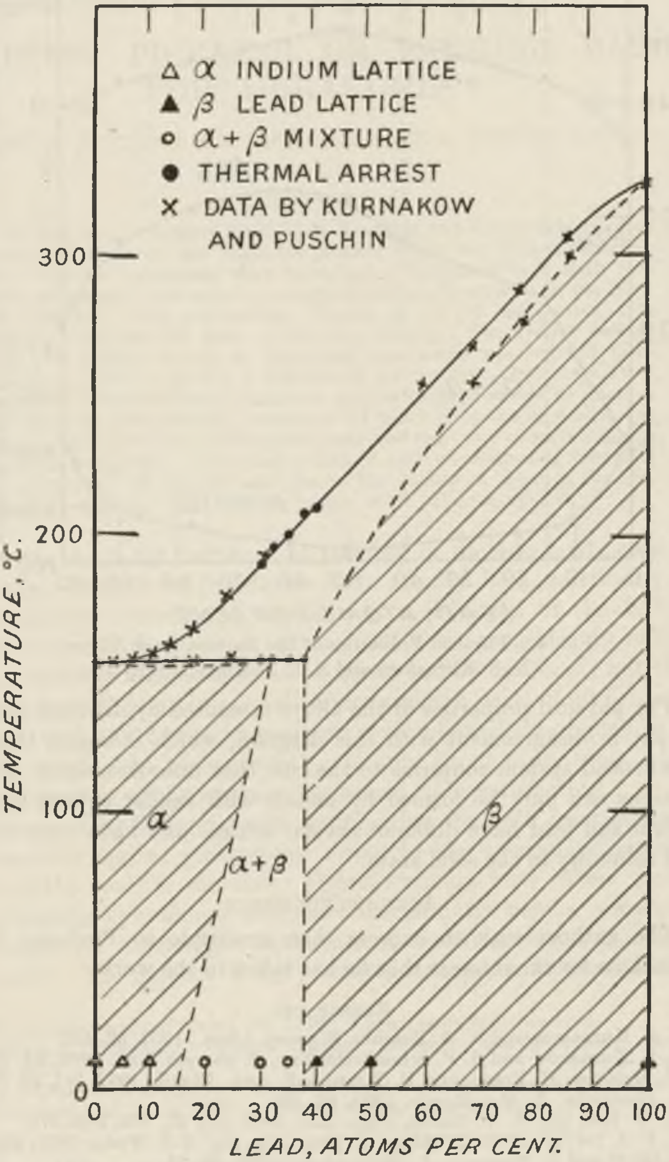

Fig. 3.—Constitutional Diagram of the Indium–Lead Alloys.

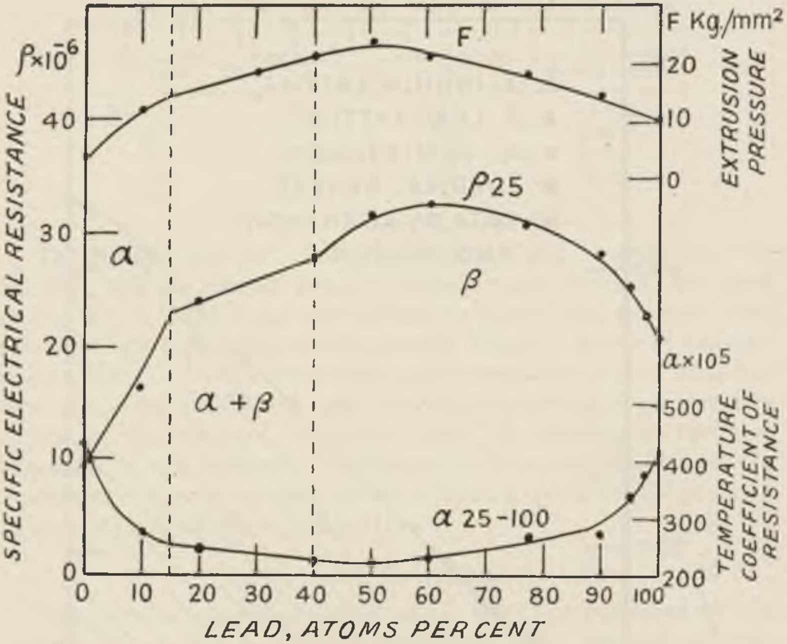

FIG. 4.—Physical Properties of the Indium–Lead Alloys.
(N. S. Kurnakow and S. F. Schemtschushny.)

The physical properties of the alloys measured by different workers are not in disagreement with this diagram, which indicates that the indium–lead system conforms to the rule that unbroken series of solid solutions can only be formed by metals with similar crystal lattices. Indium and lead have different crystal lattices and have only limited solid solubility in the solid state.

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NOTE ON PICKLING OR ETCHING BATHS FOR DURALUMIN.*

By H. SUTTON,† M.Sc. (MEMBER), and T. J. PEAKE,‡ B.Sc.

SYNOPSIS.

In view of the dangers involved in handling and transporting hydrofluoric acid, a search was made for pickling baths free from such objection. Various treatments were examined. Treatment in a bath prepared by adding 1 per cent. by weight of sodium fluoride to 10 per cent. (vol.) sulphuric acid followed by dipping in 50 per cent. nitric acid (pickling treatment D) gave satisfactory etching. The Wöhler fatigue range (10 million cycles) of Duralumin specimens was reduced from ±10·85 to ±10·1 tons/in.², a decrease of 6·9 per cent., by the pickling treatment. The resulting decrease in fatigue range is nearly as small as that observed after pickling treatment C § which gave the least that was observed in a previous investigation and less than any observed in the present investigation. From the points of view of absence of danger in the preparation of the bath and also of the quality of the etch the new treatment appears to be superior to any other yet investigated.

EXPERIMENTS on the influence of pickling or etching treatments on the fatigue-strength of Duralumin have already been described,§ all the treatments investigated resulting in a reduction of the Wöhler fatigue range. The observed reduction of stress range for 10 million cycles endurance was in one case as great as 31·4 per cent., but that resulting from pickling in a solution containing 4 parts of 10 per cent. sulphuric acid and 1 part hydrofluoric acid followed by dipping in 50 per cent. nitric acid (treatment C) was only about 6 per cent., while the etching effect of the treatment appeared to be satisfactory.

The use of hydrofluoric acid in preparing the bath for treatment C necessitates special precautions, owing to the extremely irritating effects of the acid on the skin. Operators must wear rubber gloves when handling hydrofluoric acid, and special gutta percha containers are required for its storage. A further disadvantage is the high cost of the acid. The purpose of the present investigation was to discover

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§ H. Sutton and W. J. Taylor, *J. Inst. Metals*, 1934, 55, 149.

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).

a pickling treatment for Duralumin satisfactory from the point of view of etching yet avoiding the use of hydrofluoric acid as such.

ETCHING EXPERIMENTS.

A large number of small pieces of Duralumin ($\frac{3}{4}$ in. long, $\frac{3}{4}$ in. diameter) were prepared for pickling and etching experiments. The specimens had approximately the same surface area, and therefore, by subjecting them to different pickling treatments and in each case noting the loss in weight after immersion some measure of the degree of attack could be obtained. This, in conjunction with the quality of resulting etched surface, was taken into account in judging the relative merits of different pickling treatments.

An attempt was made to replace the hydrofluoric acid in the main bath of pickling treatment C by hydrochloric acid, but this was unsuccessful; once the reaction had commenced it was practically uncontrollable and the resulting etch was very poor.

A 10 per cent. solution of sodium carbonate at increased temperatures was found to be more promising, the etch being satisfactory but the action was very sluggish.

Unsuccessful attempts were made to employ acid solutions containing chromic acid, acetic acid, and other substances, but satisfactory etching was not obtained.

A bath was prepared containing 10 per cent. of sulphuric acid and 1 per cent. of commercial hydrofluoric acid by volume. Although this bath contains only a very small amount of hydrofluoric acid, compared with the main etching bath of treatment C, with a period of immersion of 10 minutes at 20° C. the macro-etching effect obtained was superior to that of treatment C. The degree of attack was comparable with that of treatment C. Final cleaning of the specimens was effected by dipping in 50 per cent. nitric acid. This treatment also rendered fine cracks in Duralumin readily visible. These and earlier experiments indicated the very considerable advantages of etching baths containing hydrofluoric acid.

PICKLING TREATMENT D.

In order to obviate the use of hydrofluoric acid as such it was decided to try the effect of substituting an equivalent amount of sodium fluoride. In powdered form, sodium fluoride may be stored in glass containers and is fairly safe to handle. When sodium fluoride is introduced into an aqueous solution of sulphuric acid free hydrofluoric acid is produced. A bath was prepared containing 10 per cent. by volume of sulphuric acid and 1 per cent. by weight of sodium fluoride.* Since the hydrofluoric acid used in the previous bath was 50–60 per cent., this is about the equivalent amount of sodium fluoride. Immersion of the pieces in this bath initially at 20° C. for a period of 10 minutes, without previous heating, followed by a rinse in water and immersion in 50 per cent. nitric acid for 1 minute (pickling treatment D) gave a satisfactory etch on samples having machined surfaces and an improved etch on samples polished down with "0" grade emery paper. Figs. 1 and 2 (Plate I) of the same area of a Duralumin forging as received and after etching show the manner in which a fine fatigue crack is made easily visible by application of the "0" emery polish and etching treatment.

PICKLING TREATMENT E.

Another treatment (pickling treatment E) had been suggested by a light alloy manufacturer, and was investigated. The specimen is immersed, usually for 5 minutes, in a bath consisting of a 20 per cent. solution of orthophosphoric acid (sp. gr. 1·5) in water, to which 0·5 per cent. by volume of hydrofluoric acid is added. The bath is used at room temperature. After immersion in the bath, the pieces are rinsed and transferred to a bath of cold 50 per cent. nitric acid. If the pickling solution shows signs of weakening a further 0·5 per cent. of hydrofluoric acid may be added.

Pickling experiments were made on Duralumin bar the composition and properties of which are given in Table I.

TABLE I.—*Composition and Properties of the Duralumin Bar Material.*

Composition.	Per Cent.		Mark.	
			71.	723.
Copper	4·25	Diameter, in.	0·565	0·565
Magnesium	0·93	Limit of proportionality, tons/in.^{2}	12·1	14·3
Manganese	0·57	0·1% Proof stress, tons/in.^{2}	19·3	20·7
Iron	0·50	0·5% Proof stress, tons/in.^{2}	21·3	21·8
Silicon	0·32	Maximum stress, tons/in.^{2}	29·9	31·4
		Elongation on $4\sqrt{A}$., per cent.	20·0	19·5

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* This bath was mentioned by Mr. E. Wood in discussing the earlier paper, see *J. Inst. Metals*, 1934, **55**, 161.

ETCHING QUALITIES OF THE VARIOUS TREATMENTS.

Etching tests were first carried out on short lengths of bar machined all over to determine the loss of metal and the general quality of the etch. Pickling treatment E as originally proposed gave a very faint etch and only about 35 per cent. of the loss of metal resulting with treatment D. The period of immersion was increased to 15 minutes, whereupon a uniform etch was obtained and the loss of metal was of the same order as that accompanying pickling treatment D. The results are given in Table II. In the case of pickling treatment C the samples were immersed in boiling water before being introduced into the pickling bath, but this was not done with treatments D and E.

TABLE II.—*Loss of Metal in Different Pickling Treatments Applied to Duralumin Specimens.*

	Pickling Treatment.		
	C.	D.	E.
Time of immersion, minutes . . .	3	10	15
Temperature of bath, ° C. . . .	20	21	26
Loss in weight, grm.	0·0517	0·0407	0·0380
Thickness of metal removed, in. . .	0·00036	0·00029	0·00027

Fig. 3 (Plate II) shows samples which were machined from a piece of extruded light alloy tube and then subjected to different pickling treatments, in order to reveal the macro-structure of the material. It will be seen that pickling treatment D reveals the macrostructure quite plainly when applied to the "as machined" surface.

Some samples of 20-S.W.G. Duralumin sheet were subjected to pickling treatments A, C, and D for examination of the effect of the attack in the pickling treatments. Pickling treatment A (2·5 minutes in 10 per cent. sodium hydroxide solution at 60°–70° C., rinse, 1 minute in cold 10 per cent. nitric acid, 10 per cent. (vol.) sulphuric acid solution, rinse, and dry) * was the most drastic of any investigated, both with reference to the amount of metal removed and to the reduction of the fatigue strength (31·4 per cent.).

Transverse sections were cut from the pickled samples and also from a sample of the untreated material. These sections were polished, great care being exercised to prevent rounding of the edges during polishing, and then lightly etched, for the same period in each case, Figs. 4–7 (Plate III). The thickness of metal removed by treatment

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* H. Sutton and W. J. Taylor, *loc. cit.*

FIG. 1.—Duralumin Specimen Containing Fatigue Crack: Before Polishing and Pickling. × 8.

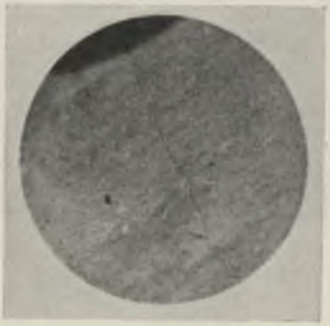

FIG. 2.—Duralumin Specimen Containing Fatigue Crack: After Polishing and Pickling Treatment D. × 8.

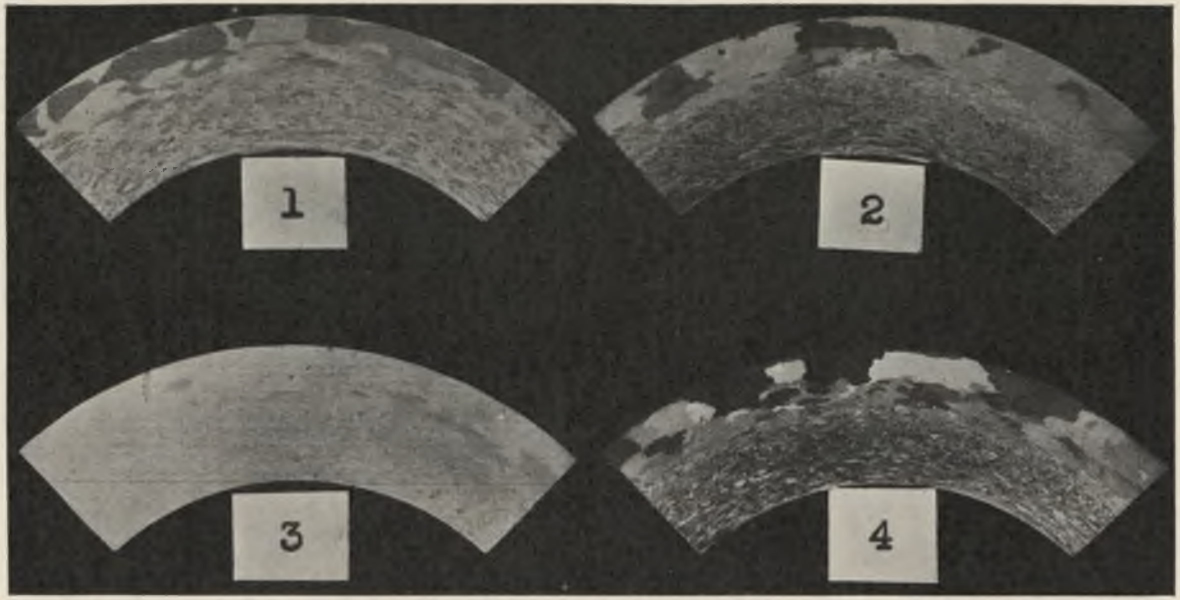

FIG. 3.—Samples of Extruded Tube Etched by Different Treatments to Show the Macrostructure. × 1½.

(1) As machined—pickling treatment C; (2) As machined—pickling treatment D; (3) As machined—pickling treatment E; (4) Polished—pickling treatment D.

PLATE III.

FIG. 4.—Untreated.

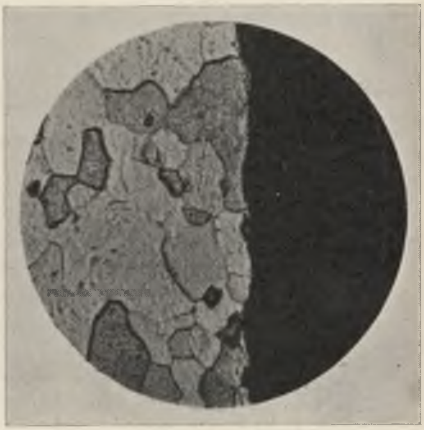

FIG. 5.—Treatment A.

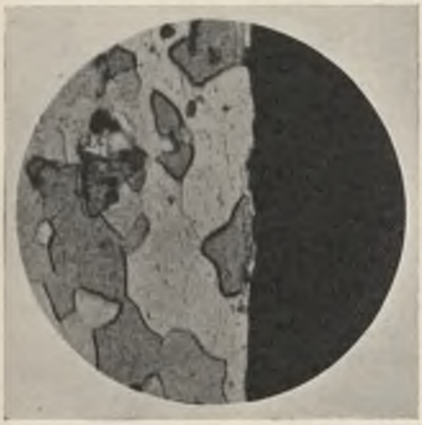

FIG. 6.—Treatment C.

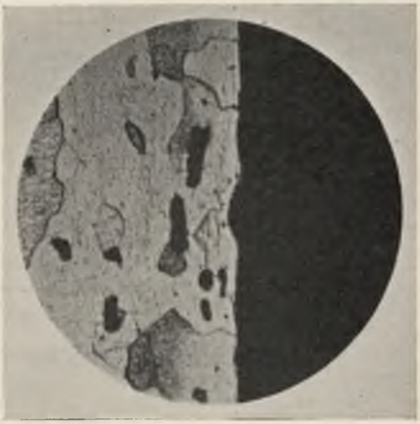

FIG. 7.—Treatment D.

Sections Cut from Samples of 20-S.W.G. Duralumin Sheet, Pickled by Different Treatments, Showing the Degree of Attack upon the Surface of the Material Produced by Pickling. × 500.

A had previously been found to be nearly 0·001 in.; on comparison with Table II it will be seen that this is approximately three times the thickness of metal removed by treatments C and D. Consideration of Figs. 4–7 discloses the fact that the degree of serration produced upon the surface of the material by pickling is greater with treatment A (Fig. 5) than with treatments C and D (Figs. 6 and 7).

Fatigue Tests.

Wöhler type fatigue tests were carried out on material in the following conditions:

(*a*) As received.

(*b*) Pickled—Treatment D (10 minutes in 10 per cent. H_2SO_4, 1 per cent. NaF at 20° C.; 1 minute in 50 per cent. HNO_3).

(*c*) Pickled—Treatment E (15 minutes in 20 per cent. H_3PO_4, 0·5 per cent. HF at 20° C.; 1 minute in 50 per cent. HNO_3).

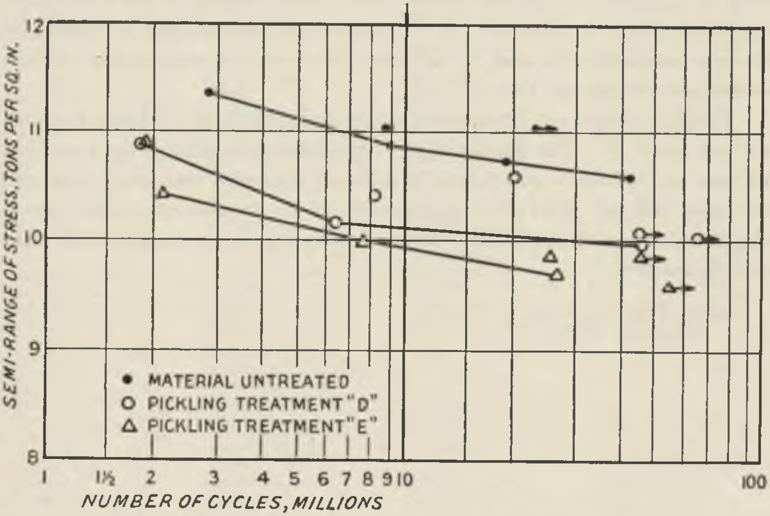

Fig. 8.—Wöhler Fatigue Tests of Treated and Untreated Samples.

The fatigue tests were commenced within 1 hr. of completion of the pickling treatment. The results are given in Fig. 8 and are summarized in Table III, from which it is seen that the reduction in fatigue limit (at 10 million cycles) of the Duralumin bar was slight in the case of both pickling treatments, that after treatment D being apparently somewhat less than that after treatment E and of the same order as that observed after pickling treatment C.*

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* H. Sutton and W. J. Taylor, *loc. cit.*

TABLE III.—*Fatigue Limits Based on* 10 *Million Cycles Endurance.*

Pickling Treatment.	Untreated.	Pickled.	
	Fatigue Limit, Tons/in.^{2}.	Fatigue Limit, Tons/in.^{2}.	Decrease in Stress, Per Cent.
Control	±10·85	...	...
"D"	...	±10·1	6·9
"E"	...	± 9·9	8·7

CONCLUSIONS AND DISCUSSION OF RESULTS.

Pickling treatment D is an improvement on pickling treatment C from the practical point of view. The preparation of the bath does not necessitate the handling of raw hydrofluoric acid, and the quality of the etch is superior to that of others examined. Owing to the very small amount of free hydrofluoric acid in the bath, the danger to operators is very much reduced and, in addition, the rate of deterioration of bath containers should be less.

Pickling treatment E possesses etching qualities much inferior to those of treatment D. The preparation of the bath necessitates the handling of raw hydrofluoric acid which is difficult to store, transport, and use without risk of injury to personnel. Both treatments result in a slight reduction of the Wöhler limit of Duralumin comparable with that of treatment C.

SOUTH FARNBOROUGH,
March 10, 1936.

AUTHOR INDEX TO ABSTRACTS

METALLURGICAL ABSTRACTS

(GENERAL AND NON-FERROUS)

Volume 3 MAY 1936 Part 5

I.—PROPERTIES OF METALS

(Continued from pp. 109–113.)

***The Mechanical Resistance of the Film of Aluminium Oxide and Its Influence on the Surface Tension of the Cast Metal.** Albert Portevin and Paul Bastien (*Compt. rend.*, 1936, **202**, (12), 1072–1074).—The mechanical resistance of the aluminium oxide film was determined by: (*a*) a thread of metal suspended at one end and heated in the middle; a tube of the oxide is formed and breaks when the weight of supported metal exceeds the mechanical resistance; and (*b*) a thread suspended at both ends and heated by the Joule effect; the mechanical resistance is calculated from the deflection at the moment of rupture. Both methods give $R_1 = 0{\cdot}2$ grm./mm. = 1960 dynes/cm. as the value of the mechanical resistance when the thread is heated to 700° C. From the thickness of the oxide film deduced from its weight determined by the volatilization of the aluminium in a current of dry chlorine at a high temperature, the tensile strength of the oxide, $R_2 = 2$ kg./mm.^{2}. The surface tension of oxidized aluminium was determined by the drop method, $A = 840$ dynes/cm. The surface tension of unoxidized aluminium was determined by 2 methods, the value given by [S. W.] Smith (*J. Inst. Metals*, 1914, **12**, 168–209), $A = 520$ dynes/cm., being considered too high: (*a*) by forming a bubble of argon in a horizontal plane in the interior of cast aluminium; this method gave $A' = 300$ dynes/cm., which agrees satisfactorily with that deduced from the calculated parachor of the metal; (*b*) by forming a large drop of the metal in cryolite and measuring its surface tension; this method gave $A' = 420$ dynes/cm., which is considered to be the upper limit of the surface tension of unoxidized aluminium. This great difference between the surface tension of the oxidized and the unoxidized metal explains the difficulties encountered in the aluminium foundry. The large drop method was also used to determine the effect of small metallic additions and of oxidation on the surface tension of metals such as lead and tin.—J. H. W.

***Elasticity of Aluminium at High Temperatures.** J. Verö (*Mitt. berg.- u. hütt. Abt. Kg. ung. Palatin-Joseph-Universität Sopron*, 1935, **7**, 163–170; *C. Abs.*, 1936, **30**, 1715).—[In German.] A modification of the method of Schwinning and Strobel (*Met. Abs.* (*J. Inst. Metals*), 1932, **50**, 600) was used in which the elongations caused by the creeping phenomenon are determined more precisely. The values for the modulus of elasticity are 5480–5750 kg./mm.^{2} at 150° C., 4650–4775 kg./mm.^{2} at 240° C., and 3700 kg./mm.^{2} at 340° C.—S. G.

***Examination of Aluminium Made in Japan.—I.** Takayasu Harada (*Suiyokwai-Shi* (*Trans. Min. Met. Alumni Assoc.*), 1935, **8**, (9), 882–890).—[In Japanese.] Spectrographic analysis showed the presence of 0·05–0·16% sodium in aluminium produced in Japan. Many of the properties of the metal are compared with those of aluminium produced in Europe and the U.S.A. The investigation is being continued.—S. G.

***Studies on Explosive Antimony. III.—The Magnetic Susceptibility.** C. C. Coffin (*Canad. J. Research*, 1935, [A], **13**, (6), 120–125).—Explosive antimony is not so diamagnetic as the ordinary polycrystalline metal. The magnetic

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* Denotes a paper describing the results of original research.

† Denotes a first-class critical review.

susceptibilities are, respectively, -0.38×10^{-6} and -0.88×10^{-6}. The explosive or amorphous form should be regarded, therefore, as a true glass of the supercooled liquid. The fact that it is less "metallic" than the molten metal cannot be the result of the metallic binding of the liquid or crystalline state changing to homopolar binding in the amorphous state.—S. G.

Beryllium and Beryllium Alloys. (Corson and Zeiser.) See p. 148.

***The Change of Resistance of Bismuth Single Crystals in a Magnetic Field at Low Temperatures.** W. J. de Haas, J. W. Blom, and L. Schubnikow (*Comm. K. Onnes Lab. Univ. Leiden*, No. **237b**, 1935, 8 pp.).—See *Met. Abs.*, this vol., p. 29.—L. A. O.

***Investigation of the Allotropy of Very Pure Calcium.** A. Schulze (*Z. Metallkunde*, 1936, **28**, (3), 55–57).—Thermal analysis, determination of the electrical resistance and thermal expansion, and X-ray investigations have shown that calcium (containing less than 0·1% of impurity) undergoes two allotropic modifications, the face-centred cubic α form being converted into the body-centred β form at about 300° C., and the β form into the close-packed hexagonal γ form at 450° C. The β–γ transformation is accompanied by a heat evolution of 5·3 cal./grm.—A. R. P.

***Effect of Some Metals on the Strength at High Temperatures and Microstructure of Copper.** I. Igarashi (*Sumitomo Densen Iho* (*Res. Rep. Sumitomo Steel, Tube, and Copper Works*), 1933, **1**, (10), 692–694).—[In Japanese.]
—S. G.

R–f **Resistance of Copper Wire.** John H. Miller (*Electronics*, 1936, **9**, (2), 38).—The ratio of the resistance of a copper wire at high frequencies to its direct current resistance is equal to $0.25 + 0.0962d\sqrt{f}$, where d is the wire diameter in inches and f the frequency in cycles per second. This applies only when the ratio is greater than 8. Curves are given for the ratio at frequencies between 0·5 and 100 megacycles for wires between $\frac{3}{8}$ in. diameter and No. 30 gauge.—J. C. C.

***Large Single Crystals of Copper. Simplified Method for Their Preparation.** J. G. Thompson (*Metals and Alloys*, 1936, **7**, (1), 19–21).—A charge of about 3500 grm. is melted in a long cylindrical graphite pot in an Arsem furnace, kept at a little above the melting point for 1·5–2 hrs., and then allowed to cool slowly from the bottom upwards. The copper used must be thoroughly deoxidized, and protected from gas absorption or vibration during melting and cooling. The etching characteristics of single-crystal copper are described.
—A. R. P.

***Permeability to Hydrogen at High Pressures of Steels, Armco Iron, Copper, Nickel, and Aluminium and Decarburization of Steels by High-Pressure Hydrogen.** W. Baukloh and H. Guthmann (*Z. Metallkunde*, 1936, **28**, 34–40).—Copper and aluminium are practically impermeable to hydrogen at high temperatures and pressures, whereas nickel and many steels are relatively quite permeable.—A. R. P.

***On the Atomic Weight of Some Samples of Lead from Radioactive Sources.** F. Hecht and E. Kroupa (*Z. anorg. Chem.*, 1936, **226**, (3), 248–256).—The atomic weights of lead from Great Bear Lake pitchblende, Katanga pitchblende, and from ordinary galena are 206·080, 206·044, and 207·216, respectively.—A. R. P.

***X-Ray Measurement of the Thermal Expansion of Pure Nickel.** E. A. Owen and E. L. Yates (*Phil. Mag.*, 1936, [vii], **21**, (142), 809–819).—The thermal expansion of the crystal lattice of nickel (purity, 99·98%) was measured at 12°–600° C. The crystal structure remains face-centred cubic throughout the temperature range. The parameter at 18° C. is $3{\cdot}5172_4$ A. and the density 8·897 grm. per c.c. An abnormally high rate of expansion followed by a rapid decrease is observed in the region of the temperature of magnetic transformation (about 370° C.). The phenomenon is apparently unaccompanied by thermal hysteresis. The maximum value of the thermal coeff. (α) occurs at 370° C. In this region the following values of α are found: 17×10^{-6} at 320° C., 26×10^{-6} at 370° C., and 15×10^{-6} at 390° C. On either side of this region the expansion is normal. The ferromagnetic change in length per unit length is found to be about $2{\cdot}4 \times 10^{-4}$, a value which is much higher than values previously found for nickel of lower purity. In considering transformations occurring at certain temperatures in alloy systems, it may be necessary to consider in addition to migration of atoms from point to point in the lattice, changes occurring at lattice points when no migration occurs.—J. S. G. T.

Effects of Annealing on the Microstructure and Mechanical Properties of Electrolytic Nickel. T. Kanetomo (*Denki Seiko*, **1934**, (June)).—[In Japanese.]—S. G.

Transformation from Vitreous to Metallic Selenium. Kenzo Tanaka and Hshi Yu Tien (*Mem. Coll. Sci. Kyoto Imp. Univ.*, 1935, [A], **18**, (6), 309–310).—[In English.] A simple relation was found between the time of annealing and the content of metallic selenium for specimens annealed at various temperatures near the transition point.—S. G.

***Diffraction of Slow Electrons on Sublimed Tungsten.** V. I. Kasatochkin (*Zhurnal Fizicheskoy Khimii* (*J. Phys. Chem.*), 1935, **6**, (8), 1002–1015).—[In Russian.] The dispersion of electrons at speeds of 40–400 v. has been studied at a layer of micro-crystals of sublimed tungsten. The value of the internal potential of tungsten, determined by displacement of maxima, is 10·5 ± 2 v. and is independent of the speed of the electrons. All the maxima can be divided into two groups, with internal potentials 10·5 and 0 v., respectively. The existence of these groups is the result of electronic interference either in the crystal or at its stepped surface. The diffraction observed in the experiments of Rupp and Sproull occurred not at the clean facet of the single crystal, but at the layer of unoriented micro-crystals which covered the surface of the single crystal.—N. A.

***Revision of the Atomic Weight of Uranium.** O. Hönigschmid and F. Wittner (*Z. anorg. Chem.*, 1936, **228**, (3), 289–309).—Analysis of the tetrabromide and tetrachloride gave a value of 238·07 ± 0·02 for the atomic weight of uranium.—A. R. P.

†Deformable Rare Metals, Vanadium, Thorium, and Uranium. W. Kroll (*Z. Metallkunde*, 1936, **28**, (2), 30–33).—Recent work on the preparation of the rarer metals by thermal dissociation of their halides and by reduction of oxides and halides with alkali or alkaline earth metals is critically reviewed. Attempts to obtain vanadium by reduction of the pentoxide with calcium in the presence of calcium and barium chlorides yielded only a semi-colloidal powder which could not be pressed into workable shapes; a second reduction of the powder under similar conditions yielded a powder which could be sintered *in vacuo* in a high-frequency furnace to a product which could be cold-worked. Workable thorium was prepared in a similar way; both metals are attacked and embrittled by heating in contact with barium chloride, but can be heated in borax without deleterious effect. Uranium was prepared by reduction of the oxide U_3O_8 with calcium under a fused chloride slag; part of the metal was colloidal and pyrophoric, but the remainder was sintered and worked successfully although it tended to crack and oxidize along the cracks.—A. R. P.

***An X-Ray Investigation of Atomic Vibrations in Zinc.** G. W. Brindley (*Phil. Mag.*, 1936, [vii], **21**, (142), 790–808).—The atomic scattering factors of zinc for $\mathrm{Cu}K_a$ radiation were measured. The results indicate that the amplitude of thermal vibration of the atoms is greater along the c axis than in the basal plane. The results are discussed in terms of Zener's theory and of more approximate calculations made by B.—J. S. G. T.

A Review of the Methods of Producing Metal Single Crystals by the Fusion and Recrystallization Methods. E. Jakovleva (*Metallurg* (*Metallurgist*), **1935**, (11), 68–81).—[In Russian.]—N. A.

Creep of Metals. K. Yamaguchi (*Kinzoku* (*J. of Metals*), 1934, **14**, (4), (5)).—[In Japanese.] A general discussion.—S. G.

***The Results of Cold-Work [on Metals] and Their Disappearance with Increase in Temperature.** (Tammann.) See p. 174.

***On the Plasticity of Metals under Deformation.** D. V. Konvisarov (*Dokladi Akademii Nauk S.S.S.R.*, 1935, **4**, (3), 131–132 (in Russian); and *Compt. rend. Acad. Sci. U.R.S.S.*, 1935, [N.S.], **4**, (3), 139–140 (in German)). Specimens of aluminium, copper, and iron wires tested in static torsion showed an increase of plasticity if they were subjected simultaneously to tensile stresses.—N. A.

***Physical Properties of Metals as Affected by Conditions of Ammonia Synthesis.** H. L. Maxwell (*Trans. Amer. Soc. Metals*, 1936, **24**, (1), 213–223; discussion, 223–224).—When copper and high-copper alloys are exposed to a 3 : 1 hydrogen–nitrogen mixture at 500° C. and 15,000 lb./in.^{2}, the effect of hydrogen is greater than that of nitrogen except in the case of aluminium–copper alloys which gradually deteriorate as a result of interaction between the nitrogen and aluminium which depletes the surface layers of aluminium. Fully deoxidized copper and its alloys retain their mechanical properties much better than similar alloys containing free oxide. Nickel–chromium–iron alloys behave better than ordinary steels or special steels free from nickel and chromium.—A. R. P.

Report of Joint Research Committee [of A.S.M.E. and A.S.T.M.] on Effect of Temperature on the Properties of Metals. H. J. French and N. L. Mochel (*Proc. Amer. Soc. Test. Mat.*, 1935, **35**, (I), 121–125).—A progress report outlining the activities of the various sub-committees.—A. R. P.

On the Theory of the Mechanical Properties of Metals at High Temperatures. N. F. Lashko (*Vestnik Ingenerow i Tehnikow* (*Messenger of Engineers and Technologists*), **1935**, (11), 697).—[In Russian.] The change in mechanical properties of metals with temperature is explained on the basis of the recent electronic theory of the metallic state.—N. A.

***Measurements of the Solid Viscosities of Metals Through the Flexural Vibrations of a Bar.** Katsutada Sezawa and Kei Bubo (*Rep. Aeronaut. Res. Inst. Tôkyô Imp. Univ.*, 1932, (89), 195–231).—[In English.] The aim of the investigation was the determination of the coeffs. of solid viscosity of aluminium, Duralumin, copper, and brass by means of the flexural vibrations of a bar, the resistance of a solid body due to damping being assumed to be proportional to the velocity of deformation of that body. The viscosities are of the order of 10^6 c.g.s. units, and increase rapidly as the amplitude increases.—S. G.

***Static and Dynamic Compression Tests on Some Metals.** S. Tamura (*Sumitomo Densen Iho* (*Res. Rep. Sumitomo Steel, Tube, and Copper Works*), 1933, **1**, (5), 332–344).—[In Japanese.]—S. G.

Sixth Report of the Atomic Weights Committee of the International Union for Chemistry. G. P. Baxter, O. Hönigschmid, and P. Lebeau (*Ber. deut. chem. Ges.*, 1936, [A], **69**, (3), 25–37).—The following revised atomic weights are accepted by the Committee: tantalum 180·88, radium 226·05, protactinium 231. Important work on the atomic weights of the following elements is summarized: carbon, potassium, chromium, arsenic, tellurium, terbium, europium, tantalum, radiogenic lead, radium, protactinium. The table of International Atomic Weights for 1936 (O = 16) is appended.—P. M. C. R.

***Change in Thermoelectric Power of Worked Metals During Annealing.** I. Igarashi (*Sumitomo Densen Iho* (*Res. Rep. Sumitomo Steel, Tube, and Copper Works*), 1933, **1**, (9), 648–652).—[In Japanese.]—S. G.

Luminescent Materials for Cathode-Ray Tubes [Metallic Activators]. T. B. Perkins and H. W. Kaufmann (*Proc. Inst. Radio Eng.*, 1935, **23**, (11), 1324–1333).—Describes the characteristics of three types of luminescent materials (phosphors) used in cathode-ray tube screens. These only become luminescent on the inclusion of very small amounts of "activators," which are generally metals. Manganese is an activator for synthetic willemite; copper, in minute quantities, for sulphide phosphors; and lead is probably necessary to activate the tungstates and molybdates.—J. C. C.

***Thomson Effect in Crystalline Substances.** Yositosi Endô (*Rep. Aeronaut. Res. Inst. Tôkyô Imp. Univ.*, 1932, (**85**), 115–149).—[In English.] By calculation of the work against the internal balancing e.m.f. as well as the energy of electrons dissociated in the metal, the formula for the Thomson effect is deduced. This formula is applied to the cases of copper, silver, gold, aluminium, and lead, compared with Borelius's observed values, and the % of the dissociated electrons estimated. For copper, silver, and gold, *i.e.* metals of the first group of the periodic system, it is given by $A_0T^{\frac{3}{2}}$, for aluminium, *i.e.* a metal of the third group, by $A_0T^{\frac{3 \cdot 3}{2}}$, and for lead, a metal of the fourth group, by $A_0T^{\frac{2 \cdot 6}{2}}$, these values being close to those expected from Richardson's theory of thermions. The formula gives the value of σ at any temperature. Applying the second law of thermodynamics, the coeff. of the Peltier effect P is given by $\sigma_B - \sigma_A = T\frac{\delta}{\delta T}\left(\frac{P}{T}\right)$, where T is the absolute temperature at the junction, and σ_A and σ_B are coeffs. of the Thomson effect of the two metals at T; but σ_A and σ_B are zero at $T = 0$; consequently P is also zero and hence $P = T\int^T \frac{\sigma_B - \sigma_A}{T}dT$. Hence, using the above formula for σ, the Peltier effect can be calculated.—S. G.

***Magnetic Effects and Current Sensitivity of Superconducting Films.** A. D. Misener (*Canad. J. Research*, 1936, [A], **14**, (2), 25–37).—A continuation of the investigation of the anomalous behaviour of superconducting metals in the form of thin films (12·2–0·3 μ). M. has studied the manner in which an external field will penetrate when applied to superconducting films of various thicknesses at a variety of temperatures below their transition points. It is found that there is a critical field that will penetrate the film, and that this field is less than the threshold field required to restore the resistance of the film at the same temperature. Even for fields much larger than the threshold field, the films act as partial magnetic shields and diminish the field strength by an almost constant amount. By measuring the current required to restore the resistance of films formed on cylindrical supports of different diameters, it is shown that their current sensitivity is due to a surface density of current. The critical magnetic field associated with this threshold current is less than either the threshold field (external) or the critical field for penetration. The similarity between these effects and those found for certain superconducting alloys is discussed.—S. G.

***Magnetic Properties of Superconductors.** T. C. Keeley and K. Mendelssohn (*Proc. Roy. Soc.*, 1936, [A], **154**, (882), 378–385).—The following percentages of magnetic flux are found to become "frozen in" when the respective metals become superconducting: mercury, 0%; tin (single crystal), 3–10%; tin (polycrystalline), 8–12%; lead, 15%. Alloys investigated, *viz.* tin 42, bismuth 58%; tin 72, cadmium 28%; lead 30, bismuth 70%; and $PbTl_2$ alloys showed that in these cases the entire magnetic flux was "frozen in." Intermediate stages of freezing in were observed in lead containing 1–4% of bismuth.—J. S. G. T.

Some Remarks on Superconductivity and Fermi–Dirac Statistics. J. A. Kok (*Comm. K. Onnes Lab. Univ. Leiden*, Suppt. No. **77a**, 1934).—See *Met. Abs.*, 1935, **2**, 211.—L. A. O.

The Photomagnetic Effect. Orazio Specchia (*Nuovo cimento*, 1935, **12**, 549–550).—A brief comparison of S.'s conclusions (*ibid.*, 1931, **8**, 291) with those of Bose and Raha (*Nature*, 1931, **127**, 520).—S. G.

II.—PROPERTIES OF ALLOYS

(Continued from pp. 113–116.)

The Equilibrium Diagrams of Aluminium Alloys. —— (*Brit. Aluminium Co. Intelligence Mem.* **I.D./2.36**; and (abstract) *Light Metals Research*, 1936, **4**, (18), 309–310).—Diagrams, with brief notes and bibliographical references, are given of 20 binary and 8 ternary aluminium alloy systems.—J. C. C.

***Hot-Shortness of Aluminium Alloys in the Form of Die-Castings.** J. Verö (*Mitt. berg.- u. hütt. Abt. Kg. ung. Palatin-Joseph-Universität Sopron*, 1935, **7**, 138–162; and (translation) *Met. Ind.* (*Lond.*), 1936, **48**, (15), 431–434, 442; (16), 491–494; (17), 491–494; *C. Abs.*, 1936, **30**, 1719).—[In English.] Hot-shortness is defined as the tendency of an alloy to form cracks during cooling in the mould. It is proposed that the extent of hot-shortness be expressed numerically by the frequency of the cracks occurring in castings of simple shape, given as a percentage of the cracked samples to all castings. In alloys containing more than 12–13% of liquid at the temperature of the critical pasty state, possible cracks can be prevented. Data on strength and load are not always sufficient to estimate hot-shortness of an alloy. The influence of temperature, weight, and cooling factor of the mould and of pouring temperature, &c., is discussed and possibilities of avoiding cracks are shown.—S. G.

***Modulus of Elasticity, Elastic Limit, and Softening Limit of Light Alloys.** M. Prever (*Indust. meccanica*, 1935, **12**, 1041–1047; *C. Abs.*, 1936, **30**, 2145).—The elastic properties of aluminium alloys after various heat-treatments were measured and tabulated. The softening limit is defined as that load applied which produces a permanent elongation of 0·2% after 2 minutes of action of each individual increment of load. The results derived show particularly that the modulus of elasticity varies with the load, and that the elastic limit and softening limit can often better be used for distinguishing between the alloys than tensile strength.—S. G.

***Comparative Tests on Some Wrought Aluminium Alloys.** T. Matsuda, S. Higashio, and S. Tamura (*Sumitomo Densen Iho* (*Res. Rep. Sumitomo Steel, Tube, and Copper Works*), 1932, **1**, (1), 1–9).—[In Japanese.]—S. G.

***Static and Dynamic Tension Tests on Wrought Aluminium Alloys.** S. Tamura (*Sumitomo Densen Iho* (*Res. Rep. Sumitomo Steel, Tube, and Copper Works*), 1932, **1**, (3), 159–162).—[In Japanese.]—S. G.

***Compression Tests on Some Binary Aluminium Alloys.** G. Koiso (*Sumitomo Densen Iho* (*Res. Rep. Sumitomo Steel, Tube, and Copper Works*), 1933, **1**, (7), 439–444).—[In Japanese.]—S. G.

***Contribution to the Knowledge of the Aluminium–Boron System.** W. Hofmann and W. Jäniche (*Z. Metallkunde*, 1936, **28**, (1), 1–5).—Boron appears to be quite insoluble in solid aluminium and there is no eutectic between aluminium and AlB_2 contrary to the statement of Haenni (*J. Inst. Metals*, 1926, **36**, 431). The compound AlB_2 has an hexagonal structure with $a =$ 3·00, $c =$ 3·24 A., one molecule per unit cell; the complete crystal structure is elucidated. (Cf. *Met. Abs.*, this vol., p. 119.)—A. R. P.

***Study of [the Constitution and Properties of] Certain Aluminium–Chromium Alloys.** Soji Hori (*Sumitomo Kinzoku Kōgyō Kenkyu Hōkoku* (*Res. Rep. Sumitomo Metal Industries, Ltd.*), 1935, **2**, (5), 351–372).—[In Japanese.] The phase boundaries in the equilibrium diagram of the aluminium–chromium alloys containing up to 50% chromium were determined by thermal, melting point, and microscopical methods between 450° and 1100° C. Three peritectic reactions were found to take place at 1018°, 803°, and 660° C., two compounds Al_2Cr and Al_4Cr and a solid solution being formed, respectively. The limit of solid solubility of chromium in aluminium at 640° C. was found to be 0·67 and 0·80%, and the value is constant down to 470° C. Rolled sheets containing up to 1·6% chromium were subjected to mechanical and corrosion tests after heat-treatment. The tensile properties increase slightly with increase of chromium. An alloy containing 0·7% chromium has remarkably greater tensile strength on annealing than alloys of near composition. The phenomenon may be due to the higher recrystallization temperature of this alloy. Corrosion tests were carried out by the "alternate wet and dry" method in artificial sea-water for 1 month, and the change in mechanical properties was observed. Alloys containing 0·7% chromium which had been annealed were exceptionally resistant as compared with alloys of near composition, and were even more resistant than annealed pure aluminium. The corrosion-resistance of this alloy in the annealed condition appears worthy of consideration in view of its abnormally high tensile strength.—S. G.

***Relation Between the Properties of Duralumin and Its Composition.** T. Matsuda (*Sumitomo Densen Iho* (*Res. Rep. Sumitomo Steel, Tube, and Copper Works*), 1932, **1**, (3), 134–145).—[In Japanese.]—S. G.

***Influence of Alumina Content of Duralumin on Its Chemical and Mechanical Properties.** S. Hori (*Sumitomo Densen Iho* (*Res. Rep. Sumitomo Steel, Tube, and Copper Works*), 1933, **1**, (12), 815–821).—[In Japanese.]—S. G.

***Properties of Some Duralumin Sheets Made in England.** K. Inamura (*Sumitomo Densen Iho* (*Res. Rep. Sumitomo Steel, Tube, and Copper Works*), 1933, **1**, (7), 471–473).—[In Japanese.]—S. G.

***Experiments to Determine the Optimum Temperature for the Heat-Treatment of Dural Type of Alloys.** U. v. Scheidt (*Light Metals Research*, 1936, **4**, (15), 252–253).—Summary from *Z. Metallkunde*, 1935, **27**, 275; see *Met. Abs.*, this vol., p. 36.—L. A. O.

***The System Iron–Aluminium–Carbon.** Rudolf Vogel and Hans Mäder (*Arch. Eisenhüttenwesen*, 1935–1936, **9**, (7), 333–340; and (summary) *Light Metals Research*, 1936, **4**, (19), 340–341).—The ternary system contains six primary crystal phases, namely ternary α-iron, ternary γ-iron, graphite, ternary FeAl (ε), ternary $FeAl_2$ (δ), and the carbide Al_4C_3. During solidification there are four points of four-phase equilibrium: (1) liquid $I + \alpha_1 + \gamma_1 = \varepsilon_1$ (1335° C.); (2) liquid $II + \gamma_2 = \varepsilon_2 +$ graphite (1132° C.); (3) liquid $III + \delta_1 = \varepsilon_3 + Al_4C_3$ (1135° C.); and (4) liquid $IV = \varepsilon_4 +$ graphite $+ Al_4C_3$ (1120° C.). There are three points of 4-phase equilibrium in the solid state: (5) $\varepsilon_5 + Al_4C_3 = \delta_2 +$ graphite (1115° C.); (6) $\varepsilon_6 + \gamma_3 = \alpha_2 +$ graphite (1111° C.); and (7) $\varepsilon_7 +$ graphite $= \alpha_3 + \delta_3$. The composition of the various phases at the equilibrium points is as follows: liquids I–IV; iron 83·1, 83·35, 56·7, and 69·92%, aluminium 14·5, 13·5, 43, and 29%, respectively; α_1–α_3: iron 85·1, 92·3, and 91·45%, aluminium 14·8, 7·6, and 8·5%, respectively; γ_1–γ_3: iron 91·7, 90·3, and 92·5%; aluminium 7·5, 7·2, and 6·9%, respectively; δ_1–δ_3, iron 54·8, 58·8, and 71·3%, aluminium 45, 28, and 28·5%, respectively, and ε_{1-7}: iron 85·2, 83·5, 55·8, 70·65, 71·7, 80·0, and 72·85%, aluminium 13·0, 13·0, 44, 29, 28, 17·5, and 27%, respectively. —A. R. P.

***Effects of Small Quantities of Iron and Silicon on the Properties of Aluminium.** S. Higashio (*Sumitomo Densen Iho* (*Res. Rep. Sumitomo Steel, Tube, and Copper Works*), 1932, **1**, (4), 225–234).—[In Japanese.]—S. G.

On Some Properties of the Aluminium-Rich Aluminium–Magnesium–Manganese Alloys. Isamu Igarashi (*Sumitomo Kinzoku Kōgyō Kenkyu Hōkoku* (*Res. Rep. Sumitomo Metal Industries, Ltd.*), 1935, **2**, (5), 373–380).—[In Japanese.] Discusses the mechanical properties at room temperature, corrosion-resistance, forming and welding properties of alloys of various compositions, and their practical applications.—S. G.

***Some Tests on the Light Alloy "25 S."** T. Matsuda (*Sumitomo Densen Iho* (*Res. Rep. Sumitomo Steel, Tube, and Copper Works*), 1933, **1**, (12), 822–837).—[In Japanese.]—S. G.

***On the Light Alloy Aeral.** G. Koiso (*Sumitomo Densen Iho* (*Res. Rep. Sumitomo Steel, Tube, and Copper Works*), 1932, **1**, (1), 20–25).—[In Japanese.]—S. G.

Beryllium and Beryllium Alloys. M. G. Corson and J. D. Zeiser (*Iron Age*, 1936, **137**, (10), 28, 32, 74).—The history of beryllium and various alloys of beryllium are discussed from the technical and practical points of view. The correct foundry procedure is described in detail, and the different properties of the various alloys which fit them for specific industrial applications are considered.—J. H. W.

***The Effect of Thallium on the Freezing Point of Lipowitz Alloy.** Sidney J. French and Donald Saunders (*Metals and Alloys*, 1936, **7**, (1), 22–23).—Cf. *Met. Abs.*, this vol., p. 74. The freezing point of Lipowitz alloy is depressed by addition of thallium, the maximum depression being 3·1° C. with 6% thallium; the alloys have a high tendency to supercooling.—A. R. P.

***Effect of Thallium on the Freezing Point of Indium–Lipowitz Alloy.** Sidney J. French (*Metals and Alloys*, 1936, **7**, (3), 64).—See also preceding abstract. A mixture of 18·1% of indium and 81·9% of the 50 : 27 : 13 : 10 bismuth–lead–tin–cadmium alloy melts at 46·8° C., whilst a mixture of 6% of thallium and 94% of the Lipowitz alloy melts at 68·6° C. Addition of thallium to the indium alloy, however, effected no further reduction in the melting point.—A. R. P.

Cadmium–Nickel Bearing Alloys. A. J. Phillips (*Production Eng.*, 1935, **6**, 365).—See *Met. Abs.*, this vol., p. 36.—S. G.

***The Reaction of Chromium with Acid Slags.** Friedrich Körber and Willy Oelsen (*Mitt. K.-W. Inst. Eisenforschung*, 1935, **17**, (21), 231–245).—The subject was investigated from the point of view of the manufacture of chromium steels by various procedures.—A. R. P.

***A Study of Oxide Films on Metal Surfaces with Cathode Ray Diffraction. I.—Copper and Its Alloys.** Shizuo Miyake (*Rikwagaku Kenkyū-jo Iho* (*Bull. Inst. Phys. Chem. Res. Tokyo*), 1935, **14**, 704–713).—[In Japanese.] Oxide films formed at high temperature on copper and its alloys were studied by means of cathode ray diffraction measurements which confirm that the resistance of aluminium–bronze to high temperature oxidation is due to a superficial film of alumina. The similar property of 70 : 30 brass is due to a surface film of zinc oxide.—S. G.

†**Present Position of the Preparation, Working, and Uses of Aluminium–"Bronzes."** E. Lay (*Z. Metallkunde*, 1936, **28**, (3), 64–67).—The mechanical properties of 4, 8, and 10% aluminium–"bronzes" at various stages of cold-work and at temperatures between 100° and 400° C. are shown graphically, and brief notes are given on the properties and heat-treatment of nickel–aluminium–copper alloys. The casting of the alloys is also discussed and some of their uses mentioned.—A. R. P.

***Examination of High-Grade Aluminium Bronzes.** A. S. Ball and S. Z. Laskin (*Tehnika Vosdushnogo Flota* (*Techn. Aerial Navy*), **1935**, (10), 48–57).—[In Russian.] Problems in the casting of aluminium–iron and aluminium–iron–nickel bronzes are examined, and their mechanical and anti-friction properties given with details of the effects thereon of heat-treatment.—N. A.

On the Basic Properties of Beryllium Bronzes. I. T. Kolenov (*Sudostroenie* (*Shipbuilding*), **1935**, (12), 40–42).—[In Russian.] A review.—N. A.

Cadmium–Silver–Copper Bearing Alloy. L. C. Blomstrom (*Production Eng.*, 1935, **6**, 364–365; *C. Abs.*, 1936, **30**, 1721).—A discussion, with a photomicrograph and photographs.—S. G.

***Properties of Cobalt–Copper Alloys, Cobalt–Brass, and Cobalt–Aluminium–Bronze.** T. Matsuda (*Sumitomo Densen Iho* (*Res. Rep. Sumitomo Steel, Tube, and Copper Works*), 1933, **1**, (10), 667–691).—[In Japanese.]—S. G.

Copper–Lead Bearings. D. E. Anderson (*Production Eng.*, 1935, **6**, 363–364).—See *Met. Abs.*, this vol., p. 37.—S. G.

***On Cupro–Nickel Condenser Tubes.** T. Tanabe (*Sumitomo Densen Iho* (*Res. Rep. Sumitomo Steel, Tube, and Copper Works*), 1933, **1**, (5), 303–311).—[In Japanese.]—S. G.

***On Some Copper Alloys Containing Silicon.—I.** Tomojiro Tanabe and Goro Koiso (*Sumitomo Kinzoku Kōgyō Kenkyu Hōkoku* (*Res. Rep. Sumitomo Metal Industries, Ltd.*), 1935, **2**, (5), 319–350).—[In Japanese.] See *Met. Abs.*, 1935, **2**, 573.—S. G.

***Season-Cracking of Copper–Zinc Alloys.—I–II.** T. Tanabe (*Sumitomo Densen Iho* (*Res. Rep. Sumitomo Steel, Tube, and Copper Works*), 1932, **1**, (1), 42–52; (2), 69–79).—[In Japanese.]—S. G.

***Improved Naval Brass "S.N.B."** T. Tanabe and G. Koiso (*Sumitomo Densen Iho* (*Res. Rep. Sumitomo Steel, Tube, and Copper Works*), 1933, **1**, (7), 415–420).—[In Japanese.]—S. G.

***Special Aluminium–Brass Condenser Tube "Albrac."** T. Tanabe (*Sumitomo Densen Iho* (*Res. Rep. Sumitomo Steel, Tube, and Copper Works*), 1932, **1**, (3), 122–127).—[In Japanese.]—S. G.

***On the Replacement of Tin in Red-Brass of the Types Rg 5 and Rg 9, Especially by Antimony.** W. Keese (*Z. Metallkunde*, 1936, **28**, (3), 58–63).—In the ternary system zinc–antimony–copper the range of homogeneous α-solid solution is bounded by a straight line in the ternary diagram joining the 38% zinc point on the copper–zinc side with the 8% antimony point on the antimony–copper side. Alloys with 2·5% zinc and up to 5% antimony can be worked without cracking, but their mechanical properties are much inferior to those of the corresponding tin alloys. Tables and graphs showing the mechanical properties of certain of the alloys are included.—A. R. P.

†**Manganese–Bronze and –Brass.** Wesley Lambert (*Proc. Inst. Brit. Found.*, 1934–1935, **28**, 712–730).—See *Met. Abs.*, 1935, **2**, 97.—S. G.

***Effect of Small Quantities of Added Metals on Brass.** T. Matsuda (*Sumitomo Densen Iho* (*Res. Rep. Sumitomo Steel, Tube, and Copper Works*), 1933, **1**, (7), 485–498).—[In Japanese.]—S. G.

***Mechanical Properties of Some Ternary Copper Alloys.** T. Matsuda (*Sumitomo Densen Iho* (*Res. Rep. Sumitomo Steel, Tube, and Copper Works*), 1933, **1**, (5), 270–291).—[In Japanese.]—S. G.

***"Electrolysis" of a Solid Gold–Copper Alloy.** G. Nehlet, W. Jost, and R. Linke (*Z. Elektrochem.*, 1936, **42**, (3), 150–153).—Wires 0·1 mm. in diameter and consisting of gold 65·7 and copper 34·3% were "electrolized" by the passage through them of a current of 3·2 amp., equivalent to 41,000 amp./cm.^{2} at 100°–150° C. below the melting point, about 1000° abs. Debye–Scherrer photographs showed that actual transport of material took place, the gold being concentrated at the anode and the copper at the cathode. The transference number of copper at about 1000° abs. was $\sim 7 \cdot 4 \times 10^{-11}$.—J. H. W.

***Physico-Chemical Investigation of Alloys of Gold with Manganese.** V. A. Nemilov and A. A. Rudnizkiy (*Dokladi Akademii Nauk S.S.S.R.*, 1935, **3**, (8), 351–353 (in Russian); and *Compt. rend. Acad. Sci. U.R.S.S.*, 1935, [N.S.], **3**, (8), 351–354 (in German)).—Thermal analysis showed two minima at 20 and 70 atomic-% of gold and a maximum at 50 atomic-% gold, corresponding to the separation of the compound AuMn. Within the range 20–35 atomic-% gold a transformation in the solid state occurs at about 650° C., owing to the formation of $AuMn_3$ and at about 66·6 atomic-% gold another transformation leads to the formation of Au_2Mn. Determination of the Brinell hardness of alloys containing 30–100% gold showed two hardness minima in slowly cooled alloys at 50 and 66 atomic-% gold. On quenching from 800° to 850° C. only the minimum corresponding to AuMn occurs, indicating that this compound is stable up to at least 800°–850° C. Micrographic examination, electric resistance measurements at 25° and 100° C., and the temperature coeff. of resistance between 25° and 100° C. confirm the existence of $AuMn_3$, AuMn, and Au_2Mn in slowly cooled alloys and of AuMn only in quenched alloys.—N. A.

***Studies on Some Wrought Magnesium-Rich Aluminium Alloys.** I. Igarashi (*Sumitomo Densen Iho* (*Res. Rep. Sumitomo Steel, Tube, and Copper Works*), 1933, **1**, (5), 323–331).—[In Japanese.]—S. G.

***Comparative Tests on Some Wrought Magnesium Alloys.** I. Igarashi (*Sumitomo Densen Iho* (*Res. Rep. Sumitomo Steel, Tube, and Copper Works*), 1932, **1**, (4), 205–211).—[In Japanese.]—S. G.

***Static and Dynamic Tension Tests on Wrought Magnesium Alloys.** S. Tamura (*Sumitomo Densen Iho* (*Res. Rep. Sumitomo Steel, Tube, and Copper Works*), 1933, **1**, (9), 646–647).—[In Japanese.]—S. G.

***On the Brinell Hardness of Magnesium Alloys.** I. Igarashi (*Sumitomo Densen Iho* (*Res. Rep. Sumitomo Steel, Tube, and Copper Works*), 1932, **1**, (4), 224).—[In Japanese.]—S. G.

***Elektron Sheet Made in Germany.** K. Inamura and S. Higashio (*Sumitomo Densen Iho* (*Res. Rep. Sumitomo Steel, Tube, and Copper Works*), 1932, **1**, (4), 212–222).—[In Japanese.]—S. G.

***Magnesium Alloy of Low Shrinkage.** I. Igarashi (*Sumitomo Densen Iho* (*Res. Rep. Sumitomo Steel, Tube, and Copper Works*), 1932, **1**, (4), 223).—[In Japanese.]—S. G.

***On Magnesium Alloys for Working and Casting.** I. Igarashi (*Sumitomo Densen Iho* (*Res. Rep. Sumitomo Steel, Tube, and Copper Works*), 1932, **1**, (4), 187–204).—[In Japanese.]—S. G.

***On the Rate of Transformation in Magnesium–Cadmium Alloys in the Region of the Compound MgCd.** N. I. Stepanov and S. A. Bulah (*Dokladi Akademii Nauk S.S.S.R.*, 1935, **4**, (3), 139–142 (in Russian); and *Compt. rend. Acad. Sci. U.R.S.S.*, 1936, [N.S.], **4**, (3), 147–151 (in French)).—The alloys tested contained 48·0–52·8 atomic-% magnesium. After quenching from 320° C. the rate of transformation at 100° C. into the modification stable at low temperatures was a maximum with the compound MgCd and decreased with addition of excess of either component.—N. A.

***Magnesium–Lead Alloys.** K. V. Peredelski (*Legkie Metalli* (*Light Metals*), **1935**, (12), 43–48).—[In Russian.] The mechanical and casting properties and corrosion-resistance of magnesium alloys containing up to 16·85% lead were studied. Good castings can be obtained in chill and in sand moulds. The density of the alloys increases slowly up to 2·0 with 16·85% lead. The alloys are stable in water and air. The best results were obtained with alloys containing 3–5% of lead which have a tensile strength of 16–18 kg./mm.^{2}, an elongation of 7–8%, and density 1·85–1·9.—D. N. S.

***Binary Magnesium–Zinc Alloys.** J. A. Amsterdamski (*Trudi Nauchno-Issledovatelskogo Instituta Legkih Metallov* "*Niisalumini*" (*Trans. Sci. Res. Inst. Light Metals*), **1935**, (10), 57–64).—[In Russian.] The microstructure and mechanical properties of magnesium alloys containing up to 15% zinc were studied in the cast, rolled, quenched, and annealed (125°–225° C. for 10–120 hrs.) states. Alloys with more than 2–3% zinc after quenching at 300°–320° C. are subject to age-hardening, the hardness increasing by 30–40%, and the tensile strength remaining unchanged. The separation of the new phase (γ)

can be detected microscopically only after ageing at 200° C. when the γ appears as tiny spots distributed throughout the δ-phase. The separation of the γ-phase begins considerably before that of the general distintegration of the δ-phase and before the beginning of increase in hardness. This separation takes place when the alloys after heating to 300° C. are not sufficiently rapidly quenched.—D. N. S.

***An Investigation of the Hardness of Alloys of Magnesium with Tin and Lead at Different Temperatures.** V. P. Schischokin, V. A. Ageewa, and V. T. Miheeva (*Metallurg* (*Metallurgist*), **1935**, (11), 81–84).—[In Russian.] The temperature coeff. of hardness was determined by the expression $\alpha_H = \frac{\log H_2 - \log H_1}{t_2 - t_1}$ between room temperature and 220° C. The hardness isotherms at 20°, 70°, 120°, 170°, and 220° C. show maxima at 33 and 61% magnesium, respectively, for the lead and tin systems corresponding to the eutectic alloy, but the sharpness of these gradually decreases with increase in temperature. The composition–temperature coeff. of hardness curve in both systems has a maximum at the eutectic point and minima at points corresponding to the intermetallic compounds.—N. A.

***The System Iron–Cementite–Manganese Carbide–Manganese.** Rudolf Vogel and Werner Döring (*Arch. Eisenhüttenwesen*, 1935–1936, **9**, (5), 247–252).—The equilibrium diagram of the system manganese–manganese carbide was determined by thermal and micrographic methods; Mn_3C melts at 1245° C. and the liquidus shows a flat minimum at about 1160°, 3·5% carbon. Mn_3C exists in two forms with a transformation point at 1050° C. which is gradually depressed by addition of manganese to a minimum at 3·5% carbon, 920° C. The eutectoid horizontal (β-$Mn_3C \rightleftharpoons \alpha$-$Mn_3C$ + γ-manganese) extends from 2·5 to 6·7% carbon and the peritectic horizontal at 1190° C. from 1·5 to 2·5% carbon. There is a second eutectoidal horizontal at 740° C. corresponding to the decomposition of γ-manganese solid solution into α-manganese and α-Mn_3C. The γ–β transformation point of manganese is lowered from 1140° to 840° C. by addition of carbon whereas the β–α point is raised from 740° to 840° C. Ternary iron–manganese–carbon alloys resemble the binary iron–carbon alloys up to 60% manganese; in alloys with a higher manganese content complex phase changes occur in the solid state owing to the allotropic changes which occur in Mn_3C and manganese, thus the equilibrium diagram of alloys with 70% manganese contains no less than 17 phase-fields. In manganese-rich alloys there are four planes of four-phase equilibrium one of which corresponds with the ternary eutectoidal change: γ-manganese $\rightleftharpoons$ α-manganese + γ-iron + α-Mn_3C (iron 25, carbon 2·05, manganese 77·95%, 6·40° C.—A. R. P.

Electrical Uses of Nickel. An Expanding Market; Recent Developments. —— (*Elect. Rev.*, 1936, **118**, (3041), 348).—The uses of nickel and its alloys are briefly enumerated. 3 new alloys are described, all containing about 30% nickel. Their expansion curves match closely those of all known glasses which exhibit a "kick" or bend just below the softening temperature. This permits a vacuum-tight and practically stress-free joint between glass and the alloy. "Iso-elastic" alloy is a metal of constant elasticity.—L. A. O.

***Eddy Currents in Composite Laminations [of Chromium Permalloy].** E. Peterson and L. R. Wrathall (*Proc. Inst. Radio Eng.*, 1936, **24**, (2), 275–286).—Laminations of 3·8 chromium Permalloy, when used as the cores of inductance coils, are found in some instances to have an inductance of the order of $\frac{1}{10}$ of that calculated from the initial permeability and resistivity of the material. By etching the surface layers from the laminations, to a depth of 0·002 in. or more, the discrepancies are almost completely removed. It is shown mathematically that the presence of a surface skin of low permeability will account for the deviations observed. This skin becomes more noticeable as the sheet thickness is reduced and it persists after annealing. The effect is not so pronounced in soft iron, 45 Permalloy, or 3·8 molybdenum Permalloy; and has not been observed in silicon steel, hydrogenized silicon steel, nickel, Perminvar, or 78 Permalloy.—J. C. C.

***Palladium Carbide.** Norbert G. Schmahl (*IX Congr. internat. quim. pura applicada, Madrid*, 1934, **3**, 468–474; *C. Abs.*, 1936, **30**, 1677).—Methane or a mixture of methane with hydrogen in contact with palladium powder formed by reducing PdO with hydrogen reaches equilibrium in several hours. The carbon content of the solid was 4·4%, corresponding closely to Pd_5C_2 (4·31% carbon). Photographs of X-ray spectra are given which show that this is a true compound. The compound shows the same capacity as palladium to absorb hydrogen, and this is explained by assuming a double intercalated structure, according to the theory of Hägg (*Met. Abs.* (*J. Inst. Metals*), 1931, **47**, 387).—S. G.

***Electrical Conductivity and Equilibrium Diagram of Binary Alloys. XVIII.—The Palladium–Cobalt System.** G. Grube and H. Kästner (*Z. Elektrochem.*, 1936, **42**, (3), 156–160).—The temperatures of the liquidus and the solidus for the palladium–cobalt alloys at 5 atomic-% were determined and are tabulated for temperatures from 40° up to 720°–1000° C. The temperature–resistance curves shows the $\alpha \rightleftharpoons \beta$ transformation of pure cobalt by a kink in the curve at 456°–475° C.; at 5 atomic-% palladium the transformation is just observable at 310° C.; at 10 atomic-% palladium and upwards it does not appear, the curves between 10 and 30 atomic-% palladium being quite smooth. The disappearance of the ferromagnetism in the solid solution between 40 and 90 atomic-% palladium is shown by a change of direction in the curves. The Curie point falls as the palladium content increases, the magnetometric value being always lower than the Curie point. An equilibrium diagram has been constructed embodying the results of these thermal, electrical, and magnetic measurements. The palladium–cobalt alloys, like the palladium–nickel alloys, freeze in a complete range of solid solutions with a minimum freezing point of 1217° C. at 50 atomic-% palladium.—J. H. W.

Physical Properties of Babbitt Tin-Base Bearing Alloys. Owen W. Ellis (*Metal Progress*, 1936, **29**, (2), 56–59).—The A.S.T.M. and S.A.E. specifications for tin-base bearing metals are considered, and an account is given of the influence on these alloys of additions of zinc, aluminium, arsenic, bismuth, cadmium, and lead. Recent methods of mechanical and service testing are summarized.—P. M. C. R.

"Titanite," a New Strong Aluminium Casting Alloy. —— (*Amer. Metal Market*, 1936, **43**, (45), 5).—A brief note. Titanite is a titanium-base alloy containing aluminium and manganese, and is said to be highly resistant to corrosion.—L. A. O.

***Pressed and Cast Hard Tungsten-Base Alloys.** T. M. Grjaznow (*Neftjanoe Khoziaystvo* (*Oil Economy*), **1935**, (10), 47–57).—[In Russian.] The hardness, wearing properties, fracture, microstructure, and X-ray structure of alloys having a composition within the range: carbon 1·86–5·68, tungsten 80–93·5, molybdenum 0·67–5·0, iron 0·84–5·8, silicon 0·36–6·35, and cobalt 0·1–11·5%, were investigated. The use of these alloys for drilling oil-wells is discussed. A *bibliography* of 21 references is given.—N. A.

Bearing Metals. F. K. von Göler and G. Sachs (*Giesserei-Praxis*, 1936, **57**, (7/8), 76–79; (11/12), 121–124).—Describes the composition, structure, and properties of (1) high-tin white metal, the improvement effected by the addition of cadmium, and the effect of 2% of lead; (2) high-lead white metals and hardened lead bearing metals; (3) cadmium-base bearing metals; (4) lead–bronzes; and (5) zinc-base and aluminium-base bearing metals. —J. H. W.

Report of [A.S.T.M.] Committee B–4 on Electrical Heating, Electrical Resistance, and Electric Furnace Alloys. Dean Harvey and F. E. Bash (*Proc. Amer. Soc. Test. Mat.*, 1935, **35**, (I), 176–178).—Some small modifications in tentative standards are proposed and a brief account is given of the activities of the 7 sub-committees.—A. R. P.

***Physical Properties of Metals as Affected by Conditions of Ammonia Synthesis.** (Maxwell.) See p. 144.

***Measurements on Thermo-Electric Forces of Some Alloys at Temperatures from 2·5° to 17·5° K.** W. H. Keesom and C. J. Matthijs (*Physica*, 1935, **2**, 623).—See *Met. Abs.*, 1935, **2**, 584.—L. A. O.

***Precipitation Along a Temperature Gradient in Supersaturated Solid Solutions.** G. Tammann and W. Boehme (*Light Metals Research*, 1936, **4**, (19), 317–318).—Short summary from *Z. anorg. Chem.*, 1935, **226**, (1), 87; see *Met. Abs.*, this vol., p. 116.—L. A. O.

A Simple Systematic Classification for All Binary, Ternary, and Quaternary Alloys. Ernst Jänecke (*Z. Elektrochem.*, 1936, **42**, (3), 128–138).—Alloys are divided into types and groups as shown by their equilibrium diagrams, and are classified accordingly.—J. H. W.

†Geometric Theory of Heterogeneous Equilibrium. Erich Scheil (*Z. Elektrochem.*, 1936, **42**, (3), 153–155).—The application of the phase rule to heterogeneous equilibrium is considered, and non- and uni-variant equilibrium systems are discussed on theoretical grounds.—J. H. W.

III.—STRUCTURE

(Metallography; Macrography; Crystal Structure.)

(Continued from pp. 116–120.)

Report of [A.S.T.M.] Committee E–4 on Metallography. C. H. Davis and O. E. Harder (*Proc. Amer. Soc. Test. Mat.*, 1935, **35**, (I), 511–512).—Future work is outlined.—A. R. P.

On the Metallographic Examination of Graphitic Products of the Metalloceramic Type (Metallized Graphite Bearings). N. M. Zarubin (*Zavodskaia Laboratoria* (*Works' Lab.*), 1935, **4**, (12), 1474–1479).—[In Russian.] Methods are described for polishing and etching the surfaces of alloys produced by sintering mixtures of powdered metals and alloys with graphite.—D. N. S.

Microstructure of Nickel and High Nickel–Chromium Alloys. —— (*Metal Progress*, 1936, **29**, (3), 57).—Photomicrographs illustrate the microstructure of hot-rolled nickel, rolled and annealed Inconel, a Nichrome-type heat-resisting alloy, and an alloy containing iron 44·5, nickel 35, chromium 18%. Analyses are given in each case.—P. M. C. R.

***Kinetics of Recrystallization in Tin, Cadmium, and Iron.** M. Kornfeld and F. Savizkiy (*Zhurnal eksperimentalnoy i teoreticheskoy Fiziki* (*J. Exper. Theoret. Physics*), 1935, **5**, (10), 996–998).—[In Russian.] The appearance and growth of new grains in the recrystallization of tin, cadmium, and iron are similar to those found previously in aluminium. The existence of an incubation period and the constancy of the linear rate of growth are established. For tin, cadmium, and iron with deformations of 2·0, 0·60, and 3·5% at 175° ± 2°, 205° ± 2°, and 930° ± 5° C., respectively, it is shown that the process of rest is concluded before the appearance of the first visible grain.—N. A.

***Formation of New Grains in Recrystallization. II.—Nature of the Incubation Period.** M. O. Kornfeld (*Zhurnal eksperimentalnoy i teoreticheskoy Fiziki* (*J. Exper. Theoret. Physics*), 1935, **5**, (10), 999–1000).—[In Russian.] Two interpretations of the nature of the incubation period are possible but only one corresponds to experimental data. According to this, the nuclei are formed as a result of an irreversible process occurring at the very outset of the annealing in a definite region of the deformed metal. The duration of the incubation period is equal to the time necessary for the conclusion of this process.—N. A.

***Spectroscopic Study of the Modifications Undergone by the Surface of Light Alloys; Application of Duralumin.** Henri Triché (*Compt. rend.*, 1936, **202**, (9), 745–747).—The spark spectrograph (see *Met. Abs.*, 1936, **3**, 84) was used to study the surface effect of Duralumin during electrolytic oxidation with a.c., using chromic and sulphuric acids as electrolytes. The lines observed were 2802·7 A. (Mg), 3082·1 (Al), 3274 (Cu), 2881·6 (Si), and the Ca-doublet 3933·7–3968·5. The chromic acid solution was very strong, and although the deposit was barely visible, the spark showed considerable weakening of the copper line compared with that of magnesium, and a slight weakening of the magnesium line compared with that of the aluminium, later the silicon and calcium lines disappeared. The action of the chromic acid is thus selective. With pure sulphuric acid no deposit was observed, only a continuous attack; the spectrum is identical with that of the untreated surface. The successive action of chromic and sulphuric acids depends on whether the former is strong enough to exert the effect. It is concluded that the oxide layer can only form if certain elements of the Duralumin are eliminated more or less completely from the surface. In the present case, those elements are first copper, which is relatively largely present, silicon, and calcium. Magnesium is only partly eliminated from the surface. The deposition can be considered as taking place in 2 operations: first, the selective action of the electrolyte, and then the real deposition of alumina with the same electrolyte or with another which has no selective action. The removal of the copper confirms the suggestion made by A. G. C. Gwyer and N. D. Pullen (*Met. Abs.*, this vol., p. 80).—J. H. W.

***The Effect of Heat-Treatment on the Structure of Gold- and Silver-Leaf.** G. D. Preston and L. L. Bircumshaw (*Phil. Mag.*, 1936, [vii], **21**, (142), 713–727).—The crystal structures of gold- and silver-leaf heated in air, hydrogen, or *in vacuo* were examined by the electron diffraction method. The contraction occurring when gold-leaf is heated in air at about 350° C. is accompanied by recrystallization and reorientation of the crystals in the leaf. The effects are either absent or occur only very slowly even at higher temperatures when the heat-treatment is carried out in hydrogen. At pressures of 10^{-4} cm. of mercury or less no recrystallization is observed even at 700° C. The effects observed at low temperatures on annealing gold-leaf in air are attributed to the presence of oxygen. Similar effects occur in silver-leaf, but take place in air at lower temperatures and are not so easily controlled. Crystal reorientation has not been observed, although crystal growth occurs. The electron diffraction spectra obtained with gold- and silver-leaf treated with mercury vapour do not correspond with those to be expected from any of the known phases of the gold–mercury and silver–mercury systems. It is suggested that the phases present in very thin films may not have the structure characterizing the massive state.—J. S. G. T.

***The Diffraction of Slow Electrons on Zinc Single Crystals.** S. G. Kalashnikov and I. A. Jakovlev (*Zhurnal eksperimentalnoy i teoreticheskoy Fiziki* (*J. Exper. Theoret. Physics*), 1935, **5**, (10), 932–941).—[In Russian.] The diffraction of slow electrons on zinc single crystals was studied by the constant angle method. In the range of the normal component of electron velocity from 5·5 to 130 v. 8 diffraction maxima were measured. The equivalent inner potential of zinc was determined and found to be an asymptotically increasing function of the order of reflection. The influence of temperature on the intensity of diffraction beams was studied quantitatively and the result compared with Debye's theory of the scattering of X-rays.—N. A.

Law of Corresponding States of Lattice Recovery. J. A. M. van Liempt (*Chem. Weekblad*, 1935, **32**, (1670), 546–550; *C. Abs.*, 1936, **30**, 1626).—The hypothesis of lattice recovery by nucleus formation (van Liempt, *J. Inst.*

Metals, 1927, **38**, 389) has been confirmed repeatedly (van Arkel, *J. Inst. Metals*, 1930, **44**, 556). In the recovery of a deformed crystal by heating, time as well as temperature is involved. If the increased energy of a deformed metal is taken proportional to the increased electrical resistance, R_k (the normal resistance is R_0), the degree of deformation will be $\beta = (R_k - R_0)/R_0$ at 0°. By taking a characteristic temperature t from $R_k = R_0 (1 + \alpha t)$ it follows that $t = \beta/\alpha$ and the excess energy of the deformed state $\Delta E = Mc\beta/\alpha$ with c the specific heat. Using $Mc = 6$, $\alpha = 0{\cdot}005$ (Tammann value) gives $E = 1200\beta$. The mean time for exchange of place of atoms is smaller for deformed metals than for normal ones by a factor $e^{-600\beta/T}$; for copper with $\beta = 6$ the ratio of mean times is 1/400. This decreased time of place exchange causes the tendency to nucleus formation (Cohen de Meester and van Lieshout, *Met. Abs.*, 1935, **2**, 415). By heating a deformed metal for a longer period than the mean time mentioned as depending on the local degree of deformation β, it will recover in the corresponding locations. For abs. temperature T, time θ seconds a relation $T \log 4\nu\theta = \text{const.} = T (13{\cdot}5 + \log \theta)$ holds, in which ν is the period of vibration of an atom and indicates the relation between T and θ required for the recovery of the metal. Per 1% increase in abs. temperature the rate of place exchange increases 36%. This law holds also for recrystallization if β is taken as a mean degree of deformation for the entire lattice. The equation is well borne out by data of Mathewson and Phillips (*J. Inst. Metals*, 1917, **17**, 333), of Moore and Beckinsale (*J. Inst. Metals*, 1922, **27**, 405), and of Karnop and Sachs (*J. Inst. Metals*, 1930, **43**, 523). In all cases the $T - \theta$ data gave a const. $T (\log \theta + 13{\cdot}43)$; the const. decreases with increase of β. At room temperature for deformed copper the recovery requires 80,000 years, at 200° 1000 seconds; for deformed aluminium 23 years at 27°. Such values are of importance for the structural use of alloys. —S. G.

On the Application of the Thomas–Fermi Theory to the Problem of Metallic Bonds. E. Feinberg (*Zhurnal eksperimentalnoy i teoreticheskoy Fiziki* (*J. Exper. Theoret. Physics*), 1935, **5**, (10), 919–925).—[In Russian.] The energy of a crystal calculated from the Thomas–Fermi theory, when expressed as the function of the interatomic distance, has no minimum; hence this theory cannot explain the stability of the crystal lattice.—N. A.

Some Relations Concerning Atomic Crystal Lattices. E. Feinberg (*Zhurnal eksperimentalnoy i teoreticheskoy Fiziki* (*J. Exper. Theoret. Physics*), 1935, **5**, (10), 926–931).—[In Russian.] A conception of the metallic crystal as a space lattice formed by the ions with the interionic space filled with free electron gas, and division of the crystal into the Wigner and Seitz spherically symmetrical cells, permits a determination of the value of the interatomic space corresponding to the stable state of the crystal, and affords a means of expressing it as a function of the valency of the element. In this way determinations are made of the dependence on the valency of (*a*) the atomic volume and Lother Meyer's atomic volume curve, and (*b*) the energy of ionization required to deprive the atom of all its valency electrons. The results are in good agreement with experimental data.—N. A.

IV.—CORROSION

(Continued from pp. 120–122.)

***Corrosion of Aluminium in Nitric Acid.** S. Higashio (*Sumitomo Densen Iho* (*Res. Rep. Sumitomo Steel, Tube, and Copper Works*), 1932, **1**, (1), 18–19).—[In Japanese.]—S. G.

***On the Mechanism of Corrosion of Aluminium in Salt Solutions.** I. Igarashi (*Sumitomo Densen Iho* (*Res. Rep. Sumitomo Steel, Tube, and Copper Works*), 1933, **1**, (9), 619–623).—[In Japanese.]—S. G.

***Oxidation of Aluminium and Aluminium Alloys by Gases and Liquids.** V. S. Zorin (*Legkie Metalli* (*Light Metals*), **1935**, (10), 12–21).—[In Russian.] Aluminium, Duralumin, and Lautal were exposed to moist oxygen at room temperature for 25 days, and at 97° and 550° C. for ¼–24 hrs., then tested for corrosion-resistance in artificial sea-water. Only specimens treated at 550° C. became corrosion-resistant; this, however, cannot be ascribed to the action of oxygen, as similar treatment in a carbon dioxide atmosphere and in a vacuum produced analogous results. Oxidation with ozone, hydrogen peroxide, nitric acid, or phosphoric acid did not produce resistant films.—D. N. S.

***Corrosion Tests on Aluminium Alloys in Salt Solutions.** I. Igarashi (*Sumitomo Densen Iho* (*Res. Rep. Sumitomo Steel, Tube, and Copper Works*), 1932, **1**, (1), 10–17).—[In Japanese.]—S. G.

***Influence of Purity and Degree of Working of Aluminium Sheet on Its Corrodibility.** K. Inamura (*Sumitomo Densen Iho* (*Res. Rep. Sumitomo Steel, Tube, and Copper Works*), 1933, **1**, (7), 468–470).—[In Japanese.]—S. G.

***Considerations on the Mechanism of Corrosion of Aluminium Alloys.** G. Koiso (*Sumitomo Densen Iho* (*Res. Rep. Sumitomo Steel, Tube, and Copper Works*), 1932, **1**, (2), 105–115).—[In Japanese.]—S. G.

***Corrosion of Duralumin Sheet in Several Acid, Alkali, and Common Salt Solutions.** K. Inamura (*Sumitomo Densen Iho* (*Res. Rep. Sumitomo Steel, Tube, and Copper Works*), 1933, **1**, (10), 726–734).—[In Japanese.]—S. G.

***Cold-Working, Tempering, and Corrodibility of Duralumin.** T. Tanabe (*Sumitomo Densen Iho* (*Res. Rep. Sumitomo Steel, Tube, and Copper Works*), 1933, **1**, (9), 624–638).—[In Japanese.]—S. G.

***Influence of Tempering on the Solubility of Duralumin in Hydrochloric Acid.** S. Hori (*Sumitomo Densen Iho* (*Res. Rep. Sumitomo Steel, Tube, and Copper Works*), 1933, **1**, (9), 639–641).—[In Japanese.]—S. G.

***Corrosion Tests on Duralumin under Load.** T. Tanabe (*Sumitomo Densen Iho* (*Res. Rep. Sumitomo Steel, Tube, and Copper Works*), 1933, **1**, (9), 642–645).—[In Japanese.]—S. G.

***Weathering Test on Duralumin Profile.** K. Inamura (*Sumitomo Densen Iho* (*Res. Rep. Sumitomo Steel, Tube, and Copper Works*), 1932, **1**, (3), 146–158).—[In Japanese.]—S. G.

***Atmospheric Exposure Tests on Non-Ferrous Screen Wire Cloth.** G. W. Quick (*Proc. Amer. Soc. Test. Mat.*, 1935, **35**, (I), 458–476).—Appendix to Report of A.S.T.M. Committee D–14 on Screen Wire Cloth. See *Met. Abs.*, 1935, **2**, 429.—A. R. P.

***The Resistance of Copper to the Solvent Action of Tomatoes.** I. Kh. Kotlyar, M. D. Oikhman, and L. O. Shnaĭdman (*Konservnaya Promishlennosti*, **1935**, (4), 13–21; *C. Abs.*, 1936, **30**, 1454).—[In Russian.] Copper plates were immersed in hot tomato juice of 0·66% acidity and in a juice acidified artificially with citric or malic acid up to 2%, *i.e.* at p_H 4·2–3·1. Circulation of the juice, variation in duration of boiling from 1 to 8 hrs., and brief admission of air during the experiment did not increase the solution of copper. Copper plates wet with water or with tomato juice for some time before the experiment became covered with oxide films; this greatly increased the solution by boiling juice. For this reason uninterrupted boiling is necessary in processing tomatoes in copper apparatus. In the industry the juice passes alternately through iron and copper apparatus or piping. The iron dissolved in the juice increases the destructiveness of copper ten-fold. —S. G.

***Corrosion of Copper in Acids and Alkalis.** K. Inamura (*Sumitomo Densen Iho* (*Res. Rep. Sumitomo Steel, Tube, and Copper Works*), 1932, **1**, (1), 36–41).—[In Japanese.]—S. G.

***Corrosion Tests on Some Binary Copper Alloys.** G. Koiso (*Sumitomo Densen Iho* (*Res. Rep. Sumitomo Steel, Tube, and Copper Works*), 1933, **1**, (5), 292–302).—[In Japanese.]—S. G.

***Relation Between the Corrodibility and Degree of Working of Brass.** T. Tanabe (*Sumitomo Densen Iho* (*Res. Rep. Sumitomo Steel, Tube, and Copper Works*), 1933, **1**, (7), 479–484).—[In Japanese.]—S. G.

***Studies on the Corrosion of Condenser Tubes.** T. Tanabe and G. Koiso (*Sumitomo Densen Iho* (*Res. Rep. Sumitomo Steel, Tube, and Copper Works*), 1933, **1**, (11), 741–794).—[In Japanese.]—S. G.

***Contact Corrosion Tests on [Naval Brass] "S.N.B."** T. Tanabe and G. Koiso (*Sumitomo Densen Iho* (*Res. Rep. Sumitomo Steel, Tube, and Copper Works*), 1933, **1**, (9), 609–618).—[In Japanese.]—S. G.

***Resistance to Corrosion of Tinned Brass Condenser Tubes.** T. Tanabe and G. Koiso (*Sumitomo Densen Iho* (*Res. Rep. Sumitomo Steel, Tube, and Copper Works*), 1933, **1**, (7), 474–478).—[In Japanese.]—S. G.

***On a New Acid-Resisting Alloy "A.R."** T. Tanabe and G. Koiso (*Sumitomo Densen Iho* (*Res. Rep. Sumitomo Steel, Tube, and Copper Works*), 1932, **1**, (3), 128–133).—[In Japanese.]—S. G.

Electrolytic Corrosion of Lead-Covered Telephone Cables. C. J. Griffiths (*Elect. Eng. and Merchandiser* (*Melbourne*), 1935, **11**, (12), 353–360).—Read before the Congress of the Australian and New Zealand Association for the Advancement of Science. The adoption of mitigative measures has reduced the number of sheath faults attributed to electrolytic corrosion in the underground telephone system in Victoria from 199 in 1930 to 58 in 1934. For making electrolytic surveys, potential methods, using lead earth plates, were adopted. Electrical drainage, controlled by measurements before and after bonding to the tramway or railway negative returns through copper–copper oxide rectifiers or relay contactors, was found the most satisfactory method of protection. Other protective measures are briefly discussed.—J. C. C.

***Corrosion of Magnesium and Magnesium Alloys.** Hideo Nishimura and Hachie Sawamoto (*Suiyokwai-Shi* (*Trans. Min. Met. Alumni Assoc.*), 1935, **9**, (9), 911–922).—[In Japanese.] The rates of corrosion of magnesium and its alloys in dilute sulphuric, hydrochloric, and nitric acids and sodium chloride solutions were studied by measurements of the gases evolved. Manganese and zinc as alloying constituents decrease the corrosion of magnesium, but the effect of aluminium and copper is to increase the corrodibility.—S. G.

***Corrosion Tests on Magnesium Alloys in Brine.** I. Igarashi (*Sumitomo Densen Iho* (*Res. Rep. Sumitomo Steel, Tube, and Copper Works*), 1932, **1**, (2), 116–121).—[In Japanese.]—S. G.

***On the Corrosion and Protection of Magnesium Alloys.** I. Igarashi (*Sumitomo Densen Iho* (*Res. Rep. Sumitomo Steel, Tube, and Copper Works*), 1933, **1**, (5), 312–322).—[In Japanese.]—S. G.

Report of Sub-Committee VIII [of A.S.T.M. Committee on Corrosion of Iron and Steel] on Field Tests of Metallic Coatings. R. F. Passano (*Proc. Amer. Soc. Test. Mat.*, 1935, **35**, (I), 88–103).—All the galvanized sheets having coatings of less than 2 oz. of zinc per $ft.^2$ have failed completely after 8 years' exposure at Altoona, and Pittsburgh (industrial atmosphere), failure has commenced at Sandy Hook with the 1·5 oz. coatings, and no failure of any of the coatings has yet occurred at Key West although the 0·75 oz. coatings are beginning to develop yellow spots. Tabulated reports are included on the behaviour of various structural shapes, tubular goods, and hardware coated in 1928 with zinc by hot-dipping, electrodeposition, and sherardizing, with cadmium by electrodeposition, with aluminium and with lead by hot-dipping, and with a phosphate film by the Parker process.—A. R. P.

Durability of Plated Steel Exposed to Weather. William Blum (*Metal Progress*, 1936, **29**, (2), 40–41).—The results are given of exposure tests on steels coated with nickel, nickel on copper, chromium, chromium on copper, zinc (hot-dipped or electrodeposited), and cadmium. Methods for measuring the thickness of coatings are described, and the specifications recently adopted by the A.S.T.M. are summarized.—P. M. C. R.

Report of [A.S.T.M.] Committee B-3 on Corrosion of Non-Ferrous Metals and Alloys. T. S. Fuller and Sam Tour (*Proc. Amer. Soc. Test. Mat.*, 1935, **35**, (I), 141).—A brief progress report.—A. R. P.

***Report of Sub-Committee VI [of A.S.T.M. Committee B–3] on Atmospheric Corrosion of Non-Ferrous Metals and Alloys.** W. H. Finkeldey (*Proc. Amer. Soc. Test. Mat.*, 1935, **35**, (I), 142–159).—The effects of 3 years' exposure in 4 industrial, 3 marine, and 2 rural atmospheres on the weight increment, tensile strength, and elongation of copper, nickel, tin, zinc, aluminium, lead, brasses, bronzes, copper–nickel alloys, and various lead, zinc, and light alloys are tabulated. The most serious deterioration in properties has occurred in the industrial areas and with the light metals and their alloys, tin, tin–bronze, and manganese–bronze. Copper–nickel alloys, Everdur, aluminium–bronze, Admiralty gun-metal, nickel, and chemical lead have suffered little or no change in mechanical properties in any atmosphere.—A. R. P.

***Report of Sub-Committee V [of A.S.T.M. Committee B–6] on Exposure and Corrosion Tests.** W. M. Peirce (*Proc. Amer. Soc. Test. Mat.*, 1935, **35**, (I), 190–226; discussion, 227–229).—Appendix II to Report of A.S.T.M. Committee B–6 on Die-Cast Metals and Alloys. Tabulated results are given for the mechanical properties of 12 aluminium alloys after exposure for 1 and 5 years at 4 indoor and 5 outdoor localities in the U.S.A. No significant changes were found which could be attributed to corrosion and only minor changes attributable to age-hardening, chiefly in the copper-containing alloys. Similar tests on zinc-base die-casting alloys showed that those prepared from zinc of purity greater than 99·99% are much superior to those prepared from 99·90% zinc, the former alone showing no visual intercrystalline oxidation. The steam test affords a rapid and reliable means of predicting whether intercrystalline corrosion will occur over long periods of time. Changes in the impact strength after atmospheric exposure, steam exposure, or exposure to paraffin at 95° C. are due entirely to the thermal effect and not to corrosion. —A. R. P.

***Report of Sub-Committee VII [of A.S.T.M. Committee B–3] on Corrosion in Liquids.** A. J. Phillips (*Proc. Amer. Soc. Test. Mat.*, 1935, **35**, (I), 160–166).—Tabulated results are given for the loss in weight in sea-water, 20% sodium hydroxide, and 20% sulphuric acid containing iron salts and an inhibitor and for the changes in tensile strength and elongation in the two first-named solutions after 2–8 months' exposure. After 8 months in sea-water the 22 : 20 : 58 nickel–chromium–iron alloy showed the least deterioration followed by aluminium–bronze and leaded tin–bronze. In the alkaline solution nickel and high nickel–copper alloys were much superior to all others tested and in the acid solution silicon–cast iron and the above mentioned ternary iron alloy showed the highest resistance.—A. R. P.

***Report of Sub-Committee VIII [of A.S.T.M. Committee B–3] on Galvanic and Electrolytic Corrosion.** C. L. Hippensteel and L. J. Gorman (*Proc. Amer. Soc. Test. Mat.*, 1935, **35**, (I), 167–175).—Sets of discs of aluminium, zinc, mild steel, lead, tin, nickel, and copper arranged in couples were exposed to atmospheric influences for 3 years in 9 localities in the U.S.A., and after cleaning away the corrosion products the loss in weight was determined and compared with that of blanks. In severe marine conditions corrosion of aluminium is considerably enhanced by contact with copper, tin, nickel, or lead, corrosion of zinc by contact with copper, iron, tin, nickel, and lead, and corrosion of tin and iron by contact with copper. Under ordinary marine conditions copper enhances the corrosion of aluminium and iron, and under industrial conditions iron accelerates corrosion of tin, and copper the corrosion of iron. In all other cases galvanic action has little or no effect.—A. R. P.

***The Dissolution of Some Metals in a Solution of Potassium Cyanide.** R. Hay (*J. Roy. Tech. Coll.* (*Glasgow*), 1936, **3**, (4), 576–586). Experiments on the dissolution of copper, aluminium, silver, zinc, lead, and zinc–lead couple in a 0·25% potassium cyanide solution, when partially immersed and when completely immersed in the presence of air and in the absence of air are discussed. Hydrogen is evolved under certain conditions, and the possibility of oxygen functioning as a depolarizer is commented upon. From a determination of the influence of the OH radicle on the p_H value of potassium cyanide solutions and on the rate of dissolution of silver in potassium cyanide solution, it is shown that the addition of lime to cyanide solutions does not depend for its beneficial results on the introduction of the OH radical, but that the presence of the radical is detrimental to the dissolution of silver and in all probability to that of gold.—J. W. D.

Scaling of Turbine Blading. Edward Ingham (*Colliery Eng.*, 1936, **13**, (145), 93–94).—The feed-water, injection, and other working conditions which influence the formation of scale on turbine blading are analyzed.—P. R.

***Effect of Continuous Corrosion and Abrasion on the Fatigue of Steel.** T. U. Matthew (*J. Roy. Tech. Coll.* (*Glasgow*), 1936, **3**, (4), 636–660).—The factors influencing the fatigue of metals are summarized and an investigation on the effects of " stress-raisers," such as abrasion and corrosion, on the fatigue strength of 4 steels is described. The experiments were conducted on a Wöhler-type fatigue testing machine fitted with specially designed auxiliaries giving a continuous abrasive and corrosive effect while the specimens were running under load, and the results obtained are compared with previous results where " surfacing " has been done previous to loading or where continuous corrosion takes place during the test. Continuous abrasion is found to have a serious crack-forming tendency, whereas continuous polishing is found to act as a crack inhibitor in proportion to the fineness of the polishing effect. Continuous abrasion and corrosion acting simultaneously are shown to have a mutually inhibitive effect, due to the reduction of abrasion to polishing by the lubricating action of the corrosive fluid. A special feature of the investigation is a new " short-time " method of determining the fatigue limit, which was found to be reliable where the specimens were tested under normal condition of loading in air, and which provided a standard basis for comparative analysis under all other conditions of testing.—J. W. D.

Is the Corrosion Test Ripe for Standardization ? O. Bauer (*Z. Metallkunde*, 1936, **28**, (2), 25–29).—Standardization of the corrosion test is possible only if the results are absolutely reproducible; experiments on steels have shown that this is the case only when the tests are made in neutral, unstirred waters, tests made under other conditions giving results which depend on numerous external and difficultly controllable variables.—A. R. P.

V.—PROTECTION

(Other than Electrodeposition.)

(Continued from pp. 122–123.)

***Anodic Oxidation of Aluminium by Superimposing Three-Phase A.C. on D.C.** Akira Miyata (*Rikwagaku Kenkyū-jo Iho* (*Bull. Inst. Phys. Chem. Res.*), 1935, **14**, (8), 651–678; *Brit. Chem. Abs.*, **1935**, [A], 1210).—[In Japanese.] Electrolysis with superimposed 3-phase a.c. on d.c. is simpler and better than the use of other polyphase a.c. for the anodic oxidation of aluminium in oxalic acid solution. A stout, hard film is obtained; the anodic current during electrolysis reverses little, even when appreciable negative voltage is applied to the anode in each cycle; the energy efficiency of the film formation is higher than by other methods; the a.c. component introduced in the d.c. generator circuit that menaces the commutation of the machine is suppressed; and pitting of the anode during electrolysis is avoided completely.—S. G.

Characteristics of Anodized Aluminium. R. E. Pettit (*Production Eng.*, 1935, **6**, 292–294).—See *Met. Abs.*, 1935, **2**, 520.—S. G.

***Investigation on the Penetration and Conductivity of Anodically Oxidized Aluminium.** J. W. Holst (*Z. Elektrochem.*, 1936, **42**, (3), 138–143).—If the electrodes were protected by J. E. Lilienfeld's method, the curves of penetration stresses rose gradually from zero. It was found, in agreement with G. Just and H. Best, that the penetration stresses for Al^+ and Al^- are very different. The conductivity of dry aluminium oxide was determined with mercury and coal-dust electrodes. The oxide layer conducts the current much better in the negative direction (Al^-) than in the positive (Al^+), which explained the difference between the penetration stresses in the 2 directions. Similar experiments were carried out on the conductivity of the dry films and of films immersed in the electrolyte. The results showed that the conductivity of the oxide layer is independent of the electron concentration of the media, metallic aluminium, and electrolyte, adjacent to the films, and do not confirm the results of A. Günther-Schulze and W. Ch. van Geel's explanation of the rectifier effect. From these results it was concluded that the conductivity of the oxide layer is limited by the movement of the OH^- and H^+ ions in the layer.—J. H. W.

***On the Anodic Oxidation of Duralumin.** K. Inamura (*Sumitomo Densen Iho* (*Res. Rep. Sumitomo Steel, Tube, and Copper Works*), 1932, **1**, (2), 92–104).—[In Japanese.]—S. G.

***On the Properties of Duralplat.—I.** T. Matsuda and S. Higashio (*Sumitomo Densen Iho* (*Res. Rep. Sumitomo Steel, Tube, and Copper Works*), 1933, **1**, (12), 795–808).—[In Japanese.]—S. G.

Plated Sheets. C. Hase (*Anz. Masch.*, 1936, **58**, (26), 16–18).—The properties of metal-plated steel sheets and plated aluminium sheets (*e.g.* Duralplat) are reviewed.—B. Bl.

***A Study of the Origin of Porosity in the Tin Coating on Tinplate.** A. W. Hothersall and J. C. Prytherch (*Iron Steel Inst. Advance Copy*, **1936**, May, 15 pp.).—The relationship of surface peculiarities or imperfections to pores was investigated. 30–50% of the pores in the coating are stated to be due to scratches produced in the final cleaning and polishing of the tinplate. The influence of scruff bands, grease marks, and particularly the tin-alloy layer on the porosity, is considered.—R. Gr.

***Methods of Detinning Tinplate for Examination of the Thickness and Continuity of the Alloy Layer.** A. W. Hothersall and W. N. Bradshaw (*Iron Steel Inst. Advance Copy*, **1937**, May, 10 pp.).—Methods of detinning tinplate are discussed, and a new electrolytic method is suggested. Recommended procedures are given for the sodium plumbite and electrolytic methods. Results are included of tests to determine the amounts of alloyed tin on plates having different tin yields and the effect of this alloy layer on the porosity.—R. Gr.

Report of Committee VI [of A.S.T.M. Committee on Corrosion of Iron and Steel] on Specifications for Metallic Coated Products. V. F. Hammel (*Proc. Amer. Soc. Test. Mat.*, 1935, **35**, (I), 86–87).—A progress report noting certain changes in Tentative Specifications.—A. R. P.

***Metallic Cementation. VIII.—Cementation of Some Metals by Means of Titanium (Ferro–Titanium) Powder.** Tsutomu Kase (*Kinzoku no Kenkyu* (*J. Study Metals*), 1936, **13**, (2), 50–60).—[In Japanese.] By means of powdered ferro-titanium the cementation of iron, copper, and nickel was investigated at various temperatures between 800° and 1300° C. The depth of penetration was measured, the layers were examined microscopically and by chemical analysis, and corrosion tests were carried out in some acids. Titanium diffuses into the above-mentioned metals at a temperature above 800° C., the rate of diffusion increasing with increase in temperature. The rate of diffusion into iron, however, increases almost abruptly at the A_3 point (906° C.). The relation between the increase in weight of the specimen ΔW or the depth of penetration P and the absolute temperature of cementation T

or the time θ required for treatment is given by an exponential function ΔW (or P) $= ae^{-b/T}$, or ΔW (or P) $= ae^{b\theta}$, where a and b are different constants in each case. Although the hardness of the cemented surfaces is greater than that of the original material, there is little advantage as regards corrosion-resistance.—S. G.

Protecting Metal Surfaces. —— (*Eng. and Min. J.*, 1936, **137**, (3), 164–165).—Two methods are outlined. In the "sweat-on" method metallic boron crystals are mixed with sodium silicate and a layer $\frac{1}{16}$ in. thick of the mixture fused into the surface of the metal to be protected. In the other method, the "cast-on" process, metallic boron crystals are held in a matrix of a nickel alloy which is poured into any desired space between a copper or cast-iron mould and the metal to be processed.—R. Gr.

***Determination of the Index of Application of Metals in the Schoop Spraying Process.** I. V. Petrov (*Metallurg* (*Metallurgist*), **1935**, (11), 66–67).—[In Russian.] Iron specimens, 250 mm. square, were sprayed with aluminium, zinc, and brass from a Schoop pistol for 60 seconds and the weight of deposited metal determined. Wire 1·5 mm. in diameter was fed into the pistol at a rate of 2·5 m./minute and the distance of the plates from the mouth of the pistol was varied from 5 to 100 cm. A sharp decrease in the proportion of metal hitting the plate occurred at a distance of 35 cm. With a distance of 15–20 cm. the percentage of the feed deposited on the plates was 82% for aluminium, 55% for zinc, and 62% for brass.—N. A.

Mogul Metal-Spraying Pistol. —— (*Metallizer*, 1936, **4**, (2), 16).—A description is given of a new type of pistol designed for the production spraying of harder metals. The wire unit and nozzle unit are separated. The tool is primarily intended for mounting on a lathe.—W. E. B.

The Repair and Metallization of the Bridge Jean-Francois-Lépine at Paris. J. Cauchetier (*Métalliseur*, **1936**, (1), 6–10).—Describes work carried out on a bridge where trouble had been experienced by the action of sulphurous gases from locomotives. The repair and the metallizing of the bridge with zinc is described, with photographs of the work.—W. E. B.

The Preparation of Light Metal Surfaces for Painting. G. O. Taylor (*Paint Manuf.*, 1936, **6**, (1), 19–21; *C. Abs.*, 1936, **30**, 1346).—A review of methods for preparing light metal surfaces to secure maximum adherence of paint under conditions of vibration, stress, and corrosion.—S. G.

The Problem of Painting Modern Materials. M. Caillaux (*Technique moderne*, 1936, **28**, (8), 303–305).—A review. Discusses suitable pigments and vehicles for the protection of ferrous, non-ferrous, and other structural materials, for indoor and outdoor use. Pitch-base aluminium paint is recommended for the protection of structural steel. Aluminium and light alloys are most effectively protected either by surface treatment or by synthetic resin paints containing chromates or red lead. Methods of cleaning and preparation are described for each type of work.—P. M. C. R.

VI.—ELECTRODEPOSITION

(Continued from pp. 123–125.)

Nickel Plating on Cadmium and Zinc-Plated Steel. John L. Roberts, Jr. (*Monthly Rev. Amer. Electroplaters' Soc.*, 1936, **23**, (3), 24–35).—For satisfactory colour and adherence without the need for applying an intermediate flash coating, the nickel plating solution should have a high content of magnesium sulphate and a p_H of about 5·8, but, above all, it should be practically free from dissolved iron.—A. R. P.

***The Effect of Sodium Fluoride on the Bright Plating Range of Chromium in a Chromic Acid Plating Bath.** E. Curschmann and H. Heinrich (*Monthly*

Rev. Amer. Electroplaters' Soc., 1936, **23**, (2), 52–55).—The addition of 8 grm. of sodium fluoride per litre to the ordinary chromic acid plating bath instead of sulphuric acid gives a bright plating range of 1–3·75 amp./in.^{2} with a current efficiency of 19% at 45° C.; at lower or higher temperatures the current efficiency is somewhat higher but the bright plating range is lower. —A. R. P.

Adventures in Electroplating Copper from Ammoniacal Solutions. E. A. Vuilleumier (*Monthly Rev. Amer. Electroplaters' Soc.*, 1936, **23**, (1), 44–47; discussion, 47–50).—Electrolysis of ammoniacal cupric solutions affords a relatively dense, smooth, adherent deposit, whereas electrolysis of ammoniacal cuprous solutions yields a thick, coarse, non-adherent mass of relatively large copper crystals, but in the presence of an excess of ammonia the cuprous oxide film responsible for the poor deposits dissolves, and good plates are obtained.—A. R. P.

***The Electroplating on Lead-Antimony Alloys.** Walter R. Meyer and Clarence C. Helmle (*Monthly Rev. Amer. Electroplaters' Soc.*, 1936, **23**, (3), 7–20; discussion, 20, 22).—The alloys are best degreased by solvent vapours followed by cathodic treatment in trisodium phosphate solution and a short dip in 20% hydrochloric acid. A copper flash in a cyanide bath should be applied before nickel-plating. Characteristic deposits are illustrated by photomicrographs.—A. R. P.

***The Electrodeposition of Manganese from Aqueous Solutions. I.—Chloride Electrolytes.** Harold H. Oaks and W. E. Bradt (*Electrochem. Soc. Preprint*, **1936**, April, 127–143).—The results are described of a study of the conditions affecting the electrodeposition of manganese from aqueous chloride solutions. Variables investigated included cathodic current density, temperature, addition agents, cathode material, anode material, diaphragm, concentration of manganese, and agitation. Data are given on the variation of manganese content of the bath during electrolysis, on current efficiency, and on the nature and purity of the deposited manganese. Smooth, silver-white plates of pure manganese were obtained that could be given a very high polish and had a Mohs' hardness of 5·5–6·0. The preferred bath contained manganese chloride 350 grm./litre, and ammonium chloride 30 grm./litre at 26° C. and 20 amp./dm.^{2}.—S. G.

***The Hardness of Electrodeposits of Nickel.** Jean Cahour (*Compt. rend.*, 1936, **202**, (8), 659–660).—The variation of the pendulum hardness of electrodeposited nickel with the nature of the support, the current density, the temperature of the bath, and the presence of gelatine in the bath was investigated. If the support is less hard than the deposit, the hardness begins by increasing to a limiting value corresponding to a thickness of about 0·1 mm. whatever the nature of the support; after this the true hardness of the deposit is measured. The deposits were formed on rolled copper, soft steel, quenched steel, rolled nickel, and cast silver. The hardness varied very closely with the nature and physical state of the support. As the current density increased, the hardness first increased to a maximum and then rapidly diminished, the maximum hardness being attained with a current density of about 1·2 amp./dm.^{2} with a bath consisting of $NiSO_4 \cdot 7H_2O$–100, $(NH_4)_2SO_4$–12, NH_4Cl–9 grm./litre the p_H value being between 6·7 and 6·5, and the temperature 18° C. The hardness decreases to a minimum at 50° C. under the above-mentioned conditions as the temperature of the bath is increased. The addition of small quantities of gelatine to the bath increases the hardness, but if too much is added, the hardness decreases rapidly. The gelatine content of the bath to give the maximum hardness varies with the temperature; it is 0·1 grm./litre at 50° C. and 0·01 grm./litre at 18° C. Microscopic observations indicate that factors which cause the hardness to increase tend to diminish the crystal size. —J. H. W.

Modern Anodes for Nickel Baths. O. Reichardt (*Chem.-Zeit.*, 1936, **60**, 98–99).—Recent attempts to improve the efficiency of nickel cathodes and to prevent passivation and the formation of anode slime are reviewed. The best results are obtained from cast anodes containing small amounts of nickel oxide. —A. R. P.

Rhodium Plating. Lionel Cinamon (*Monthly Rev. Amer. Electroplaters' Soc.*, 1936, **23**, (3), 36–42).—Rhodium phosphate baths are claimed to be superior to sulphate baths as they can be operated at lower temperatures and give whiter deposits. Spray from sulphate baths is liable to produce skin troubles on the operators whereas that from phosphate baths has no ill-effects. On the other hand phosphate baths must be operated at a much higher voltage (7–10 v.) as no conducting salt is known which will not spoil the colour of the plate when added to the bath. Methods of controlling the composition of the bath and the nature of the plate are briefly discussed.—A. R. P.

***The Simultaneous Electrodeposition of Thallium and Zinc.** W. George Parks and I. Milton Le Baron (*Electrochem. Soc. Preprint*, **1936**, April, 171–182).—The relative concentrations of thallium (as perchlorate) and zinc (as nitrate) in the baths and of the two metals in the resulting deposits at different current densities were determined. Cathode potential measurements were made at different current densities and with varying composition of solution. It is shown how the percentage composition curves can be determined from the cathode potential measurements. Electrodeposits of different composition were polished and compared microscopically with cast alloy specimens. A similar structure was observed for the eutectics only. No serviceable or useful deposits were obtained.—S. G.

History of Tin Plating. August Eyspamer (*Monthly Rev. Amer. Electroplaters' Soc.*, 1936, **23**, (1), 25–37).—Various electrolytes that have been proposed from time to time for tin-plating are briefly described.—A. R. P.

***Electrolysis in Fused Phosphates. II.—On a New Tungsten Phosphide W_4P.** Hellmuth Hartmann and Joachim Orban (*Z. anorg. Chem.*, 1936, **226**, (3), 257–264).—Electrolysis of solutions of tungsten trioxide in alkali metaphosphates at temperatures below 520° C. affords an amorphous metallic-looking deposit on the cathode which, when the current density does not exceed 4 amp./dm.^{2}, consists entirely of the subphosphide W_4P which has a density of 16·03 and is decomposed above 550° C. into the phosphide W_2P and α-tungsten.—A. R. P.

***A Study of Aluminium–Mercury–Zinc Anodes in Acid Zinc-Plating Baths.** A. K. Graham and P. G. Kolupaev (*Metals and Alloys*, 1936, **7**, (1), 14–17).—Sand-cast zinc anodes containing about 0·25% mercury and 0·4–0·5% aluminium can be used in zinc sulphate plating baths without danger of formation of anode slimes or polarization. Baths containing aluminium sulphate and ammonium chloride are best operated at a p_H of 2–4 with a current density of up to 300 amp./ft.^{2} of anode area.—A. R. P.

Electroplating [on] Aluminium. —— (*Machinery* (*Lond.*), 1936, **47**, (1221), 693–694).—Briefly refers to the Siemens-Schuckert process for plating aluminium with nickel. No details are given of bath compositions.—J. C. C.

Modern Filtration Practice in Electroplating. —— Pace (*Monthly Rev. Amer. Electroplaters' Soc.*, 1935, **22**, (12), 40–48).—Modern presses and filter aids for clarifying plating solutions are briefly described.—A. R. P.

The Adhesion of Electrodeposits. Walter R. Meyer (*Monthly Rev. Amer. Electroplaters' Soc.*, 1936, **23**, (2), 5–30; discussion, 30–37).—The conditions leading to non-adherence of electrodeposits are reviewed, and photomicrographs are given of characteristic plates on various basis metals. A *bibliography* of 19 references is included.—A. R. P.

Microscopic Measurements of Metallic Coatings. C. E. Heussner (*Monthly Rev. Amer. Electroplaters' Soc.*, 1936, **23**, (1), 5–20; discussion, 20–23).—

Methods of mounting and polishing cross-sections of plated articles for microscopic measurement of the thickness of the plate are described and some examples are illustrated.—A. R. P.

The Use of Inhibitors (with Special Reference to Antimony) in the Selective Removal of Metallic Coatings and Rust [from Iron]. S. G. Clarke (*Electrochem. Soc. Preprint*, **1936**, April, 209–220).—Immersion of tin-, zinc-, cadmium-, or chromium-plated iron, nickel, cobalt, or copper in hydrochloric acid (*d* 1·16) containing 1–2% of antimony results in a rapid and complete removal of the deposits without attack on the basis metal. The rate of removal depends to a considerable extent on the grain-size of the deposit, being greater with bright fine-grained deposits than with the coarser matt deposits. To prevent dissolution of the basis metal it is essential that the acid be concentrated and the antimony content not below about 0·2%; copper and brass are attacked slightly by the solution since the film of Cu_2Sb formed is not as impermeable as the pure antimony film formed on iron.—A. R. P.

VII.—ELECTROMETALLURGY AND ELECTROCHEMISTRY

(Other than Electrodeposition.)

(Continued from p. 84.)

***Direct Electrolytic Manufacture of Aluminium–Magnesium Alloys.—I–IV.** Ichitaro Namari and Tashio Ishino (*Kōgyō Kwagaku Zasshi* (*J. Soc. Chem. Ind. Japan*), 1935, **38**, (10); *C. Abs.*, 1936, **30**, 1307).—[In Japanese, with English summary in supplemental binding, pp. 583–591.] The direct electrolytic production of aluminium–magnesium alloys by deposition of magnesium on aluminium cathodes was investigated. The effects of sodium chloride or potassium chloride additions to the magnesium chloride electrolyte were the same, both decreasing the temperature at which electrolysis could be carried out. The results were not affected by change in current density and temperature of the bath above 660° C. An almost constant current efficiency of 94% was obtained. With magnesium chloride only, as electrolyte, the best results were obtained and the mean current efficiency was 95%, the only disadvantage being that electrolysis had to be carried out at about 700° C. The alloys produced corroded in the air more rapidly if made in the potassium chloride or sodium chloride diluted bath; if magnesium chloride alone was used the alloys were very resistant. The most suitable electrolyte for practical operation, however, was magnesium chloride + 5–10% sodium chloride, temperature of electrolysis about 670° C. The time of electrolysis did not affect the current efficiency very much. The composition of the final alloys estimated from the weight increase of the cathode agreed with the analytical results. Iron and silicon are possible impurities. Metallographic examination showed that the alloys produced were of quite uniform composition and compact structure.—S. G.

***The Effect of Certain Impurities in the Forming Acid on Plate Forming Time [in the Manufacture of Accumulators].** J. E. Hatfield and H. R. Harner (*Electrochem. Soc. Preprint*, **1936**, April, 161–169).—With increasing amounts of sodium in the electrolyte the plate clearing time decreases, iron increases the forming time, chloride in amounts greater than 0·05% prevents clearing of the plates, vanadium in amounts greater than 0·01% prevents clearance of the positive plates and greatly increases the time required for clearing the negative plates, formic acid behaves similarly to vanadium, but to a much less marked extent, and antimony and magnesium are without effect.—A. R. P.

VIII.—REFINING

(Continued from p. 14.)

Application of Metallographic Theory to the Refining of Metals. Hideo Nishimura (*Suiyokwai-Shi* (*Trans. Min. Met. Alumni Assoc.*), 1935, **8**, (9), 851–858).—[In Japanese.] The refining of metals by such processes as the Parkes and Pattinson process is discussed on the basis of the theory of heterogeneous equilibrium. Probable ternary diagrams of application in the removal of impurities from metals are explained, and some suggestions are made regarding the refining process.—S. G.

IX.—ANALYSIS

(Continued from pp. 125–126.)

Report of [A.S.T.M.] Committee E–2 on Spectrographic Analysis. H. V. Churchill and C. C. Nitchie (*Proc. Amer. Soc. Test. Mat.*, 1935, **35**, (I), 508–510).—A progress report.—A. R. P.

†**The Use of the Spectrograph in Industry.** H. W. Lohse (*Sands, Clays, and Minerals*, 1936, **2**, (4), 133–141).—Modern spectrographic apparatus is described and its use in industry reviewed with special reference to the detection of impurities in metals and alloys and of the minor constituents of ores.—A. R. P.

Micro-Analytical Tests for Rare and Common Metals. J. Gordon Pearson (*Chem. Eng. Min. Rev.*, 1936, **28**, (328), 108–110).—The reagents used for the micro-detection of Ti, Sn, Na, Cd, Pb, Sb, and Be—their strength and how they are made up—are described.—J. H. W.

***New Method for the Qualitative Detection of Thallium.** L. M. Kulberg (*Zavodskaia Laboratoria* (*Works' Lab.*), 1935, **4**, (10), 1215–1218).—[In Russian.] The solution is treated with *N*-NaOH, and $K_3Fe(CN)_6$ and the precipitate, containing the Tl as $Tl(OH)_3$, is collected, washed, and mixed with a 20% solution of tetraethyldiaminonitrotriphenylmethane (leuco-base of *ortho*-nitro-brilliant green) in 80% CH_3CO_2H. If Tl is present, a dark blue-green colour develops; sensitivity 0·09 γ (1 : 550,000). No other cation interferes. —D. N. S.

***On the Separation of Bismuth from Lead and Copper.** E. A. Ostroumov (*Zavodskaia Laboratoria* (*Works' Lab.*), 1935, **4**, (9), 1016–1020).—[In Russian.] The following methods for separating Bi from Pb were studied with synthetic mixtures: (1) hydrolysis of the Bi salt with (*a*) $KBrO_3$ and KBr, (*b*) $H{\cdot}CO_2Na$; (2) precipitation with pyrogallol; (3) precipitation with cupferron. Method (1*a*) was the most reliable and method (1*b*) the least satisfactory. Method 1*a* can also be used for separating Bi from Cu; good results are also obtained by converting the Cu into a cyanide complex and precipitating the Bi with alkali. The basic carbonate method is unsatisfactory.—D. N. S.

***Rapid Method for Separating Copper from Other Metals.** S. L. Zinberg (*Zavodskaia Laboratoria* (*Works' Lab.*), 1935, **4**, (10), 1161–1163).—[In Russian.] The solution is treated with 2·5 grm. of tartaric acid, neutralized with NaOH (phenolphthalein indicator), acidified with 15 c.c. of 1 : 9 HNO_3, and treated with a 2% alcoholic solution of 8-hydroxyquinoline to precipitate the Cu. The method affords good separations of Cu from Cd and Zn.—D. N. S.

***Separation of Iron, Aluminium, and Chromium from Manganese, Cobalt, and Nickel by Means of Pyridine.** E. A. Ostroumov (*Zavodskaia Laboratoria* (*Works' Lab.*), 1935, **4**, (11), 1317–1320).—[In Russian.] $Fe^{\cdots}$, $Al^{\cdots}$, and $Cr^{\cdots}$ may be separated from Mn, Co, and Ni by precipitation of the hydroxides from a chloride solution containing NH_4Cl with C_5H_5N.—D. N. S.

***Determination of Alumina in Aluminium and Its Alloys.** S. N. Suhov and B. M. Korotevskaia (*Zavodskaia Laboratoria* (*Works' Lab.*), 1935, **4**, (9), 1104–1114).—[In Russian.] The alloy is dissolved in a solution containing $CuCl_2$ and KCl, the precipitate is examined for SiO_2 by the usual method. Fe_2O_3 is separated from the insoluble Al_2O_3 by digestion with *aqua regia*. [*Note by Ed.*: This separation is considered to be quite unreliable.]
—D. N. S.

***Estimation of Alumina in Aluminium and Its Alloys.** S. Hori (*Sumitomo Densen Iho* (*Res. Rep. Sumitomo Steel, Tube, and Copper Works*), 1933, **1**, (10), 735–739).—[In Japanese.]—S. G.

***Determination of Calcium in the Presence of Zinc.** S. J. Fainberg and L. B. Fligelman (*Zavodskaia Laboratoria* (*Works' Lab.*), 1935, **4**, (12), 1459–1462).—[In Russian.] In the separation of Ca from Zn by precipitation as CaC_2O_4 several repetitions are necessary when more than 6% Zn is present.—D. N. S.

***Determination of Chromium in Aluminium Alloys.** J. A. Kliachko and E. E. Gurevich (*Legkie Metalli* (*Light Metals*), **1935**, (12), 37–39).—[In Russian.] The alloy is dissolved in 1 : 1 HCl and a little HNO_3, the solution cooled, slowly poured into 30% NaOH containing H_2O_2, boiled, reacidified with HCl, cooled, diluted, and after addition of $FeSO_4$, titrated with $K_2Cr_2O_7$ using $K_3Fe(CN)_6$ as external indicator.—D. N. S.

***The Application of Potentiometric Volumetric Methods in Steelworks Laboratories. VII.—The Determination of Cobalt and Manganese with Potassium Ferricyanide.** Peter Dickens and Gerd Maassen (*Mitt. K.-W. Inst. Eisenforschung*, 1935, **17**, (16), 191–192).—$K_3Fe(CN)_6$ oxidizes $Co^{\cdot\cdot}$ to $Co^{\cdot\cdot\cdot}$ in ammoniacal citrate solutions and the end-point can be determined accurately by the potentiometric method; the process is suitable for determining Co in the presence of much Ni, *e.g.* in commercial Ni and its alloys. Since $Mn^{\cdot\cdot}$ is oxidized simultaneously to $Mn^{\cdot\cdot\cdot}$ the method gives the sum of the Co and Mn in an alloy; the Mn is, in such cases, determined in a separate trial by the $K_2S_2O_8$ or similar method.—A. R. P.

Iodometric Determination of Copper. Thomas E. Hillis, Sidney C. Rittenberg, and Raymond F. Evenson (*Indust. and Eng. Chem.* (*Analyt. Edn.*), 1936, **8**, (1), 9–11).—In the iodometric determination of Cu the interference of $Fe^{\cdot\cdot\cdot}$ and AsO_4''' is prevented by addition of KHF_2 and adjustment of the p_H to 3·3–4·0; addition of K biphthalate as a buffer is unnecessary.—A. R. P.

***A Rapid Method for the Volumetric Determination of Indium [in Dental Alloys].** Henry B. Hope, Madeline Ross, and J. F. Skelly (*Indust. and Eng. Chem.* (*Analyt. Edn.*), 1936, **8**, (1), 51–52).—The chief use of In is in dental alloys containing Au, Ag, Pt, Pd, Cu, Zn, and Ni. To determine In in such alloys the metal is dissolved in *aqua regia* and the solution evaporated with 5–10 c.c. of H_2SO_4 until fumes are evolved. After dilution the solution is made $1N$ in acidity by addition of HCl and saturated with H_2S at 90° C. The precipitated sulphides are removed, the filtrate boiled to expel H_2S, the In precipitated with NH_4OH and the washed precipitate dissolved in 60%$CH_3{\cdot}CO_2H$. The solution is treated with 0·5 grm. of KF if $Fe^{\cdot\cdot\cdot}$ is present, then with two drops of a 2% solution of diphenylbenzidine in H_2SO_4 (d 1·84) and titrated with a 0·25% solution of $K_4Fe(CN)_6$ containing 0·02% of $K_3Fe(CN)_6$; the end point is shown by a change in colour from dull green to bright blue if KF is present and from slate blue to pea-green if no KF has been added.
—A. R. P.

***Accurate Separation of Precipitated Mercuric Sulphide and Sulphur in the Gravimetric Determination of Mercury.** Earle R. Caley and M. Gilbert Burford (*Indust. and Eng. Chem.* (*Analyt. Edn.*), 1936, **8**, (1), 43).—The HgS precipitate obtained in the usual way is collected in a porous-bottom crucible, washed, dried at 110° C. and weighed as HgS + S. The former is then removed by dissolution in constant-boiling HI (cold), the residual S washed with

5–10% HI then with cold H_2O, dried in a vacuum desiccator and weighed, and the HgS obtained by difference.—A. R. P.

†**The Determination of Rhenium. I.—Qualitative.** Loren C. Hurd (*Indust. and Eng. Chem.* (*Analyt. Edn.*), 1936, **8**, (1), 11–15).—Published qualitative and spectrographic methods are critically reviewed. In Prescott and Johnson's scheme of qualitative analysis, Re accumulates with the As. A *bibliography* of 33 references is appended.—A. R. P.

***Rapid Determination of Silicon in Silumin and Silico–Aluminium Alloy.** I. I. Pomeranz (*Zavodskaia Laboratoria* (*Works' Lab.*), 1935, **4**, (10), 1281).—[In Russian.] To avoid the tedious fusion of the graphitic silicon residue after dissolution of the metal in acid it is recommended to dissolve it in 25% NaOH and then pour the solution into the acid mixture and proceed as usual. —D. N. S.

***A Rapid Method for the Determination of Titanium.** Henry B. Hope, Raymond F. Moran, and Arthur O. Ploetz (*Indust. and Eng. Chem.* (*Analyt. Edn.*), 1936, **8**, (1), 48–49).—The method depends on the reduction of $Ti(SO_4)_2$ to $Ti_2(SO_4)_3$ by shaking with liquid Zn amalgam and subsequent titration with $FeNH_4(SO_4)_2,12H_2O$ using KCNS as indicator.—A. R. P.

X.—LABORATORY APPARATUS, INSTRUMENTS, &c.

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

(Continued from pp. 126–127.)

Measuring Tools for Interchangeable Parts. —— Berndt (*Anz. Masch.*, 1935, **57**, (87), 27–30).—Modern science and tools for measuring length and angles accurately in works' practice are described.—B. Bl.

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

(Continued from pp. 127–128.)

Report of [A.S.T.M.] Committee E–1 on Methods of Testing. W. H. Fulweiler and R. E. Hess (*Proc. Amer. Soc. Test. Mat.*, 1935, **35**, (I), 486–496). —A progress report.—A. R. P.

Possibilities of Error in Measurements. W. Bülow (*Anz. Masch.*, 1935, **57**, (87), 30–32).—Possible sources of error due to the condition of the tools, temperature changes, and the personal equation are discussed.—B. Bl.

Material Testing Machines. H. Holdt (*Anz. Masch.*, 1935, **57**, (87), 22–23). —Some new German types of static and dynamic testing machines are described.—B. Bl.

Testing and Measuring in the Workshop. W. Fleischhauer (*Anz. Masch.*, 1935, **57**, (87), 33–38).—Numerous examples are given.—B. Bl.

***A New Method of Thickness Measurement of Metal Films.** Sin Tanaka (*Rep. Aeronaut. Res. Inst. Tôkyô Imp. Univ.*, 1933, (**91**), 293–306; *Sci. Abs.*, 1933, [A], **36**, 468).—[In English.] The estimation by weighing of the thickness of a thin metal film chemically deposited or sputtered on glass is open to the objection that the density of such a film is not necessarily that of the metal in the mass. The thickness of films thicker than 0·05 micron can also be determined by the interference method, but the necessary allowance for the difference of phase changes on reflection is doubtful. Kiessig's method (*Ann. Physik*, 1931, **10**, 769) employing interference of X-rays is reliable, but is only applicable to extremely thin films having a very uniform surface. The new method is applicable down to thicknesses $<0·01$ micron, and can be used even when the metal surface is somewhat granular. The image of a lattice of parallel straight lines is formed by a contracting microscope on the boundary of the film, part of which has been scraped away so as to expose the glass below. The lines are formed perpendicular to the straight boundary between the film and the exposed glass. The displacement between the images of the lines after reflection from (*a*) the metal film, and (*b*) the glass, is photographed using a microscope the axis of which is perpendicular to that of the contracting microscope, both microscopes being inclined at 45° to the film. The two images are not quite continuous and a lateral separation less than that resolvable between two parallel straight line images can be measured. The derivation of the thickness of the film from measurements on the photograph is treated in detail. Photographs are reproduced.—S. G.

A General Review of the Testing Methods for Determining the Mechanical Properties of Aluminium Castings. A. v. Zeerleder (*Light Metals Research*, 1936, **4**, (15), 240–241; and *Light Metals Rev.*, 1936, **2**, (15), 256–257).—Summary of *Aluminium*, 1935, **17**, (11), 570; see *Met. Abs.*, this vol., p. 17.

***Ultra-Acoustic Oscillations and Their Application.** S. J. Sokolov (*Zavodskaia Laboratoria* (*Works' Lab.*), 1935, **4**, (5), 527–538).—[In Russian.] Methods for obtaining ultra-acoustic oscillations with frequencies of 2×10^4–3×10^7 cycles and indicators for detecting and measuring their intensity, and their passage through metals and along conductors were studied. After passage through up to 70 cm. of steel, cast iron, bronze, and brass the oscillations were sufficiently intense to detect when the metal was homogeneous. When two pieces of metal are placed one on top of the other, no oscillations pass from one to the other even if contiguous surfaces are polished almost optically flat, unless the surfaces are lubricated with transformer oil. The absorption of ultra-acoustic oscillations by aluminium, copper, glass, and steel is almost identical, and decreases with increase in frequency. The conducting media for the oscillations from the vibrator to the specimen were mercury and transformer oil. The change in intensity of oscillations produced in a small area and passing along the surface of the specimen was studied. The intensity is always at a maximum opposite the vibrator and declines in all directions, the more sharply the higher the frequency. Defects in metal specimens 0·0005 cm. thick can be detected by the method described. The passage of oscillations through a metal can be detected by three methods: (1) a small beaker of transformer oil is placed on the surface; passage of the oscillations through the metal is shown by the appearance on the oil of ripples visible to the naked eye or by light reflections on to a screen; (2) by a piezoelectric indicator; (3) by immersing the specimen supported on ball bearings in a tank of transformer oil, about 1 mm. above the vibrator and observing the ripples formed in the oil surface as in method (1).—D. N. S.

Ultra-Acoustic Methods for Determining Defects in Metal Goods. S. J. Sokolov (*Zavodskaia Laboratoria* (*Works' Lab.*), 1935, **4**, (12), 1468–1473).—[In Russian.] The theory of the propagation of ultra-acoustic oscillations in different media is outlined and apparatus and appliances employed by the author for detecting defects in metal goods are described (see also preceding abstract).—D. N. S.

Report of the [A.S.T.M.] Committee on Fatigue of Metals. H. F. Moore (*Proc. Amer. Soc. Test. Mat.*, 1935, **35**, (I), 111–112).—The Debye method is shown to be unsuitable for detecting impending fatigue failure in aluminium alloys.—A. R. P.

Notes on Fatigue Tests on Rotating-Beam Testing Machines. —— (*Proc. Amer. Soc. Test. Mat.*, 1935, **35**, (I), 113–120).—Appendix to Report of the A.S.T.M. Research Committee on Fatigue of Metals (preceding abstract). Several types of rotating beam and cantilever fatigue testing machines are described and illustrated and their advantages and disadvantages discussed. Vibration should be kept to a minimum by applying the load with dead weights and maintaining it by means of adjusting nuts on a threaded rod.

Suitable types of specimens and their dimensions are discussed and hints are given for obtaining surfaces free from scratches or tool marks. Finally, the test procedure and the method of recording the results graphically are described.—A. R. P.

Examination of Welds and Weld Seams. G. Fiek (*Anz. Masch.*, 1935, **57**, (87), 25–27).—Modern methods for determining the strength under static, dynamic, and vibratory stresses, the capacity to undergo deformation, and the freedom from defects of welded joints are briefly described with reference to their usefulness and suitability for testing welds.—B. Bl.

Bend Testing of Welds—A Summary. M. F. Sayre (*J. Amer. Weld. Soc.*, 1935, **14**, (12), 2–10).—A valuable review of bend testing methods and specifications at present in use: the relative merits of the various methods are discussed, and a *bibliography* of 47 references is given.—H. W. G. H.

Vacuum-Tube Rectifiers for Material Testing Machines. —— (*Machinery* (*Lond.*), 1936, **47**, (1224), 793–794).—A valve-controlled machine for "dynamic" transverse bending or torsional tests is briefly described and illustrated. Reversed stresses, of a frequency between 50 and 250 reversals per second, are set up in the test-bar by the alternate excitation of two (or, for torsional tests, four) coils.—J. C. C.

***Impact Torsion Test (First Report). Impact Torsion of Mild Steel and Copper. Impact Torsion of Notched-Bar Test-Pieces of Mild Steel.** Mititosi Itihara (*J. Soc. Mech. Eng. Japan*, 1932, **35**, (183), 678–691).—[In Japanese.] See *Met. Abs.*, 1934, **1**, 615.—S. G.

Modern Tension and Elongation Measurements. —— Volk (*Anz. Masch.*, 1935, **57**, (87), 24–25).—Methods for determining the true stress distribution in a structural part are described by reference to examples.—B. Bl.

***The Upper and Lower Yield-Points and the Breaking Strain.** G. Welter (*Metallurgia*, 1936, **13**, (78), 183–187). Cf. *Met. Abs.*, this vol., p. 50. From tests carried out on testing machines with three types of loading (positively rigid, positively flexible, and direct free loading) it is concluded that the occurrence of an upper and lower yield-limit is merely a matter of test performance and test machine. There is no upper or lower yield-limit, either in connection with mild steel or other metals, and all theoretical hypotheses to explain the decrease in load at the yield-point are untenable. The upper yield-limit is not contingent on the material and is merely to be attributed to the loading mechanism as also to the loading and strain measuring device of the testing machine, and has nothing in common with a characteristic property of the material tested. Only an accelerated yielding of the material takes place at the yield-limit, owing to which no decrease is caused in the load from an upper to a lower load stage of the test-bar. Similarly, the decline in loading from the maximum load to the breaking load on the material is a matter of a peculiarity of the machine, according to which the actual conditions obtaining in the tensile test are not reproduced true to reality.—J. W. D.

Determination of the Hardness of the Structural Components of Cast Hard Alloys (Micro-Hardness). I. S. Brokhin (*Zavodskaia Laboratoria* (*Works' Lab.*), 1935, **4**, (12), 1480–1483).—[In Russian.] Methods for the determination of the hardness of the individual structural components of Stellite and similar alloys in which nickel is substituted for cobalt (Sormite; Smena).—D. N. S.

***Mechanical Properties Due to the Values of the Ionic Radii.** V. D. Kuznetzov (*Zhurnal Fizicheskoy Khimii* (*J. Phys. Chem.*), 1935, **6**, (6), 813–815).—[In Russian.] Determination of the hardness by the pendulum method and by grinding for the following three groups of elements (1) copper, silver, gold, (2) beryllium, magnesium, zinc, cadmium, (3) arsenic, antimony, bismuth, indicates that the hardness depends on the ionic radii within the limits of each of the three groups of Goldschmidt.—N. A.

XII.—TEMPERATURE MEASUREMENT AND CONTROL

(Continued from p. 128.)

Construction of a Sensitive Vacuum Thermocouple. E. Picker and G. Rudinger (*Z. tech. Physik*, 1935, **16**, (9), 265–267).—Describes the construction of a vacuum thermocouple, consisting of films of iron and Constantan of respective thicknesses 0·06 μ and 0·5 μ, deposited upon mica by vaporization *in vacuo*. The sensitivity of the device is compared with that of various other thermocouples.—J. S. G. T.

Two New Applications of the Expansion Pyrometer. P. Chevenard (*Génie civil*, 1935, **107**, (18), 424–427; *C. Abs.*, 1936, **30**, 1266).—Improvements in construction have made this type of pyrometer sufficiently robust for factory use, either as a control apparatus or as an automatic heat regulator. Drawings and photographs explain the construction and working principles of the pyrometers and their use in grain-growth studies.—S. G.

Increasing Sensitivity of Bimetal Thermometers. J. Blair Dowden (*Production Eng.*, 1935, **6**, 388–389; *C. Abs.*, 1936, **30**, 1266).—A multiple helix form of bimetal thermometer is described and illustrated, and the underlying principles are discussed. A single strip is wound in the form of concentric helices. The several coils are additive in rotational deflection, but the axial displacement is mutually counterbalanced between the coils. A thermal element no larger than the bulb of a thermometer is accurate to fractions of a degree.—S. G.

The Calibration of Platinum Thermometers at the Boiling Point of Sulphur. C. D. Niven (*Canad. J. Research*, 1936, [A], **14**, (1), 1–15).—A description is given by which certain difficulties in experimental technique can be overcome. —S. G.

XIII.—FOUNDRY PRACTICE AND APPLIANCES

(Continued from p. 128.)

Non-Ferrous Castings. A. Logan (*Met. Ind.* (*Lond.*), 1936, **48**, (13), 379–382; and *Found. Trade J.*, 1936, **54**, (1022), 231–232, 234).—Summary of a paper read before the East Midlands Branch of the Institute of British Foundrymen. Discusses methods of melting non-ferrous alloys, costs of coke, oil-fired, and rocking arc electric furnaces and gives details regarding a number of aluminium alloys and the difficulties to be met in die-casting. —J. H. W.

Some Factors Which Influence Soundness in Non-Ferrous Castings. A. Logan (*Proc. Inst. Brit. Found.*, 1934–1935, **28**, 683–706; discussion, 706–711).—See *Met. Abs.*, 1935, **2**, 357.—S. G.

***The Influence of Gases on the Production of Pores in the Casting of Copper Alloys.** E. Raub and F. Distel [with M. Marchand] (*Giesserei*, 1936, **23**, (5), 111–114).—Alloys of copper with up to 10% of zinc, aluminium, tin, or nickel were melted in atmospheres of hydrogen, water vapour, carbon dioxide and sulphur dioxide, and after cooling quickly the sp. gr. was determined. Addition of even small quantities of zinc to copper prevented absorption of all gases except sulphur dioxide, and addition of more than 1% of aluminium had the same effect even with sulphur dioxide. On the other hand tin prevents absorption of water vapour and carbon dioxide only and nickel has very little effect, copper–nickel alloys being very sensitive to all the atmospheres tested.—A. R. P.

†Present Position of the Preparation, Working, and Uses of Aluminium–Bronzes. (Lay.) See p. 148.

On the Use of Cupola Furnaces in Brass Foundries. Edmund R. Thews (*Giesserei*, 1936, **23**, (6), 135–136).—The advantages and disadvantages of cupola melting are briefly outlined.—A. R. P.

On the Selection of the Type of Moulds [for Casting Muntz Metal Ingots]. V. O. Gagen-Torn (*Metallurg* (*Metallurgist*), **1935**, (11), 104–106).—[In Russian.] The best type of moulds for casting cylindrical ingots of Muntz metal is discussed. One-piece moulds involve difficulties in cleaning and checking the condition of the surface, but are practically free from heat deformation, produce no tangential forces in the ingot, give comparatively equal cooling throughout their length, and produce no seams down the sides of the ingot, whereas all these advantages are absent with split moulds.—N. A.

The Antifriction Mechanical Mixture of N. S. Orlenko. P. E. Korjak (*Metallurg* (*Metallurgist*), **1935**, (11), 101–104).—[In Russian.] Instead of pure Babbitt, the bearings are filled with a mechanical mixture of bronze shavings and Babbitt by Orlenko's method. For high-speed machinery the mixture contains 40–50% of bronze shavings and for rolling-mills 80–90%. The first mixture is prepared by preheating the bronze to 200°–250° C. and then stirring in the molten Babbitt. The mixture is cast as a pasty mass at 460°–480° C. The second mixture is prepared similarly except that the bronze is preheated at 350°–370° C. and cast at 500°–530° C. Tables of results of tests on bearings are given.—N. A.

New Methods in the Preparation of Bearings with Lead–Copper Alloy Linings. Kurt Nischk (*Giesserei*, 1936, **23**, (1), 4–7; and *Met. Ind.* (*Lond.*), 1936, **48**, (14), 415–416, 422).—A review of recent patents.—A. R. P.

Use of Babbitting Jigs Saves Machining. Oliver Herbert (*Machinery* (*N.Y.*), 1936, **42**, (7), 470–471).—Jigs for Babbitting locomotive cross-heads, cross-head slippers, and T-shaped cross-head guides are illustrated and described.—J. C. C.

†**On Elektron and Hydronalium Castings.** P. Spitaler (*Giesserei*, 1936, **23**, (8), 177–181).—The mechanical properties of various Elektron and Hydronalium sand-casting alloys are tabulated, practical hints for producing sound castings are given, and some actual and possible uses of the alloys are indicated.—A. R. P.

Standardization of Foundry Operations in Japanese Railway Works. Shinzaburo Onishi (*Suiyokwai-Shi* (*Trans. Min. Met. Alumni Assoc.*), 1935, **8**, (9), 827–836).—[In Japanese.] Various foundry methods are standardized to simplify the operations, *e.g.* sizes of moulding boxes and methods of moulding light castings.—S. G.

Sand Problems in a Brass Foundry. F. Howitt (*Proc. Inst. Brit. Found.*, 1934–1935, **28**, 90–114; discussion, 114–121).—See *Met. Abs.*, 1935, **2**, 394.
—S. G.

Centrifugal Castings in Non-Ferrous Metals. Adolf H. Ludwig (*Anz. Masch.*, 1936, **58**, (26), 13–14).—See also *Met. Abs.*, 1935, **2**, 536. The advantages of centrifugal over sand- and chill-casting are discussed.—B. Bl.

Report of [A.S.T.M.] Committee B–6 on Die-Cast Metals and Alloys. J. R. Townsend and P. V. Faragher (*Proc. Amer. Soc. Test. Mat.*, 1935, **35**, (I), 181–183).—Minor modifications in tentative standards are proposed, and the activities of 7 sub-committees are outlined.—A. R. P.

An Investigation of Aluminium Die-Casting Alloys Nos. IVa and Va. E. E. Thum (*Proc. Amer. Soc. Test. Mat.*, 1935, **35**, (I), 184–189).—Appendix I to Report of A.S.T.M. Committee B–6 on Die-Cast Metals and Alloys. A large number of round and flat die-castings of three aluminium alloys were prepared by two American producers to standard specifications and their composition and properties determined. The results showed that there should be little difficulty in producing die-castings to specification although the products of one producer were more porous than those of the other.—A. R. P.

Die-Casting the Light Alloys. E. Stevan (*Machinist* (*Eur. Edn.*), 1936, **80**, (7), 120–121E).—Describes the cold-chamber plastic die-press method for aluminium and magnesium alloys, using a modification of the Polak and Buhler types of machine.—J. H. W.

***Hot Shortness of Aluminium Alloys in the Form of Die-Castings.** (Verö.) See p. 146.

High-Strength Zinc-Base Alloys. Recent Developments in Die-Castings. A. H. Mundey (*Met. Ind.* (*Lond.*), 1936, **48**, (15), 443–446).—Summary of a paper read before the Midland Metallurgical Societies (Birmingham Local Section of the Institute of Metals, Birmingham Metallurgical Society, and Staffordshire Iron and Steel Institute). Early work on the production of zinc and the manufacture of zinc alloys is summarized, and the requirements of the American Society for Testing Materials for zinc-base die-casting alloys are examined. [*Note:* That part of the original paper illustrating the construction, development, and use of die-casting machines is not reproduced.]—J. H. W.

Metals Used in Die-Casting. Charles H. Hughes (*Machinery* (*N.Y.*), 1936, **42**, (7), 446–449).—Tables are given of the composition and mechanical properties of the generally used die-casting alloys, and their applications are discussed.—J. C. C.

Which Alloy for Die-Castings? Herbert Chase (*Production Eng.*, 1935, **6**, 379–382).—See *Met. Abs.*, 1935, **2**, 625.—S. G.

XV.—FURNACES AND FUELS

(Continued from p. 129.)

†**[Use of Town's Gas for] Bright-Annealing.** —— (*Gas World* (*Indust. Gas Suppt.*), 1936, **8**, (3), 12–13).—The use of town's gas for the bright-annealing of sterling silver articles and for annealing nickel silver is described. No muffle is employed and no additional source of purging gas other than the products of combustion of the gas used to heat the furnace is required. The annealed silver requires no pickling and is free from "fire-mark."—J. T.

On the Use of Cupola Furnaces in Brass Foundries. (Thews.) See p. 171.

A New Furnace for Melting Aluminium and Aluminium Alloys. U. Schwedler (*Z. Metallkunde*, 1936, **28**, (3), 69–71).—An induction type of furnace is described and illustrated; the furnace is operated on 3-phase current and has internal iron cores in the bottom so arranged as to produce circulation of the charge. In melting Hydronalium a loss of 0·1% magnesium and a total metal loss of less than 1·2% is claimed.—A. R. P.

Natural Gas for Cutting, Galvanizing, and Soldering. Frank Pexton (*Gas Age-Record*, 1936, **77**, (14), 339–340, 346).—Natural gas is applied in Kansas for cutting steel, for galvanizing (in place of coke), and for soldering (in place of hydrogen). Experience in these operations is briefly discussed.—J. T.

British Coals; Their Analyses and Uses. —— (*Fuel Economist*, 1936, **11**, (126), 232–233).—Analyses are given of coals supplied by the Backworth Collieries, Ltd.—J. S. G. T.

XVI.—REFRACTORIES AND FURNACE MATERIALS

(Continued from pp. 129–130.)

Report of [A.S.T.M.] Committee C–8 on Refractories. R. A. Heindl, E. H. Van Schoick, and C. E. Bales (*Proc. Amer. Soc. Test. Mat.*, 1935, **35**, (I), 259–264).—Modifications in tentative standards are suggested and the work of the various sub-committees is outlined.—A. R. P.

Refractories for Foundry Use. W. J. Rees (*Proc. Inst. Brit. Found.*, 1934–1935, **28**, 73–82; discussion, 82–89).—See *Met. Abs.*, 1935, **2**, 721.—S. G.

***An Apparatus for Investigating the Corrosive Action of Slags on Refractory Materials.** A. E. J. Vickers and R. A. Bell (*J. Soc. Glass Tech.*, 1935, **19**, (74), 151–155).—The apparatus described consists of a circular furnace built of the materials under test. The furnace is heated with a rotating blowpipe fed with gas and air under pressure, and the slag is injected through the blowpipe flame.—F. S.

The Temperature Conductivity of Ceramic Bodies. W. Steger (*Ber. deut. keram. Ges.*, 1935, **16**, (11), 596–606).—The temperature conductivity relates to the storage of heat in a body through which heat is passing, and is distinct from thermal conductivity. It may be taken as a measure of the rate of heat absorption. Apparatus was developed for measuring the temperature conductivity of ceramic bodies up to 400° C.—F. S.

Notes on the Suitability of Silicon Carbide Bricks. R. Klesper (*Sprechsaal*, 1935, **68**, (25), 385–388).—Silicon carbide or Carbofrax bricks have remarkably high thermal conductivity and resistance to thermal shock, but they have comparatively low resistance to water vapour, alkalis, molten slags rich in lime and iron, and molten metals. They are resistant to molten silica and acid slags. The uses to which silicon carbide refractories can be put are outlined; they are, however, definitely limited by the ready decomposability of the material.—F. S.

***A Note on Some Characteristics of Fireclay, with Special Reference to Manufacturing Difficulties.** C. A. G. Thomas and J. R. Adderley (*J. Soc. Glass Tech.*, 1935, **19**, (74), 139–142).—A study was made of iron content, plasticity, shrinkage, and porosity. Electromagnetic separation did not remove more than 0·15% of the total iron content of two clays investigated. Weathering did not suffice to make a non-plastic clay plastic. Plasticity is often in inverse ratio to the depth of the clay seam below the surface.—F. S.

Recent Revisions of High Temperatures. L. D. Morris and S. R. Scholes (*J. Amer. Ceram. Soc.*, 1935, **18**, (12), 359–360).—New points have recently been established which differ from those previously accepted in pyrometry. Of special importance to refractories are the following melting points: Al_2O_3–SiO_2 eutectic, 1551° C. (1545°); cristobalite, 1729° C. (1713°); mullite, 1827° C. (1810°); and alumina, 2083° C. (1050°), the old values being given in parentheses.—F. S.

***Solid Reactions at 1000° to 1200° C. Between MgO or BeO and Ni, Fe, Cr, Mn, and Their Oxides.** L. Navias (*J. Amer. Ceram. Soc.*, 1936, **19**, (1), 1–7).—Nickel, iron, chromium, and manganese and their oxides NiO, Fe_2O_3, Cr_2O_3, and MnO_2 were brought into contact, in a fine state, with granular, fused MgO in loose form and in pressed discs, and also with slabs of high-fired MgO and BeO. Temperatures of 1000°, 1100°, and 1200° C. were reached in an air atmosphere. The degree of reaction was determined by the extent of discolouration of the MgO and BeO near the contact material. In order of increasing reactivity, the elements are nickel, iron, chromium, and manganese and the oxides were in the corresponding order. The elements caused more reaction in all cases than the oxides, and there was less reaction with BeO than with MgO. In a hydrogen atmosphere, fused MgO showed no reaction with nickel and iron, chromium very slight, and manganese slightly more. NiO and Fe_2O_3 were reduced to their elements without reaction, whereas Cr_2O_3 did not reduce and gave no reaction. MnO_2 became somewhat sintered with a very slight reaction. Moist and dry air or nitrogen were also passed into mixtures of granular fused MgO and manganese, MnO_2, or chromium. Reaction was greatest with moist air at 1200° C.—F. S.

The Determination of Alkalis in Silicates, with Special Reference to High-Alumina Refractories. E. B. Read (*J. Amer. Ceram. Soc.*, 1935, **18**, (11), 341–346).—High-alumina materials can be decomposed by the J. Lawrence Smith method with a single fusion, provided that this is conducted at about 1200° C. In a second procedure, the material is decomposed with a mixture of nitric, sulphuric, and hydrofluoric acids. Magnesia is eliminated by precipitation with 8-hydroxyquinoline, and the alkalis are weighed as sulphates. The exact analysis of high-alumina materials is best done by the J. Lawrence Smith method.—F. S.

XVII.—HEAT-TREATMENT

(Continued from p. 130.)

***The Quenching of Aluminium Alloy Pistons in Boiling Water.** I. Podolskiy (*Metallurg* (*Metallurgist*), **1935**, (11), 99–101).—[In Russian.] Experiments on quenching an aluminium alloy containing copper 11–13, magnesium 0·2, lead 0·1, bismuth 0·1, nickel 0·5–1·2, manganese 0·2, silicon 0·7, antimony 0·2, and iron 1·0% after a 45 minutes' anneal at 510°–520° C. in boiling water, 0·5% sodium hydroxide solution, and cold water-glass showed that hot-water quenching is the equivalent of oil quenching. After quenching in boiling water and tempering at 220° C. for 2 hrs. the Brinell hardness is 107 and the tensile strength 15·05 kg./mm.^{2}, whereas after oil quenching the corresponding values are 121 and 15·8 kg./mm.^{2}.—N. A.

***Some Experiments on the Strain of Duralumin Caused by Quenching.** I. Igarashi (*Sumitomo Densen Iho* (*Res. Rep. Sumitomo Steel, Tube, and Copper Works*), 1933, **1**, (12), 809–814).—[In Japanese.]—S. G.

***Tempering of Duralumin.** T. Matsuda (*Sumitomo Densen Iho* (*Res. Rep. Sumitomo Steel, Tube, and Copper Works*), 1932, **1**, (2), 80–91).—[In Japanese.] —S. G.

***Artificial Ageing of Duralumin.** A. T. Gornostaeva (*Metallurg* (*Metallurgist*), **1935**, (12), 73–78).—[In Russian.] Results of the artificial ageing of Duralumin at 100° C. are given in tables. Maximum increase of mechanical properties is obtained by artificial ageing immediately after quenching.—N. A.

***Heat-Treatment of a Nickel–Bronze.** G. Koiso (*Sumitomo Densen Iho* (*Res. Rep. Sumitomo Steel, Tube, and Copper Works*), 1933, **1**, (12), 860–870).—[In Japanese.]—S. G.

The Production of Copper Wire. Annealing and Drawing Operations Described. (Fielding.) See p. 175.

XVIII.—WORKING

(Continued from p. 130.)

†The Results of Cold-Work [on Metals] and Their Disappearance with Increase in Temperature. G. Tammann (*Z. Metallkunde*, 1936, **28**, (1), 6–17); and (summary) *Light Metals Research*, 1936, **4**, (16), 261–263).—Recent work on the recovery of mechanical and electrical properties of cold-worked copper, silver, gold, aluminium, iron, nickel, platinum, and palladium is critically reviewed and the behaviour of various solid solutions is also discussed. A *bibliography* of 29 references is appended.—A. R. P.

***On the Working Temperature and Working Degree of Metals and Alloys.** I. Igarashi (*Sumitomo Densen Iho* (*Res. Rep. Sumitomo Steel, Tube, and Copper Works*), 1933, **1**, (7), 421–438).—[In Japanese.]—S. G.

On the Rolling Theory of Karman and Pavlov's Conditions for the Planes of Entrance and Discharge of Metal in Rolling. N. F. Lashko (*Metallurg* (*Metallurgist*), **1935**, (12), 59–64).—[In Russian.] A mathematical discussion. —N. A.

On the Deformation of the Mounts of Rolling Mills. S. D. Brilkin (*Metallurg* (*Metallurgist*), **1935**, (11), 107–113).—[In Russian.] The technique of measuring these deformations is discussed since they can be utilized for checking the load on the mill, if desired, with an automatic recorder. The presence in the mount, of a faulty bending indicates that the design or the assembly of the rolling mill is faulty. By extensometric measurements of the deformations of the mounts the pressure on the screw during the rolling can be calculated.—N. A.

Metallurgical Aspects of Deep-Drawing. I.—Improvement Effected in the Quality of Metal During the Last Ten Years. J. D. Jevons (*Met. Ind.* (*Lond.*), 1936, **48**, (14), 403–408).—Discusses some of the improvements made in the quality of deep-drawing materials during the past decade, the more serious troubles encountered in the deep-drawing industry at the present time, the desirable characteristics of good-quality drawing material, the form and usefulness of specifications, and the trend of current and the nature of desirable developments in both metal and drawing practice with respect to brass sheet and strip.—J. H. W.

Stamping, Pressing, and Deep-Drawing of Light Metals. H. Stein (*Anz. Masch.*, 1936, **58**, (18), 1–4).—Numerous examples of these methods of working light metals are given.—B. Bl.

Aluminium 1936 Practice. F. V. Hartman (*Machinist* (*Eur. Edn.*), 1936, **80**, (9), 185–192E).—Describes the modern practice in forming aluminium, extruding aluminium shapes, impact extrusion, and forging, welding, and machining aluminium.—J. H. W.

Rubber and Wood Used for Dies in Forming Airplane Parts. Charles O. Herb (*Machinery* (*N.Y.*), 1936, **42**, (7), 425–430).—For producing shapes in small quantities from aluminium alloy or steel sheet, rubber pads may be used on a hydraulic press to force the metal to the contour of a zinc die. Zinc punches and dies may also be used. The dies are made by casting zinc in plaster-of-Paris moulds. Large and small shells are spun on wooden forms. —J. C. C.

Hot-Pressings in Brass and Other Non-Ferrous Metals. J. Willis Beard (*Met. Ind.* (*Lond.*), 1936, **48**, (15), 438–442).—Read before the North-East Coast Local Section of the Institute of Metals. Gives detailed consideration to many of the finer points involved in the successful production of pressings in both brass and an increasing range of other non-ferrous alloys.—J. H. W.

Impact-Extrusion of Soft Metals. —— (*Machinery* (*Lond.*), 1936, **47**, (1222), 717–718).—In the impact-extrusion process, a disc of soft metal such as zinc, aluminium, or even copper, is placed at the bottom of a die and struck with high pressure by a punch so that the metal is forced to flow up the annular clearance space between punch and die. Tests on tin-coated lead discs gave uniformly-tinned shells when the discs were perfectly tinned. A crank-driven press for the production of aluminium shells with a maximum stroke of 270 mm., a pressure capacity of 125 metric tons, capable of an output of 65 pieces per minute, is illustrated. The minimum tube diameter which can be extruded is 8 mm., the minimum wall thickness ranges from 0·1 to 1·5 mm., according to the tube diameter, and the ratio of depth to diameter is 6 : 8 for small diameters, with a maximum depth of 250 mm. Oval, rectangular, or ribbed cans or shells can be produced, eyes or lugs can be formed on the ends, and the wall thickness can be made to taper to the top.—J. C. C.

The Production of Copper Wire. Annealing and Drawing Operations Described. A. Walker Fielding (*Wire Industry*, 1935, **2**, (24), 411, 413, 415).—F. discusses the poling process as applied to H.-C. copper, the influence of impurities on the metal, and particularly the risk of gassing oxygen-containing coppers by annealing in reducing conditions. [*Note by Abstractor :* F.'s statements relating to the solubility of copper (*i.e.* cuprous) oxide in solid copper are not in agreement with generally accepted views, while his use of the term " oxygen-free " to describe copper deoxidized with zinc, aluminium, or silicon is open to serious objection.] He briefly discusses old and more modern methods of annealing, pickling, tandem-type drawing machines, properties of drawn wire and influence on them of die design, synthetic and diamond dies, economics of fine-wire-drawing machines, a suitable pot for bright-annealing fine wire on reels, and drawing solutions.—W. E. A.

Decorative Wires for the Silversmith. A. J. Dodworth (*Wire Industry*, 1935, **2**, (24), 441–443, 445).—A well-informed, detailed practical discussion of methods of production of decorative wires of silver, nickel, nickel silver, and aluminium–bronze. Manufacture is described in all its stages, from casting and machining of the cast bars, through breaking-down and V-rolling, wire-drawing and/or rolling, to the production of finished patterned wires by rolling, stamping, or piercing. Methods of roll-cutting and -punching are described.—W. E. A.

Wire Beginnings. Kenneth B. Lewis (*Wire Industry*, 1936, **3**, (25), 3, 5, 7, 9; (26), 49, 51, 53, 55, 57).—Historical.—W. E. A.

Wire-Drawing Machine. A Multiple-Unit Design. —— (*Machinery Market*, **1936**, (1848), 27).—A new type of machine is illustrated and described. It can be built up of any number of units which are each complete in themselves, the only difference being in the ratio of the driving gear to accommodate the increase of speed as the wire travels from one pass to another.

Some Non-Ferrous Metal Powders. J. C. Chaston (*Aluminium and Non-Ferrous Rev.*, 1936, **1**, (6), 229–231).—The methods used for making metal powders from magnesium, aluminium, copper, and lead are outlined, and the characteristics and uses of the products described.—J. C. C.

The Autogenous Cutting of Metals by the Application of Various Heating Gases. —— Schneider (*Anz. Masch.*, 1935, **57**, (94), 3–4).—The influence of hydrogen, coal-gas, and acetylene on the formation of the cutting flame is discussed.—B. Bl.

XIX.—CLEANING AND FINISHING

(Continued from pp. 130–131.)

The Use of Catalysts in the Pickling of Metals. M. Pécriaux (*Verre et silicates indust.*, 1936, **7**, (3), 30–31).—S. G.

Cleaning of Aluminium Equipment in a Brewery. H. Pasdermadjian (*Aluminium Ltd., Geneva, Abstract Bull.*, **1936**, Jan. 15; *Light Metals Rev.*, 1936, **2**, (19), 335).—A successful cleaning medium for aluminium equipment used by a Scottish brewery is fine ashes taken from the boiler smoke-box and mixed with natural yeast. A paste is formed and applied with a cloth, the equipment being thoroughly rinsed with water afterwards.—L. A. O.

Barrel Burnishing. Walter R. Meyer (*Oberflächentechnik*, 1935, **12**, (20), 243–247; and (abstract) *Monthly Rev. Amer. Electroplaters' Soc.*, 1935, **22**, (12), 36–39).—Practical hints are given on dry sand burnishing, wet burnishing in soap solutions, and ball burnishing.—A. R. P.

Applying [Nickel and Chromium Plated] Finish to Chevrolet Bumpers. J. M. Bonbright (*Machinery (N.Y.)*, 1934, **41**, (3), 158–160).—Details are given of the sizes, grades, and working speeds of the wheels used in polishing automobile bumpers before and after plating with nickel and chromium at the Chevrolet plant in Detroit, U.S.A.—J. C. C.

XX.—JOINING

(Continued from pp. 131–132.)

British Standard Specification for the Dimensions of Small Rivets (Ferrous and Non-Ferrous, of Nominal Diameters Below ½ In.) for General Purposes. —— (*Brit. Stand. Inst.*, No. **641**, 1935, 13 pp.).—S. G.

Advances Made in Welding Aluminium. G. O. Hoglund (*Iron Age*, 1936, **137**, (12), 46–47).—Discusses the application to various industrial requirements of improved technique in welding aluminium.—J. H. W.

The Welding of Thick Aluminium. —— (*Soudure et Oxy-Coupage*, 1935, **12**, (71), 276).—Over 6 mm. thickness, it is recommended that the welding should be carried out in two runs, using a blowpipe of capacity 75–100 litres per mm. thickness, and a filler rod of diameter equal to the thickness. The edges of the sheet should be chamfered to form a single Vee of 70°–90°. The bottom of this Vee is filled in by the first run for a few inches, and then the second run superposed, the process being repeated until the seam is complete. The seam is finished by hammering and annealing.—H. W. G. H.

Aluminium Canoe. —— (*Oxy-Acetylene Tips*, 1935, **14**, (12), 280).—An oxy-acetylene welded canoe is described and illustrated.—H. W. G. H.

Adherent Lead Coating. —— (*Soudure et Oxy-Coupage*, 1935, **12**, (71). 275).—Steel vessels are lined with lead by means of the oxy-acetylene flame. The steel surface is cleaned with hydrochloric acid and "tinned" with solder or with pure lead, using sal ammoniac as flux, the lead coating itself then being applied by building-up to the required thickness. It takes 30 hrs. to deposit 57 kg. of lead/m.^{2}, and 50 hrs. to deposit 112 kg./m.^{2}.—H. W. G. H.

Chemical Plumbing and Lead Burning Ancient and Modern. E. B. Partington (*Indoxco*, 1935, **1**, (2), 8–12).—The properties of lead are described and a brief *résumé* is given of its manufacture. The properties to be expected of chemical lead are described, and mention is made of the alloys of lead used in chemical works. A short description is given of the best flame to be used in lead burning.—W. E. B.

Flame Lead Burning in the Manufacture, Maintenance, and Repair of Batteries and Accumulators. E. B. Partington (*Indoxco*, 1936, **1**, (6), 12–16).—Describes methods used in the repair of accumulators with the oxy-acetylene blowpipe.—W. E. B.

Oxy-Acetylene Welding. L. C. Percival (*Aluminium and Non-Ferrous Rev.*, 1936, **1**, (4), 161–167; (5), 202–207).—Read before the Swansea Local Section of the Institute of Metals. Deals with the welding of aluminium and its alloys, magnesium and its alloys, alpha and alpha-beta brasses, and copper. Bronze welding as applied to cast iron, copper, and steel, hard facing, the use of copper–phosphorus alloy welding rod, and the welding of zinc-base die-castings are also discussed.—J. C. C.

Electrical Characteristics of the Welding Arc. S. C. Osborne (*J. Amer. Weld. Soc.*, 1935, **14**, (11), 11–18).—Voltage and energy distribution in the arc, ionization and thermionic emission, the three arc zones, and transient conditions are discussed in order to determine the requirements for optimum arc performance. Oscillographic records with different generators show that the slope of the initial voltage rise after short circuit and the value of the subsequent dip are more important than the total time required to establish uniform conditions, which is often regarded as a criterion of a good generator. The machine with the highest current uniformity factor produced the best conditions in the arc. It is concluded that conduction in the arc is dependent on the voltage and is little affected by the current, whilst fusion is dependent on the current and little affected by the voltage, and the temperature is controlled by the boiling points of electrode materials.—H. W. G. H.

British Standard Specification for Rating of Electric Arc Welding Plant and Equipment and for Welding Accessories. —— (*Brit. Stand. Inst.*, No. **638**, 1935, 10 pp.).—S. G.

Spot-Welding Problems. J. H. Zimmerman (*J. Amer. Weld. Soc.*, 1935, **14**, (12), 20–25).—A review of recent developments in operating mechanism, electrode materials, and timing devices is followed by a discussion of the research in progress at the Massachusetts Institute of Technology. The welding of Alclad and structural steels, and the factors influencing electrode deterioration, are the main problems under investigation. A *bibliography* of 40 references is given.—H. W. G. H.

Prediction of Weld Performance. Nairne F. Ward (*J. Amer. Weld. Soc.*, 1935, **14**, (12), 11–15).—The general factors which influence the performance of welds are discussed, and the use of models for verification of design data is described. Welded models, subjected to tests which simulate service conditions, are recommended for showing stress concentrations and enabling the probability of premature failure to be recognized.—H. W. G. H.

Examination of Welds and Weld Seams. (Fiek.) See p. 169.

Bend Testing of Welds.—A Summary. (Sayre.) See p. 169.

XXI.—INDUSTRIAL USES AND APPLICATIONS

(Continued from pp. 132–135.)

Light Metals for the Construction of Machines and Vehicles. —— Methe (*Anz. Masch.*, 1935, **57**, (51), 22–23).—Examples of the use of light metals in the construction of the framework of railway wagons, fire-engine pumps, blowers, vanes of mine ventilators, and economizers with copper tubes enclosed in Silumin shells are described.—B. Bl.

Aluminium in the Textile Industry. H. J. Fahrney (*Amer. Silk Rayon J.*, 1936, **15**, (Feb.), 33–34, 53; *C. Abs.*, 1936, **30**, 2392).—The numerous applications of aluminium in textile machinery parts are enumerated. Aluminium is widely used in the manufacture of viscose rayon.—S. G.

New Textile Uses of Aluminium. J. R. Whitelegg (*Textile Manufacturer*, 1936, **62**, 26; *C. Abs.*, 1936, **30**, 2392).—The anodic treatment of aluminium is expected to increase the uses of aluminium in textile manufacture.—S. G.

Aluminium and the Light Alloys in Means of Transport. M. Pubellier (*Rev. Aluminium*, 1936, **13**, (77), 25–32).—Read before the regional group of the Ingénieurs des Arts et Métiers de Saint Étienne. Describes the applications of light aluminium alloys in the motors and coachwork of automobiles, trains, ships, lifts, &c.—J. H. W.

New Articulated Light-Metal Coaches of the Northern Railway of France. —— Chatel and —— Yollant (*Railway Gazette*, 1936, **64**, (17), 795–799).—Describes a 3-coach articulated unit with aluminium–magnesium alloy bodies assembled by welding and attached to a welded steel underframe of braced girder construction. About 37½% saving in weight is effected, compared with ordinary steel coaches.—L. A. O.

Aluminium Alloys in Shipbuilding and Marine Engineering. J. W. Donaldson (*Metallurgia*, 1936, **13**, (78), 173–177).—A review of recent progress in the application of aluminium alloys in shipbuilding and marine engineering. The alloys used, conditions which they have to withstand—particularly as regards corrosion—and methods of protection are discussed. The use of light alloys in hull and superstructural work, for ship equipment and fittings, for insulation purposes; of pure aluminium as a paint; and of aluminium alloys in marine engineering and in small craft are dealt with.—J. W. D.

Oil Industry Affords Many Favourable Opportunities for Use of Aluminium. —— (*Oil and Gas J.*, 1936, **34**, (40), 42, 44).—The special applications of aluminium and certain of its alloys in the storage and transport of acid and sulphur-rich oils are discussed. A table summarizes the principal mechanical properties of pure (commercial) aluminium, Alclad, and some casting or forging alloys.—P. M. C. R.

Calcium–Aluminium as a Deoxidant for Steel. G. P. Fenner (*Iron Steel Ind.*, 1936, **9**, (7), 244).—A range of calcium–aluminium alloys containing up to 25% calcium has been produced on the commercial scale by means of the so-called Calloy process. In general steel practice, an alloy containing 8–12% calcium has been found satisfactory as a substitute for pure aluminium as deoxidizer. Where special steels require treatment, an increase in calcium content to 25% is advantageous, since the higher prices which such steels command, leave a wider margin for production costs. The calcium–aluminium is added in the form of 1-in. cubes for deoxidation of steel in the ladle, and in standard stick form for ingot steels.—J. W. D.

Bending Thin-Walled Tubes. A New Filler Alloy of Low Melting Point [Bendalloy]. —— (*Motor Transport*, 1936, **62**, (1622), 15).—See *Met. Abs.* (*J. Inst. Metals*), 1933, **53**, 103.—L. A. O.

Report of [A.S.T.M.] Committee A–10 on Iron–Chromium, Iron–Chromium–Nickel, and Related Alloys. Jerome Strauss and H. D. Newell (*Proc. Amer. Soc. Test. Mat.*, 1935, **35**, (I), 107–110).—Brief accounts are given of the programmes adopted by the 10 sub-committees.—A. R. P.

Report of [A.S.T.M.] Committee on Copper and Copper Alloys, Cast and Wrought. C. H. Mathewson and D. K. Crampton (*Proc. Amer. Soc. Test. Mat.*, 1935, **35**, (I), 179–180).—Various proposed tentative standards are discussed briefly.—A. R. P.

Report of [A.S.T.M.] Committee B–1 on Copper Wire. J. A. Capp and J. H. Foote (*Proc. Amer. Soc. Test. Mat.*, 1935, **35**, (I), 133–135).—The committee is preparing standard specifications for bare, concentric-lay copper cable, bronze trolley wire, and copper trolley wire.—A. R. P.

British Standard Specification for Dimensions of Varnished Cambric Insulated Annealed Copper Conductors for Electricity Supply, Including Voltage Tests. —— (*Brit. Stand. Inst.*, No. **608**, 1935, 39 pp.).—S. G.

***On Materials for Commutator Bars.** G. Koiso (*Sumitomo Densen Iho* (*Res. Rep. Sumitomo Steel, Tube, and Copper Works*), 1933, **1**, (9), 597–608).—[In Japanese.]—S. G.

British Standard Specification for Light Gauge Copper Tubes. —— (*Brit. Stand. Inst.*, No. **659**, 1936, 9 pp.)—Applies to light gauge copper tubes suitable for connection by means of compression joints or capillary joints or by bronze welding, and for working water pressures up to 150 lb./in.^{2} (350 ft. head). The specification does not apply to re-drawn used tubes.—S. G.

[Uses of Copper.] —— (*Bull. Copper Brass Res. Assoc.*, 1936, (**86**), 1–16).—The following subjects are referred to and illustrated : the durability of copper roofs erected in America, Europe, and the Far East ; copper convectors used in conjunction with heat radiators ; old clocks and watches made of brass ; the use of copper in house construction ; ornamental brass and bronze used in the building of stores ; copper and bronze implements unearthed in Persia and dating from A.D. 266 to 644, and chromium-plated ware.—J. S. G. T.

Copper Houses. E. J. Malvey (*Metal Progress*, 1936, **29**, (2), 46, 88).—Describes a house built of millboard faced with copper sheet, supported on steel frames, and gives details of joints, roofing, and internal finish.—P. R.

Beryllium–Copper Used in Electrical Switch Spring. A. L. Riche (*Electrochem. Soc. Preprint*, **1936**, April, 197–198 ; and (abstract) *Met. Ind.* (*Lond.*), 1936, **48**, (18), 519).—Springs made of 2·25% beryllium–copper alloy heat-treated at 260° C. have withstood many million flexures ; they are superior to those made of phosphor–bronze and are, furthermore, resistant to corrosion and good conductors of electricity.—S. G.

Beryllium-Copper: Established Properties and Proved Applications. Robert W. Carson (*Production Eng.*, 1935, **6**, 175–177; *C. Abs.*, 1936, **30**, 1719).—Photographs indicate a variety of applications. Hardness, fatigue strength, conductivity, ductility, and stability are controlled by heat-treatment and cold-work in fabrication.—S. G.

***On the Uses of Albrac Other Than for Condenser Tubes.** Gorô Koiso (*Sumitomo Kinzoku Kōgyō Kenkyu Hōkoku* (*Res. Rep. Sumitomo Metal Industries, Ltd.*), 1935, **2**, (5), 391–394).—[In Japanese.] Experiments on Albrac tubes show that on account of their excellent corrosion-resisting properties, they may be used for purposes other than for condenser tubes, *e.g.* condensing and evaporating tubes for refrigerating machines, pipes for hot-water supply or oil transport, and for machine parts and components which are in contact with superheated steam or water, dilute acids, mercury, &c.—S. G.

***"A.R." [Copper] Alloy Tube Used for Aero Engine.** T. Tanabe and S. Tamura (*Sumitomo Densen Iho* (*Res. Rep. Sumitomo Steel, Tube, and Copper Works*), 1933, **1**, (12), 871–875).—[In Japanese.]—S. G.

British Standard Specification for Lead Pipes for Other Than Chemical Purposes. —— (*Brit. Stand. Inst.*, No. **602**, 1935, 6 pp.)—S. G.

Machine Bearings of Domestic and Substitute Materials. Wolf von Bleichert (*Anz. Masch.*, 1936, **58**, (8), 13–14).—The substitution of lead alloys for Babbitts and of aluminium for tin in bearing bronzes is discussed.—B. Bl.

Bearing Requirements in Automotive Engines. V. Skillman (*Production Eng.*, 1935, **6**, 362–363; *C. Abs.*, 1936, **30**, 1722).—The evolution of the different bearing alloys is discussed.—S. G.

Magnesium in Aero Construction. R. de Fleury (*Usine*, 1936, **45**, (9), 29; (10), 34–35).—Brief summary of *Publ. Sci. Tech. Ministère de l'Air*, No. **75**, 1935. See *Met. Abs.*, this vol., p. 62.—P. M. C. R.

Nickel Alloy Gear Materials and Their Heat-Treatments. J. W. Sands and F. J. Walls (*Production Eng.*, 1935, **6**, 370–373; *C. Abs.*, 1936, **30**, 1721).—Gears made of nickel alloys, heat-treated steel, cast iron, and bronzes are compared as regards composition and physical properties. Diagrams and photographs are given.—S. G.

Producing Steel Rolls Faced with Nickel and Monel. —— (*Amer. Metal Market*, 1936, **43**, (62), 2).—A brief note. Steel rolls have been successfully covered with nickel and Monel metal by a welding process. It is expected that they will be used in all industries where non-corrosive rolls are required.—L. A. O.

Niobium and Its Uses. L. Sanderson (*Sands, Clays, and Minerals*, 1936, **2**, (4), 94–101).—A review of the occurrence, methods of extraction, uses, and properties of niobium. At present the chief use seems to be as an addition to stainless steel to prevent intercrystalline corrosion.—A. R. P.

A Sparking Plug with Platinum Electrode. —— (*Motor*, 1936, **69**, (1781), 55).—The advantages of a general-purpose plug suitable for most engines are enumerated and results of tests are given in a brief article.—L. A. O.

Sparking Plugs with Platinum Points. —— (*Engineer*, 1936, **161**, (4180), 211).—See preceding abstract.—L. A. O.

Zinc as a Chemical Raw Material. Bruce R. Silver (*Chem. Industries*, 1936, **38**, (1), 25–28; (2), 141–144).—Contains information on the following points *inter alia:* the annual production of zinc from 1914 to 1934 in the principal producing countries, the estimated consumption by American industries in 1934, American brands of zinc, standard specifications for purity and price statistics for 1914–1934.—A. R. P.

Consumption of Zinc for Galvanizing. —— (*Amer. Metal Market*, 1936, **43**, (62), 3).—Statistical.—L. A. O.

Report of [A.S.T.M.] Committee B–2 on Non-Ferrous Metals and Alloys. R. F. Mehl and E. E. Thum (*Proc. Amer. Soc. Test. Mat.*, 1935, **35**, (I), 136–140).—Modifications are recommended in the standard specifications for common lead, special high-grade zinc and certain analytical procedures.
—A. R. P.

Non-Ferrous Alloys Available for the Use of Industry. —— (*Aluminium and Non-Ferrous Rev.*, 1936, **1**, (5), 198–201; (6), 241–242).—Cf. *Met. Abs.*, this vol., p. 98. Particulars are given of a number of aluminium alloys and high-tensile bronzes and brasses.—J. C. C.

German Materials in the Construction of Water Pipe-Lines. S. Clodius (*Gas- u. Wasserfach*, 1935, **78**, 589–593; 615–623).—The substitution of imported metals, *e.g.* nickel, copper, and lead, by materials of German origin is discussed with especial reference to the use of aluminium wool instead of lead wool as a packing material for joints in iron pipes.—B. Bl.

Effect of Metals on Flavour of Dairy Products. H. A. Trebler (*Proc. Internat. Assoc. Milk Dealers, Plant Sect., 28th Ann. Convention*, **1935**, Oct., 107–123; *C. Abs.*, 1936, **30**, 2272).—A general discussion and review.—S. G.

The Construction of New Dairy Plant. G. S. Perham (*Proc. 8th Ann. State Coll. Wash. Inst. Dairying*, **1935**, 28–32; *C. Abs.*, 1936, **30**, 2271).—Discusses plant lay-out and choice of materials which will withstand the corrosive action of dairy products.—S. G.

Metals and Alloys in the Chemical Industry. Frederick A. Rohrman (*J. Chem. Education*, 1936, **13**, (2), 53–59; (3), 106–110).—The electrochemical theory of corrosion is briefly outlined, and the composition and treatment of the ferrous and non-ferrous metals used in the chemical industry for the handling of hydrochloric acid, hot crude phosphoric acid, and hot gases such as sulphur dioxide and sulphur trioxide are described.—J. H. W.

Metals and Alloys in Locomotive Construction. V. Harbord (*J. Inst. Locomotive Eng.*, 1936, **26**, (129), 46–62; discussion, 62–77).—Examples, mainly ferrous, are described of the failure of engineering parts from various causes; including stress concentration by tool marks, sharp corners, or date stamps, and "caustic embrittlement." Reference was made in the discussion to the use of Hiduminium for connecting rods.—J. C. C.

All-Metal Bodywork. William Swallow (*Automobile Eng.*, 1936, **26**, (342), 75–77).—A summary of the considerations in modern body requirements and design. The materials available for metal body construction are dealt with, and reference is made to the use of aluminium alloys from the point of view of weight–strength ratio, and of zinc alloy die-castings for many subsidiary parts and for door hinges.—J. W. D.

Metal in Functional Architecture. F. Charles Thum (*Metal Progress*, 1936, **29**, (2), 43–46).—Metal structural members, which are increasingly employed in modern architecture, include light alloys of the Duralumin type, and white nickel bronzes. Dirt-proofing in industrial atmospheres is discussed.
—P. M. C. R.

Heat and Sound Insulation. André Kessler (*Technique moderne*, 1936, **28**, (8), 297–302).—The thermal conductivity and sound-absorbing capacity of 29 insulating materials are tabulated; lead and a lead–asbestos mixture are included. The use of lead in the sound-proofing of music-rooms and in deadening the vibrations of machinery is illustrated by diagrams.—P. M. C. R.

†Alloys for Sparking Plug Electrodes in Aero-Engines. J. B. Fridman (*Tehnika Vosdushnogo Flota* (*Technology Aerial Navy*), **1935**, (11), 46–54).—[In Russian.] The literature is reviewed and some results of tests on plugs of foreign make are described.—N. A.

Recent Applications of Metallization Classified by Industries. —— (*Métalliseur*, **1936**, (1), 11–14).—Describes the metallizing of the ventilation system, refrigerating coils, fire-proof bulkheads, and the smoke stacks of the liner

Normandie and the repair of the propellers by the same process. The use of aluminium for aircraft exhausts and the spraying of steel carriages for railway Companies are described. The metallizing of condensers by spraying the plates of mica with lead or silver is mentioned.—W. E. B.

California Testing Laboratories, Inc., Make Report [on Metal Spraying]. (*Metallizer*, 1936, **4**, (2), 8, 9).—Tests showed that sprayed aluminium coatings are better than lagging with ½ in. of asbestos plaste as insulators against heat losses. The tests were carried out on a small boiler. Although the metallized coatings gave good results, they were not much superior to coatings of aluminium paint.—W. E. B.

***Metallization of Electrodes for Electric Furnaces.** G. F. Morenko (*Domez*, **1935**, (8), 39–45; *C. Abs.*, 1936, **30**, 1306).—[In Russian.] Graphite electrodes coated with copper and aluminium were compared with non-coated electrodes in the actual operation of smelting steel in the electric furnace. Copper withstood these conditions better than aluminium, but neither was as good as iron or steel coatings.—S. G.

XXII.—MISCELLANEOUS

(Continued from p. 135.)

Recent Advances in Metallurgy. D. Hanson (*Met. Ind.* (*Lond.*), 1936, **48**, (14), 409–411).—Summary of a paper read before the Midland Metallurgical Societies (Birmingham Local Section of the Institute of Metals, Birmingham Metallurgical Society, and Staffordshire Iron and Steel Institute). Discusses the importance of equilibrium diagrams, the nature of solid solutions, the structure and properties of different phases, and the working and strength properties of metals.—J. H. W.

Ten Years' Work of the Mechanical Group of the Leningrad Physico-Technical Institute. N. N. Davidenkow (*Metallurg* (*Metallurgist*), **1935**, (12), 103–112).—[In Russian.] Reviews work carried out at the Institute on the plasticity, strength, and elastic properties of solid bodies, new methods of testing materials and structures, and on brittleness of metals. 56 *references* are given.—N. A.

Man and Metal. (Sir) William Larke (*Proc. Inst. Brit. Found.*, 1934–1935, **28**, 54–72).—Edward Williams Lecture. See *Met. Abs.*, 1935, **2**, 405. —S. G.

†**Fifty Years of Aluminium Alloy Development.** E. H. Dix, Jr., and J. J. Bowman (*Metals and Alloys*, 1936, **7**, (2), 29–34).—An historical review. —A. R. P.

The Platinum Industry in 1935. Charles Engelhard (*Aluminium and Non-Ferrous Rev.*, 1936, **1**, (4), 160).—See also *Met. Abs.*, this vol., p. 98. Uses of the platinum metals are briefly surveyed. A flute made entirely of platinum-iridium alloy is claimed to have exceptional purity of tone on account of the high density of the material.—J. C. C.

The Photo-Electric Cell and Its Applications. Robert Dreyfus (*Usine*, 1936, **45**, (17), 34–35).—A review of the general principle of the photo-electric cell is followed by a description of the principal types, and by a summary of their uses. Works' applications include a device for the automatic cutting of a given length of metal sheet, an apparatus for the testing of the surface finish of sheet, and an automatic switch for stopping the rotation of spools from which wire has been wound.—P. M. C. R.

XXIII.—BIBLIOGRAPHY

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(Continued from pp. 135–138.)

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[Contents: O. W. Roskill: "The European and World Zinc Situation in 1935"; J. O. Elton: "Zinc Mining in the Rocky Mountains Region"; R. B. Paul: "Zinc Mining in the Eastern Region (including Virginia)"; M. D. Harbaugh: "Zinc Mining in the Mississippi Valley Region"; R. Ammon: "Retort Smelting Operations"; C. R. Ince: "Electrolytic Smelting Operations."]

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XXIV.—BOOK REVIEWS

(Continued from pp. 139–140.)

The Metal—Iron. By H. E. Cleaves and J. G. Thompson. Med. 8vo. Pp. xii + 574, with 113 illustrations. 1935. New York: McGraw-Hill Book Co., Inc. ($6.00); London: McGraw-Hill Publishing Co., Ltd. (36*s.* net).

This monograph has been prepared at the National Bureau of Standards as a part of its contribution to Alloys of Iron Research. It consists of a review of available information on the preparation and properties of metallic iron of high purity. After chapters on laboratory and commercial methods for the production of electrolytic iron and on the chemical preparation of high purity iron, there is an introduction to the properties of iron. A chapter on the structure includes a consideration of crystal form, allotropy, and microstructure, six chapters deal with particular groups of properties such as thermal, magnetic, chemical, mechanical, &c.; there is a chapter on heat-treatment and ageing, and lastly one on the effects of minor constituents. At the end of each chapter there is an authors' summary of the chief matters dealt with. There is an excellent bibliography appended, consisting of 86 pages. It refers mainly to articles which have been consulted for the work and the references are arranged chronologically by year of publication from 1827 to 1935, and by authors alphabetically.

This book will prove to be a handy reference work for matters connected with the metal iron.—C. O. BANNISTER.

Metallography of Aluminium and Its Alloys. By V. Fuss. Translated from the German by Robert J. Anderson. Roy. 8vo. Pp. xiv + 424, with 337 illustrations. 1936. Cleveland, O.: The Sherwood Press, Box 2617 Lakewood Branch. ($10.00 post free.)

Although the metallography of aluminium and its alloys has been discussed in several books, Dr. Fuss' book is one of the few dealing primarily and exhaustively with this subject, and therefore an English translation will be widely welcomed. The German edition has already been favourably reviewed in *Met. Abs.* (1935, **2**, 132). The translator has not attempted to amplify or to reduce the subject-matter, but he has re-arranged the text considerably, so that the systems are now dealt with in alphabetical order, and the diagrams now appear in the text instead of in folding plates at the end of the book. The bibliography, too, has been re-arranged, amplified, and brought up to date. The translation is excellent, and the changes which the translator has made do nothing but enhance its value. The book is very well printed and the illustrations leave nothing to be desired.—H. W. L. PHILLIPS.

Principles of Metallography. By Robert S. Williams and Victor O. Homerberg. Third Edition. Post 8vo. Pp. ix + 313, with 302 illustrations. 1935. New York: McGraw-Hill Book Co., Inc. ($3.50); London: McGraw-Hill Publishing Co., Ltd. (21*s.* net).

This book is intended to give to those students of general science or engineering who do not specialize in metallography, the fundamentals of physical metallurgy and to serve as an introduction to larger and more specialized books.

The first two chapters are devoted to the development of the equilibrium diagram, binary and ternary. The explanations given are clear, but perhaps too elementary, and too much is made of Tammann's "time of solidification" method for the determination of the composition of eutectic mixtures. In Fig. 21 is shown what purports to be the normal cooling curve of a solid solution; only alloys in a system where the liquidus and solidus are sensibly parallel can give curves of this type. The phase rule is explained in some 3 pages, a treatment either too adequate or entirely inadequate. There is then a chapter on non-ferrous alloys of technical importance. The principal alloys of copper and aluminium are mentioned and there are short accounts of the formation of slip-bands, hardening by work, age-hardening, and grain-size. The familiar diagrams of the brasses, the bronzes, and the aluminium–bronzes are reproduced, but a typical diagram to illustrate the structures of some simple aluminium-rich alloy is not to be found.

The long central section of the book is devoted to a description of the structure and common defects of iron and steel. This section is clearly and concisely written, although in the heat-treatment of case-hardened steel (p. 134) it is not immediately obvious that it is the core which must be heated above its Ac_3 point. The constitution of the chromium steels is described in some detail and in an interesting manner, but the subject is perhaps a little difficult for the student who has only a slight acquaintance with metallography.

The final chapter, on laboratory methods, we find somewhat strange. The description of thermal analysis is only second rate. Some 30 pages are devoted to descriptions of mounting, polishing, and photographing sections, and though there are no less than 10 photographs of metallographs and their attachments, no place has been found for the Vickers outfit. There are then 5 pages on magnetic testing, 2 pages on radiography, and 2 pages on the X-ray diffraction method, a treatment which does not seem to justify the note in the preface that these sections have been rewritten and extended. There is no mention of the electrical resistance method and very little about mechanical testing, though we think that the subject of hardness deserves a large place in a book of this type. There is practically nothing about fatigue and nothing at all about creep, but the book is, at least in part, for students of engineering. There are various appendices—a brief, and not very satisfactory outline of a laboratory course in metallography, a list of books and journals, a list of common alloys, and various tables of etching reagents reproduced from the Handbook of the American Society for Steel Treating and other sources.

The volume is pleasant to handle; the photomicrographs and print are excellent. The authors are reluctant to use hyphens and we find words such as "preeminent" and "nonuniform."—D. Stockdale.

Metallurgical Dialogue. By Albert Sauveur. Demy 8vo. Pp. iii + 166. 1935. Cleveland, O.: American Society for Metals. ($3.00.)

This volume consists entirely of an imaginary dialogue between pupil and master commencing with the pupil's question "Do we know why steel hardens when plunged red hot in cold water"? From the nature of this question it will be realized that the book deals mainly with matters arising on the changes which take place during the heating and cooling of steel, on its constitution and heat-treatment, properties, &c. Certain non-ferrous metals and alloys are used as examples to illustrate particular subjects, *e.g.* Duralumin in the case of age-hardening and Carpenter and Elam's work on aluminium in the case of single crystals of metals. The author takes the opportunity to express strong views against the examination system, and also makes quite clear his loyalty to the existence of beta iron.

In lieu of a preface, Dr. Sauveur makes a statement indicating his inability to think of a good reason why anyone should read this conversation, but he may rest assured that many metallurgists will read it with pleasure and profit as it brings out in an interesting manner much varied information which cannot be otherwise than helpful to practitioners who have left their student days behind.

Excellent photographs are reproduced and details of careers given of Bessemer, Sorby, Tschernoff, Roberts-Austen, Howe, Osmond, Brinell, Stead, White, Arnold, Mathews, and Rosenhain.—C. O. Bannister.

Galvanizing. A Theoretical and Practical Treatise for the Use of Works Managers, Students, and Others. By Heinz Bablik. Translated by Margaret Juers-Budicky. Second Edition, Completely Rewritten and Greatly Enlarged. Demy 8vo. Pp. viii + 367, with 226 illustrations. 1936. London: E. & F. N. Spon, Ltd. (20*s*. net.)

The small treatise " On the Galvanizing of Iron," which was published in Vienna in 1924, was followed in 1926 by the author's " Galvanizing," published in London and New York. As our knowledge of the subject became enriched by subsequent research these former works were added to by " La Galvanisation du Fer " (Paris, 1927) and " Grundlagen des Verzinkens " (Berlin, 1930). In his latest book Herr Bablik has produced a practical work dealing in a straight-forward manner with the actual conditions and difficulties met with in the industry.

The several operations of the hot-galvanizing process are each dealt with in some detail. The influence of the temperature and the strength of the pickling solutions employed is discussed, attention is given to the important question of maximum iron content permissible for efficient scale removal, and to the inhibitory effect of sodium chloride and the dissolved salts of arsenic, antimony, bismuth, and mercury in the pickling solution. The formation of blisters and the production of acid brittleness are considered, and the use of inhibitors as an aid to their prevention is discussed.

After a study of flux compositions and reactions the author passes on to the theory of galvanizing and the structure of galvanized coatings, which are considered in great detail. The author deals with the effect on the appearance of the spangle and the physical properties of the coating, of the time and temperature of dipping, the type of zinc used, the impurities in the zinc, the intentional addition of elements such as tin, antimony, and aluminium to the bath, and the condition of the articles before dipping, with particular reference to their hydrogen content.

Lay-outs and descriptions of pickling and galvanizing equipments are discussed, and the lead–zinc and the dry galvanizing processes are considered.

The electrodeposition of zinc from acid and alkaline baths is treated in a rather elementary manner, the sherardizing and spraying processes are dealt with in two short chapters, whilst the final chapter deals at some length with the testing and judging of galvanized coatings.

The bibliography which is appended contains over 200 references, and gives the book an added value as a work of reference to those engaged in all branches of the galvanizing trade.

—E. R. Howell.

Leitfaden für Azetylenschweisser (Verschmelzen und Durchbrennen von Metallen). Von Theo. Kautny. Elfte, erweiterte Auflage. Herausgegeben von H. Holler. Cr. 8vo. Pp. viii + 284, with 364 illustrations. 1935. Halle a. S.: Carl Marhold. (Geb., R.M. 4.50.)

The " smaller Kautny " is intended for welding operators, foremen, and inspectors, and is probably the most popular handbook on welding ever published. It was revised by Dr. Holler several years ago and this the eleventh edition contains much of his work—notably the nomograms of welding speeds and gas consumptions, which will be found extremely useful. The book refers briefly to every matter of importance to an acetylene welder, and although the non-ferrous welder may be far from completely satisfied, yet he is better served than usual. A definite improvement would be effected by omitting some of the very poor photomicrographs, which are quite useless.—H. W. G. Hignett.

Procedure Handbook of Arc-Welding Design and Practice. Third Edition. Med. 8vo. Pp. x + 596, with 714 illustrations. 1935. Cleveland, O.: The Lincoln Electric Company. ($1.50.)

The first two chapters of this book deal with welding methods, equipment, and technique. Speeds and costs for welding mild steel are then detailed and the properties of weld metal are discussed. In the fifth chapter, or " part," are the only references to non-ferrous metals; copper, Everdur, brass, bronze, and aluminium being considered. The carbon arc is recommended for copper and brass, but both carbon and metallic arcs may be used for the other materials. Full details of technique for welding aluminium by heavy-coated metallic electrodes are given. The remainder of the book is devoted to design for welding in the mechanical, electrical, and structural fields, and to typical applications. The binding, printing, and illustrations of this book are excellent, advertising matter is confined to a short section at the end frankly labelled " Advertising Section," and there is a reliable index: altogether, remarkable value for money.—H. W. G. Hignett.

Precision Workshop Methods. By H. R. Davies. Med. 8vo. Pp. viii + 306, with 208 illustrations. 1935. London: Edward Arnold and Co. (20*s.* net.)

In the preface it is stated that the book is based on notes for a course of University lectures, and it is, therefore, fair to assume that it is intended for students and draughtsmen, as opposed to workshop staff; the value of such a book is obvious provided that the whole project is carried through satisfactorily. The earlier part of the book covering the need for precision, limits, machinability, and setting out is good, but a chapter on cutting lubricants might well be added. The usual methods of location are described clearly; the author apparently favours line and punch-mark methods more than the average mechanic does, but doubtless the choice of this or other methods depends on the equipment available.

About half-way through the work the author appears to have become a little weary of his task. The descriptions of special machines on pp. 148–150 is difficult to follow, and the reader wishes for the drawing or illustration from which the description was written. There are other signs in this part of the book of lack of re-reading by the author—on p. 256 discussing " Go " and " Not Go " gauges, the descriptions are interchanged; this can scarcely be a compositor's error.

There is one notable omission; full chapters are devoted to " Measurement and Gauging " and " Limit Gauging," but there is no reference to Rolt's book on " Gauges and Fine Measurements," which, although published in 1929, is still the standard work on the subject.

To the metallurgist or student who requires information, the book is one to be read, but the reader should beware of reading it and then assuming himself qualified to direct a workshop.

Electron Emission and Adsorption Phenomena. By J. H. de Boer. Translated from the Manuscript by Mrs. H. E. Teves-Acly. Demy 8vo. Pp. xi + 398. with 150 illustrations. 1935. Cambridge: University Press. (21*s.* net.)

The subject of electron emission from metals, when its intricacies were first investigated by Richardson, appeared to be of academic interest only. Now the matter is of extreme importance both in scientific theory and in technology. The radio-valve is the grand-child of Richardson's pioneering experiments, and I have heard Richardson remark how surprised he was when he found that " the egg of thermionic emission had hatched out an elephant." This book, one in the Cambridge Series of Physical Chemistry, edited by Dr. E. K. Rideal, deals with two aspects of the subject, *viz.* it examines what light can be thrown on the subject of adsorption on surfaces by the study of electron emission and *vice versa.* The contents of the book may be briefly indicated: the first chapter deals with emission phenomena, the second with adsorption; then follow four chapters devoted to the influence of conduction electrons on the emission, and the second part of the book deals with the individual properties of adsorbed atoms. The author is attached to the Physical Laboratory of the N. V. Philips' Gloeilampenfabrieken at Eindhoven, whence so much of our knowledge of these subjects has originated. The book is, therefore, authoritative in character. It is a happy blend of experimental work and theory, and is a valuable addition to the literature of a subject which is of extreme importance in both the scientific and industrial senses.

The book is well bound, is well printed on good paper, the illustrations are clear, and adequate name and subject indexes are provided. Its price is quite a reasonable one. The volume will be found indispensable to advanced students of physics and chemistry; industrial laboratories interested in the subject will not require my commendation of the book, as they have been impatiently awaiting its appearance.—J. S. G. Thomas.

Crystal Chemistry. By O. Hassel. Translated from the German by R. C. Evans. Demy 8vo. Pp. xi + 94, with numerous illustrations. 1935. London: William Heinemann, Ltd. (6*s.* net.)

The aim of crystal chemistry is to formulate the relationships existing between the structures and chemical constitutions of crystalline substances. The first step was taken by Mitscherlich in 1818 when he discovered the isomorphism of certain salts of phosphoric and arsenic acids. Laue, aided by Friederich and Knipping, got the subject fairly going when they discovered the diffraction of X-rays by crystals. The literature of the subject is now extremely extensive, difficult, and far from consistent within itself. The blurb of this little book suggests that there is presented " a simple and readily accessible account of some of the work in this field." I dissent. With the subject in its present chaotic state no simple account is possible. What have we here? The chapters on the crystal chemistry of the metals and of intermetallic systems —I choose the chapters of more immediate interest to metallurgists—have, respectively, 3 and 9 pages devoted to them. Polarization in crystal lattices and the geometrical basis of morphotropy are dismissed in something less than 2 pages each. The average length of a chapter is

6 pages. Such condensation may have its purpose; I can't think what that purpose may be. The book is not sufficiently detailed to serve as a text-book; it contains too few references to be of much service to the advanced worker. In so far as it makes available, in English, a book which ordinarily might not come the way of the English reader (Dr. Hassel is Lecturer in Physical Chemistry at Oslo University) the publication of the book is to be commended; but even so, Dr. Hassel's book "Kristallchemie" appeared in 1933, and I know that views expressed in two chapters of the work are already out-of-date.—J. S. G. THOMAS.

Principles and Applications of Electrochemistry. In two volumes. Med. 8vo. Volume I.—**Principles.** By H. Jermain Creighton. Third Edition, Revised and Enlarged. Pp. xviii + 502, with 84 illustrations. Volume II.—**Applications.** By W. A. Koehler. Pp. xiv + 545, with 245 illustrations. 1935. New York: John Wiley and Sons, Inc. (Vol. I, $4.00; Vol. II, $5.00); London: Chapman and Hall, Ltd. (Vol. I, 20*s*. net; Vol. II, 25*s*. net).

The call for a third edition of Volume I within a period of 12 years is testimony to the success of the author in providing a readable book of reasonable size dealing with the fundamental principles of the electrochemistry of solutions, fused salts, and gases. The present edition has been revised and brought up to date, but it does not differ to any marked extent in size or arrangement from the previous one.

Volume II, which is in its first edition, includes a chapter reviewing the fundamental principles of the subject and may thus be regarded as complete in itself. A wide range of industrial processes is dealt with, including subjects some of which might be considered inappropriate in a volume on electrochemistry, for example the construction and use of electric furnaces in both metallurgical and non-metallurgical industries (the treatment of which occupies nearly one-sixth of the book), photo-electric cells, gaseous conduction lamps, magnetic and electrostatic separators. The sections on electro-refining and electro-extraction of metals from aqueous and fused electrolytes and on electrolytic processes in industrial chemistry are, on the whole, well done. The same cannot be said of the two chapters on electroplating which are unbalanced and out of date. The chapters on corrosion and electro-analysis suffer from undue compression. The author has attempted a difficult task but he has produced a readable and well-illustrated book.—A. W. HOTHERSALL.

A Short Manual of Systematic Qualitative Analysis by Means of Modern Drop Reactions. By C. J. van Nieuwenburg and (Miss) G. Dulfer. Second Edition. Med. 8vo. Pp. 96. 1935. Amsterdam: D. B. Centen's Uitg. Maatschappij (N.V.). (Fl. 3.75.)

The aim of this work is to provide the student with a modified systematic course of qualitative analysis for the principal and some of the less common metals and for the common acid radicals with details of modern drop tests for identification or confirmation purposes. The book contains six chapters dealing, respectively, with tests for the common cations, tests for the common anions, tests for some of the rarer elements, dry and other preliminary tests, a systematic course of qualitative analysis, and recommended procedures for some reactions. A short bibliography and a list of necessary reagents are included.

Taken as a whole the work is well done and the explanations and details of procedure, although rather on the brief side, are adequate for most purposes. The least satisfactory part of the book is that dealing with the less common metals, which contains several statements requiring amplification or modification, especially in the tests for tungsten, the earth acids, and zirconium. A number of unimportant misprints have been noticed and the punctuation is, at times, peculiar; the use of the abbreviation prec. for precipitate is unusual in a book written in English, and a similar remark applies to the nomenclature adopted for some of the organic reagents, *e.g.* ortho-oxyquinoline (for 8-hydroxyquinoline) and zincuranyl acetate.
—A. R. POWELL.

V.D.I. Jahrbuch 1936. Die Chronik der Technik. Herausgegeben von A. Leitner. 15 × 21 cm. Pp. xii + 192. 1936. Berlin: V.D.I.-Verlag G.m.b.H. (R.M. 3.50.)

In this, the third of the annual volumes, references to work published during the years 1934 and 1935 are given and in a parallel column are brief summaries of their subject-matter. All the sciences and branches of technology are covered. An interesting account is given in the introduction of the co-ordinated scheme for obtaining scientific books through the medium of centralized lending libraries in Germany.—W. A. C. NEWMAN.

Book of A.S.T.M. Tentative Standards. Issued Annually. (1935 Edition.) Med. 8vo. Pp. xxxiv + 1591. 1935. Philadelphia, Pa.: American Society for Testing Materials, 260 S. Broad St. (Cloth, $8.00; heavy paper, $7.00.)

This annual publication of the American Society for Testing Materials is the only volume containing all of the A.S.T.M. tentative specifications, methods of test, and definitions of terms covering engineering materials and the allied testing field. These *tentative* standards embodying the latest thoughts and practices, are widely used in American industry.

The 1935 edition of the Book (1500 pp.) contains 290 tentative standards. Of these 75 are included for the first time, while some 65 were revised this year and are given in their latest approved form.

New tentative specifications published for the first time in 1935 cover the following ferrous and non-ferrous materials: seamless steel still tubes for refinery service, seamless steel heat-exchanger and condenser tubes, steel pipe flanges for general service, heat-treated carbon steel and alloy steel track bolts, carbon steel and alloy steel castings for railroads, steel castings for miscellaneous uses, uncoated and zinc-coated wrought iron sheets, electrodeposited coatings on steel, several types of chromium and chromium–nickel steel castings and sheets, lead-coated sheet copper, lead- and tin-base alloy die-castings, phosphor–bronze plates for bridges and structures. Three new methods of spectrochemical analysis of various non-ferrous metals are given also.

In addition to the 290 A.S.T.M. tentative standards, the 1935 Book of Tentative Standards includes all proposed revisions of standards, which are published to elicit criticism before final adoption. Changes in some 35 standards have been proposed.

To facilitate the use of the book a complete subject index is included, listing items under the materials and subjects to which they apply, and two tables of contents are given, one listing the standards in the order they appear (grouped under general subjects) and the second listing the items in numeric sequence of serial designations.

The production maintains the high standard set by the Society.

American Society for Testing Materials. Proceedings of the Thirty-Eighth Annual Meeting held at Detroit, Mich., June 24–28, 1935. Med. 8vo. Volume 35. **Part I.—Committee Reports, New and Revised Tentative Standards, Tentative Revisions of Standards.** Pp. xvi + 1488, illustrated. **Part II.—Technical Papers.** Pp. v + 769, illustrated. 1935. Philadelphia, Pa: American Society for Testing Materials, 260 S. Broad St. (Paper, $5.50; cloth $6.00; half-leather, $7.00, per part.)

The annual volumes of A.S.T.M. *Proceedings* are published in two parts, Part I comprising committee reports (and appended papers) and the new and revised A.S.T.M. tentative standards, while Part II consists of technical papers, including the Marburg Lecture.

In Part I (1488 pp.) reports from 40 standing committees are included and there are 136 tentative specifications either newly published or revised in 1935. In the section pertaining to ferrous metals, there are extensive reports covering standardization and research on steel products, wrought iron and cast iron, corrosion, magnetic properties, iron–chromium and related alloys, fatigue and effect of temperature. Appended papers discuss fatigue tests on rotating-beam machines and effect of long-time heating on impact strength of 18 : 8 steel. The non-ferrous metal reports are concerned with copper wire, corrosion, electrical-heating and resistance alloys, copper and alloys (cast and wrought), die-cast metals and screen wire cloth. Extensive data are given on the widespread corrosion tests (atmospheric, liquid, and galvanic) of non-ferrous metals and on the extensive exposure tests of die-cast metals. Other reports deal with methods of testing, spectrographic analysis, and metallography.

During 1935, there were issued many new proposed standard specifications and methods of testing materials not previously covered; these are given in this volume in their latest approved form.

Part II (769 pp.) contains in addition to the 37 technical papers presented at the 1935 annual meeting, about 150 pp. devoted to written and oral discussions. The Marburg Lecture on "Aircraft: Materials and Testing" is included in this part. The Symposium on Spectrographic Analysis comprises six technical papers describing methods in current use as applied to various materials—steel, platinum, magnesium and other non-ferrous materials, graphite electrodes, &c.

In the metals field the papers cover such topics as life of rear axle gears, high-speed fatigue tests, influence of time on creep of steels, tests on tin–bronzes at elevated temperatures, continuous-flow corrosion tests of pipe, hardness testing of light metals, relation between tension, static and dynamic tests, and a survey of testing in the precious alloy field. (*Note:* All the papers of non-ferrous or general interest have been abstracted in *Met. Abs.*)