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Vol. 3

Part 3

The Monthly Journal of the
INSTITUTE OF
METALS

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MARCH 1936



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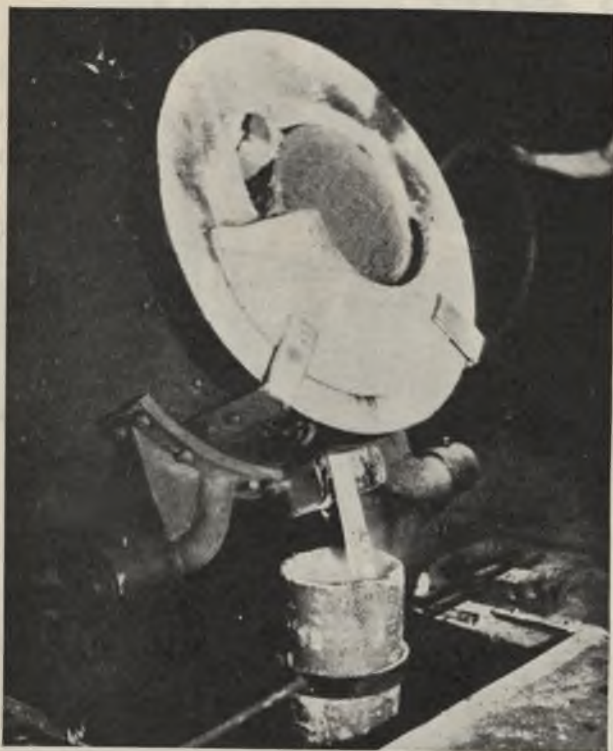
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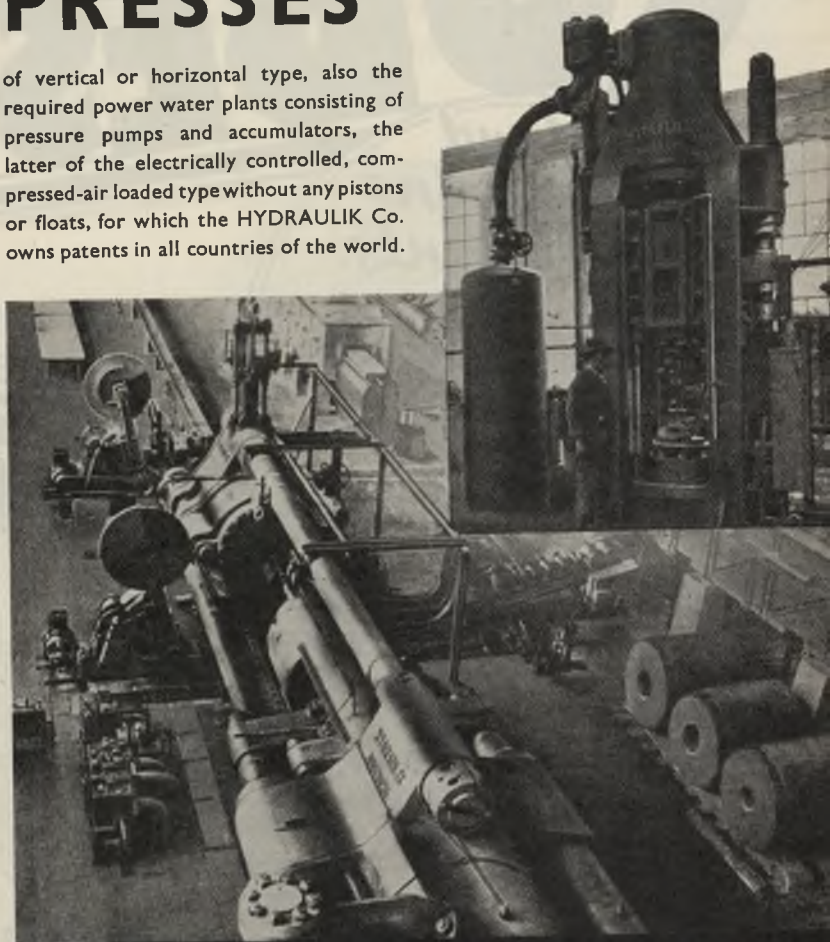
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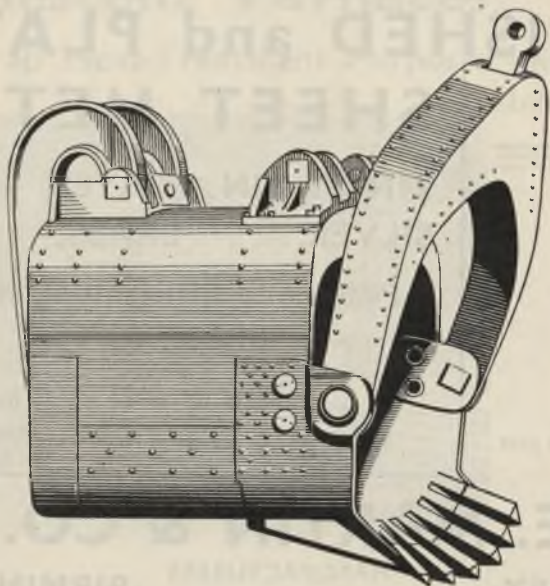
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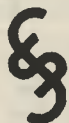
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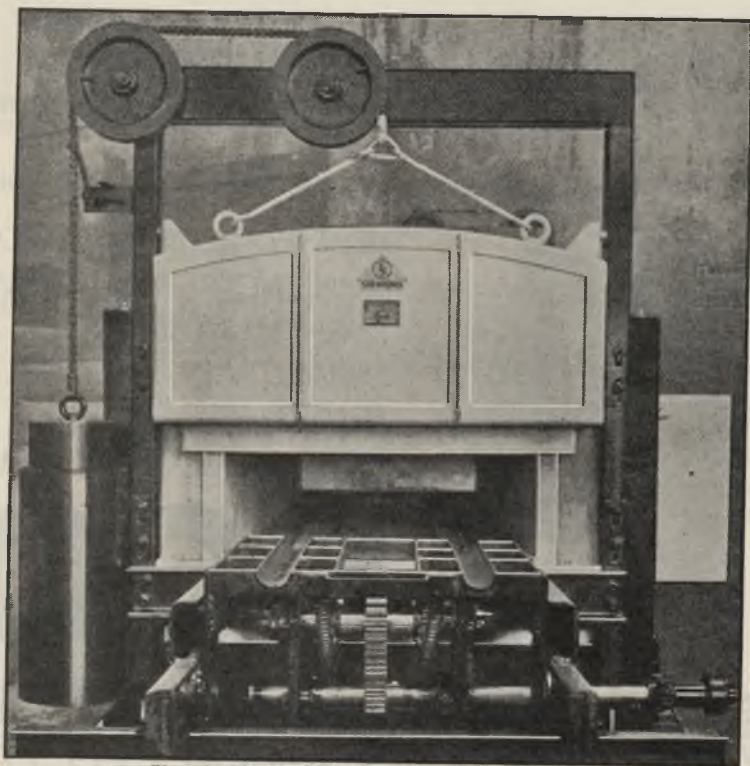
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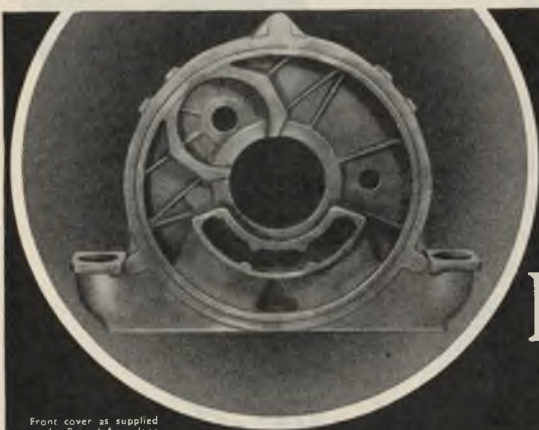
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Volume 3

MARCH, 1936

Part 3

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INSTITUTE NEWS AND ANNOUNCEMENTS

The New President.

THE new President of the Institute is Mr. W. R. Barclay, O.B.E. His Presidential Address, which appears in this issue of the *Monthly Journal*, was delivered at the Annual General Meeting, in London, on March 11. An account of the meeting will appear in our April issue.

Mr. Barclay, who is an Original Member of the Institute, was born in 1875 and was educated privately and at Sheffield Technical School and



University College. For some time he was lecturer in Electrometallurgy in the University of Sheffield. During the War he was Chief Metallurgist to the Non-Ferrous Rolled Metal Section of the Ministry of Munitions. In 1919 Mr. Barclay entered the service of Henry Wiggin & Company, Ltd.; in 1923 he was appointed Technical Director, and subsequently Managing Director. He was appointed to his present post of Consulting Metallurgist to the Mond Nickel Company, Ltd., in 1931. In addition to having served on the Council of the Institute of Metals

since 1925—and being Vice-President from 1929 to 1936—Mr. Barclay is a Past-President of the Birmingham Metallurgical Society; Past-Chairman of the Sheffield and Birmingham Local Sections of the Institute of Metals, and Vice-Chairman of the British Non-Ferrous Metals Research Association, of which he is an Original Member of Council. In 1931 Mr. Barclay was awarded the Thomas Turner Gold Medal of the University of Birmingham for distinguished services to industrial metallurgy.

May Lecture, 1936.

As already announced, Mr. C. C. Paterson, O.B.E. (Member), Director of the Research Laboratories of The General Electric Company, Ltd., Wembley, has accepted the Council's invitation to deliver this year's May Lecture. The subject of his discourse will be "The Escape of Electricity from Metals: Its Practical Consequences." Experimental demonstrations will be arranged in connection with the lecture.

By the courtesy of the Council of the Institution of Mechanical Engineers the lecture will be delivered in the Hall of that Institution, on Wednesday, May 6, at 8 p.m. Members requiring cards of invitation for the use of visitors can obtain these on application to the Secretary.

"Monthly Journal" Title Pages and Contents Lists.

With this issue of the *Monthly Journal* there are circulated the title pages and contents lists for the *Monthly Journal* for the years 1934 and 1935. These are issued in response to requests from members who desire to bind their copies of the *Monthly Journal*, which contain matter that is not reproduced in the bound half-yearly volumes of the *Journal*. The title pages and contents lists do not cover the monthly issues of the *Metallurgical Abstracts* supplement, which are re-issued in bound form each year; the monthly issues of the abstracts are intended to be cut up for card indexing purposes.

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 April issue of the Monthly Journal should reach him not later than March 25.

DR. L. C. BANNISTER, a member of the research staff of Messrs. I.C.I. Metals, Ltd., since 1930, has been appointed Metallurgical Chemist to Messrs. British Insulated Cables, Ltd., and commences his new duties in April.

MR. J. L. CHRISTIE of the Bridgeport Brass Company, has been nominated a Director of the American Institute of Mining and Metallurgical Engineers.

MR. L. N. REEVES, who was for some time Spectroscopist to the Rhokana Corporation, Ltd., N'kana, Northern Rhodesia, has been re-appointed to the staff of the British Non-Ferrous Metals Research Association.

Obituary.

M. RENE BERRIER met with a fatal accident while flying from Marseilles

to Tunis on January 21. M. Berrier, who was Chief Engineer to Brissonneau & Lotz, Nantes, joined the Institute in 1931.

MR. JOHN A. CRABTREE died at Walsall on December 3, 1935. He had been a member since 1918. He was head of the accessories and switchgear business of J. A. Crabtree & Company, Ltd., and achieved, in 1933, the highest office in British Rotary.

LIEUTENANT-COLONEL N. A. DENSON died at Madeira on December 27, 1935. He was a member of the firm of Messrs. Poppleton and Appleby, of Birmingham, who have been the Institute's auditors since its foundation. Colonel Denson became a member of the Institute in 1930.

MR. JAMES PONISOVSKY, B.Sc., died in Brussels on December 31. He had been a member of the Institute since 1932.

HERR CARL SCHWIER died on January 7, 1936, at Cologne. A director of Felten & Guilleaume Carlswerk A.-G., he was elected to membership of the Institute in 1929.

LOCAL SECTIONS NEWS

The work of the six Local Sections for the present session is coming to a close, the remaining gatherings being those of the Swansea Local Section (March 17), when Mr. A. J. Murphy, M.Sc., will read a paper on "Metallurgical Control and the Bronze Foundry"; the London Local Section (April 2), when the Annual General Meeting will be followed by an Open Discussion; and the North-East Coast Local Section (April 7), when, after the business meeting, there will be a demonstration of a high-frequency induction furnace.

The Birmingham Local Section is holding on April 2 its final meeting, at which Mr. A. H. Munday will read a paper on "Recent Developments in the Casting of High-Strength Zinc-Base Alloys." The last meeting of the session of the Manchester Metallurgical Society is to be held on March 18, when the Annual General Meeting will precede an Open Discussion on "Materials and Maintenance of Lifting Gear," to be led by Mr. R. W. Colbeck, M.A.

The Committees of the various Local Sections are now engaged in preparing their programmes for the session 1936-1937; they will be glad to receive offers of papers. The names and addresses of the Honorary Secretaries of the Sections are given on pp. 72-75 of the February issue of the *Monthly Journal*.

The annual meeting of the Local Sections Committee will be held in London on Wednesday, May 6 (on the same day as the May Lecture), when it is expected that the Secretaries of the various Sections will be in a position to present outline programmes for the coming sessions, as well as reports on work accomplished during the past year.

PRESIDENTIAL ADDRESS.

729

DELIVERED BY W. R. BARCLAY, O.B.E.

March 11, 1936.

IT is a conventional opening of a Presidential Address to acknowledge the honour paid to the occupant of this Chair by his election, but I assure you that it is in no merely conventional spirit that I thank you for the confidence thus shown in me. I remember that in similar circumstances the late Dr. Rosenhain said "There is to my mind no higher honour which could be conferred upon a metallurgist interested in non-ferrous metals." With this I am in complete accord. My chief consciousness at the moment is one of inadequacy for the post, but I have received so many assurances of goodwill and support that I feel encouraged to hope that I may be able to render such service to the Institute as will afford a measure of justification of your confidence. I have perhaps two qualifications for the office which, since I can claim no personal credit for them, I may the more freely mention. The first is that as an original member of the Institute and a past-Chairman of its two oldest Local Sections (Birmingham and Sheffield) I have watched its growth from its earliest days and have had internal experience of its activities in the provinces as well as in London. The second is that during the past twelve or fourteen years I have travelled a good deal in Europe and in America and have had somewhat exceptional opportunities of making contact with our members outside this country—thus gaining some knowledge of our standing and influence internationally as well as nationally.

One is greatly tempted on such an occasion as this to indulge in historical reminiscences and to survey in some detail the activities and development of the Institute since its foundation in 1908. I shall resist the temptation, in spite of the attraction of the subject, but one point I feel I must make in these opening remarks is that the measure of the success of this Institute does not lie in the fact that during the years intervening since its foundation its membership has grown from under 200 to well over 2000, or that its income and expenditure

Note to Abstractors and Other Readers.—This paper will be published, in permanent form, in the *Journal of the Institute of Metals*, Vol. LVIII, 1936. Reference should accordingly be as follows: *J. Inst. Metals*, 1936, 58 (Advance copy).

Presidential Address

is reckoned now in thousands instead of hundreds of pounds, but in the influence which it exercises to-day on non-ferrous metallurgy, not only in this country but in almost every civilized portion of the earth. This influence extends beyond anything its founders visualized.

It is difficult for those who belong to the younger generation of metallurgists to realize how much the existence of this Institute has meant to us during the last quarter of a century. Prior to its inception there was no organized body in this or any other country through which original research work in our subject, with critical discussions, could be published to the world on such a scale and under such auspices as would assure either adequate publicity or reasonably easy access. Papers on non-ferrous metallurgy were, of course, published, and tribute should be paid to some of our older engineering institutions and chemical societies for their hospitable reception of these papers, but since many such bodies had little or no obvious connection with non-ferrous metals, it was almost impossible to obtain adequate discussion of them and too often they were overlooked and neglected by those to whom they should have specially appealed. It is no small service that the Institute of Metals has rendered in that it has directed renewed attention to and often breathed new life into some of these pre-Institute contributions to our subject. As the result of reference in the Institute's *Journal* and discussions, some at least of the members of this Institute had their attention called for the first time to such classical researches as those of Heycock and Neville. Still further, it is not too much to say that before the founding of our body the "atmosphere" in regard to research in non-ferrous metals, even for the University worker, was by no means conducive to systematic investigation, and for the industrialist it was definitely discouraging. It was rare indeed in those days to find any appreciable amount of research, as we understand it, proceeding in non-ferrous metal works even in the largest and most important, and even where such research was carried out the results were for the most part embodied in manuscript notes and reports which never went beyond the personal files of the Management or Directorate. It is scarcely necessary for me to enlarge on the contrast to-day, although we are still far below ideal standards. May I remind you that this difference does not apply merely to the inspiration of research and its publication, but to industry itself. The founding and development of this Institute, and more recently of the British Non-Ferrous Metals Research Association, have had an indirect but none the less profound influence on industrial standards and technique, the importance of which I think it is impossible to exaggerate. The stimulus given to research has unquestionably been an incentive to

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the industrial worker to improve technological methods and processes, and the research influence and spirit is slowly but surely penetrating even in those works where no research laboratory exists.

The Institute has also brought within our vision ideals of wider co-operation and co-ordination. Its founders were men of foresight, and not the least of the many evidences of this is found in the original conception of our body as an organization which should include not only "scientific metallurgists" and "manufacturers of non-ferrous metals" but also "engineers and users." It is an important function of the Institute to bring these classes together, and their co-operation will be essential in dealing with the great problems which have to be solved in the future.

In these introductory remarks I wish further to stress the world-wide standing of the Institute. It is a fact of great significance in assessing its value in our scientific and industrial life that, although our offices are in London and we hold our Annual General Meetings there, at least one-third of our members are permanently resident abroad and, as Dr. Seligman has pointed out,* "not wholly in the British Dominions, but for the greater part in countries owing no allegiance to the British Crown." I have already referred to my visits to other countries. In the course of these, many contacts have been made with overseas members of our Institute, and I am grateful for a number of friendships thus formed. In my period of office I earnestly hope to do something to strengthen the bonds between our members abroad and at home, for I believe that this Institute is rendering no small service to the cause of international friendship and co-operation in thus extending and strengthening its fellowship: science, whether theoretical or applied, knows no geographical boundaries, and nothing but good can come from such developments, for we have much to learn from each other. Experience has taught that even in the fiercest commercial competition for international trade some element of co-operation is possible; how much more, therefore, is it attainable in a body which in its original Articles and Memorandum of Association deliberately excludes commercial questions and confines itself to science and technology!

It is fitting that I should quote here from another of our greatly esteemed Past-Presidents, Sir Harold Carpenter, who, in his Address to us in 1918,† said "We organized ourselves from the beginning as an Institute on an international basis. Thereby we gave a definite pledge to mankind that in our judgment peace and not war was the

* *J. Inst. Metals*, 1930, 43, 34.

† *J. Inst. Metals*, 1918, 19, 54. (*N.B.*—During the War period.)

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normal relation between the nations of the earth. . . . Are we not entitled to hope," he continued, "that our act of faith constitutes one of the nuclei from which the League of Nations will ultimately crystallize in a stable and enduring form?"

I am glad to be able to tell you to-day, from my own experience, that the Institute of Metals is held in the highest esteem by its members abroad, and its *Journal* is eagerly looked forward to and valued as an "organ of communication" containing the considered fruits of non-ferrous metallurgical research.

In your name I wish to pay a well-deserved tribute to the many overseas members who themselves have contributed to our proceedings; their service is deeply appreciated.

THE DEVELOPMENT MOVEMENT IN NON-FERROUS METALLURGICAL INDUSTRY.

"The knowledge within our reach is the only knowledge that can be of service to us."

HERBERT SPENCER, "First Principles."

The foregoing remarks on the progress of the Institute and its influence are only introductory to this Address, the major portion of which will be devoted to the consideration of a "movement" which perhaps at first sight has not a very obvious connection with the Institute of Metals, but which, I am convinced, has an important potential bearing on our future progress and prospects. I refer to what may be termed the "development" or "propaganda" movement in modern industrial metallurgy—a movement entirely "post-war," and still in a relatively evolutionary stage. It is founded on the idea that the best method of advancing the interests of the non-ferrous metal industries is to provide the ultimate consumer of metals with information, as up-to-date and accurate as possible, on the properties and applications of non-ferrous metals and alloys as affecting every field of their use, actual or potential. The movement has so far been developed chiefly in four sections of our industries, *viz.* aluminium, copper, nickel, and tin, but a number of firms concerned with other of the elementary metals, particularly zinc and lead, are now organizing themselves in some degree for similar objects. The movement is both national and international, and furnishes opportunities for interchange of information and ideas in and from all markets.

Modern industrial conditions are exceptionally favourable for such activities, for there is to-day passing over all users of metals a profound and far-reaching change of attitude. At the beginning of my industrial life I remember clearly that the constructional

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engineer, whatever his particular branch of work, had certain fixed ideas about metals, from which he rarely departed. He had been trained principally in the use of ferrous materials; *i.e.* to use steel for one purpose, wrought iron for another, cast iron for another, and so on; and except for highly specialized purposes, the non-ferrous metals to him were mainly summed up in copper and brass, in the use of which he again relied chiefly on custom and experience. Each material had its own field and there was a definite gulf between them. The question of replacing one by another was rarely considered except for abnormal requirements.

The introduction and development of alloy steels marked the first departure from the traditional idea that steel, cast iron, brass, copper, &c., had each its individual and exclusive applications. Slowly but surely new alloys intruded on existing fields, and users began to find that improved results were attainable in the quality and efficiency of their manufactures by the adoption of the newer materials which metallurgical science had provided. This change of attitude has now progressed far beyond those initial stages, and there are unmistakable signs of its further development. Probably the United States of America have provided the most spectacular evidence of this, but even in conservatively-minded European countries the user of metals has to-day a far more open mind and receptive attitude to new alloys, and makes a much closer study of their comparative properties. Given a choice—and the field of choice is widening almost daily—he will select the material which gives him what may be roughly but fairly accurately described as “the best value for money,” not necessarily the cheapest, but that which provides him with the means of making the best of his particular product. He will not confine himself to any one class of alloy but will take into consideration all the types now available and the factors of fundamental importance in determining the quality, standard, and reputation of the goods that he himself places in the hands of the ultimate consumer.

It is in this changed atmosphere and environment that these new Development Organizations have been born and although admittedly still in their infancy they are, I feel, already so fully justifying themselves as to deserve at least a brief review in a Presidential Address to this Institute, particularly since our membership, as I have already reminded you, includes the “user” class, to which such activities must make a special appeal.

May I, in passing, point out that the movement is by no means confined to our own industries? Vigorous organizations are now springing up in far wider fields, and the latent possibilities of the idea

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are forcing themselves on the attention of nearly all producers of raw materials, whether metals or non-metals. Recent developments in the coal, gas, timber, rubber, paint, and food industries furnish excellent examples.

In dealing with this subject I propose in the first place to give a brief account of some particular organizations which come within the scope of this Institute, and secondly, to offer a few general observations and suggestions on the movement as a whole.

(1) DEVELOPMENT ORGANIZATIONS.

A. *Nickel.*

I refer to this industry first, since it was here, soon after the Great War 1914-1918, that the abstract ideas behind the movement were primarily given concrete form and systematically developed. Mr. Robert C. Stanley (then a senior official of The International Nickel Company of New Jersey,* America, who at the end of 1921 was appointed its President) together with a colleague, Mr. A. J. Wadhams, were the pioneers in the field. They conceived the idea that so essentially valuable an element as nickel must have potentially far wider uses than the limited field of armaments, which up to the War had been its chief outlet. The problem as conceived by Stanley and Wadhams was to find directions in which nickel might with general advantage be much more widely used in peace industries, and they saw clearly that the first and vital step was to convey reliable information about nickel to the user of metals. Such an end, it was considered, could be attained only by a special organization, and accordingly plans were drawn up for a development department of the Company, staffed by selected specialists with both scientific and practical experience. Mr. Wadhams was appointed its manager, and has held this position continuously to the present day.

Soon afterwards The Mond Nickel Company, Ltd., in England set up a committee to investigate the possibilities of development work on somewhat similar lines, and at the beginning of 1923 a programme was drawn up. A fundamental principle laid down by this Committee was that development work should be based on research, since (to quote from a report made in the early days of the Committee's work) "It is absolutely necessary that, amongst engineers and users of metal generally, a feeling of confidence should be engendered in regard to statements and publications about nickel."

Thus on the American Continent and in Europe, the movement

* Now incorporated, together with The Mond Nickel Company, Ltd., in The International Nickel Company of Canada, Ltd., with Mr. Stanley as President.

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may be said to have taken on a definite form at least fourteen years ago, and although following somewhat differing lines, the two nickel organizations worked with some degree of collaboration. In the United States and the North American Continent generally the work was carried out by the Development and Research Department of The International Nickel Company, and in England by the Research and Development Department of The Mond Nickel Company, Ltd.

In Europe, an important step forward was taken on the initiative of the former company during the year 1927, by the organization of a series of Bureaux of Information on Nickel, operating in leading business and industrial centres, *viz.* London, Paris, Frankfurt, Brussels, Milan (in recent years a Bureau has also been set up in Japan), and when, in 1929, the two companies amalgamated, these Bureaux became an essential factor in organized development work in the nickel industry.

It is not possible within the limits of this Address to give a detailed description of all the activities of the various sections of this organization; the main features, however, are :

- (i) The systematic collection and classification of information concerning nickel and its alloys. For this purpose, a regular search is made of all the world's important technical publications; patent literature of the more important countries is also included. The organization is in close touch, by means of the membership of its research and development staff, with all scientific and technical institutions whose activities relate directly or indirectly to the development of the nickel industry.

By means of a weekly reference sheet, immediate notification is made of all items of interest, to all branches of the Company. This information is classified and filed for permanent reference, and is also made the basis of abstracts which are a specially valued feature of the regular publications of the organizations, *viz.* : *Inco* (U.S.A.); *The Nickel Bulletin* (England); *Revue du Nickel* (France); *Nickel Berichte* (Germany); *Il Nickel* (Italy); *The Japan Nickel Review* (Japan). A digest is also made of pertinent statistical information, with the object of directing work into the channels dictated by current industrial conditions.

Research covering a wide field is in constant progress in the various laboratories of the Company, and the results serve as a basis for development work and the supply of technical information.

- (ii) The issue of monthly or quarterly bulletins summarizing current

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literature on nickel; and of individual publications dealing with specific aspects of the subject. The nickel publications are now a well-known feature of modern metallurgical literature, and there is ample evidence of their usefulness to metallurgists and to engineers.

- (iii) The supply of information to individual enquirers, whether manufacturers, users, or research workers. All enquiries of a technical character are dealt with by specialists in the respective fields.
- (iv) The provision of technical assistance by means of works' visits and personal contacts. This is an important side of the work, because it not only attempts the solution of individual problems arising in manufacture and utilization, but also affords valuable opportunities for estimating the potential future requirements of industry.

As indicated, the foregoing activities are in all cases intimately linked with and supported by research, the policy of the organization being governed by a strong conviction of the usefulness of a reliable technical service as an aid to the establishment of closer liaison between research and practice and as a means for the promotion of sound industrial development. Some current uses of nickel-containing materials which have resulted, directly or indirectly, from the prosecution of this policy, may be briefly mentioned :

In the transportation field (land, air, and marine) the properties of the nickel alloy steels and of non-ferrous alloys containing nickel, *e.g.* aluminium alloys, are being widely utilized to effect reduction of weight combined with an increased factor of safety. As a further step in this direction, the corrosion-resisting nickel-chromium steels are now being employed for constructional purposes. This field is also among the largest users of nickel alloy cast iron, a material whose commercial development represents one of the outstanding examples of the practical results of systematic research. The chemical and chemical engineering industries employ, for a variety of purposes, substantially the entire range of nickel-bearing products, *e.g.* nickel and nickel-clad steel in caustic soda evaporators, nickel-copper alloys in food-handling equipment, pickling plant, and many other forms of chemical apparatus, nickel-chromium alloys in the food and photographic industries, high-nickel nickel-chromium steels and cast iron in the oil, paper, and textile industries. The architectural uses of nickel alloys have also been developed for decorative and for utilitarian purposes. The investigations of the technology of nickel-plating and

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of the properties of nickel deposits have placed this process more and more on a scientific instead of an empirical basis. The wide circulation of the results of research, particularly with regard to the importance of thicker deposits of nickel as an underlay for chromium plating, has had a marked effect in improving the standards of quality in this branch of industry.

In all these developments the nickel research departments and information bureaux have taken an active and often a leading part, and, in addition, they have given wider publicity to highly specialized applications of nickel, as in the sphere of radio and long-distance communication, and in electrical engineering.

B. Aluminium.

The aluminium industry differs somewhat materially from other of the non-ferrous industries in its commercial organization, in that in each country of industrial importance aluminium production is mainly in the hands of one large producer, whose interests are obviously to engage in "development" work on its own account. The endeavour to popularize the use of aluminium by publicity efforts has been throughout its history an outstanding factor in the success of the industry, and within certain limits may be said to have paved the way for the more scientific development work not only in its own but in other fields to which reference is made in this Address.

The present "development" organizations of the aluminium industry are the natural outgrowth of what may be termed "propaganda" publicity—and have been evolved from a period almost coincident with the beginnings of the industry itself. They have in the course of time reached a very high standard and have contributed in no small measure to the amazing industrial and commercial progress of the metal.

Probably the most important stage in their growth was the formation, in 1927, of the International Aluminium Bureau, which is now the official liaison between the individual countries carrying on development work. This Bureau is unique among development organizations in that, although supported by all the principal producers in Europe, it has no external activities of its own except in very special circumstances. All development work which it might institute is normally carried out by its members in each country. Its main function is to collect and circulate information within its own circle and to organize frequent meetings for the exchange of views by technical representatives. In this way each country is kept advised of progress and new developments throughout the world.

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The special circumstances in which the Bureau may itself function are illustrated by such efforts as :

- (1) The collection and arrangement of a joint exhibit in large international exhibitions.
- (2) The organization of an international competition open to competitors in all countries.
- (3) The compilation of publications of international value.

The last-mentioned is a particularly valuable educational feature of the Bureau's activities and is well illustrated by a recent publication on the chemical reactions of aluminium with different chemical compounds and material used in industry. The data for this volume were obtained in all countries, but the volume was compiled and edited by the Bureau. French and German versions of this work have already appeared, and an English edition is on the eve of publication.

Research work, which, as in other industries, is the "backbone" of the development organizations, is carried out by the individual producers in their respective countries; the International Bureau forms a convenient and valuable *forum* for the comparison and discussion of such results of research as are of especial value to development work.

It is, I think, scarcely necessary to point out how successful this movement has been in the aluminium industry. The dissemination of information to consumers has in this field reached a high level of achievement and has extended the use of aluminium and its alloys in almost every conceivable direction. It is true, of course, that in probably no metallurgical industry has research work been more intensive than in this one, and unquestionably the introduction of a number of aluminium alloys possessing valuable industrial and engineering properties has been one of the chief factors in its progress—yet without well-planned and efficiently organized development work no such spectacular advance as that made in the last decade would have been possible. Remarkable evidence of this is the increase in the consumption of aluminium and its alloys in marine engineering. In aeronautical work the metal has so obvious an asset in its lightness that to engineers in this field it has been the metal *par excellence*, but in marine work it is not too much to say that in its earlier history it was a metal to be avoided rather than to be used. Now it is rapidly becoming one of the important materials for ships' fittings and even for ship construction.

Equally interesting are the extensions in the applications of aluminium in other forms of transport. Road vehicles of all types now embody this metal in considerable quantity. In rail transport

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developments have been slower, but several all-aluminium trains in service in the United States are giving entirely satisfactory results, and such an application is itself a tribute to the high degree of development to which both aluminium and its alloys have been brought. In structural engineering also the newer aluminium alloys are proving highly successful, and recent erections of bridges, cranes, and even the frame-work of buildings well illustrate my earlier remarks on the departure from tradition which is a feature of modern developments in the use of metals.

Research and development work in aluminium has also been remarkably successful in finding new uses and applications. Illustrations of this are found in the new fields opened up for the metal by applying special surface treatments such as anodic oxidation, &c. An important example is the discovery, quite recently, of a method whereby the remarkable reflective properties of aluminium can be preserved without deterioration, thus leading directly to its adoption for reflecting surfaces of all kinds—mirrors, flood-light reflectors, heat reflectors, and so on.

C. Tin.

The formation of the International Tin Research and Development Council will be readily recalled by all here to-day. In December, 1931, the Governments of the chief tin-producing countries decided to provide certain funds for this purpose, and the organization thus formed commenced work in the early part of 1932—Mr. D. J. Macnaughtan, now a member of our own Council, being appointed its Director, with headquarters in London. Its aims were defined as follows :

“To acquire and disseminate scientific and technical knowledge relating to tin, its alloys and chemical compounds, the processes involved in the production of these materials and their applications; to discover and develop new industrial applications of tin; to improve the existing products and processes; and to assist tin consumers in overcoming technical difficulties and problems.”

At an early stage a Bureau of Technical Information and a Statistical Office were established, organized for the collection and examination of scientific and technical literature relating to tin in its various applications. This information is filed and indexed so as to be available in the planning and prosecution of researches and for supplying information in response to technical inquiries from

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industry. A unique collection of data has been made since the Bureau was established. Numerous communications have been forwarded to the Bureau by Government departments, research institutions, industrial establishments, and individual research workers all over the world, a large proportion being from America. The services of the Bureau are available to anyone who wishes to acquire information on any of the applications of tin. The Statistical Office surveys all the statistical information on tin in all departments of its uses, and this service is of great importance in guiding research and development along the lines likely to prove most productive and in providing users of tin with authoritative and comprehensive information regarding the production, consumption, and stocks of tin throughout the world.

As its name implies, the organization is definitely international, and its research activities are spread over the chief industrial countries. Its staff maintains regular contacts with technical and industrial organizations throughout the world. It has a permanent representation in the United States of America, and is now arranging for correspondents in other countries.

The founders early recognized that scientific and technical knowledge concerning tin had been allowed to fall behind as compared with other metallurgical industries, and it has accordingly made one of its chief objects "a vigorous and extensive plan of research," aiming at the improvement of tin products by attacking basic problems connected with the major applications of tin. Researches already undertaken include improvements in tinplate, bearing metals, solders, other lead-tin alloys, bronzes, hot-tinning of cast iron, steel, and copper, &c., the electrodeposition of tin and tin alloys, spraying processes, tin-foil, tin pipe, and tin compounds.

Although the Tin Council has only been functioning for a few years, a considerable amount of valuable work has already been accomplished in some of these fields, and a large number of valuable papers have appeared in our own and other scientific journals. A systematic survey of the effect of different alloying elements on the mechanical properties of tin in progress in various laboratories has provided much new information, and has revealed possibilities of securing enhanced properties for a wide variety of applications. An important outcome of this work is that it has been established that certain classes of tin-base alloys may be strengthened permanently by heat-treatment, *viz.* annealing after quenching.

Only a fraction of the very considerable amount of work in progress on improving the quality of tin coatings, particularly tinplate, has reached the stage of publication, but already methods of testing

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developed in the course of the Council's researches, to facilitate the control of the tin-coating process, are being extensively used in industrial organizations in this country and elsewhere. A new detergent, which has unimpaired cleansing action, but does not attack the tin, has been devised, and is now finding application in the industry in the cleaning of tinned ware.

Advances have also been made in the field of electrodeposition. Whilst in the past it has been difficult to build up more than a thin coating by this method, a process has been developed by which an electrodeposit of tin of any desired thickness is readily obtained. The technique of applying coatings of hardened tin by simultaneous electrodeposition of another metal, such as nickel, with tin, has been worked out and should, with further development, lead to industrial applications. A process has also been devised whereby it is possible to apply non-porous electrodeposits of bronze to steel or other basis metals.

In the development of new uses for tin, special attention has been given to the chemical compounds of the metal. Heretofore these have been largely confined to applications in the silk and enamelling industries. In one of its publications the Council has shown that tin compounds have special merits in improving the behaviour and increasing the service life of lubricating oils. This discovery is already finding industrial use in the form of tin oleate.

As in sister organizations, the publication of technical data is regarded as a vital part of its programme, and examples of such activities are found in its recent booklets on such subjects as "Tin-plate and Canning," "Solder," and "Contemporary Pewter."

A particularly important service rendered by the Tin Council to the tin industries is through the research organizations which it has established or supported. Its standing and influence are already indicated by the increasing use which industry is making of its resources.

D. Copper.

Development work in this field has been, until recent years, somewhat spasmodic and localized. About the year 1923 a movement for extending and developing the uses of copper and its alloys was started in the United States and resulted in the formation of the American Copper and Brass Research Association which, strongly supported financially by the producers, embarked on a vigorous publicity campaign. In its early days the Association's efforts savoured more of advertising than of the educative and informative aims of the development movements in other sections of industry. Nevertheless, much



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useful work was accomplished in extending knowledge of copper and its alloys in engineering construction, and particularly in the building trade. This American movement had a direct influence in Europe by "inspiring" and largely financing the "Deutsches Kupfer Institut" which, established in 1926 and operating from Berlin, has exercised a considerable influence not only in Germany itself but on the German-speaking industrialists and engineers of Central Europe. This Institute, from its earliest days, has had aims and ideas similar to those influencing the movement in the nickel industry. It has sought to maintain close contacts with the producing and manufacturing industries on the one hand and the engineering profession on the other, and was fortunate in securing on its Managing Committee a number of leading German industrialists interested in the production of semi-manufactured materials. Its publicity work has been throughout of a high technical standard. Some of its publications, notably one last year, "Wass muss der Ingenieur vom Messing wissen?" are quite worthy of a place on any metallurgist's book-shelves.

In England the first move in the direction of systematic development work among potential users of copper was taken in 1924 by the Brass and Copper Trade Associations in forming a "Copper and Brass Extended Uses Council" with headquarters in Birmingham. As its name implies, this Council interested itself primarily in exploring new uses for copper and its alloys, and in pursuance of this aim made a number of investigations into various potential fields for the use of copper, particularly in domestic services and in building and architectural work. Several important publications of technical value were inspired by it; one which may be particularly referred to as an example is "Copper in Architecture"—a volume of appreciable size, containing a number of excellent illustrations and diagrams together with a mass of technical and practical data for the engineer, architect, and builder. The demand for this work was much greater than had been anticipated, and a second edition was called for within two years of its publication. This Council continued its activities until the formation of the Copper Development Association, referred to below.

In 1932 C. H. Schneider (then technical adviser to the Roan Antelope Copper Mines, Ltd.) and I were commissioned by some of the principal Empire producers of copper to make a survey of the main fields of copper consumption in this and other countries in Europe and report on the possibilities for development work and the advisability of forming an organization for such purposes. In the course of this survey we visited nearly all the more important manufacturers of copper and its alloys in England and in Central Europe and made a

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series of enquiries on the current position and on the type and quality of development work then being carried out by existing organizations and individual firms. The results of our investigations were embodied in a report presented to the copper producers in the early part of 1933, in which we recommended the formation of a Copper Development Association in this country, to be supported by both producers and manufacturers. This Association, as most of you know, was duly formed towards the end of 1933, under terms of reference which provided for widely extended activities in development work in copper. Mr. D. P. C. Neave was appointed General Manager, and under him a carefully selected staff possessing both engineering and metallurgical experience. In broad outline the organization as it exists to-day embodies the scheme laid out in the report referred to above. Special attention is devoted to the electrical industry, since this is by far the greatest present (and possibly potential) user of copper, but other spheres, notably that of building construction, architecture, and general engineering are being explored.

In the course of our enquiries, Schneider and I were impressed by the urgent need for furnishing engineers with information on modern developments on copper and its alloys. The widespread applications of copper and its long history and traditions have drawn the attention of scientific workers throughout the world, and a vast amount of research work has been carried out. Much of this work has considerable industrial value, yet it has not been at all adequately disseminated.

In our suggestions for the establishment of a Copper Development Association, we therefore laid special emphasis on the collection of data and information as a more urgent immediate need than research itself. Nevertheless, the scheme included plans for establishing liaison with University and other research laboratories, and particularly with the British Non-Ferrous Metals Research Association, with which the nickel, aluminium, and tin development bodies also maintain contact. Amongst the objects laid down in the original recommendations, the following may be quoted as illustrative :

- (1) To inspire and encourage general research on copper.
- (2) To attempt in every way possible to "carry over" the results of existing knowledge to the industry in general and in particular to the ultimate consumer.

Although the Copper Development Association has been functioning for so short a time it has already attained a considerable standing among copper users. Its publications, of which some outstanding

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examples are given in a footnote,* have throughout been highly practical and have received recognition on all hands as both informative and helpful. Special mention should be made of its work in the building trades; in particular to the development of the use of copper in water supplies, which has been recently extended to other pipeline services such as sanitation. As a direct result of informative publicity, architects and builders are now showing a much greater interest in the possibilities of sheet and strip copper for roofing and similar purposes.

In the electrical industry the development of copper conductors of special types for overhead transmission lines has been given close study, and the co-operation of the Association with the electrical engineering profession in general is proving of great value in technical advances (*e.g.* in the application of copper-cadmium alloys). Work is also actively proceeding in such subjects as the improvement of high-conductivity castings, and the extended use of copper as an alloying element in ferrous metallurgy.

The Association maintains close contact with its sister organizations in other countries, notably America and Germany (and more recently in France and Belgium). The number of technical enquiries now daily received is itself ample proof (if no other existed) that it fulfils a valuable purpose in industry and meets a real need.

(2) SOME GENERAL OBSERVATIONS.

“Of transcendent moment is not whether such or such knowledge is of worth, but what is its relative worth.”

HERBERT SPENCER, “Education.”

It will be observed that, although differing somewhat in detail, the fundamental aim of all these organizations is the same, *i.e.* to circulate by publication and personal service reliable and detailed technical data and information relating to their respective “raw materials” of industry in such forms and by such methods as will furnish the engineer and general user with the means of applying expert and up-to-date knowledge to the products which metallurgists and engineers together place at the service of the ultimate user.

The movement is, however, undergoing to-day a further development to which I attach great importance. Producers and refiners of

- * “Sheet Copper Work for Building” (Practical handbook for builders, &c.).
- “Brasses” (Engineering and metallurgical data).
- “Copper for Domestic Water Services” (Technical book for architects, &c.).
- “Steel-Cored Copper Connections” (data for electrical engineers).
- “Copper Data” (for engineers).
- “Bearing Bronzes.”
- “Cadmium-Copper Conductors” (erection charts).

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metals, whether of copper, nickel, aluminium, tin, or any other of the primary elements of nature, are beginning to realize that although their first duty is to place at the disposal of the metallurgical industries the purest and most uniformly reliable material which their present methods and technique are capable of producing, they depend in the ultimate for the final standing and reputation of such products on the secondary producer of semi-manufactured materials—in other words, on the standards attained by the foundry, the rolling, drawing, and extrusion mills from which the constructional engineer obtains in turn his “raw materials,” particularly alloy products. The service of the refiner stops short at a “half-way house,” and however high his standards and efficient his technique, the ultimate reputation of copper, nickel, aluminium, or any other metal depends on the quality attained in converting them to the forms required by the engineer in every branch of his profession. There is, therefore, inherent in the ideals of development organizations the further *aim* of assisting the manufacturing metallurgical industries to improve their own standards of quality and efficiency.

The sequence of our industry is three-fold :

- (a) The primary producer ;
- (b) The manufacturing metallurgist ; and
- (c) The user (*i.e.* the maker of ultimate products).

It will be seen from our review above that a considerable proportion of development work at the moment is directed towards (c), but the first contact of (a) is with (b), and the former is beginning to realize more and more fully how greatly his reputation is influenced by the latter. There is evolving as a result a “technical service” relationship between the two classes (a) and (b), which I believe is destined to play a vitally important part in the future progress of our industries.

This particular phase has probably been up to the present more in evidence in some industries than in others, but it will undoubtedly extend to all. In theory it appears a fairly simple conception, but it is by no means so in practice. It involves the creation of a highly specialized class of industrial metallurgists who must combine training and experience with wide vision and great adaptability. In the nickel industry * (of which I can speak with some experience) we have during the last few years made special efforts in this phase of development service. We are perhaps fortunate as compared with some other branches of the metal industries in being largely controlled by one organization and in having our own works and laboratories in which

* See H. Moore, Presidential Address, *J. Inst. Metals*, 1934, 54, 37.

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both men and ideas can be tested out, and we have now "in the field" a number of experienced workers who aim definitely at this ideal of improving standards of quality, and conveying to industry the results of investigation and research. It is in this connection that the links between development and research must be strengthened.

I have already pointed out that research is the backbone of all successful development work. The fact is clearly recognized by every responsible development worker. On the other hand the "development movement" can be and often is an invaluable handmaiden to research. Industrial metallurgical research aims *inter alia* not only at the discovery of new alloy materials but at the improvement of the properties of existing ones either by some modification in composition or treatment in manufacturing processes. It often happens, however, that the results of such research are by no means easy of application and when attempts are made to adopt them in practice the outcome is unsatisfactory. The research work itself may be fundamentally sound, but it is in its industrial development that the difficulty lies—one reason being that conditions in works' practice, whether in process, or plant, or equipment are often far more complex than in research.

It was aptly pointed out by Rosenhain, in an address* delivered some twenty years ago, that "the scientific investigator endeavours in all his work to simplify his conditions as far as possible." In works' practice, on the other hand, conditions can scarcely be simplified in any appreciable degree. They are necessarily complex if only in the sense that all industrial processes are so and are carried on under composite conditions which may be eliminated in a research laboratory.

I feel that it is scarcely necessary to emphasize to members of this Institute the importance of this aspect of the question. We have of set purpose included in our ranks both manufacturers and users of metals, and on this ground alone I am justified in directing your special attention to it. Metallurgical workers, whether in the research or industrial spheres, know full well that the results of an immense amount of valuable investigatory work are at the moment lying dormant through lack of application. One hears from time to time the statement—sometimes uttered in the form of a complaint—that "scientific progress is too rapid in these days, and that the time has come when a halt should be called." Such statements find their chief, if not their only justification, in the fact that so much valuable knowledge is not *applied*. My hope and belief is that in this development movement to which I direct your attention to-day we shall find a solution to the problem so far as our profession is concerned.

* W. Rosenhain, West of Scotland Iron and Steel Institute, Session 1915-1916.

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In these days of specialization I submit that the movement is already rendering invaluable service to engineers and to metal users in all branches of industry. Moreover, I am convinced that in it there are latent possibilities of far greater achievements than it has yet accomplished.

The quotations I have ventured to cull from Herbert Spencer could well be its "Apologia," if one were needed. "Man," said Carlyle,* "is a tool-using animal . . . without tools he is nothing, with tools he is all." It is by the construction and use of tools that man emerges from barbarism to civilization—at least in the material sense. Giving this word "tools" its widest meaning, it follows that man's physical progress depends on continuous advancement in knowledge of materials and their use. Generalizations are not always accurate, but it is a reasonably fair definition of all engineering construction that its chief concern is to "put the right things in the right place," having in mind their immediate or ultimate purpose.

To be able to put the right material in the right place without the slightest possibility of error is beyond human power. Limitation of knowledge is inevitable, but the nearer our approximation to this ideal the more enduring our work and the greater our progress. The wise man in any sphere is the man who seeks that specialized knowledge which will enable him to attain efficiency in the choice and application of the raw materials of his profession.

This specialized knowledge is, I conceive, exactly what these development organizations are endeavouring to provide. They are "service" departments in the true sense of the word, and their usefulness will unquestionably increase as their organizations become more efficient and their efforts more fully appreciated.

The chief criticisms I have heard directed against them hitherto have been :

- (a) They are mainly "glorified advertizing" associations, and/or
- (b) That they tend to over-emphasize the particular virtues of the class of materials with which they are respectively concerned.

With regard to (a) undoubtedly the element of advertizing necessarily enters, but advertizing has become so important a factor in our ordinary everyday experience that it is almost impossible to imagine modern civilized life without it, and it is by no means to be despised as a real aid to higher standards of comfort, in almost every department of our public and private industrial and social life. Like some

* "Sartor Resartus," Chap. V.

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other modern developments, it is open to abuse; but who can deny that it enlarges our knowledge and directly and indirectly brings to us much that we might otherwise lose? But the movement I am describing now is far more than merely advertizing. In so far as it stops at advertizing it falls short of its ideals. It is primarily an educative and informative movement. In the report by C. H. Schneider and myself on the copper industry referred to above, the statement is made :

“ What is needed is . . . a type of propaganda work which we term educative . . . and we emphasize suggestions (made earlier) that definitely educational publicity should be undertaken in all branches of the engineering industries, bringing to the fore the results of modern scientific and technical research.”

This ideal is, I believe, essentially that of all development organizations, although admittedly not yet wholly attained.

As to (b) I think that it must be frankly confessed that in the earlier days of the movement the zeal of its exponents in every section outran discretion, and the tendency to over-emphasis was often in evidence, but some degree of crudity is inevitable in all new schemes of so far-reaching a range and character. Experience has already to a large extent corrected this tendency and will undoubtedly in time eliminate it altogether, for as I have already pointed out, the essence of successful development work in industry is absolute accuracy, and particularly is this so in setting forth the properties of materials of engineering construction. There is naturally a greater tendency to over-emphasis in regard to new alloys or materials possessing special properties, whether intrinsic or conferred by treatment, than in those which have been known for many years, and it is here that a word of advice to those engaged in development work is most needed. “ Always understate your case rather than overstate it.” The engineer rightly demands a high factor of safety.

I have endeavoured in a limited space to give you a general description of the main lines and features of this development movement in our industries. Possibly you will say that I have rather idealized it and that much more could and should be said of its limitations, its crudities, and its weaknesses. That much could be said on these points I agree, but I have set it before you deliberately in a perspective which takes in horizons as well as working levels, for I wished to emphasize the ideals and possibilities of the movement as well as its present attainments. To engineers it should make an especial appeal, since its highest aim and final justification is “ the more intelligent use

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of materials," and I can think of nothing more vitally and permanently important to our joint professions.

In conclusion I wish to emphasize one or two factors essential to the future progress and ultimate success of the movement in general and its sectional organizations in particular.

- (1) Its first aim must always be to impart knowledge and to impart it clearly, succinctly, and above all accurately.
- (2) It must keep in the closest touch with the needs of industry.
- (3) It must be, so far as possible, impartial and scrupulously fair in the estimation of the comparative worth of materials.

The first and second are implied in all that I have said previously.

On the third point only I will enlarge briefly. An element of competition between the various branches of our industries must always exist, and the development worker in a particular field experiences from time to time the temptation to be somewhat less than fair to materials which appear to compete with those with which he himself is concerned. I would only ask in this connection that we should recall a passage from the late Lord Acton's lecture on "The Study of History":

"It is a source of power and an excellent school of principle not to rest until by excluding the fallacies, the prejudices, the exaggerations which perpetual contentions and the subsequent precautions breed, we have made out for our opponents a stronger and more impressive case than they present themselves."

In other words, seek to understand the real strength of your competitor's case. It is the essential qualities and properties of materials which make them of service to mankind, not ornate descriptions of them by over-zealous expositors.

It is not on the competitive note, however, that I wish to end this Address. I look forward to the time, not far distant I hope, when all sections of this development movement in our industries will work in as complete co-operation as is possible in an imperfect world. And equally I look forward to the collaboration of all branches of the engineering profession in this work. The ultimate aim of both metallurgists and engineers is the "service of man," and in both our professions a high ideal of such service exists.

This century has witnessed such an extension of our activities in almost every sphere as has never before been known. "These activities,"

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to quote from a recent article in the *New York City Bank Review*, "are pouring an ever increasing stream of products and services into the public market." The control of the standard of quality of these is vital, and the welfare of man, in so far as material products and services can promote it, is the only ultimate basis on which any industry can be permanently established.

ACKNOWLEDGMENTS.

In the preparation of this Address I have received valuable assistance from conversations and correspondence with Mr. E. T. Painton, Mr. D. J. Macnaughtan, of the Tin Research and Development Council, and from my colleagues in the nickel and copper industries. To these I desire to express grateful appreciation.

FURTHER STUDY OF COPPER-TIN ALLOYS BY X-RAY ANALYSIS.*

By PROFESSOR E. A. OWEN,† M.A., D.Sc., MEMBER, and
E. C. WILLIAMS,‡ M.Sc.

SYNOPSIS.

An account is given of a further study of copper-tin alloys by X-ray analysis. Attention is particularly directed to the δ and η phases. The δ region was examined at temperatures below 550°C . and it was found to be a solid solution, the range of solution increasing from zero at the eutectoid point which occurs at a composition of 67.4_5 per cent. copper and a temperature of 330°C ., to 0.4_8 per cent. composition by weight at 550°C . The η -phase was also found to be a solid solution, the range of solution at 250°C . extending from 61.68 to 62.10 and at 530°C . from 61.68 to 62.20 per cent. copper by weight. Observations are also recorded which confirm the conclusion that the δ -phase transforms to $(\alpha + \eta)$ at a temperature of 330°C . approximately.

In a previous paper¹¹ an account was given of a detailed study of the α -phase boundary in the copper-tin series and in the course of the investigation evidence was obtained that the δ -phase transforms into $\alpha + \eta$ at a temperature a little higher than 300°C . Brief references were made also to preliminary work on the δ - and η -phases.§ This paper deals in greater detail with these two phases, and further evidence is given in support of the transformation of the δ -phase. The previous measurements were not extensive enough to decide whether there existed a region of solubility for the δ -phase, but it could be stated quite definitely that the η -phase existed over a range of compositions; it was only possible, however, to give outside limits within which the range of solubility existed.

The method of procedure in the present investigation was precisely the same as that in the previous work carried out on this series, with the exception that no chemical analyses of the alloys were made after the first few, as it was found by accurately weighing the constituent elements that the composition could be fixed to about 0.1 per cent.

* Manuscript received January 30, 1936.

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‡ University College of North Wales, Bangor.

§ These were termed the γ - and ϵ -phases, respectively, in the previous paper, but as this alteration caused difficulty to some readers of the paper, the ordinary nomenclature is reverted to in this paper.

Note to Abstractors and Other Readers.—This paper will be published, in permanent form, in the *Journal of the Institute of Metals*, Vol. LVIII, 1936. Reference should accordingly be as follows: *J. Inst. Metals*, 1936, 58 (Advance copy).

THE δ -PHASE.

In the diagram reproduced in the International Critical Tables, the δ -phase is shown at 68 per cent. copper, the $(\alpha + \delta)$ region extends from 68 to 86 per cent. copper, and the $(\delta + \eta)$ region from 62 to 68 per cent. copper. If the δ -phase were an "intermetallic compound" its lattice parameter should be the same in all alloys in which it is a constituent.

The results of the preliminary survey already published showed that the δ -phase parameter in alloys quenched from 480° C. was 17.917 A. in the $(\alpha + \delta)$ region, and 17.924 A. in the $(\delta + \eta)$ region. The difference between these δ -parameters, namely 0.007 A., is much greater than the experimental error of measurement.

Alloys Nos. 70A * and 66 containing, respectively, 69.6 and 66.0 per cent. copper, used in the present investigation, were the same lump annealed ingots as were used previously. The following alloys were prepared in addition by the method already described: 66.5, 67, 67.5, 68, 70, and 74 per cent. copper. Alloys 66.5, 67, 67.5, and 68 were lump annealed for 360 hrs. at 600° C., and alloys 70 and 74 for 600 hrs. at 600° C. The powder specimens were all annealed for 26 hrs. at 480° C. and quenched.

X-ray photographs of the alloys were taken at room temperature with nickel radiation, which yielded lines on the film at large glancing angles and, therefore, in positions for accurate measurement of the parameter. It was evident from the photographs that there was a small but definite difference in arc between the δ -phase lines in alloys in the $(\alpha + \delta)$ and $(\delta + \eta)$ regions. The following were the results of the measurements of the photographs.

The photographs with cobalt radiation were taken to check those obtained with nickel radiation. The lines were in about the same positions and were of equal intensity with the two radiations.

It was desirable at this stage to make quite certain that the observed difference in the parameter was not due to the quenching process but existed at the temperature from which the material was quenched. Accordingly, X-ray photographs were taken with some of the alloys when they were maintained at 480° C. during exposure in the evacuated chamber enclosing the camera. The procedure was to heat the specimen when mounted on the camera, to 480° C. *in vacuo*, and to maintain it at this temperature for about 2 hrs. before commencing the exposure, as well as during the exposure.

The doublet in the photograph obtained when the specimen was

* The letter "A" in this connection denotes that the alloy was prepared by chill-casting.

Copper-Tin Alloys by X-Ray Analysis

TABLE I.—*Powder Annealed for 26 Hrs.
at 480° C.*

Alloy No.	Composition, Copper, Per Cent. by Weight.	Mean Parameter of the δ -phase, A.
<i>Nickel Radiation—Reflecting Planes (16.10.10).</i>		
66	66	17.924
66.5	66.5	17.924
67	67	17.923 ₅
67.5	67.5	17.918
68	68	17.915 ₅
70A	69.6	17.915 ₅
70	69.6	17.915
74	73.9	17.916
<i>Cobalt Radiation—Reflecting Planes (14.14.0).</i>		
67	67	17.923 ₇
70A	69.6	17.914 ₅

cold, was observed now to have moved outwards and owing to thermal effects had considerably diminished in intensity, but it could still be measured accurately. Photographs at high temperature (480° C.) were taken with three alloys with the following results :

Alloy.	δ -Parameter at 480° C., A.
70	18.093
67.0	18.102
66.5	{ 18.102 18.103

Thus, at 480° C. the δ -parameter changes from 18.093 to 18.102 A. and at 18° C. (after quenching from 480° C.) from 17.915 to 17.924 A. when the composition of the alloy changes from 69.6 to 67 per cent. copper. These figures show definitely that there is a difference in the parameter of the δ -phase at 480° C. in the ($\alpha + \delta$) and ($\delta + \eta$) regions. These results confirm the figures published in the previous paper.

Having now definitely established the existence of a slight degree of solubility at 480° C., it was decided to investigate more alloys within the range 67–68 per cent. copper at various other temperatures. The alloys prepared were of compositions 67.2, 67.25, and 67.75 per cent. copper by weight. They were all lump annealed at 600° C. for 360 hrs.

All the alloys investigated at this temperature were annealed in powder form at 450° C. for 126 hrs. and quenched. The results of the measurements of the photographs are summarized in column 3 of Table II.

TABLE II.

Com- position, Copper, Per Cent. by Weight.	Mean Parameter of the δ -Phase (A.).					
	Temperature and Time of Annealing the Powder.					
	350° C. for 260 Hrs.	450° C. for 126 Hrs.	480° C. for 26 Hrs.	505° C. for 26 Hrs.	530° C. for 40 Hrs.	550° C. for 24 Hrs.
66.0			17.924			17.928
66.5	17.919 ₇	17.922	17.924	17.925	17.927 ₅	17.927 ₅
67.0	17.919 ₇	17.923	17.923 ₆		17.928	
67.25		17.923		17.925 ₅		
67.5		17.918 ₅	17.918	17.918		17.919
67.75		17.918		17.913		17.914 ₅
68.0		17.919	17.915 ₅		17.915	
70A	17.919	17.918 ₅	17.915	17.914	17.914	17.914 ₅
70			17.915			
74		17.919	17.916			
80A	17.920					
83A	17.920					

At this temperature as well as at 480° C., the alloy containing 67.5 per cent. copper appeared to be in the pure phase. If this be so, the range of the δ -phase must lie between 67.25 and 67.75 per cent. copper, and the change in parameter from one side of the δ -phase boundary to the other is less at 450° C. than it is at 480° C.

Alloys 66.5, 67.25, 67.5, 67.75, and 70A were then annealed for 26 hrs. at 505° C. The results, included in Table II, column 5, show that the difference in parameter of the δ -phase on the two sides is still greater than at 480° C., and they indicate also that alloy 67.5 is in the pure phase.

According to all the equilibrium diagrams of the system, a transformation temperature exists at about 518° C. where the β -phase changes into ($\alpha + \delta$) over the range of alloys from 68 to 84 per cent. copper. It was of interest to find what results alloys in this range of composition would yield when annealed at temperatures higher than this transformation temperature. A few specimens were accordingly annealed at 530° C. for 40 hrs. The photographs obtained with these gave, on measurement, the results shown in column 6 of Table II, and the difference between the δ -parameter on either side of the pure phase is still further increased. The δ -phase region, therefore, passes beyond the transformation line at 518° C.

Photographs taken with specimens annealed in powder form at 550° C. for 24 hrs. yielded similar results.

As a final check a new alloy containing 67.4 per cent. copper was prepared and quenched from 530° C. after being annealed at this tem-

Copper-Tin Alloys by X-Ray Analysis

perature for 40 hrs. The parameter was found to be 17.920 Å., which by comparison with the figures in Table II shows that the alloy is in the pure δ -region, as was expected.

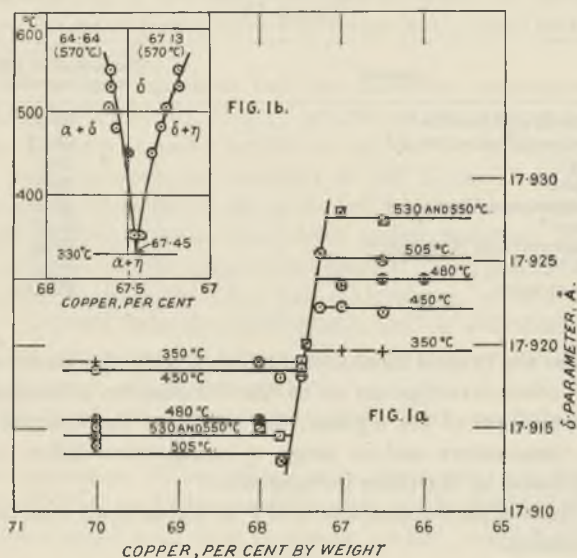
Further measurements made on alloys which had been annealed at 350° C. for 260 hrs., showed the range of solubility at this temperature to be exceedingly small.

The figures in Table II are plotted in Fig. 1(a) and the positions of the δ -phase boundaries deduced from these are shown in Fig. 1(b). The compositions corresponding to the δ -boundaries at different temperatures are given in Table III. The δ -region is very narrow, its

TABLE III.

Temperature, ° C.	Boundary (Copper Per Cent. by Weight).	
	$(\alpha + \delta) - \delta$.	$\delta - (\delta + \eta)$.
550	67.6 ₈	67.1 ₈
500	67.5 ₇	67.2 ₈
450	67.5 ₃	67.3 ₄
400	67.4 ₉	67.3 ₉
350	67.4 ₈	67.4 ₄
330	67.4 ₅	67.4 ₅

width at 570° C. being about 0.5 per cent. in composition by weight. It comes to a eutectoid point at a composition of 67.4₅ per cent. copper



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and a temperature of about 330° C., which is an approximate estimate made from Fig. 1(b).

The equilibrium diagram produced by Carson⁸ shows the δ -phase to exist over a range of compositions from 67 to 68 per cent. copper by weight at all temperatures below about 500° C. The X-ray measurements described here are not in agreement with these results.

The only other equilibrium diagram which shows an appreciable region of δ -phase as far as we have been able to ascertain is that of Hamasumi and Nishigori.⁹ At 570° C. the phase extends from 67.2 to 67.5 per cent. copper, but it closes at the top and the bottom at temperatures of 580° and 560° C., approximately, the composition at both these temperatures being 67.5 per cent. copper. The present results agree fairly closely with the width of the phase at 570° C. but it is now found that the region closes in a eutectoid point at a temperature (330° C.) much lower than the lowest temperature (560° C.) for the δ -region recorded by Hamasumi and Nishigori. It is interesting to note that the eutectoid point now recorded occurs at a composition of 67.4₅ per cent. copper which is almost exactly the composition of the δ -phase (67.4₈ per cent. copper) recorded in the diagram of the above authors at temperatures below 560° C.

In the different equilibrium diagrams the authors have examined the composition of the δ -phase below 500° C. was found to be as shown in Table IV.

TABLE IV.

Authors.	Composition of δ -Phase Alloy below 500° C.
Heycock and Neville ¹	68.2
Bauer and Vollenbruck ²	68.17
Raper ⁴	68.6
Isihara ⁶	68.6
Westgren and Phragmén ⁷	67.3
Carson ⁸	68-67
Hamasumi and Nishigori ⁹	67.48
Verö ¹⁰ .	67.5
Present work	67.45

Whereas the present measurements agree with the latest measurements by other investigators as to the composition corresponding to the mean position of the δ -phase, the extent of the δ -region both in range of temperature and in range of composition differs markedly from that found by the other investigators.

The extent of the δ -region above 570° C. will be dealt with in another communication.

Copper-Tin Alloys by X-Ray Analysis

THE η -PHASE.

The equilibrium diagram reproduced in the International Critical Tables gives the η -phase as an alloy containing 62 per cent. copper by weight. The thermal diagrams of Isihara³ and Matsuda⁵ show the phase as a solid solution extending over a range of composition from about 59 to 62 per cent. copper. Hamasumi and Nishigori found this range to extend from 61 to 62.5 per cent. but Verö¹⁰ in another investigation concluded that the η -alloy is of unique composition corresponding to the formula Cu_3Sn .

From previous measurements¹¹ the authors concluded that the η -phase is a solid solution, the values of the parameters of the copper-saturated and the tin-saturated alloys in the phase showing a definite difference. The observations then made were, however, not extensive enough to determine the positions of the limits of the phase. Seven alloys were previously investigated extending over a range of composition from 66.0 to 54.0 per cent. copper by weight, and it was concluded that the range of the phase at 380° C. was not greater than 1.5 per cent. in composition.

The alloys now examined ranged in composition from 65 to 60 per cent. copper, as the previous work had shown that the region of solid solubility exists somewhere between the compositions 63 to 61 per cent. copper. The alloys were hard and brittle; only powders of them which had passed through a 250 sieve were used to obtain the photographs. These powders gave spectral lines which were well defined and could be measured with accuracy.

The alloys now examined had the following compositions: 65, 64.25, 64, 63.5, 63, 62.5, 62, 61.5, 61, and 60 per cent. copper by weight. They were all lump annealed for 360 hrs. at 380° C.; powder specimens of them were prepared and annealed at 360° C. for 12-13 hrs. For examination on the camera, the annealed powders were mounted on aluminium backing sheets, since, with nickel radiation, aluminium gives no lines within the range of the camera. Two pairs of doublets, due to reflection from the (211) and (114) planes, were obtained on the film. A β -line from the (213) planes and an α -doublet from the (212) planes also appeared faintly, but could not be measured with sufficient accuracy and so were omitted.

The results of the measurements of the films are summarized in Table V.

Other specimens of the alloys were prepared; one batch was annealed at 310° C. for 72 hrs., and the other batch at 370° C. for 22 hrs. The results obtained with these specimens are also included in Table V.

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The figures show that a range of solubility exists for the η -phase and that it is the same in extent at 370° C. as at 310° C., within the accuracy of measurement.

A few alloys were then annealed at 250° C. X-ray spectra taken at

TABLE V.—*Mean Parameters of the η -Phase.*

Composi- tion, Copper, Per Cent. by Weight.	Temperature of Annealing in Powder Form.								
	310° C. for 72 Hrs.			360° C. for 12½ Hrs.			370° C. for 22 Hrs.		
	Mean Parameter, A.		Atomic Volume.	Mean Parameter, A.		Atomic Volume.	Mean Parameter, A.		Atomic Volume.
	a.	c.		a.	c.		a.	c.	
58	***	***	***	***	***	***	***	***	***
60	2-7534	1-5687	14-179	2-7531	1-5687	14-175	2-7531	1-5690	14-177
61	2-7534	1-5686	14-178	2-7535	1-5686	14-179	2-7535	1-5686	14-179
61-5	***	***	***	2-7531	1-5688	14-176	2-7531	1-5689	14-177
62	2-7503	1-5706	14-148	2-7500	1-5708	14-145	2-7501	1-5706	14-145
62-5	2-7485	1-5718	14-131	2-7486	1-5716	14-131	2-7486	1-5717	14-132
63	2-7485	1-5719	14-132	2-7486	1-5717	14-132	...	...	...
63-5	2-7486	1-5718	14-132	2-7486	1-5717	14-132	...	...	...
64	***	***	***	2-7486	1-5717	14-132	...	...	...
64-5	***	***	***	2-7488	1-5715	14-133	...	...	...
65	2-7487	1-5715	14-132	2-7485	1-5717	14-131	...	...	...

480° C. with one of these, the composition of which was 66 per cent. copper by weight, had shown the δ -phase quite strongly but the η -phase faintly. After annealing for 420 hrs. at 250° C., the powder gave a photograph which showed no trace of the δ -phase. The η -doublets were recorded on the film but the α_2 line of the outer doublet was rather faint. The film yielded the following values for the parameters of the η -phase: $a = 2.7487$ A. and $c = 1.5713$.

The remainder of the powder was replaced in the furnace and annealed at 250° C. for a further period of 264 hrs. After this heat-treatment, the η -phase doublets were both well defined, but the δ -phase doublets were still absent. A photograph taken with a specimen of alloy 66 annealed at 300° C. for 120 hrs. also showed the absence of the δ -phase lines. Other alloys of compositions near to the 66 alloy yielded similar results; for instance, photographs taken at 480° C. with alloys 66-5 and 67 contained intense δ -phase lines but faint η -lines, whereas the same alloy annealed at 250° C. for 500 hrs. gave photographs showing no trace of the δ -phase lines but intense η -lines.

These results confirm the conclusion reached in the previous paper¹¹ that a transformation of δ to $(\alpha + \eta)$ takes place at a temperature slightly higher than 300° C. Further observations on this transformation are recorded later in this paper. The results of the measurements of the η -phase in alloys annealed at 250° C. are summarized in Table VI.

Copper-Tin Alloys by X-Ray Analysis

TABLE VI.—*Powders Annealed at 250° C.*

Composition, Copper, Per Cent. by Weight.	Time of Annealing, Hrs.	Mean Parameters of the η -Phase.		
		Base Side (A.).	Axial Ratio.	Atomic Volume, (A.) ³ .
60	270	2.7534	1.5684	14.177
61.5	400	2.7533	1.5684	14.176
62	270	2.7501	1.5706	14.145
62.5	400	2.7491	1.5713	14.136
63	270	2.7490	1.5713	14.135
66.5	500	2.7490	1.5712	14.133
66	684	2.7489	1.5713	14.133

The results so far obtained, showed that a range of solubility existed for the η -phase and that this range at 250° C. was rather smaller than at higher temperatures. Also there was definitely a transition temperature slightly higher than 300° C. where the δ -phase changed into ($\alpha + \eta$)

To determine the boundary of the pure η -phase within closer limits, more alloys having composition 61.7, 61.9, and 62.2 per cent. copper by weight were examined. They were all lump annealed at 380° C. for 360 hrs. Powder specimens of these alloys with specimens also of alloys 58, 62, and 63 were annealed at 420° C. for 14 hrs. Alloy 58 showed signs of melting during the annealing which is in accordance with the thermal diagram in the International Critical Tables; in this diagram the ($\eta + \epsilon$) phase changes at 415° C. into ($\eta + \text{liq}$). When the specimen was crushed lightly, it crumbled up into powder sufficiently fine to enable a photograph to be taken.

Alloys 61.7, 61.9, and 62.2 were also annealed at 350° C. for 21 hrs. The results of the measurements of the films are contained in Table VII.

TABLE VII.—*Mean Parameters of the η -Phase.*

Com- position, Copper, Per Cent. by Weight.	Temperature of Annealing in Powder Form.					
	420° C. for 14 Hrs.			350° C. for 21 Hrs.		
	Mean Parameter, A.		Atomic Volume.	Mean Parameter, A.		Atomic Volume.
	<i>a.</i>	<i>c.</i>		<i>a.</i>	<i>c.</i>	
58	2.7533	1.5686	14.177	...	...	...
61.7	2.7531	1.5690	14.177	2.7529	1.5690	14.174
61.9	2.7509	1.5704	14.156	2.7510	1.5702	14.156
62.0	2.7504	1.5706	14.150
62.2	2.7489	1.5716	14.136	2.7484	1.5719	14.132
63.0	2.7485	1.5719	14.132

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A further series of photographs were taken with the same alloys after annealing in powder form at 530° C. for 24 hrs. Some of these alloys were in the (η + liq.) phase above about 415° C. and so the powders had "coked." They could be broken up, however, to enable photographs to be taken. The results of the measurements in this series are given in Table VIII.

TABLE VIII.—Powders Annealed at 530° C. for 24 Hrs.

Com- position, Copper, Per Cent. by Weight.	Mean Parameters of the η -Phase, A.		Atomic Volume.
	a.	c.	
58	2.7533	1.5686	14.177
60	2.7531	1.5689	14.176
61.7	2.7530	1.5690	14.176
61.9	2.7507	1.5705	14.154
62.2	2.7480	1.5723	14.128
62.5	2.7480	1.5723	14.128

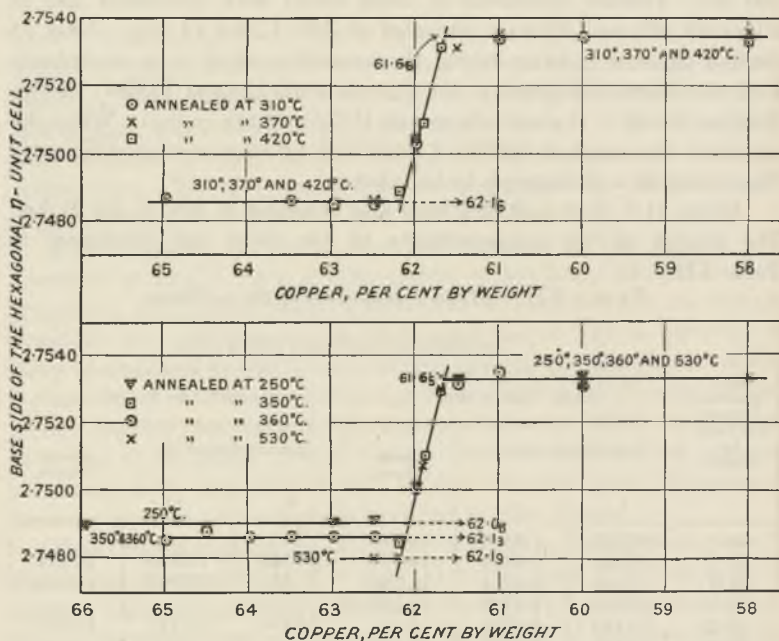


FIG. 2.

Copper-Tin Alloys by X-Ray Analysis

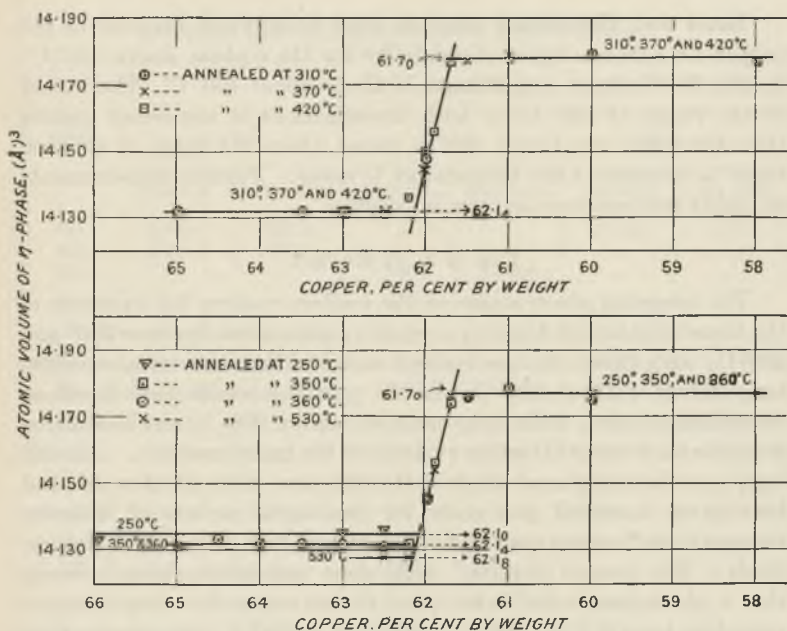


FIG. 3.

All the results are incorporated in Figs. 2 and 3, from which it will be seen that there is a definite range of solubility for the η -phase. The positions of the boundaries are given in Table IX. The range of the η -phase at 250° C. extends from 62·1₀ to 61·6₈ per cent. copper by

TABLE IX.

Temperature, ° C.	Compositions, in Per Cent. Copper by Weight, Corresponding to the η -Phase Boundaries.	
	$\frac{(a + \eta) - \eta}{(\gamma + \eta) - \eta}$	$\frac{\eta - (\eta + \epsilon)}{\eta - (\eta + \text{liq.})}$
250	62·1 ₀	61·6 ₈
310-420	62·1 ₅	61·6 ₈
530	62·2 ₀	61·6 ₈

weight, or 75·20 to 75·0 atomic per cent. copper, and it shows a tendency to increase slightly as the temperature is increased over the range of temperature investigated, namely from 250° to 530° C. The average range of composition for the pure η -phase between 250° and 530° C. may be taken to be from 62·15 to 61·68, that is, a range of 0·47 per cent. in composition by weight.

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Bauer and Vollenbruck show in their equilibrium diagram of the copper-tin series a region of solubility for the η -phase above 420°C ., so also do Westgren and Phragmén above about 450°C . The extent of the range at 530°C . in both investigations is somewhat greater than the value now found, but as stated above the range of solution tends to increase as the temperature is raised. Further measurements at higher temperatures are now in progress.

THE ($\alpha + \eta$) REGION.

The foregoing observations on the η -alloys confirm the existence of the transformation of δ into ($\alpha + \eta$) at a temperature between 300° and 350°C ., and those on the δ -alloys indicate that the transformation temperature is about 330°C . As the previous results were based on observations taken with only one alloy (alloy 80), it was considered desirable to obtain still further evidence of the transformation. Accordingly, powder samples of alloys 70A, 80A, and 83A, all of which had been lump annealed previously for prolonged periods at different temperatures,* were annealed for 170 hrs. at 350° and 300°C ., respectively. The spectra obtained with these specimens showed clearly that a phase change had taken place in decreasing the temperature of annealing from 350° to 300°C . Whereas at 350°C ., the photographs contained δ -phase and no η -phase lines, those at 300°C . contained η -phase and no δ -phase lines.

Alloy 80A was then annealed for 400 hrs. at 250°C . The photographs taken with the alloy after this heat-treatment, showed the η -phase doublets but they were too weak to be measured accurately.

The specimen of alloy 70A which after annealing for 170 hrs. at 300°C . had yielded η -phase lines, was mounted on an aluminium backing sheet, sealed with its mounting in an evacuated glass tube and annealed at 450°C . for 100 hrs. After this heat-treatment the tube was removed from the furnace and the specimen allowed to cool rapidly to air temperature. The photograph subsequently taken with the specimen showed no trace of the η -phase, but there were now present the two δ -doublets. On measurement they gave a parameter of 17.918 A., which agrees with the value obtained previously after annealing at 450°C . (see Table II).

Alloys 70A, 80A, and 83A after the first heat-treatment were further annealed at 300°C . for periods of from 400 to 600 hrs. The results are summarized in Table X.

It is evident that the η -phase in alloy 83A did not reach its equilibrium value after 500 hrs. at 300°C . Possibly the presence of a large

* See Owen and Iball.¹¹

Copper-Tin Alloys by X-Ray Analysis

TABLE X.—Mean Parameters of the η -Phase.

Alloy.	Time of Annealing.					
	400 Hrs.		500 Hrs.		600 Hrs.	
	Base Side.	Axial Ratio.	Base Side.	Axial Ratio.	Base Side.	Axial Ratio.
70A	2.7491	1.5714	***	***	2.7489	1.5715
80A	2.7501	1.5710	***	***	***	***
83A	***	***	2.7502	1.5708	***	***

proportion of α -phase in alloys containing between 80 and 88 per cent. copper may have some effect in retarding the rate at which the η -phase reaches its equilibrium state. With alloy 70A, which contains proportionately less α -phase, the η -phase parameter after annealing for 600 hrs. is almost identical with the parameter after annealing for 400 hrs., and the value compares well with the parameters of the copper saturated lattice at 310° C., viz. 2.7485 A. and 1.5719, or at 250° C., viz. 2.7490 A. and 1.5713, so it may be said that it reached its state of equilibrium after 400 hrs.' annealing. Alloy 83A on the other hand was still far from being in equilibrium after 500 hrs.' annealing.

To investigate whether the phases were being distorted in the quenching process from 300° C., specimen 83A, after being annealed for 500 hrs. at 300° C., was heated to 300° C. in the evacuated camera chamber, and was maintained at this temperature for 5 hrs. before commencing the exposure and for a further 1½ hrs. while the exposure was being made. The photograph showed the α and η -phase doublets, their definition being about the same as in the photograph taken with the cold specimen, but the intensity of the α -phase relative to that of the η -phase doublet was a little greater for the hot than for the cold specimen. There was no evidence, therefore, that any distortion was produced by quenching the alloys.

Specimens of alloys 85A and 88A which are nearer to the α -phase boundary than those alloys previously used, were annealed at 300° C. for 190 hrs. The photographs obtained with both of these alloys, showed the presence of the η -phase and there were also recorded the α -phase doublet; thus the α -phase boundary at 300° C. must correspond to a composition less than 12 per cent. copper. This agrees with the conclusion reached and recorded in the previous paper. It was then found that the actual position of the boundary at 300° C. corresponds to a composition of 90.1 per cent. copper by weight.

A number of alloys in the ($\delta + \eta$) region, namely alloys 67, 66½, 66, and 65, which yielded strong δ -doublets at 480° C., showed no trace of

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the δ -phase at 300° and 250° C., but all showed intense η -phase doublets at these temperatures. These observations confirm the results previously obtained at low temperatures. They show that the δ -phase in the $(\alpha + \delta)$ and $(\delta + \eta)$ regions is transformed at about 330° C. to

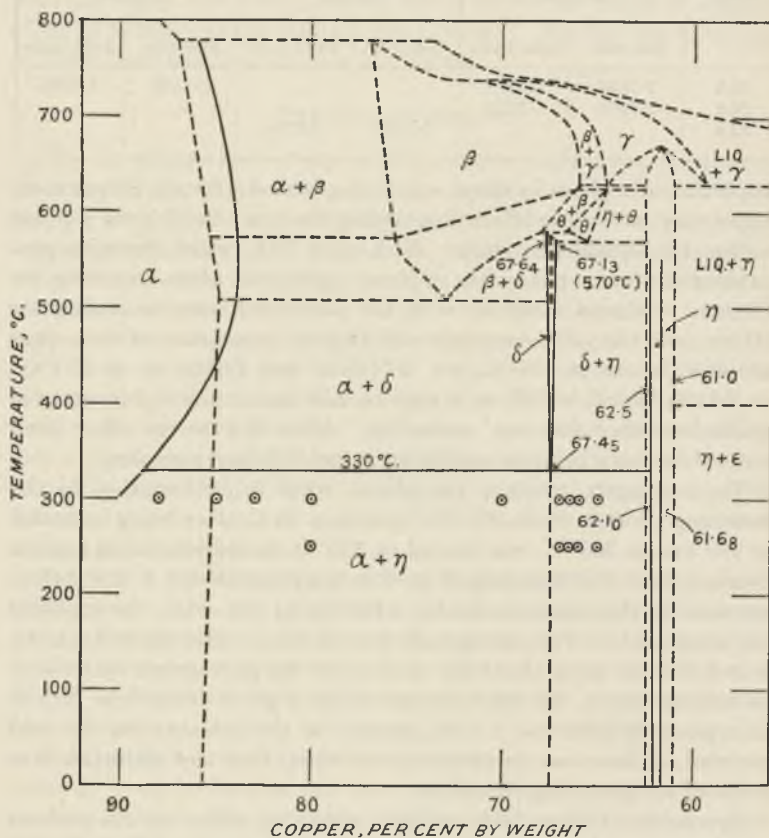


FIG. 4.

$(\alpha + \eta)$. The points shown in Fig. 4 below 330° C. are those at which there was evidence of the η -phase but no δ -phase.

No systematic attempt was made in the present investigation to locate exactly the position of the α -phase boundary at these low temperatures. This with other features of the equilibrium diagram will be dealt with in a later paper.

Fig. 4 shows the equilibrium diagram proposed by Hamasumi and Nishigori. The phase boundaries are shown by dotted lines. In the

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diagram are shown the alterations so far suggested in the phase boundaries from the results recorded in this and the previous paper on this alloy system. It will be noted that the α -phase boundary at temperatures above about 440° C. is displaced in the direction of greater tin content, but below this temperature in the opposite direction reaching at 300° C. the composition 90.01. The transformation of δ to ($\alpha + \eta$) is shown at 330° C. The δ region at 570° C. is approximately the same width, namely, 0.45 per cent. composition by weight as that in the diagram of Hamasumi and Nishigori at the same temperature, but the region extends to the eutectoid line at 330° C., the composition corresponding to the eutectoid point being 67.4₅ per cent. copper by weight. The η -region is about half the width of the same region as shown in the diagram of Hamasumi and Nishigori, but it agrees with this diagram in one respect that it is almost of constant width from the lowest to the highest temperature now reached, namely, 530° C.

ACKNOWLEDGMENTS.

The authors have pleasure in expressing their indebtedness and thanks to the Department of Scientific and Industrial Research for a grant which enabled them to carry out this work.

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METALLURGICAL ABSTRACTS

(GENERAL AND NON-FERROUS)

Volume 3

MARCH 1936

Part 3

I.—PROPERTIES OF METALS

(Continued from pp. 29-35.)

Study of the Manufacture, Properties, and Uses of Refined Aluminium. R. Gadeau (*Rev. Mét.*, 1935, **32**, (11), 503-508).—The Betts, Hoopes, and A.F.C. processes, employed by the Compagnie d'Alais, Froges et Camargue, are described. The A.F.C. process yields aluminium of 99.99% purity. G. compares the more important physical properties with those of less pure aluminium. The high-purity material possesses much increased resistance to corrosion and greater ductility.—H. S.

***On the Figuring and Correcting of Mirrors by Controlled Deposition of Aluminium.** John Strong and E. Gaviola (*Phys. Rev.*, 1936, [ii], **49**, (2), 207).—Abstract of a paper read before the American Physical Society. By controlled deposition of metals evaporated in a vacuum, it is possible to change the figure of reflecting surfaces quantitatively. A spherical 12-in. mirror has been parabolized repeatedly, a surface being obtained perfect within $\frac{1}{10}$ of a wave-length. A $5\frac{1}{2}$ -in. spherical mirror has been parabolized with the optical axis outside of its periphery. A defective parabolic mirror was corrected of turned up and down edges and asymmetric zones. A convex spherical Cassegrain mirror was hyperbolized.—S. G.

***Photoelectric Work-Function of Barium.** R. J. Cashman and N. C. Jamison (*Phys. Rev.*, 1936, [ii], **49**, (2), 195).—Abstract of a paper read before the American Physical Society.—S. G.

†**Beryllium.** (Gadeau.) See p. 74.

***Specific Resistance of Bismuth Single Crystals [Effect of Impurities in Single Crystals].** Alfred B. Focke and John R. Hill (*Phys. Rev.*, 1935, [ii], **48**, (12), 973).—Abstract of a paper read before the American Physical Society. The purpose of this investigation was to study the effect of impurities in single crystals. Measurements were made in the range -185° to $+100^{\circ}$ C. on samples containing lead, tin, antimony, and tellurium. The effects were found to be complicated, but the following generalizations may be made. Decreasing temperature results in greater effectiveness of the impurity present, except when the concentration of impurity is such that a separation of phases occurs at low temperatures. Extremely small amounts (less than 0.03%) of all impurities cause a sharp increase in the resistance. The effect of larger amounts depends on the nature of the impurity. Lead and tin continue to increase the resistance, additional tellurium forces the resistance to decrease to lower values than that of pure bismuth; additional antimony causes the initial increase of resistance to decrease and then slowly to be re-established. More than 0.03% tin and more than 0.3% lead result in a negative temperature coeff. for the resistance parallel to the principal axis. In other cases the coeff. is positive. The results may be explained qualitatively in the light of previous work on the magnetic properties of such crystals and the distribution of impurities within them, together with a study of the phase equilibrium diagrams for the system involved.—S. G.

***Diamagnetism of the Trivalent Bismuth Ion.** S. S. Bhatnagar and Bhim Sain Bahl (*Current Sci.*, 1935, **4**, 153-154; *C. Abs.*, 1936, **30**, 339).—From measurements carried out on 10 of its compounds, values for the diamagnetic

* Denotes a paper describing the results of original research.

† Denotes a first-class critical review.

susceptibility of the trivalent bismuth ion are calculated. The extreme values for $\chi_A \times 10^6$ are 38.45 and 43.45, with 41.24 as the mean value. The susceptibility is also calculated by Slater's theory to be 43.8. It is pointed out that Angus's modification of Slater's method would give still better agreement between theoretical and experimental results.—S. G.

***The Plastic Deformation of Cadmium Single-Crystals.** R. Roscoe (*Phil. Mag.*, 1936, [vii], 21, (140), 399-406).—Observations of the bending of single-crystal wires show that, when the stress over the glide-planes of a crystal is not uniform, slip begins when the *maximum* values of the resolved shear stress reaches the critical value for deformation under uniform stresses. Surface oxidation of cadmium single-crystals produces an increase in their resistance to plastic deformation, which is probably due to healing of submicroscopic cracks by the oxide film.—J. S. G. T.

†On the Allotropy of Calcium. M. C. Neuburger (*Z. Elektrochem.*, 1935, 41, (11), 790).—From the results hitherto obtained, calcium possesses 3, not 4, allotropic modifications. The first has a cubic face-centred lattice (A1 type) existing below 300° C., the second between 300° and 450° C., and the third with a hexagonal lattice (A3 type) is stable above 450° C.—J. H. W.

***The Photoelectric Work-Function of Calcium and Photo-Emission from Non-Homogeneous Surfaces.** N. C. Jamison and R. J. Cashman (*Phys. Rev.*, 1936, [ii], 49, (2), 201).—Abstract of a paper read before the American Physical Society.—S. G.

***The Hardness of Electrolytic Chromium.** S. P. Makariewa and N. D. Birükoff (*Z. Elektrochem.*, 1935, 41, (12), 828-842).—The effect of different conditions on the hardness and hydrogen content of electrodeposited chromium was investigated: (a) by the examination of chromium deposits with a current density of 3-120 amp./dm.²; (1) the hardness curve of different chromium deposits after the removal of the hydrogen shows breaks which were characteristic before the removal of the hydrogen; the hardness of the chromium does not depend on the hydrogen content; (2) the maximum value of the hydrogen solubility is reached at 25 amp./dm.², but the hardness of the metal decreases as the current density increases from 7 to 120 amp./dm.²; (b) by determining the temperature effect on the chromium deposit; (1) the solubility of hydrogen in chromium increases as the temperature of the electrolyte increases to 35° C.; from 35° to 40° C. it decreases slightly, and then again rapidly increases; (2) the hardness curves of the metal and the hydrogen solubility curves do not go in the same direction up to 30° C., but do so in the interval 30°-40° C. because the hydrogen solubility as well as the hardness of the chromium are dependent on a third factor, such as the grain-size of the deposit; (3) after the removal of the hydrogen, the hardness curves of different deposits remain nearly unaltered, which is confirmation that the hardness is independent of the presence of the hydrogen in chromium.—J. H. W.

Columbium and Tantalum. Clarence W. Balke (*Indust. and Eng. Chem.*, 1935, 27, (10), 1166-1169).—Electrolysis of the fused double fluorides of these metals (with potassium) yields the metals in the form of fine crystalline powder, which is hydraulically compressed into bars. These bars are heat-treated in vacuum furnaces to produce ingots (not fused) which are hammered, again heat-treated, and then worked by rolling or drawing. All working must be done at room temperature, as both metals combine with all common gases at high temperatures. The sheet metal may be spun, drawn, or converted into seamless tubing. Fabricated tantalum is used in the chemical and rayon industries, being chemically inert below 200° C. except in the presence of hydrofluoric and concentrated sulphuric acids and strong alkalis. Tantalum may be gas-hardened to a Brinell hardness of 600. Degree of hardness and depth of penetration can be varied through wide ranges. Both metals are being increasingly used in the construction of power and other

vacuum tubes. Their carbides have been incorporated into a series of compositions for use as tools, dies, and abrasion-resisting surfaces.—F. J.

Oxygen-Free Copper. Henry M. Schleicher (*Wire and Wire Products*, 1935, 10, (11), 514–515).—A brief account of the properties of oxygen-free copper and of the hydrogen-anneal test for the absence of oxygen in copper.—A. R. P.

***Experimental Researches Relating to the Surface Tension of Mercury and Its Alloys.** M. Lemarchands and L. Convers (*J. Chimie physique*, 1935, 32, (9), 657–669).—The drop-weight method was employed to determine the surface tension of mercury and some of its alloys. The value of the surface tension of mercury in air at 17° C., so determined, is found to depend on the rate of formation of the drop, decreasing from the value 494.3 to 445 dynes/cm. as the period of formation increased from 10 seconds to 28 minutes. The effect is possibly attributable to the adsorption of impurities from the air. In a vacuum, the value of the surface tension of mercury is found to be practically constant and to have the value 434 dynes/cm. Results of experiments with calcium amalgam suggest that the drop-weight method is possibly unsuitable for the determination of the surface tension of other than pure liquids.—J. S. G. T.

***The Longitudinal Thermoelectric Effect. VI.—Mercury.** J. L. Ch'en and W. Band (*Proc. Phys. Soc.*, 1936, 48, (264), 164–167).—The Benedicks e.m.f. in mercury contained in an unconstricted glass tube is found to undergo a reversible decrease with increasing temperature. It is suggested that there is an anisotropic quasi-crystalline arrangement of the surface molecules of mercury which is dependent on temperature. Quantitative analysis of the temperature distribution failed to give the homogeneous coeffs., presumably because the effect of temperature on the constants is very marked.—J. T.

***Magnetic Inversion Points by the Diffusion of Hydrogen Through Nickel and Iron and Through Iron-Nickel and Palladium-Nickel Alloys.** W. R. Ham and J. D. Sauter (*Phys. Rev.*, 1936, [ii], 49, (2), 195).—Abstract of a paper read before the American Physical Society. The diffusion of hydrogen through homogeneous metals follows the formula $R = A[(p_0^y - p^y)/X]T^e b^x$, where R is the rate of diffusion, A is a constant of the diffusing metal, p_0 and p are pressures on ingoing and outgoing sides, y is a variable exponent often nearly 0.5, T is the temperature Kelvin, X is the thickness of diffusing sheet, and b is the total work-function expressed in equivalent degrees. Over a range between 200° and 800° C. the isotherms for the metals mentioned in the title are almost linear between pressures of 74 cm. and 1 cm. of mercury, but the slopes (y) are not necessarily constant with temperature change, nor are the isobars necessarily linear. Pure nickel shows a discontinuity in diffusion isobars at 360° C. which cannot be mistaken, as does also palladium slightly alloyed with nickel. The cooling curves and magnetometer curves for nickel show the magnetic inversion to be very nearly at this same point. In the case of iron alloyed with nickel, the isobars show a sharp change in slope about 600° C., whereas pure iron shows a large change in its isobars beginning at 760° C. The energy changes involved in these magnetic transformations are discussed.—S. G.

***Phenomenon of Negative Hysteresis in Nickel.** S. Sharan (*Current Sci.*, 1935, 4, 157; *C. Abs.*, 1936, 30, 338).—Specimens of nickel wire were first carried through a few complete magnetization cycles and then left in a weak field to produce a small positive magnetization while alternating fields were applied. Longitudinal alternating fields produced effects similar to those in iron. Circular alternating fields, produced by passing an a.c. through the specimen itself, brought out the phenomenon of negative hysteresis, similar to effects observed in studies of the magneto-resistance change in nickel. S. directs attention to the fact that in both cases the nickel is carrying current, so that the effect may be associated with movement of the conduction electrons.

—S. G.

***The Thermomagnetic Properties of Nickel.—II.** William Band and Y. K. Hsü (*Proc. Phys. Soc.*, 1936, 48, (264), 168-177).—The homogeneous thermoelectric e.m.f. in nickel is examined for various tensions up to 8 kg. in a wire of pure nickel of diameter 1 mm. Analysis gives the Benedicks' coeffs. as functions of the magnetic field and tension. An anti-symmetric part of the e.m.f. with respect to the magnetization is found. It is suggested that the effect may be controlled by the regularity or anisotropy of arrangement of microcrystals within the wire.—J. S. G. T.

***The Surface Ionization of Potassium on Tungsten.** M. J. Copley and T. E. Phipps (*Phys. Rev.*, 1935, [ii], 48, (12), 960-968).—S. G.

***The Absolute Measurement of the Viscosity of Liquid Tin.** A. J. Lewis (*Proc. Phys. Soc.*, 1936, 48, (264), 102-110).—Values of the viscosity (η) of liquid tin were determined by the capillary-tube method between 235° and 330° C. The values of (η), measured in poises, found were: 235° C., 0.0195; 240° C., 0.0192; 250° C., 0.0186; 260° C., 0.0181; 270° C., 0.0176; 280° C., 0.0173; 290° C., 0.0170; 300° C., 0.0167; 310° C., 0.0164; 320° C., 0.0162; 330° C., 0.0160. These values are in good agreement with those obtained by Stott, and confirm the general accuracy of the work of Sauerwald and Töpler. The temperature variation of viscosity and the value of the viscosity at the freezing-point are adequately represented by Andrade's theory.
—J. S. G. T.

***Correlation of Emission and Adsorption Properties with Lattice Direction in Single Crystal Tungsten Wire.** W. Shockley and R. P. Johnson (*Phys. Rev.*, 1935, [iii], 48, (12), 973).—Abstract of a paper read before the American Physical Society. Investigation of single crystal tungsten wires by means of an electron microscope arrangement (Johnson and Shockley, *ibid.*, p. 973) reveals a marked correlation between crystallographic direction in the lattice and the emission and adsorption properties of the surface. Single crystals grown by heat-treatment in a drawn wire of pure tungsten, having the 110 direction along the wire axis, give a pattern with a minimum about 20° broad about the 110 direction, and minima about 5° broad in directions 60° from 110. Crystal orientations are determined from Laue pictures of the wire after it has been removed from the tube. When the filament is run at low temperatures in equilibrium with saturated caesium vapour at room temperature the contrast between light and dark regions on the tube wall is much more marked, and the pattern goes through a variety of phases as the filament temperature is changed over the observation range 700°-900° K. In general, directions of minimum emission from clean tungsten are directions of large emission from the caesium-tungsten surface. There is, however, much more "fine structure" in the caesium-tungsten patterns, regions less than 5° apart on the wire circumference differing markedly in electron emission and therefore presumably in equilibrium coverage of caesium. In every case the emission pattern exhibits the two reflection planes, 100 and 110, of the tungsten single crystal, and the pattern reproduces itself in each quadrant down to the smallest observable detail. Experiments with potassium-tungsten surfaces and with composite layers give similar results. Preliminary investigations of single crystal tungsten wires grown by the Pintsch process, which gives crystals of random orientation, indicate the possibility of mapping out emission and adsorption properties over the entire group of lattice directions in tungsten and in other metals which can be obtained in the form of small single crystal wire.—S. G.

***The Growth of Metal Crystals in Metal Vapours [Tellurium].—IV.** M. Straumanis (*Z. physikal. Chem.*, 1935, [B], 30, (2/3), 132-138).—Sublimation experiments were carried out with tellurium at various pressures both below and above the melting point to test the validity of Kossel and Stranski's theory of homopolar crystal growth. The crystals obtained were measured and their equilibrium form determined.—K. S.

An Apparent Regularity in β -Ray Reflection. Samuel C. Curran (*Phil. Mag.*, 1936, [vii], 21, (140), 406-415).—Diffraction rings, obtained by the multiple-scattering of β -rays from thin films of brass, lead, copper, iron, aluminium, and carbon, are shown to be attributable to reflected β -particles having velocities approximately the same as the incident particles; the results can be used to deduce the relative reflecting powers of materials.—J. S. G. T.

II.—PROPERTIES OF ALLOYS

(Continued from pp. 36-39.)

***Density Changes in Solid Aluminium Alloys.** L. W. Kempf and H. L. Hopkins (*Metals Technology*, 1936, 3, (1), 1-16; *Tech. Publ. No. 671*).—The "growth" of aluminium alloys on reheating in the range 175°-230° C. following rapid cooling from a solution heat-treatment is investigated. The "growth" varies between 0 and 0.16% according to composition and heat-treatment. The rate of "growth" under isothermal conditions depends largely on composition. The attainment of maximum "growth" requires much longer periods of time than the attainment of maximum hardness.—J. S. G. T.

***Aluminium-Magnesium Alloys.** Pierre Vachet (*Rev. Mét.*, 1935, 32, (12), 614-626; and *Rev. Aluminium*, 1935, 12, (76), 3087-3099).—V. determined the lattice spacing of the α magnesium-aluminium solid solution for 8 and 12% magnesium. Addition of manganese did not affect "a" appreciably. Effects of annealing and quenching are studied for alloys containing from 5 to 13% magnesium with and without an addition of 0.5% manganese. Difficulty is experienced in precipitating the β -phase from solid solution containing less than 8% magnesium. The alloys were subjected to mechanical tests in various conditions. Quenching from 450° C. gives moderate strength and a useful degree of ductility as shown by elongation values. Reheating the quenched alloys to 150° or 200° C. gives in some cases a slight increase in tensile strength, but treatment for long periods causes a considerable reduction in elongation value. Corrosion properties are studied by change in tensile properties. Quenched samples and "as rolled" samples showed very slow deterioration, but annealed and quenched and tempered samples deteriorated more rapidly. The properties of cast and cast-heat-treated bars are examined.—H. S.

***Optical Changes in Freshly Evaporated Aluminium-Magnesium Films.** Hiram W. Edwards and Robert P. Petersen (*Phys. Rev.*, 1936, [ii], 49, (2), 207).—Abstract of a paper read before the American Physical Society. Deals with a study of reflection and transmission characteristics of freshly evaporated films of an aluminium-magnesium alloy. Apparatus was arranged inside an evaporation chamber so that measurements could be made during and after deposition of the metallic film. Three types of changes in reflection and transmission coeffs. were observed: (1) Occurring at pressures of 10^{-4} mm. or less. This consists of a small, rapid decrease in reflectivity and an increase in transmissivity. One minute is required for this change. The transmission coeff. alters more rapidly than the reflection coeff. No further effect takes place in the vacuum. (2) The second type occurs during the admission of air or nitrogen into the vacuum chamber. It consists of a decrease in reflectivity and an increase in transmissivity. The rate of change is definitely dependent on the rate of increase of pressure in the vacuum chamber. (3) This type takes place very slowly, over a period of several days. The final value of the reflection or transmission coeff. is approached asymptotically. The magnitudes of the 3 types of changes for a film having an initial reflection coeff. of 58% were observed to be 8, 5, and 10%, respectively, and for another film having an initial transmission coeff. of 35% they were 5, 8, and 5%.—S. G.

†**Beryllium.** R. Gadeau (*Rev. Mét.*, 1935, **32**, (12), 627-637).—The occurrence, extraction, and properties of beryllium are discussed. The properties and main features of the binary alloys of beryllium with aluminium, nickel, iron, and copper, are described, special reference being made to beryllium-bronze (2.3% beryllium).—H. S.

A New Low-Melting Alloy. Sidney J. French (*Indust. and Eng. Chem.*, 1935, **27**, (12), 1464-1465).—The fusible quaternary eutectic alloy usually termed the "Lipowitz eutectic alloy" (bismuth 50, lead 27, tin 13, cadmium 10%) melts sharply at 72° C. and freezes at 70° C. Quinary alloys were prepared by adding indium to the above-mentioned alloy. The freezing ranges of these alloys are tabulated. The addition of 18.1% indium to the Lipowitz alloy resulted in the freezing-point being lowered to 46.5° C. Its composition is bismuth 40.95, lead 22.11, indium 18.10, tin 10.65, cadmium 8.20%. The cost of this alloy would be \$5 per oz. in small lots. The human body can come into contact with the molten alloy without discomfort; it would therefore be suitable for making casts of features and finger-print impressions and for surgical work. It oxidizes very little in the molten state, being thus superior to wood, metal, and Lipowitz alloy.—F. J.

***The Abnormal Phenomenon of Cast Copper-Rich Copper-Silicon Alloys During Heating.** Takumi Taketani and Saburo Katori (*Nippon Kwagaku Kwaishi (J. Chem. Soc. Japan)*, 1935, **56**, (9), 1058-1064; *C. Abs.*, 1936, **30**, 65).—[In Japanese.] The abnormal thermal expansion which takes place on heating the cast copper-silicon alloys containing 3.0-7.5% silicon at 200°-800° C. was studied. The phenomenon is attributed to the homogenization of the α -phase, and the solution of the β -phase into the α -phase as solid solution.—S. G.

***The Homogenization of Cast Structures in Copper-Rich Copper-Silicon Alloys.** Takumi Taketani (*Nippon Kwagaku Kwaishi (J. Chem. Soc. Japan)*, 1935, **56**, (9), 1064-1071; *C. Abs.*, 1936, **30**, 65).—[In Japanese.] Cf. preceding abstract. With increase of silicon content the temperature required to bring about homogenization of the α -phase becomes lower and the tendency of the β -phase to remain undissolved by heating predominates.—S. G.

Tungum Alloy. — (*Aluminium and Non-Ferrous Rev.*, 1935, **1**, (3), 115-116).—Describes the physical, mechanical, and corrosion-resisting characteristics of this non-ferrous alloy (composition not given).—J. C. C.

***Electrical Conductivity and Equilibrium Diagram of Binary Alloys. The Lithium-Aluminium System.** G. Grube, L. Mohr, and W. Breuning (*Z. Elektrochem.*, 1935, **41**, (12), 880-883; and (abstract) *Light Metals Research*, 1936, **4**, (14), 230).—The equilibrium diagram of the system lithium-aluminium was investigated by thermal analysis and temperature-resistance curves of the solid alloys. The fluid metals are not mutually soluble in all proportions, but a gap occurs in the fluid state extending from 44.5 to 60.0 atomic-% lithium at 698° C. The limiting concentration of the α -solid solution on the aluminium-side was determined between 600° C. and room temperature by conductivity measurements. The intermediate crystal form, LiAl, found by A. Müller (*Z. Metallkunde*, 1926, **18**, 231), and described as to its structure by Zintl and Woltersdorf (*Met. Abs.*, this vol., p. 76), forms, with excess lithium, the β -solid solution, whose range of homogeneity at 521° C. extends from 50 to 56 atomic-% of lithium. The existence of the crystal form, Li₂Al, was detected; it is formed at 521° C. by the peritectic reaction between the β -solid solution and the melt.—J. H. W.

***X-Ray Analysis of the Lithium-Zinc Alloys.** (Zintl and Schneider.) See p. 77.

***Experimental Researches Relating to the Surface Tension of Mercury and Its Alloys.** (Lemarchands and Convers.) See p. 71.

K Monel. W. A. Mudge and P. D. Merica (*Japan Nickel Rev.*, 1935, **3**, (4), 506-512).—[In English and Japanese.] An analysis of a typical material

is nickel 63.32, copper 30.84, aluminium 3.45, iron 1.50, manganese 0.50, carbon 0.16, silicon 0.20, sulphur 0.005%. The alloy can be hardened by heat-treatment and is produced in four different degrees of hardness, the highest having a Brinell number of 325. Any grade may be softened by heating to 760° C. and then quenching in water or oil. The alloy retains its properties at moderately elevated temperatures.—W. A. C. N.

***Accelerated Service Tests of Pintle Bearings.** Ambrose H. Stang and Leroy R. Sweetman (*J. Research Nat. Bur. Stand.*, 1935, **15**, (6), 591–600; *Research Paper No. 854*; and (abstract) *Mech. World*, 1936, **99**, (2565), 219–220).—Accelerated service tests of pintle bearings with different combinations of materials for the pintles and cups, different pressures, and different conditions of lubrication were made under conditions similar to those which might obtain in practice as to the line of thrust and angle of swing. The bearings were under water during the tests. The results indicated that of the materials tested one must be phosphor-bronze to give satisfactory service for pressures as great as 2000 lb./in.². Pintles of H-Monel, M-Monel, and S-Monel gave satisfactory service at this pressure with phosphor-bronze cups. Cups of stainless steel, chromium-steel, chromium-nickel steel, malleable cast iron, and Monel alloys were scored badly after only a few cycles when tested under a pressure of 2000 lb./in.². Aluminium-“bronze” cups were worn excessively at a comparatively small number of cycles. Phosphor-bronze was the only cup material tested in this investigation which gave satisfactory service with a pressure as great as 2000 lb./in.². A stainless steel pintle and phosphor-bronze cup provided with grooves for water circulation and tested under a pressure of 4000 lb./in.² withstood more than 288,000 cycles, the number of cycles expected in 20 years' service. A stainless steel pintle and phosphor-bronze cup lubricated with white lead or with grease having a lead-soap base and asphalt content did not fail when tested under a pressure of 6000 lb./in.² and subjected to more than 288,000 cycles.—S. G.

New Alloys. T. W. Lippert (*Iron Age*, 1936, **137**, (1), 171–182).—Describes low-alloy, high-tensile steels, developments in non-ferrous metallurgy during 1935, new heating elements, free-machining aluminium, new Monel alloys, boride alloys, and other new alloys.—J. H. W.

†**Two-Dimensional Diagrams.** L. Grenet (*Métaux*, 1935, **10**, (123), 248–263).—Read at the 7e. Congrès International des Mines, de la Métallurgie et de la Géologie appliquée. The application of the Phase Rule to the construction of 2-dimensional equilibrium diagrams, the distinction between chemical and physical or mechanical equilibrium, and the conception of the term “phase” are discussed. Equilibrium diagrams with 2 variables, the interpretation of binary diagrams, and diagrams of 2 variables admitting of the existence of a number of masses under constraint, are explained and illustrated.—J. H. W.

III.—STRUCTURE

(Metallography; Macrography; Crystal Structure.)

(Continued from pp. 39–41.)

***A Method for Obtaining Perfectly Polished Metallic Surfaces.** Pierre Jacquet (*Compt. rend.*, 1935, **201**, (27), 1473–1475).—Polishing metal surfaces by mechanical abrasion leaves scratches and a thin film of a structure different from that of the subjacent metal. Good results have been obtained with copper and certain of its alloys by attacking the metal anodically in a concentrated aqueous solution of ortho- or pyro-phosphoric acid. The solution contains 400 gm./litre of the acid and is kept at 15°–25° C. The cathode is a copper plate of larger surface than the anode. An ammeter, a voltmeter, and a variable resistance complete the circuit. The voltage used depends on the concentration of the solution and especially on the position of the anode, and is that at which

the evolution of gas appears. The solutions must be filtered, and the fine bubbles of gas, which sometimes appear on the metal when it is immersed, must be eliminated.—J. H. W.

***The Anisotropic Growth of Silver Crystals by Condensation from Vapour.** Joseph H. Howey (*Phys. Rev.*, 1936, [ii], 49, (2), 200).—Abstract of a paper read before the American Physical Society. It has been found that silver vapour condensing in a vacuum on suitable nuclei of solid silver maintained at a temperature just below the melting point forms single crystal needles under certain conditions. The observed habit of growth is probably dependent on the presence of certain impurities, but it is noteworthy that a metal having face-centred cubic symmetry in the solid state should ever condense in the form of needles. The longest needles grown were about 3 mm. long and several tenths of a mm. in diameter. At least 5% of the needles have abrupt changes in direction, the appearance of which indicates that the boundary between the two linear portions coincides closely with a single crystallographic plane extending across the entire cross-section. Abrupt changes in direction both less and greater than 90° have been observed, but no branching has been found. One tentative explanation of the growth of these needles is to consider their occurrence as experimental evidence for the idea that the forces between metal atoms in a crystal may be greater in one direction than in others which are crystallographically identical and that the direction of this anisotropy may be constant throughout a domain of considerable size. The existence of such anisotropy would serve to explain the growth of the needles regardless of whether the growth is conditioned by the presence of impurities or not.—S. G.

†The Structure of Some Copper Alloys. W. Broniewski (*Rev. Mét.*, 1935, 32, (12), 649–657).—A survey of the results of structural investigations of binary alloys of copper with nickel, aluminium, zinc, tin, and gold.—H. S.

***The Structure of the Zinc-Cadmium Eutectic.** M. Straumanis and N. Brakšs (*Z. physikal. Chem.*, 1935, [B], 30, (2/3), 117–131).—The zinc-cadmium eutectic consists of relatively coarse fibres which can be observed at low magnifications. These fibres are not homogeneous but are built up of layers to produce a true eutectic structure which is resolved at high magnifications.—K. S.

***X-Ray Study of Iron-Nickel Alloys.** Eric R. Jette and Frank Foote (*Metals Technology*, 1936, 3, (1), 1–14; *Tech. Publ. No. 670*).—The results are given of an X-ray investigation of 15 iron-nickel alloys, with a number of heat-treatments. The γ -phase (face-centred cubic) alloy lattice constants were determined over the range 25–100% nickel where this phase could be retained intact by drastic quenching. Positive large deviations from the additivity rule were found. The maximum lattice constant was found at about 35 atomic-% nickel. From 100 to 43 atomic-% nickel the lattice constant a was given by $a = 3.64033 - 0.0012379N$, where N is the percentage (atomic) of nickel. The value of a decreases sharply from its maximum value, and from 0 to 20% nickel it extrapolates linearly to Öhman's value for pure γ -iron. The α -phase range up to about 5 atomic-% nickel similarly showed marked positive deviations from the additivity rule. Tentative limits for the two-phase region are suggested. No indication was obtained of the existence of compounds or superstructures. A table of densities of the alloys calculated from the lattice constants is given.—J. S. G. T.

***Lattice Structure of Lithium-Aluminium.** E. Zintl and G. Woltersdorf (*Z. Elektrochem.*, 1935, 41, (12), 876–879); and (summary) *Light Metals Research*, 1936, 4, (14), 228–229).—Lithium-aluminium alloys were melted under lithium fluoride in argon in a zirconia crucible from the components. X-ray analysis showed only the intermediate phase LiAl in the range 0–50 atomic-% lithium. Aluminium saturated with lithium has the largest lattice dimensions, but the widening of the lattice is less than that to be expected from the additivity of the atomic radius. LiAl has a cubic body-centred lattice of the NaTl

type, with $a = 6.360$ Å. From the lattice interval and the fact that especially elements with 3 valency electrons with lithium or sodium form NaTl structures in which the nobler atoms form a diamond lattice, a conception of the reciprocal effect of the atoms in such structures was derived as a working hypothesis for further investigations.—J. H. W.

***X-Ray Analysis of the Lithium Amalgams.** E. Zintl and A. Schneider (*Z. Elektrochem.*, 1935, **41**, (11), 771-774).—The results of X-ray analysis agreed with those of thermo-analysis, in that in the system lithium-mercury at room temperature in the range 0-78 atomic-% lithium, 5 intermediate phases occurred, having the approximate compositions LiHg_3 , LiHg_2 , LiHg , Li_2Hg , and Li_3Hg . The structure of 2 of these phases, *viz.* LiHg_2 and Li_3Hg , could not be cleared up. From revolving crystal, goniometer and powder diagrams of LiHg_3 , a hexagonal element was found with $a = 6.240$ Å., $c = 4.794$ Å., and $c/a = 0.768$. It contains 2 atoms of lithium in the planes 0 0 0 and $\frac{1}{3} \frac{2}{3} \frac{1}{2}$, and 6 atoms of mercury in the planes $\frac{1}{2} 0 0$, $0 \frac{1}{2} 0$, $\frac{1}{2} \frac{1}{2} 0$, $\frac{1}{3} \frac{1}{3} \frac{1}{2}$, $\frac{5}{6} \frac{1}{3} \frac{1}{2}$, and $\frac{5}{6} \frac{2}{3} \frac{1}{2}$. The lattice of LiHg_2 is an overstructure of the hexagonal densest sphere packing. LiHg has the structure of β -brass with $a = 3.287$ Å. The powder diagram of Li_3Hg indicates a cubic lattice with $a = 6.584$ Å., face-centred translation group, with 4 mercury and 12 lithium atoms per cell. Li_3Hg has the same structure as Cu_3Al , the β -phase of the copper-aluminium system.—J. H. W.

***X-Ray Analysis of the Lithium-Zinc Alloys.** E. Zintl and A. Schneider (*Z. Elektrochem.*, 1935, **41**, (11), 764-767).—X-ray investigation of the lithium-zinc alloys by the powder method essentially confirmed the results of Grube and Vosskühler (*Met. Abs.*, 1934, **1**, 125), who found 5 intermediate crystal forms at room temperature. The β' -phase with about 10 atomic-% lithium has a hexagonal lattice with the densest sphere packing, $a = 2.782$ Å., $c = 4.385$ Å., $c/a = 1.576$, and static atomic arrangement. For the γ' -phase with about 28 atomic-% lithium, a hexagonal pseudo-cell with $a = 4.362$, $c = 2.510$, and $c/a = 0.575$ is suggested, with 2 zinc atoms on the 0 0 0 and $\frac{1}{2} \frac{2}{2} \frac{1}{2}$ planes. The δ'' -phase (LiZn) has a cubic structure of the NaTl type, with $a = 6.209$ Å.

—J. H. W.

***Structure of the Platinum-Thallium Alloys.** E. Zintl and A. Harder (*Z. Elektrochem.*, 1935, **41**, (11), 767-771).—Platinum takes up little thallium with a widening of the lattice of about 1.5%; conversely, the solubility of platinum in thallium appears to be very low. Both metals form only one intermediate crystal form with the formula PtTl, whose structure has been determined by layer-line, goniometer, and powder diagrams. It has a hexagonal lattice, $a = 5.605$, $c = 4.639$, $c/a = 0.828$, with 6 atoms per cell on the following planes: 0 0 0, $\frac{1}{2} \frac{1}{2} 0$, $\frac{1}{2} 0 0$, $0 \frac{1}{2} 0$, $\frac{1}{2} \frac{2}{3} \frac{1}{2}$, $\frac{2}{3} \frac{1}{3} \frac{1}{2}$. On account of the almost equal scattering of platinum and thallium, it cannot be decided whether both kinds of atoms are regular or distributed on the lattice point. Thallium forms no compound with platinum with the nickel arsenide structure. A process is described for the production of small amounts of the alloys from the partly high melting and partly volatile components. The metals are heated under argon in a sintered corundum crucible which is made gas-tight with an oxy-acetylene flame.—J. H. W.

†Study of Metallic Crystals. E. Schmid (*Rev. Mét.*, 1935, **32**, (12), 638-648).—A survey of the results of X-ray studies of the structures of single crystals. Attention is given to physical properties in different directions, plastic deformation, separation of a constituent from a saturated phase, and relationship between properties of aggregates and single crystals. A short bibliography is appended.—H. S.

***The Hume-Rothery Conception of the Metallic State.** C. D. Niven (*Phil. Mag.*, 1936, [vii], **21**, (139), 291-299).—It is considered that Hume-Rothery's (8 - N) rule for the metallic state is more clearly stated thus: In crystallizing, each atom has (8 - N) near neighbours, where N is the number of electrons in

the "p" system. The unique case of bismuth is associated with 6 shared electrons. The phenomena of metallic conduction and of superconduction are explained in terms of transit of electrons; change of hardness due to impurities depends on the size of the foreign atom relative to that of the other atoms, while change of electrical conductivity depends on the periodicity of the electron motion in the foreign atom relative to that in the pure atom.

—J. S. G. T.

***The Rate of Diffusion in Metal Crystals and Atomic Structure.** W. Seith (*Z. Elektrochem.*, 1935, **41**, (12), 872–876).—Cf. *Met. Abs.*, this vol., p. 7. The solubility of a metal in solid lead and the rate of diffusion of this metal in the lead are dependent on its place in the periodic system, and therefore on the atomic size and the number of the valency electrons.—J. H. W.

***The Effect of Crystal-Size on Lattice Dimensions.** G. I. Finch and S. Fordham (*Proc. Phys. Soc.*, 1936, **48**, (264), 85–93).—It is shown experimentally that crystal-size can, and sometimes does, exert an appreciable effect upon the lattice dimensions of ionic crystals.—J. S. G. T.

IV.—CORROSION

(Continued from p. 42.)

Action of Dilute Acids on Aluminium. Charles F. Poe, R. M. Warnock, and A. P. Wyss (*Indust. and Eng. Chem.*, 1935, **27**, (12), 1505–1507).—Tests were carried out on sheet aluminium of the composition: aluminium 99.26, iron 0.53, copper 0.03, silicon 0.16%, and manganese nil. Pieces of the sheet were boiled in 0.1N acids for 30 minutes each day for 12 weeks and also allowed to stand immersed at 25° C. for varying periods up to 12 weeks. The results are tabulated. Tests were also carried out on various aluminium (including die-cast) cooking utensils, the compositions of which are not given. Of the inorganic acids, the halogen acids seem to be most active. Of the organic acids, acetic and its chlorine derivatives, and formic and lactic, are rather active. Glycolic, hydric, malonic, oxalic, and sulphurous acids, among others, showed considerable activity for the first few weeks, thereafter decreasing. Most of the acids found in fruits and vegetables are more or less active on aluminium. It is not known to what extent the solubility of aluminium would be altered by the other constituents of foods, nor is it suggested that aluminium is not a proper material for use in the manufacture of cooking utensils, the physiological action of its salts not being considered in this article.—F. J.

†Corrosion-Resistance of Aluminium and Standard Aluminium-Base Alloys. P. Mabb (*Metallurgia*, 1936, **13**, (76), 109–113).—The corrosion-resistance of many aluminium alloys is reviewed and that of aluminium and of standard aluminium-base alloys including Duralumin, copper-silicon, copper-nickel-silicon, aluminium-manganese, and aluminium-magnesium is compared with special reference to the influence of impurities and alloying elements. Practical examples of corrosion tests of these alloys by means of the salt-spray are given. Additional safeguards against corrosion, where the natural protective film is inadequate, are considered, and available methods of protection, e.g. electrodeposited, paint, or other organic films, chemical oxidation, and electrolytic oxidation are dealt with in brief.—J. W. D.

***Additions of Inhibitors to Solutions which Corrode Aluminium.** Hans Röhrig (*Rev. Mét.*, 1935, **32**, (11), 577–580; also (summaries) *Light Metals Research*, 1936, **4**, (15), 241–243; and *Light Metals Rev.*, 1936, **2**, (15), 257–259).—See *Met. Abs.*, this vol., p. 8.—H. S.

Corrosion of Underground Cables. Ito Panara (*Elettrotecnica*, 1935, **22**, (18), 653–660; *Sci. Abs.*, 1935, [B], **38**, 652).—P. discusses corrosion effects under two groups: (1) corrosion due to the presence in the soil of certain chemicals and

to irregularities in the sheath; and (2) corrosion due to stray currents in the soil. Protection against corrosion may be effected by armouring the cables, but care has to be taken in the selection of the materials. Where armouring is not possible, as for instance in towns where plain lead-covered cables are drawn into ducts, the usual practice is to arrange for the cable-sheath to be kept at a potential lower than that of the surrounding earth; in this way no stray currents leave the cable-sheath except through definite drainage points.

—S. G.

The Use of the Schlumberger Circuit in the Study of the Electrolysis of Underground Pipework. R. Gibrat (*Rev. gén. Elect.*, 1936, 39, (2), 51-69).—A detailed account is given of the Schlumberger differential method for measuring stray currents between any point in a buried cable and the surrounding soil, and the precautions which must be taken to ensure accurate results are discussed. Methods of protecting lead cable-sheath against electrolytic corrosion are surveyed.—J. C. C.

***The Influence of Admixtures on the Corrosion of Zinc.** A. I. Samokhotski and A. P. Bliudov (*Vestnik Metallopromishlennosti (Messenger Metal Ind.)*, 1935, 15, (12), 122-124).—[In Russian.] The solubility of zinc in 0.5% sulphuric acid is increased by additions of copper, iron, antimony, arsenic, and tin and decreased by cadmium, aluminium, lead, and mercury.—D. N. S.

***The Electrochemical Anodic Behaviour of Alloys.** W. J. Müller (*Z. Elektrochem.*, 1935, 41, (11), 774-778).—Read before the Verein Deutscher Chemiker E.V. (after the experiments of H. Freissler and E. Plettinger). The electrochemical behaviour of copper-zinc alloys containing from 29.3 to 89.0% copper was investigated as regards: (1) colorimetric determination of the anodic solubility and the ratio in which the components go into solution, (2) determination of the potential against approximately normal salt solution mixtures which correspond in composition to the proportions of the solubility of the constituents, (3) determination of the passivity time of the alloys which, with the above tests, leads to conclusions as to the presence of a protecting oxide layer.—J. H. W.

***Corrosion of Metals by Contact with Leather.** R. F. Innes (*J. Internat. Soc. Leather Trades Chem.*, 1935, 19, (12), 548-563; *C. Abs.*, 1936, 30, 641).—Leathers tanned with single tanning materials (chromium, syntan, sulphite cellulose, and 8 vegetable tannins) were kept in contact with metal strips (steel, copper, zinc, tin, Duralumin, brass, and bronze) for 36 weeks at relative humidities of 50, 70, and 90% at room temperature, and at 70% relative humidity at 37° C. Corrosion was judged from appearance. Of the materials tested, tin was the most resistant and copper and its alloys were the least resistant. Of the leathers tested, that tanned with syntan caused greatest corrosion, probably because of an abnormally low p_H value, followed by leathers tanned with sumac and myrobalans. Leathers tanned with oak bark, gambier, mimosa, quebracho, and sulphite cellulose caused least corrosion. Apart from the syntan leather there was no direct relationship between leather p_H value and corrosion. The amount of corrosion increased with increasing temperature or humidity. Corrosion was increased when leathers were oiled with cod-liver oil containing about 12% free fatty acids, and decreased but was not eliminated when leathers were oiled with petrolatum. (Cf. Kubelka, Nemeec, and Zuravlev ("Action of vegetable tanned leather on metallic iron"), *Cuir tech.*, 1935, 24, 300-304).—S. G.

***Attack by Liquid Fuels on Certain Materials.** K. R. Dietrich and W. Lohrengel (*Oel u. Kohle*, 1936, 12, (5), 91-92).—Recent German legislation demands the addition of 10% methanol to ethyl alcohol intended for admixture with petrol or benzole. An account is given of comparative corrosion tests, lasting 10 weeks, on 12 light alloys, pure aluminium with and without M.B.V. coating, ordinary iron, and iron protected by coatings of lead, tin, or

zinc. Attack was inappreciable except in the case of plain, galvanized, and lead-coated iron, Silumin with M.B.V. coating, and Elektron. The results are summarized in comparative curves.—P. M. C. R.

Corrosion in the Mineral Oil Industry : Discussion. — (*Oel u. Kohle*, 1936, 12, (5), 93–95).— *Baudrexel* stated that the fuel tanks of aircraft, whether of galvanized iron or light metal, were especially liable to corrosion owing to the combined effects of air bubbles and moisture introduced during filling. He recommended the use of synthetic lacquer as a protective coating on account of its high elasticity. — *Klas* distinguished between corrosive effects as observed in open and closed systems, and reproduced graphically the results of comparative tests on tinsplate, galvanized iron, and sheet iron in 3 benzol mixtures and 3 ordinary petrols for periods of 7–420 days. — *Schikorr* referred to comparative tests on light alloys.—P. M. C. R.

[Petroleum] Refinery Corrosion. W. L. Nelson (*Petroleum Eng.*, 1936, 7, (4), 90–93).—The principal corrosive agents in refinery work are hydrogen sulphide, hydrochloric, sulphuric, and sulphurous acids, and ammonia. A table shows the type of corrosion or other special form of attack to which the various parts are liable, and suggests some alternative materials. These include Monel and Muntz metal, aluminium-bronze, pure aluminium, and lead : the last-named is most conveniently applied by spraying, which process is frequently adopted with copper and copper-base alloys.—P. M. C. R.

Turbine-Blade Erosion. C. Richard Soderberg (*Electric J.*, 1935, 32, (12), 533–536).—Erosion of turbine blading is affected by the speed of impact between blade and steam, the amount of moisture participating in the impact, and the properties of the blade material. The existence of critical limits of speed and moisture suggests that after a limiting strength of the material against bombardment by water drops is exceeded, erosion is very rapid. Blades of stainless steel, protected by Stellite shields silver-soldered to the blades, have given the most promising results. Chromium-plated blades have good initial resistance, but the coating is liable to crack, after which erosion is rapid. An erosion testing machine, in which a specimen is rotated at 12,000 ft./second, striking a $\frac{1}{8}$ -in. jet of water at each revolution, is briefly described.—J. C. C.

V.—PROTECTION

(Other than Electrodeposition.)

(Continued from p. 43.)

***Oxide Films on Aluminium and Its Alloys.** A. G. C. Gwyer and N. D. Pullen (*Rev. Mét.*, 1935, 32, (12), 658–667).—A general discussion of the subject of anodic films on aluminium is followed by an account of investigations of films produced in chromic acid, oxalic acid, and sulphuric acid on aluminium alloys containing copper 3–12, zinc 13, or silicon 10–12%. The thickness of the films and the effect of the treatment on the underlying metal were studied microscopically, and numerous photomicrographs are given.—H. S.

The Anodic Oxidation of Aluminium with Particular Reference to the British Patents. — (*Brit. Aluminium Intelligence Memorandum 1D/1a 36*; and (summary) *Light Metals Research*, 1936, 4, (13), 203–206).—Reference is made to the factors which influence the nature of the film produced by anodic oxidation, and to methods of modifying its properties by subsequent treatments. The characteristics of oxide films, and their applications in service, are discussed.—J. C. C.

On the Surface Protection of Aluminium and Aluminium Alloys. W. Birett (*Maschinenbau*, 1935, 14, (21/22), 615–618).—Various methods for producing oxide films on aluminium are discussed.—K. S.

***Surface Treatment by Welding Technique [Metal Spraying] for the Production of Coatings.** A. Matting (*Maschinenbau*, 1935, **14**, (23/24), 683-686).—The technique of metal spraying is described and the properties of sprayed coatings are examined. It is concluded that such coatings have not the strength nor the wear-resistance of the solid metal owing to their non-homogeneity. Consequently the use of such coatings must be restricted to special purposes, such as the covering-up of pores, &c., the production of aluminium coatings, or the beautifying of metal or other surfaces.—K. S.

Painting Aluminium and Its Alloys. Junius D. Edwards and Robert I. Wray (*Indust. and Eng. Chem.*, 1935, **27**, (10), 1145-1146).—Minor differences in paint adhesion have been noted on different wrought alloys of aluminium, and some observations on the correlation of paint adhesion and alloy composition are presented. An important factor discussed, which results in loss of paint adhesion, is chemical reaction at the interface between paint film and metal. Good resistance of the vehicle to alkali is generally found in practice to help paint adhesion. When the alkalinity is due to magnesium, it is related to its structural occurrence and distribution rather than to the amount present. Combined as Mg_2Si or as $MgZn$, it is more reactive than when in solid solution. The production of passive surfaces, as best exemplified by certain anodic coatings, minimizes any differences between alloys and gives an excellent base for holding paint, particularly where subjected to immersion in water or very humid conditions. Even without special surface preparation, aluminium alloys hold paint very satisfactorily in comparison with other structural metals. In the painting or repainting of surfaces which have been corroded, preliminary treatment with chromate solution has been found effective.—F. J.

Painting Zinc and Zinc Alloy Surfaces. Harley A. Nelson (*Indust. and Eng. Chem.*, 1935, **27**, (10), 1149-1151).—The factors thought to influence the initial adherence and adherence retention of paint on zinc and zinc alloy surfaces are discussed. These are considered in the light of surface relationships that may exist between the metal and the paint and the possible influence of changes in the chemical and physical nature of the paint film on ageing. A limited theoretical discussion is given of (1) selective absorption; (2) progressive changes in the paint film; (3) disturbance of the oxide film normally existing at the surfaces of the metal; and (4) electrolytic attack of the metal. Pre-treatment of the metal surface before painting is also discussed. The pigment that has the most beneficial effect on adherence retention, particularly of air-drying oil primers, in which acid decomposition products are formed, is metallic zinc powder (zinc dust).—F. J.

VI.—ELECTRODEPOSITION

(Continued from pp. 43-45.)

Electrodeposition of Chromium for Wear Resistance. John Kronsbein (*J. Electrodepositors' Tech. Soc.*, 1936, **11**, 23-26; and (abstract) *Met. Ind. (Lond.)*, 1936, **48**, (6), 193-194).—Plug gauges are coated with 0.007-0.012 in. of chromium of which 0.002-0.004 in. is ground off to set up the gauge. The base metal should be hardened before plating to obviate subsequent chipping. The electrolyte consists of chromic acid 250 gm./litre and sulphuric acid 2.40 gm./litre, and is used at 37°-41° C. and 80-200 amp./ft.². Current consumption is 500 amp.-hrs./ft.² for 0.001 in. Throwing power is poor, and anodes should conform to the cathode shape. The sulphate ratio should be maintained between 60 and 100. Chromium increases the life of gauges from 10 to 25 times as compared with hardened steel, but is useless for cutting edges.—A. I. W.-W.

The Electrodeposition of Bronze Using Bronze Anodes. S. Baier and D. J. Macnoughtan (*J. Electrodepositors' Tech. Soc.*, 1936, **11**, 1-14; also *Tech. Publ. Internat. Tin Res. Develop. Council, Series A*, 1936, (27), 14 pp.; and *Met. Ind.*

(*Lond.*), 1935, **47**, 543-544, 567-570; discussion, 1936, **48**, 15-18).—Satisfactory deposits of bronze can be obtained from an electrolyte containing copper cyanide 150 gm./litre, sodium stannate, 50 gm./litre, and sodium cyanide, 15 gm./litre at 65° C. and current densities up to 50 amp./ft.². The p_H of the solution was maintained by caustic soda at 12.5-12.7 and controlled by the use of alizarin yellow as a colorimetric indicator in samples of electrolyte diluted 100/1. Annealed cast bronze anodes contained 12% tin. Anode and cathode efficiencies in relation to current density, although discordant, allow the metal content of the electrolyte to be controlled during operation. Bronze deposits of more than 0.0003 in. thickness are completely non-porous, and throwing power is exceptionally high. A bronze deposit of 0.0002 in. is a satisfactory undercoat for chromium. The hardness of the deposit increases with the tin content from Brinell No. 222 at 11.7% tin to 345 at 17.0% tin. Methods of analysis of the electrolyte and deposits are described.—A. I. W.-W.

The Electrodeposition of Bronze Using Bi-Metallic Anodes. C. Béchard (*J. Electrodepositors' Tech. Soc.*, 1936, **11**, 15-22; and *Tech. Publ. Internat. Tin Res. Develop. Council, Series A*, 1936, (28), 8 pp.).—Bronze can be deposited from solutions of ammonium stannoxalate and ammonium cupri-oxalate in the presence of oxalic acid. Insoluble anodes are used, and the copper and tin contents of the electrolyte is maintained by two independent auxiliary circuits with cathodes enclosed in porous pots. Increase in current density or decrease in temperature favour the deposition of tin. The electrolyte is unstable, the tin being oxidized to stannic salt by the catalytic action of the copper salt. A solution containing potassium cuprocyanide, stannic chloride, potassium hydroxide, and potassium cyanide will give bronze deposits having a tin content varying from 10 to 25% according to the proportions of the constituents. Copper and tin and insoluble anodes are used with independent control of current density to maintain the balance of anode and cathode efficiency. [*Note*: The two circuit diagrams are reversed.].—A. I. W.-W.

Progress of Nickel in the Past Ten Years. John F. Thompson (*Rev. Mét.*, 1935, **32**, (11), 509-516).—T. surveys the progress in the extraction of nickel, and of nickel alloys and nickel steels during the past 10 years, in which the world's consumption of nickel has doubled, and mentions advances in electro-deposition of nickel.—H. S.

†**The Present Position of Nickel and Chromium Deposition.** M. Ballay (*Rev. Mét.*, 1935, **32**, (10), 494-500).—A review of recent advances.—H. S.

Platinum Plating. Taro Yoshida (*Japan Nickel Rev.*, 1936, **4**, (1), 82-84).—[In English and Japanese.] A solution containing platinum chloride 0.5, caustic soda 0.25, sodium phosphate 6.00, sodium bicarbonate 1.00, potassium nitrate 1.00, boracic acid 1-2 oz., and water 1 gall. is recommended. An alternative solution contains ammonium potassium chloride 15.5, ammonium chloride 6.25, sodium citrate 125.00 gm., and water 1 litre. A platinum plate is used as anode. A voltage of 5-6 v. is necessary. Time of plating depends on the nature of the base metal.—W. A. C. N.

Methods of Platinum Plating. Kinzo Sadakata (*Japan Nickel Rev.*, 1936, **4**, (1), 85-93).—[In English and Japanese.] For economic reasons carbon anodes are widely used. Brush plating is frequently adopted. The following solutions are mentioned as being in general use: (1) Platinum (as platinum chloride) 5 gm., ammonium phosphate 45 gm., and sodium phosphate 240 gm., water 1 litre. Boil until ammonia fumes are removed and the solution is slightly acid. Use warm. (2) Platinum (as platinum chloride) 4 gm., ammonium phosphate 45 gm., boric acid 15 gm., water 1 litre. Use at 70°-80° C. with a current density of 0.1 amp./dm.². (3) Platinum ammonium chloride 15 gm., caustic soda optimum, ammonium chloride 5 gm., citric acid 100 gm., water 1 litre. Use at 80° C. E.m.f. 5-6 v. (4) Hydrochloroplatinic acid 7 gm., ammonium phosphate 27 gm., sodium phosphate 140 gm., salt

7 gm., boric acid 2.5 gm., water 1 litre. Keitel and Zschiegner suggest diammino platinous nitrite 10 gm., sodium nitrite 10 gm., ammonium nitrate 100 gm., water 1 litre, *aqua ammonia* 50 ml. Used at 95° C.; 3–5 v., with a current density up to 20 amp./dm.². A platinized article resists any ordinary wear or chemical corrosion, but against iodine attack it is no more resistant than chromium plate.—W. A. C. N.

***Electrodeposition of Zinc and Cadmium on Aluminium and Aluminium Alloys.** B. K. Braund and H. Sutton (*Trans. Faraday Soc.*, 1935, **31**, (12), 1595–1611; and (summary) *Light Metals Research*, 1936, **4**, (15), 250–251).—Specimens of aluminium, Duralumin, and various cast aluminium alloys were plated with zinc from sulphate and cyanide baths and with cadmium from cyanide baths, and then exposed to an intermittent salt-spray test for 2 years. All the specimens were given a light sand-blasting but no other preliminary treatment before plating. The corrosion tests showed that zinc deposits from sulphate baths are superior in protective power to those produced in cyanide baths, and that cadmium deposits are equal to or slightly inferior to zinc deposits from cyanide baths. The best plating bath was that containing zinc sulphate crystals 144, sodium acetate crystals 34, and gum arabic 1 gm./litre when operated at 10–30 amp./ft.² at a p_H of 4. Tests on Duralumin showed that the protection afforded by electrodeposits of zinc is equal to that afforded by anodic treatment by the Bengough–Stuart process supplemented by the application of grease and superior to that afforded by varnish or enamel coatings but somewhat inferior to that afforded by coatings of high-purity aluminium (Alclad sheet). Since a preliminary sand-blasting treatment has several disadvantages attempts were made to devise an alternative procedure for preparing the surface for plating. None of the chemical or electrochemical pre-treatments described in the literature proved entirely satisfactory in this respect; plating with zinc in an ammoniacal cyanide bath does not yield a satisfactory basis plate for a subsequent plating in a sulphate bath, the ferric chloride etch is satisfactory only for small articles, and immersion in an alkali zincate solution is liable to give dark-coloured, non-adherent deposits, although when a good deposit is obtained in this way it forms an excellent undercoat for further deposition of zinc from a sulphate bath. Eventually a good undercoat was obtained by addition of a little sodium stannate to the zincate dip; after this treatment excellent zinc deposits were obtained in a bath containing zinc chloride 136, aluminium chloride 20, and sodium chloride 243 gm./litre. Throwing power tests on zinc sulphate baths showed that when the half cathodes are both on the same side of the anode there is a marked screening of the remote by the near half cathode in the standard throwing power box but when the electrodes are arranged in the same relative positions in a large bath the current distribution is more favourable although there is still some screening even when the half cathodes are arranged on opposite sides of the anode.

—A. R. P.

***The Electrolysis of the Bromides and Iodides of Zinc, Nickel, and Cobalt in Mixtures of Water and Alcohol.** Claude Charmetant (*Compt. rend.*, 1935, **201**, (24) 1174–1176).—The method of investigation of the bromide and iodide solutions was similar to that followed for the chloride solutions (*Met. Abs.*, 1935, **2**, 526). All the solutions studied contained 0.5 gm.-mol./litre of salt, the electrodes being platinum and the current density 1.2 or 4 amp./dm.². In the case of the bromides, free bromine forms at the anode and dissolves in the solution and diffuses little by little into the cathodic region. The bromine reacts partially with the alcohol to form hydrobromic acid and aldehyde, the more so the stronger the concentration of alcohol. In the case of the iodides, the free iodine formed does not react with the alcohol. The zinc deposited is very adherent and becomes more and more crystalline as the concentration of alcohol increases; the efficiency is a decreasing function of the time of electro-

lysis and the alcohol concentration. In nickel solutions, nickel hydrate, not nickel, is deposited at the cathode, black in water and more green as the alcohol concentration increases, hydrogen being evolved. With iodide solutions, the acidity being necessarily stronger, the yield is less than with the bromide solutions. The cobalt deposited is grey at low alcohol concentrations, black and but little adherent at stronger ones; it is spongy and adsorbs the salt in solution. The yield is always high and increases with the concentration of alcohol.—J. H. W.

On the Electrodeposition of Alloys. Charles Béchard (*Bull. Soc. Franç. Élect.*, 1936, [v], 6, (62), 209–214).—The conditions regarding potential differences and depolarization phenomena are examined in their bearing on the deposition of heterogeneous deposits, consisting of two distinct metals, and deposits composed of a true alloy. The importance of maintaining constant composition of the bath, of constant stirring, and of temperature control are emphasized; passivity phenomena are briefly considered, and the use of compound anodes is described. The case of copper-tin alloys is considered throughout.—P. M. C. R.

Some Peculiarities of the Formation of Electrodeposits. Jean Billiter (*Rev. Mét.*, 1935, 32, (11), 518–521).—A brief study of the factors influencing the occurrence of irregularities in electrodeposits.—H. S.

The Trend of Recent Developments in Electrodeposited Coatings. A. W. Hothersall (*Met. Ind. (Lond.)*, 1936, 48, (3), 115–120; and (summary) *Light Metals Rev.*, 1936, 2, (16), 278–279).—Recent improvements in the control of adhesion, the properties and protective quality of electro-deposited coatings, particularly of nickel and chromium, are discussed. A *bibliography* of 29 references is given.—J. H. W.

VII.—ELECTROMETALLURGY AND ELECTROCHEMISTRY

(Other than Electrodeposition.)

(Continued from p. 45.)

Electrolytic Production of Boron and Its Alloys. L. Andrieux (*Rev. Mét.*, 1935, 32, (10), 487–493).—L. describes electrolytic extraction from a fused mixture of boric anhydride, an oxide of another metal, and fluoride or chloride of the other metal. Boron is deposited in a mass of infusible borate at the cathode. By adding to the bath halides of other metals such as calcium, barium, strontium, cerium, or manganese, borides of these metals may be obtained. Boron alloys may be obtained by using cathodes consisting of the metal or metals to be alloyed with boron.—H. S.

IX.—ANALYSIS

(Continued from pp. 45–49.)

Uses and Limitations of the Spectrograph for Industrial Control. Thomas A. Wright (*Metal Progress*, 1936, 29, (1), 53–57).—Spectrographic methods of analysis, whilst primarily best suited to the control of quality and the establishment of the presence or otherwise of certain impurities, supplements and in certain instances replaces ordinary chemical analysis. The presence of certain non-metals vitiates the process and limits its applications, many of which are enumerated.—P. M. C. R.

***Study of the Structure of Alloys by the Spectrograph.** Henri Triché (*Compt. rend.*, 1935, 201, (24), 1178–1180).—When a spark is passed between a very thin gold wire (0.1 mm. in diameter) and a plane aluminium or aluminium alloy surface, it can be seen through a microscope that the spark leaves the wire at many points, and always passes to the same points of the plane surface. Speci-

mens are therefore immersed in an oxidizing mixture or in lime-water, and the spark, which only passes to crystals, is registered by the spectrograph. Practical details are given which enable qualitative analysis (determination of the nature of impurities) and quantitative analysis of certain constituents to be carried out on suitably prepared alloys without having to separate those constituents.—J. H. W.

Purification of Electrode Carbons for Spectrum Analysis. Th. Zürcher and W. D. Treadwell (*Helv. Chim. Acta*, 1935, 18, (5), 1181–1189; *C. Abs.*, 1936, 30, 392).—The working portions of small electrode carbons are freed from impurities which interfere in emission spectra by passing a 12-amp. arc between them for 2–3 minutes in an atm. of A together with 5% Cl₂. No Cl₂ is necessary in most cases, but the presence of B, Cu, and Mg in the carbons would require it. HCl is not effective. Tables are given showing the strength of lines of 15 elements in carbons purified in various ways.—S. G.

Practical Analysis by Use of X-Ray Diffraction. J. D. Hanawalt and H. W. Rinn (*Phys. Rev.*, 1936, [ii], 49, (2), 199).—Abstract of a paper read before the American Physical Society. The X-ray diffraction of a crystalline substance provides a practical method of chemical analysis because the diffraction pattern can be used empirically as a unique identification of a substance without any need for a theoretical interpretation of the pattern. In the course of a few years of use of X-ray diffraction as a supplement to chemical analysis, the patterns of about 1000 substances have been accumulated. A suitable system of classification of these films makes it possible to use them for crystalline substances in an analogous way to that in which finger prints are used to identify persons. The system of classification which has been adopted allows a pattern to be identified in less than a minute if it is contained in the portfolio of standard patterns.—S. G.

***Determination of Gallium in Aluminium.** J. A. Scherrer (*J. Research Nat. Bur. Stand.*, 1935, 15, (6), 585–590; *Research Paper No. 853*).—Two procedures are described for the gravimetric determination of Ga in Al. One of these is based on the separation of Ga from Al in H₂SO₄ solution by precipitation with cupferron. In this method Ga is determined by difference in an oxide residue containing Ga, V, Ti, and Zr. The other procedure is based on the separation of Ga from Al in HCl solution by extraction with ether. In this method Ga is determined directly as the oxide Ga₂O₃.—S. G.

X.—LABORATORY APPARATUS, INSTRUMENTS, &c.

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

(Continued from p. 49.)

New Oil-Fired Assay Furnace. G. B. O'Malley (*Chem. Eng. Min. Rev.*, 1935, 28, (325), 491–492).—A description is given of a self-contained oil-fired unit containing a fusion chamber holding 12 crucibles, a muffle holding 12 cupels, the muffle being heated by the combusted gases from the fusion chamber which also supplies the heat for a preheating chamber holding 6 crucibles.—J. H. W.

A Vacuum Furnace for the Production of Large Refractory Metal Single Crystals [Nickel]. H. E. Farnsworth (*Phys. Rev.*, 1935, [ii], 48, (12), 972).—Abstract of a paper read before the American Physical Society. The arrangement permits a slow progressive cooling of a cylindrical alundum crucible from one tapered end. This is accomplished by decreasing slowly the heating current in a molybdenum heating element wound directly on the crucible in such a manner as to maintain a temperature gradient along the axis. The crucible is supported within a triple radiation shield which is suspended by



a single wire in a Pyrex tube, which may be evacuated. The temperature is observed by means of an optical pyrometer. With this arrangement a nickel single crystal $\frac{3}{8}$ in. in diameter and 2 in. long was formed in a high vacuum.

—S. G.

Determination of Magnetic Hysteresis with the Fahy Simplex Permeameter. Raymond L. Sanford and Evert G. Bennett (*J. Research Nat. Bur. Stand.*, 1935, 15, (5), 517-522; *Research Paper No. 845*).—An attachment for the Fahy Simplex permeameter is described by which the H -coil can be rotated quickly end for end. By means of this attachment values of magnetizing force, H , corresponding to points on a hysteresis loop can be attained with as high precision as could be attained previously only for points on the normal induction curve. By the use of this attachment, smoother curves are obtained in less time than can be done with the original arrangement.—S. G.

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

(Continued from pp. 49-51.)

Investigating the Surface Finish of Automobile Parts. A. Wallichs and G. Depiereux (*Automobiletech. Z.*, 1936, 39, (1), 1-8).—Surface finish may be investigated either by optical methods or by mechanical exploration: the results of the latter may be recorded phonographically or by photographic means which usually include an enlargement apparatus. An improved testing machine is described, and specimen records are reproduced: methods of evaluation are compared. The parts investigated included pistons, cylinders, connecting rods, crankshafts, valves, and camshafts; the results obtained in each case are discussed, and the importance of corresponding standard of finish in parts which are to work in contact is emphasized.—P. M. C. R.

An Optical Method for Comparing Surface Finishes. A. Karsten (*Werkstatt u. Betrieb*, 1936, 69, (3/4), 34-36).—The microscope described permits the simultaneous observation, through a single eye-piece and on the upper and lower halves of the same field, of the magnified images of the surfaces of specimen and standard pieces. The method is applicable to specimens in the lathe, as well as to laboratory and bench examination: it is said to be especially useful in the examination of worn machine parts, welds, and electrodeposits.—P. R.

***Stress Analysis by X-Ray Diffraction.** C. S. Barrett and M. Gensamer (*Physics*, 1936, 7, (1), 1-8).—A mathematical analysis is given for determining stresses in a metal by X-ray diffraction. The treatment is general, and includes as special cases methods for determining uniaxial stresses or the sum of two principal stresses in the plane of the metal surface. The analysis is extended to determine the two principal surface stresses separately. Methods are proposed by which these stresses can be determined with an accuracy of the order 1300 lb./in.² for iron, and 320 lb./in.² for Duralumin. Camera design, exposure technique, and the applicability of the method to practical problems are discussed.—J. S. G. T.

A New Extensometer. P. Mercier (*Usine*, 1936, 45, (6), 35).—The limit of proportionality determined in tensile tests approximates to the true elastic limit when the stress-strain curve is horizontal; otherwise a considerable error is introduced. Other sources of error are the reduced scale of the diagram, the difficulty of reading from the latter the exact "elastic limit," and the type of extensometer employed. A robust direct-reading instrument, intended for cylindrical test-pieces but adjustable to flats, is described and illustrated.

—P. M. C. R.

***Plastic Deformation and the Hardness of Lead.** Marcel Ballay (*Compt. rend.*, 1936, 202, (3), 222-224).—Cold-worked lead behaves differently in the

hardness test according to whether it has been annealed at a relatively high temperature or allowed to self-anneal at room temperature. This difference can be represented by comparing the values of the expression: $(\Delta_1 - \Delta_2)/(t_2 - t_1)$, where Δ_1 and Δ_2 are the hardness numbers at times t_1 and t_2 , respectively. In the case of pure lead (99.984%) reduced 60% by rolling, part annealed at 250° C. for 1 hr. and part allowed to self-anneal for 17 hrs. at room temperature, the unannealed lead exhibits much greater speed of deformation under pressure than the annealed metal, which is considered to be bound up with the grain-size, that of the annealed metal being at least 1700 times the greater. This was confirmed by cutting a specimen from a strip of the lead strongly cold-worked after resting for 3 months at room temperature and having very fine grain structure. After 4 days' rest, a macroscopic attack showed grains on each side of the cut edge on the mean 1800 times larger due to the recrystallization of the metal lightly worked by shearing. This effect of preliminary plastic deformation is not confined to pure lead; it has equally been observed in harder lead alloys, containing cadmium or antimony, which self-anneal at room temperature much less rapidly.—J. H. W.

Radium for Industrial Radiography. R. A. Gezelius and C. W. Briggs (*Radon Co., Inc.*, 16 pp.; *Bull. B.N.F.M.R.A.*, 1935, (76)).—Gives an account of the use of γ -rays from radium for the radiographic examination of materials, with the necessary practical details. Examples mentioned (but not discussed) include an aluminium casting 5 in. thick and a bronze casting 3 in. thick.

—S. G.

XII.—TEMPERATURE MEASUREMENT AND CONTROL

(Continued from p. 51.)

***(A) The Construction of Platinum Thermometers and the Determination of Their Basic Points. (B) Comparison of Some Platinum Thermometers with the Helium Thermometer Between 0° and -183° C.** W. H. Keesom and B. G. Dammers (*Proc. K. Akad. Wet. Amsterdam*, 1935, 38, (9), 958, 959).—[In English.] (A.—) In 1927 the General Conference of Weights and Measures fixed a temperature scale called the International Temperature Scale, which, for temperatures between -190° and 660° C., depends on readings of the platinum thermometer. The Kammerlingh Onnes Laboratory did not accept the scale. Platinum thermometers made from wires of different origins have been compared with the helium thermometer. The best annealing temperature is at 840°–850° C. The oxygen point is -182.98₅° C. The accuracy of calibration of platinum thermometers at the ice-, steam-, and oxygen points is 0.002°–0.003°. (B.—) Five platinum thermometers, satisfying the conditions stated in the definition of the International Temperature Scale, have been compared with the helium thermometer between 0° and -183° C. Three of the thermometers agree within 0.003°; the fourth agrees with them to within the accuracy of reading of the helium thermometer; the fifth differs from the first three by 0.03° at -183° C. The International Temperature Scale, between 0° and -100° C. is below the thermodynamic scale; the difference is 0.04° at -80° C. Between -120° and -183° C. the former scale is above the latter; the maximum difference occurs at between -130° and -140° C.

—J. S. G. T.

The Function of Platinum in Measuring High Temperatures. Toyozo Nakada (*Japan Nickel Rev.*, 1936, 4, (1), 113–118).—[In English and Japanese.] A dissertation on thermocouples, embracing a study of construction and the International Temperature Scale.—W. A. C. N.

XIII.—FOUNDRY PRACTICE AND APPLIANCES

(Continued from pp. 52-53.)

Time of Pouring and Cross-Section. Guy Hénon (*Rev. Fonderie moderne*, 1935, 29, (Dec. 25), 375-380).—The best rate of pouring for filling a given mould is discussed on theoretical grounds according to the data of various workers, whose conclusions are critically reviewed. The corrections necessary for very small or very large sizes are given. The best rate of pouring being given, considerations of the best cross-section of the gate are discussed. 8 references to the literature are given.—J. H. W.

A Short Review of the Development of Material for Non-Ferrous Casting Metals. Willi Claus (*Giesserei-Praxis*, 1935, 56, (43/44), 452-454; (45/46), 469-472).—The chief metal in remote antiquity was copper. This was also mixed with other metals to give Black Copper (*Schwarzkupfer*). Real tin-bronzes were developed in ancient times, but since tin and lead were not then separable, lead-tin bronzes also appeared about the same time. Zinc occurred as an alloy for copper in Roman times. The three alloy types, tin-bronze, red and yellow brass, were handed down from the Middle Ages to modern times practically unaltered. The alloys of aluminium, magnesium, zinc, and lead, as used to-day, are modern inventions. Tables are given showing the composition of alloys used in the earliest and later times, and the mechanical properties of modern alloys when sand-, die-, centrifugal- and pressure die-cast.

—J. H. W.

Casting Processes for Precious Metals for Dentistry. Hideo Yamaguchi (*Japan Nickel Rev.*, 1936, 4, (1), 102-112).—[In English and Japanese.] The first dental alloy of precious metals was used by Orendolf in Germany in 1905. For casting purposes machines used are: (1) Taggart machine, in which the molten alloy is forced into the mould under a pressure of about 12 lb. of nitrous oxide; (2) centrifugal machine, which forces the molten gold into the mould by centrifugal force; (3) vacuum casting machine, which utilizes atmospheric pressure to force the metal into the mould; and (4) Solbrig's machine, in which superheated steam generated within the mould space is the impelling force. A table shows the metals and alloys used for gold inlays. Casting has now virtually eliminated the use of the pressed plate for making partial and full dentures. Tables of alloys for dentures and for gold crowns are given.

—W. A. C. N.

Melting, Casting, and Machining Platinum. Seiji Goto (*Japan Nickel Rev.*, 1936, 4, (1), 170-173).—[In English and Japanese.] Abstracted from "Alloy Metallurgy," Vol. III, 1931, p. 207 (presumably in Japanese). Oxy-hydrogen, oxy-gas, or oxy-acetylene is used for melting. The flame should be slightly oxidizing to prevent absorption of carbon which causes brittleness. High-frequency furnaces are used for larger quantities. The alloy platinum 89.44, iron 0.006, iridium 10.37, rhodium 0.62, copper 0.13% is used in France for the standard ruler. Working of platinum alloys is done hot—pure platinum at 600° C., commercial platinum at 1000° C., platinum containing 5-15% iridium at 1100° C., and an alloy with more than 15% iridium at 1200° C.—W. A. C. N.

Light Alloy Practice. I.—Magnesium Alloys. II.—Aluminium Alloys. H. G. Warrington (*Met. Ind. (Lond.)*, 1936, 48, (4), 136-140; (5), 160-163; discussion, (6), 187-188).—Read before the Midland Metallurgical Societies (Birmingham Local Section of the Institute of Metals, Birmingham Metallurgical Society, and Staffordshire Iron and Steel Institute). (I.—) The development, control during melting, heat-treatment, and die-casting of magnesium alloys are described. The compositions and physical properties of such alloys suitable for forging, welding, and stamping are tabulated, and the corrosion of the alloys and methods of countering it are discussed. 17 references are given.

(II.—) Describes the moulding and coring, gating and running, melting practice, and die-casting of aluminium alloy castings; the forging practice, extrusion, rolling, heat-treating, soldering, and welding of wrought aluminium alloys, and their corrosion and protection. 11 references are given.—J. H. W.

Difficulties in Metal Casting and Their Removal. Werner Frölich and E. T. Richards (*Giesserei-Praxis*, 1935, 56, (47/48), 494–496).—Describes the manufacture of copper alloys, permanent castings, the composition and cooling of the moulds and their protection, the casting of phosphor-bronze, and the effect of the melting temperature and of overheating on the casting of copper alloys.

—J. H. W.

†**Progress in the Production of Cast Bronzes.** Francis W. Rowe (*Metallurgia*, 1936, 13, (76), 119–120).—Melting practice in the production of bronze is critically considered with reference to the furnace atmosphere, gas-absorption, and solid and gaseous impurities present in the metal before melting. For most of the commonly used brasses and bronzes a slightly oxidizing atmosphere gives in all normal melting conditions less trouble than one which is reducing. Sulphur compounds in the fuel and water in the fuel are comparatively innocuous in an oxidizing atmosphere, but may easily be a source of profound unsoundness, if the atmosphere is reducing. Melting equipment and types of fuel used are considered, and crucible, open-flame, and electric furnaces are compared, with references to the speed of melting, fuel costs, cost of repair, facility of control, and quality of metal produced.—J. W. D.

The Manufacture of Carbon-Containing Bearing Bronzes. Richard Thews (*Giesserei-Praxis*, 1936, 57, (1/2), 11–15).—Describes the production of bearing bronzes containing copper 70.18, tin 13.72, lead 9.00, graphitic carbon about 5.35, zinc 1.45, iron 0.22, and phosphorus 0.055%. The lubrication effect of the graphite in these bronzes is determined not only by the % of carbon present, but also by the method of casting by which the condition of the carbon in the metal and the structure of the alloy itself are influenced. The tensile strength and elongation of the alloy are very low, and the breaking strength and yield-point are both about 5.5 kg./mm.². On the other hand, the compressive strength is about 35 kg./mm.², and the Brinell hardness (500 kg.) is about 21.6.

—J. H. W.

The Casting and Treatment of Magnesium Alloys. A. J. Murphy (*Met. Ind. (Lond.)*, 1936, 48, (3), 108–109).—The die-casting methods, corrosion-resistance, and applications of magnesium-base alloys are discussed.—J. H. W.

Working Experience with Monel Metal in Japan. I.—Casting and Welding. II.—Casting. III.—Casting and Rolling. (I.) Shimpei Tonami. (II.) Yoshio Bando. (III.) Chuji Kato (*Japan Nickel Rev.*, 1935, 3, (4), 632–642).—[In English and Japanese.] In moulding, sand similar to that used for steel castings is used. Freedom from carbon and sulphur in the Monel metal is considered essential.—W. A. C. N.

Fabrication of Monel Metal in Chemical Equipment. Saiki Nakamura (*Japan Nickel Rev.*, 1935, 3, (4), 602–610).—[In English and Japanese.] Describes the manufacture of a large centrifugal separator. It is found that more corrosion occurs in alkaline and acid media where internal stresses have not been completely removed. Sheet metal should be well polished. The melting charge contains 70% virgin metal and is run down in electric furnaces. Metallic silicon is added and magnesium or nickel-magnesium is used as de-oxidizer. High-silica sand is used for moulding purposes, and silica sand with clay and molasses for facing. Atomic hydrogen, electric arc, and oxy-acetylene welding are adopted.—W. A. C. N.

Methods and Equipment in the Non-Ferrous Foundry. A. Logan (*Met. Ind. (Lond.)*, 1936, 48, (3), 103–107).—A summary of developments in 1935.

—J. H. W.

[Mould] Dressings Which Form a Good Insulating Layer. Gustav Krebs (*Giesserei-Praxis*, 1936, 57, (1/2), 9-10).—Mould dressings are discussed. Good results are obtained by a coat of blacking allowed to dry naturally for some minutes to form a layer of the desired hardness. Such blacking consists of 3 parts of good oiled carbon, 1 part of plaster of Paris, 1 of talc, and 1½ of good wood charcoal dust mixed in alcohol. Dressings recommended for iron, brass, and red brass consist of 25-30 grm. rosin in 1 litre of alcohol with the addition of 2 parts of graphite, 1 part of very fine, powdered coke, and 1 of talc. For aluminium castings, a talc-resin-alcohol dressing is recommended.—J. H. W.

Gypsum Core Boxes for Single Castings. R. Löwer (*Werkstatt u. Betrieb*, 1936, 69, (3/4), 40-41).—The use of gypsum core boxes is stated to effect a 50% economy in the case of single castings. The method of construction is described and illustrated.—P. M. C. R.

High-Chromium Alloys in Centrifugal Castings and Tubes. R. J. Wilcox (*Metal Progress*, 1936, 29, (1), 44-48).—Centrifugal casting is now applied to most of the heat-resisting iron-chromium-nickel alloys, including alloys containing nickel 65, chromium 15%, remainder iron, and nickel 35, chromium 15%, remainder iron. The limited solidification range of these alloys demands careful timing and close temperature control. The preparation and drying of the moulds are described. The method imposes certain limitations on the form of the casting, but the structure of the product is unusually free from segregation.—P. M. C. R.

The Pressure Moulding of Small Aluminium Pieces by Means of Simple Machines. Charles O. Herb (*Machine moderne*, 1936, 30, (324), 25-28).—An illustrated description is given of the pressure-casting of a small light-alloy piece of irregular shape. A feature of the process is the complex contact surface of the halves of the mould. The casting temperature is about 700° C.; the water-cooling system is shown.—P. M. C. R.

Small Aluminium Die-Castings Made in Machines of Simple Design. Charles O. Herb (*Machinery (N.Y.)*, 1935, 42, (4), 244-247; and *Machinery (Lond.)*, 1936, 47, (1213), 437-439).—Describes the construction of dies for casting aluminium alloy hair-clipper parts. A very irregular parting line was necessary.—J. C. C.

A Million and a Half Brass Die-Castings Yearly [Polak Die-Casting Machine]. Charles O. Herb (*Machinery (N.Y.)*, 1936, 42, (6), 361-366).—Describes the construction and operation of Polak die-casting machines for producing pressure die-castings from brass.—J. C. C.

Recent Developments in Pressure Die-Casting [Schuler-Polak Process]. — (*Machinery (Lond.)*, 1936, 47, (1216), 529-531).—The Schuler-Polak process for making die-castings in nickel-brass is described. The metal is forced in a semi-fluid condition from a cylindrical container into the die by a hydraulically-operated plunger, using pressures up to 6.3 tons/in.². Typical products are illustrated.—J. C. C.

New Ways for Old in the Foundry. Frank Whitehouse (*Iron Steel Ind.*, 1936, 9, (5), 172-173).—A number of practical examples of new methods adopted in the foundry for increasing the production of castings, in which the essential feature is the casting on edge in one box of a number of castings in preference to casting one or two such castings per box in the old flat method. Reference is also made to the casting of sticks of metal out of which castings are cut rather than making individual castings.—J. W. D.

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

(Continued from p. 53.)

Recovering Tin from Soldered Sections. C. C. Downie (*Machinery (Lond.)*, 1936, 47, (1217), 555).—It is suggested that tin should be recovered from scrap tinned parts by "washing" in a bath of molten lead.—J. C. C.

XV.—FURNACES AND FUELS

(Continued from pp. 54–55.)

Production of High Temperatures. G. Ribaud (*Chim. et Ind.*, 1936, 35, (1), 3–11).—The types of high-temperature furnaces are reviewed and their uses, advantages, and disadvantages discussed. In particular the modern tendencies in the evolution of such furnaces, reaching up to temperatures of 1700° C., are summarized. The question of suitable refractories is also necessarily introduced. Flame furnaces in which town's gas, hydrogen, methane, carbon monoxide, &c., are separately burned with correct proportions of air or oxygen are considered first. With the atomic hydrogen burner as developed by Langmuir, temperatures up to 3400° C. can be obtained. A gas laboratory furnace for temperatures up to 2300° C. is illustrated and described. Under electric furnaces, the granular carbon resistor, platinum-wound vertical and tube and also arc types are discussed. High-frequency furnaces of the ordinary commercial types and also those for melting silica, the graphitization of carbon, and for studying the sublimation of carbon are illustrated. Finally, cathodic ray furnaces are described.—W. A. C. N.

Progress in Melting and Heat-Treatment Furnaces. — (*Metallurgia*, 1936, 13, (75), 73–76; (76), 133–135).—A description of recently constructed furnaces. Melting furnaces described include the rotary furnace suitable for all types of bronze, brass, and cupro-nickel castings and also for recovering waste materials; the semi-rotary furnace in various sizes for brass; the aluminium ladling furnace; and the rocking-arc electric furnace, which is capable of applications to an extremely wide range of processes, covering almost all ferrous and non-ferrous metals. Heat-treatment furnaces for non-ferrous alloys dealt with include salt-bath furnaces for aluminium alloys, furnaces for long aluminium tubes, continuous belt-conveyor furnaces for annealing non-ferrous sheets, and equipment for bright-annealing nickel-chromium wire. Consideration is also given to improved types of crucible melting furnaces for high-duty alloys and for aluminium alloys.—J. W. D.

Developments in Annealing Furnace Design for Non-Ferrous Metals. John Fallon (*Met. Ind. (Lond.)*, 1936, 48, (3), 99–102).—The factors in the choice of equipment, muffle design, and the developments in bright-annealing processes are described.—J. H. W.

Industrial High-Frequency Power. H. V. Noble (*Electronics*, 1935, 8, (10), 364–366).—The design of a 20 kw. high-frequency valve converter for providing power at 7–10 kilocycles is considered. Brief reference is made to the use of high-frequency power in induction furnaces and also in arc welding. In the latter application it may be superimposed on a 60-cycle welding current in order to maintain the arc during the zero part of the cycle.—J. C. C.

Town's Gas in the Ferrous and Non-Ferrous Metals Industries. — (*Metallurgia*, 1935, 13, (74), 63–66; 1936, 13, (75), 85–87; (76), 115–116).—The use of town's gas in general heating processes carried out in gas-fired furnaces for billet-heating for forging and drop-stamping; for sheet heating, for annealing; and for heat-treatment for hardening are discussed, and the more recent applications of gas as a heating medium and processing agent are described, particularly those involving atmosphere-control in heat-treatment. Consideration is also given to the application of town's gas for annealing nickel silver, sterling silver, and the bright-annealing of copper, and it is shown that other factors besides the initial cost of the fuel have an important bearing on the ultimate cost of a manufacturing process.—J. W. D.

The Possibilities of Gas Fuel in the Non-Ferrous Metal Industries. Joseph E. White (*Met. Ind. (Lond.)*, 1936, 48, (5), 167–168).—Summary of a paper read at a joint meeting of the Institute of Fuel and the Manchester District Association of Gas Engineers. See *Met. Abs.*, this vol., p. 19.—J. H. W.

XVI.—REFRACTORIES AND FURNACE MATERIALS

(Continued from p. 55.)

Recent Development in Refractories. C. E. Moore (*Met. Ind. (Lond.)*, 1936, 48, (1), 8-13; discussion, 36-37; and (summary) *Iron Coal Trades Rev.*, 1936, 132, 4).—Read before the Midland Metallurgical Societies (Birmingham Local Section of the Institute of Metals, Birmingham Metallurgical Society, and Staffordshire Iron and Steel Institute). The production figures and average prices of various refractories are given. Different methods of shaping refractories are explained and the effects of alumina, silica, and iron oxide in firebrick materials are described. The methods of manufacture of a number of different refractories, their composition, and the effects of the various constituents are discussed.—J. H. W.

XVIII.—WORKING

(Continued from p. 56.)

The Plastic Working of Metals. Georg Sachs (*Met. Ind. (Lond.)*, 1936, 48, (3), 51-54).—The most important theoretical knowledge obtained during recent years concerning plastic working of metals is briefly reviewed. The rôle of the properties of the material, the design of the tools, and the friction conditions in technological processes are discussed. 5 references are given.—J. H. W.

Modern Developments in Cold-Rolling Mills. C. E. Davies (*Metallurgia*, 1936, 13, (75), 79-81; (76), 107-108).—In a review of up-to-date mill designs, with reference to representative examples of mills which have fulfilled present-day requirements in cold-rolled strip and sheet production, consideration is given to mills for non-ferrous metals and alloys of which the most important are copper, brass, nickel silver, and aluminium. Cold-strip mills described are four-high mills, cold-breaking-down mills, high-speed intermediate mills with automatic coilers, and finishing mills with and without automatic coilers. Reference is also made to high-speed mills and to a reversing mill for intermediate and finishing passes with coilers on both sides.—J. W. D.

The Rolling of Sheet and Strip. A. L. Molineux (*Met. Ind. (Lond.)*, 1936, 48, (3) 61-66).—The equipment and lay-out of a rolling mill and typical rolling operations are described.—J. H. W.

Smooth Edges on Slit Metal Coils. — (*Blast Furnace and Steel Plant*, 1936, 24, (1), 101).—A note on a machine in which edge conditioning is carried out by rolls with their feed and pinch rolls mounted on three planes. Round or square edges can be produced on both edges of 8 slit strips from a 38 in. strip.—R. Gr.

The Deep-Drawing of Sheet Metal. J. D. Jevons (*Met. Ind. (Lond.)*, 1936, 48, (3), 67-72).—The importance of regularity of crystal size, current troubles, and general considerations in connection with deep-drawing of sheet are discussed.—J. H. W.

Forging the Light Alloys. J. Towns Robinson (*Met. Ind. (Lond.)*, 1936, 48, (3), 87-91).—The control of the various operations and conditions in the forging of aluminium alloys is discussed.—J. H. W.

Making Fine Silverware. C. H. Vivian (*Compressed Air Mag.*, 1935, 40, (12), 4891-4896).—A popular account of the development of silver tableware is followed by an illustrated account of the spinning, stamping, and chasing of flatware and the annealing of worked material.—P. M. C. R.

The Extrusion of Non-Ferrous Metals. A. Wragg (*Met. Ind. (Lond.)*, 1936, 48, (3), 73-77).—Press design and construction and the physical properties of extruded alloys are discussed.—J. H. W.

The Manufacture of Seamless Tubing. A. B. Graham (*Met. Ind. (Lond.)*, 1936, 48, (3), 81-86).—The hot-working processes and the extrusion processes

for making non-ferrous tubes, the cold-working and the White tube reducing process, and the annealing, quenching, and finishing of tubes are described.

—J. H. W.

Extruding Square-Sectioned [Brass] Organ Pipes. A. G. Arend (*Machinery (Lond.)*, 1935, 47, (1211), 377).—A brief account is given of the procedure used for making square-section organ pipes from cylindrical brass billets. [Note by Abstractor: This appears to be wholly a process of drawing between rolls or mandrels, and not one of extrusion.] In annealing, the tubes are suspended vertically to avoid distortion.—J. C. C.

Recent Progress in the Wire-Drawing Industry. Edgar L. Francis (*Met. Ind. (Lond.)*, 1936, 48, (3), 78–80).—Improvements in the technique of wire-drawing are discussed.—J. H. W.

Coppering Fine Sizes of Mild Steel Wire. A. Walker Fielding (*Wire Industry*, 1935, 2, (22), 327, 329, 333).—The procedure recommended is to pickle the annealed wire in cold 5% sulphuric acid containing flour as an inhibitor, coat with copper by simple immersion in an acid 1% solution of copper sulphate containing ammonium chloride and flour, transfer to the drawing tub, and draw continuously through several dies using an alkaline lubricant.—A. R. P.

Tungsten Carbide and Cobalt Cutting Material. Arthur Haslam (*Metallurgia*, 1936, 13, (76), 103).—A description of a new cutting material made up of tungsten carbide and cobalt. Its modulus of rupture in a transverse or cross-bending test is about 250,000–275,000 lb./in.² of section or about half the strength of high-speed steel, and it has a hardness next to the diamond. It also possesses toughness, does not tarnish and has a very strong resistance to chemical attack. It has been found particularly suitable for cutting fused quartz, alternate layers of copper and mica, Bakelite, and hard cast iron.

—J. W. D.

Cemented-Carbide Cutting Tools in Present-Day Shop Practice. Roger D. Prosser (*Machinery (N.Y.)*, 1935, 42, (4), 268–270).—The efficient use of cemented carbide tools is discussed. Full advantage is not generally taken of the high cutting speeds of which they are capable.—J. C. C.

Some Factors Affecting the Machinability of Steel and Other Alloys. — (*Metal Progress*, 1936, 29, (1), 31–34).—Summary of a discussion on machinability held by the Cleveland Chapter of the American Society for Metals. The machining quality of high-strength materials is generally improved by a diminution of tensile strength and an increase in brittleness. A single-phase matrix becomes more easily machinable on the emergence of a second constituent. Although grain-size has comparatively little influence, fine structures are, contrary to a general belief, better than coarse. Special tool settings for aluminium and light alloys are discussed, and the excellent working qualities of magnesium and its alloys are emphasized.—P. M. C. R.

XIX.—CLEANING AND FINISHING

(Continued from p. 21.)

Metal Finishing Advanced in 1935. Herbert R. Simmonds (*Iron Age*, 1936, 137, (1), 553–560; (2) 44–47).—The practical application of laboratory experiments made during 1935 are reviewed. These include aluminium plating on steel, bright nickel and bright aluminium plating, chemical black coating, plating on plastics, and improvements in the properties of lacquers and enamels.—J. H. W.

Swaging Dies Supplant Hand-Chasing for Finishing Non-Ferrous Castings. William C. Betz (*Machinery (N.Y.)*, 1935, 42, (4), 259–260).—Sharp lines and a burnished finish can be produced on the surface of brass or bronze sand-castings by striking once or more with hardened steel dies, using a knuckle-type or high-speed hydraulic press. By this means fancy hardware can be cheaply produced.—J. C. C.

XX.—JOINING

(Continued from pp. 56-58.)

Electric Furnace Brazing. A New Method of Fabrication. A. G. Robiette (*Met. Ind. (Lond.)*, 1936, **48**, (4), 131-135; (5), 157-159).—Outlines the process of electric brazing and describes the development of the electric brazing furnace, the factors to be considered, the metals which can be so brazed, the strength and character of the joints, the advantages and the costs of the process, the use of controlled atmospheres, and furnace installation. Examples from practice are given.—J. H. W.

Electric Spot-Welding of Aluminium. — (*Machinery (Lond.)*, 1935, **47**, (1206), 221).—For spot-welding aluminium, water-cooled electrodes made of a copper-base hard alloy should be used. A typical air-operated machine for spot-welding aluminium is illustrated.—J. C. C.

Little Known Facts Concerning the Repair of Bells. M. Ralph Horne (*Aluminium and Non-Ferrous Rev.*, 1935, **1**, (2), 79-80).—Bells which have cracked on account of constant impact of the clapper on one spot can be satisfactorily repaired by welding. The composition of the weld metal should be matched to that of the bell. Instances are given of a number of church bells which have been repaired in this manner.—J. C. C.

Welding Methods for the Non-Ferrous Metals. H. W. G. Hignett (*Met. Ind. (Lond.)*, 1936, **48**, (3), 92-98).—The methods in common use for welding non-ferrous metals are described. They are: (1) oxy-hydrogen and oxy-coal-gas, (2) oxy-acetylene, (3) carbon arc, (4) metallic arc, (5) atomic hydrogen, (6) electrical resistance spot- and seam-welding. 32 references are given.

—J. H. W.

Welding in the Building Industry. William Spraragen (*Indust. and Eng. Chem.*, 1935, **27**, (10), 1137-1138).—Among the various applications of welding important to the building industry are: framing for industrial buildings, bridge members, earthquake bracing, industrial piping, and framing for private dwellings. Special connections and fittings for welded piping have been developed, the trend being towards a welded product. This is true not only of steel piping but also of copper and brass piping. Piping erection practice is discussed. To obtain the maximum economies, it is necessary to design for welding. Only a small fraction of the advantages of welding can be obtained if the original design is on the basis of other methods of fabrication and welding is merely substituted. Proper use of welding requires suitable materials, correct design, qualified operators, suitable equipment, and trained inspectors.

—F. J.

A New Idea Applied to Arc Welders. — (*Elect. J.*, 1935, **32**, (12), 526).—The use of a generator having only two series-excited poles allows the welding current to be pre-selected, reduces energy consumption, and allows polarity to be changed at will, with no tendency for self-reversal.—J. C. C.

Resistance Welding and the Metal Vacuum Tube. R. J. Bondley (*Machinist (Eur. Edn.)*, 1936, **79**, (51), 764-765E).—The method of resistance welding metal mounts to large and small radio valves is described. Owing to the porosity of the joint caused by other methods, resistance welding is the only one available. The duration of the current is limited by a thyatron valve to a small fraction of a second.—J. H. W.

When is Resistance Welding Applicable? M. L. Eckman (*Machinery (N.Y.)*, 1936, **42**, (5), 297-301).—All the common metals can be joined by resistance welding, the most difficult to deal with being lead, tin, molybdenum, zinc, aluminium, and magnesium. A large number of examples of the application of resistance welding is described.—J. C. C.

Resistance Welds Widely Used. George H. Hall (*Elect. World*, 1936, **106**, (3), 226-229, 272).—Typical machines for butt-, flash-, spot-, seam-, and

projection-welding are illustrated, and a number of their applications considered.—J. C. C.

Methane as a Fuel for Autogenous Welding. S. J. Miloslavski and D. L. Glizmanenko (*Vestnik Metallopromishlennosti (Messenger Metal Ind.)*, 1935, 15, (11), 102–114).—[In Russian.] The gas produced at the Moscow sewage disposal works consists of a mixture of methane 60–65, carbon dioxide 30–35, and air 2–5%; after removal of carbon dioxide the gas can be used satisfactorily in the welding and cutting of aluminium and iron.—D. N. S.

XXI.—INDUSTRIAL USES AND APPLICATIONS

(Continued from pp. 58–63.)

Aluminium as a Material for Building Construction. Francis C. Frary (*Indust. and Eng. Chem.*, 1935, 27, (10), 1128–1130).—The architectural uses of aluminium are described and illustrated. The aluminium capstone casting on the tip of the Washington Monument, placed there as a lightning arrester in 1884, is substantially unaffected, and it is predicted that it will not materially alter for another 50 years.—F. J.

Advantages of Light Metals and Alloys in the Textile Industry. A. Nau-Touron (*Bull. Soc. d'Encour. Ind. Nat.*, 1935, 134, 586–592).—A review of the applications of aluminium and its alloys in the construction of textile machinery.—J. C. C.

Accessories for Aluminium Aerial Lines. N. Hubert (*Rev. Aluminium*, 1935, 12, (75), 3035–3042).—The design and construction of anchorages, junctions, alignment clamps, the fixing of conductors on rigid insulators, and guard rings are described.—J. H. W.

Calculation of the Mechanical Properties of Aerial Conductors. E. Maurer (*Bull. Assoc. Suisse Elect.*, 1936, 27, (2), 41–43).—The recalculation of mechanical data regarding deflection, sag, modulus of elasticity, &c., has been necessitated by the revised Swiss specifications for aerial conductors. A table states certain fundamental physical and mechanical properties of cable wires in hard and half-hard copper, and in iron, and of cables in copper, bronze, aluminium, and Aldrey. The calculations reproduced include those of the elastic modulus and linear thermal expansion of a cable consisting of two metals, with special application to aluminium-iron conductors.—P. M. C. R.

The Development of the Metal Aeroplane. — (*Aluminium and Non-Ferrous Rev.*, 1935, 1, (3), 95–96, 98–99).—J. C. C.

Sweep-Float Made Portable Through Use of Aluminium Alloy. Vernon H. Donaldson (*Eng. News-Record*, 1936, 116, (2), 50–51).—A sweep-float for checking depths in navigable harbours was made portable by constructing it in small units, using an (unspecified) aluminium alloy for the structure below the deck line. The total weight is 2.8 tons, and the length 40 ft.—J. C. C.

The Uses and Occurrences of Chrome. Gordon H. Chambers (*S. African Min. Eng. J.*, 1935, 46, (1), 708–709).—S. G.

[Uses of Copper.] — (*Copper and Brass Research Assoc.*, 1935, (84), 1–16).—Briefly discusses and illustrates the use of copper in plant designed for mechanical refrigeration; chromium-plated gift ware; the use of copper, brass, and bronze in the construction of houses and roofs. An all-copper house has been erected at Bethesda, Maryland, and in North Carolina a house has been roofed with tiles fashioned from 14-ounce sheet copper.—J. S. G. T.

Metal Rectifiers in Telephone Circuits. B. Winch (*Post Office Elect. Eng. J.*, 1936, 28, (4), 310–311).—Discusses copper oxide rectifiers.—P. M. C. R.

Bell Metal in Bengal. — (*Aluminium and Non-Ferrous Rev.*, 1935, 1, (3), 114).—An alloy of copper 60, tin 10, zinc 30% has been proposed as a substitute for the 77–23 copper-tin alloy commonly used for the manufacture of metal eating utensils in Bengal.—J. C. C.

Lead in Building and Construction. G. O. Hiers and C. H. Rose (*Indust. and Eng. Chem.*, 1935, 27, (10), 1133-1135).—Discusses the use of lead and its alloys for piping, roofing, pressure-relieving joints, vibration-absorption pads, &c. Reference is made to some of the uses of lead in ancient Rome and Greece.—F. J.

†**Magnesium Alloys in Aeroplanes.** E. R. Gadd (*Aircraft Eng.*, 1935, 7, (82), 299-302).—The working properties and general features of castings and wrought forms of magnesium-rich alloys used in aircraft are discussed, with special reference to engine parts and airscrews. The physical and mechanical properties are compared with those of other aircraft materials.—H. S.

Nickel Alloys in the Architectural Field. C. F. Geiger and R. E. Case (*Indust. and Eng. Chem.*, 1935, 27, (10), 1130-1132).—Specifications, composition, available forms, physical properties, and application of nickel alloys are discussed.—F. J.

Modern Uses of Monel Metal. James A. Rabbitt (*Japan Nickel Rev.*, 1935, 3, (4), 513-584).—[In English and Japanese.] A summary of the chemical and physical properties and of the commercial applications of this alloy.

—W. A. C. N.

Monel Metal Turbine Blading. C. A. Crawford (*Japan Nickel Rev.*, 1935, 3, (4), 585-593).—[In English and Japanese.] This alloy has been used for turbine blades to meet modern requirements in steam production—pressures up to 28 kg./cm.², temperatures up to 410° C., and speeds up to 1800 r.p.m. on low-pressure turbines and 3500 r.p.m. on the high-pressure side. There have been concurrent improvements in the silver solders and fluxes used with Monel metal. Special inspection methods have been instituted to detect any kind of defect. A bright-annealing furnace using propane atmosphere is used. The assembly of turbine blades is described.—W. A. C. N.

Monel Metal in the Chemical Industry of Japan. Takashi Okamoto (*Japan Nickel Rev.*, 1935, 3, (4), 594-601).—[In English and Japanese.] An illustrated description of different types of plant made of this alloy.—W. A. C. N.

Monel Metal in Chlorine Handling Valves. Kimitoshi Nishino (*Japan Nickel Rev.*, 1935, 3, (4), 620-623).—[In English and Japanese.] Tobin bronze and alloys having the following composition are used for valve bodies: copper 61-65, tin 2-3, lead 30-35, nickel 2-4%. Monel metal spindles are used.

—W. A. C. N.

Certification for Purity of Precious Metal Ware. Takashi Shibata (*Japan Nickel Rev.*, 1936, 4, (1), 119-130).—[In English and Japanese.] Japan is the only nation which has adopted a voluntary system for the hall-marking of platinum. The appropriate ordinance is quoted in full.—W. A. C. N.

Uses of Platinum in the Industries of Japan. Hideji Okuda (*Japan Nickel Rev.*, 1936, 4, (1), 51-62).—[In English and Japanese.] An illustrated summary of common uses of platinum. An alloy with 10% rhodium is used as a lining 0.03 in. thick on an alundum support to form a die which resists the high temperature of flowing glass in the production of electric light bulbs. The life of the die is 190 times that of porcelain previously used.—W. A. C. N.

Precious Metals from Nickel Sulphide Ores. Hisaharu Komatsubara (*Japan Nickel Rev.*, 1936, 4, (1), 4-17).—[In English and Japanese.] An account is given of the Acton refinery for the recovery and refining of the precious metal contents of the Sudbury nickel ores. The properties and uses of the various precious metals are briefly described.—W. A. C. N.

Platinum Metals for Jewelry. Yuzo Yamamoto (*Japan Nickel Rev.*, 1936, 4, (1), 29-47).—[In English and Japanese.] Discusses the use of the platinum metals and their alloys for jewelry. Since 1932 the Japanese Mint has certified platinum articles, but few manufacturers avail themselves of this. Y. advocates the universal use of "950" platinum (95%) and of 18 carat gold. Pure platinum is too soft to be made into ornaments. The alloys of platinum with

copper, aluminium, nickel, tungsten, tantalum, gold, and silver are briefly described and a table is given of the properties of the gold-base platinum and palladium alloys. Iridium, rhodium, ruthenium, osmium, and palladium are mainly added to platinum to improve the corrosion- and heat-resistance, hardness, strength, and lustre. A table summarizes the physical properties of these alloys.—W. A. C. N.

Platinum Metals as Materials of Construction. Frederick E. Carter (*Japan Nickel Rev.*, 1936, 4, (1), 21-28).—[In English and Japanese.] Tables of the hardness in the annealed state of alloys of platinum and the other platinum metals and of palladium with the other metals are given. Several of the alloys can be age-hardened. Jewelry is the largest consumer of the platinum metals. Much platinum is used as a catalyst in chemical industry—in the manufacture of oleum and nitric acid, for example. Precious metal alloys are practically indispensable for the spinnerets used in the rayon industry. They are also used for resistance furnace windings where high temperatures are needed, and for electrical contacts. In the latter case d.c. is more severe on the contact than a.c. of smaller voltage and current. Platinum metals are the best contacts for low currents, and also where the make and break occurs with only slight pressures since no insulating compounds such as oxides, sulphides, &c., are formed on their face. Silver contacts are best for high currents. Platinum or platinum-10-iridium alloys are used as electrodes in the reduction of chlorates, perchlorates, &c. Graphite under such conditions disintegrates. Iridium-platinum is also used for fuse wires in detonating caps where base metals would in time tend to corrode and possibly cause misfires. The electroplating of the platinum metals—particularly of platinum and of rhodium—has advanced considerably in recent years. In the dental field probably the most progress of all is now being made in the use of the platinum metals owing to the increased price of gold. The alloys in many instances can be manipulated in the soft condition and are given a hardening treatment in the final form.

—W. A. C. N.

Spinnerets for the Rayon Industry. Fred J. Canthal (*Japan Nickel Rev.*, 1936, 4, (1), 48-50).—[In English and Japanese.] Platinum-gold is the best alloy for spinnerets. It is tough, machines well, is immune to corrosion and has a high scrap value. Cylindrical holes down to 0.025 mm. diameter with a measurable accuracy of 1 micron are mostly used. Recently hyperbolic holes have been introduced. These are more easily cleaned, less liable to be blocked by coagulation, lead to less waste, and increase the flow of the viscose.

—W. A. C. N.

Electrical Contact Point Materials. Gabachi Suzuki (*Japan Nickel Rev.*, 1936, 4, (1), 63-74).—[In English and Japanese.] The properties demanded of good contact points are good electrical and thermal conductivity, high melting point, resistance to abrasion and to chemical changes, moderate price. The materials considered are carbon, nickel, copper, tungsten, silver, and silver-cadmium and silver-copper alloys, gold-platinum-silver alloy, and platinum or platinum-iridium alloy. The advantages and disadvantages of each are discussed. "Metallic" carbon, consisting of powdered silver mixed with carbon, is sometimes used. It has $\frac{1}{5}$ the resistance of carbon. S. says that a platinum-iridium contact point is ideal. Tables of physical properties of the precious metal alloys that are commonly used are given.—W. A. C. N.

Precious Metals for Pen Nibs. Mitsunaga Homma (*Japan Nickel Rev.*, 1936, 4, (1), 94-101).—[In English and Japanese.] The pen nib must have elasticity, durability, ductility, and be resistant to corrosion by ink. 14-carat gold is usually adopted for most classes of nibs, and this material may contain silver 13-30, and copper 11-42%. A table of the commonly used alloys is given. The so-called iridium point is not the pure metal but a product of the refining of the natural alloys iridosmine or osmiridine. The hardness of platinum-

iridium alloys is shown by a table and curves. Microstructures of iridosmine and of iridium are given.—W. A. C. N.

From Reed to Platinum. — (*Japan Nickel Rev.*, 1936, 4, facing p. 131).—From the *Literary Digest*. Describes a flute made of platinum which is said to have given great satisfaction.—W. A. C. N.

Silver-Palladium Dental Alloys. Senji Hatada (*Japan Nickel Rev.*, 1936, 4, (1), 75-81).—[In English and Japanese.] The characteristics necessary for dental alloys are discussed, and suitable alloys for dental purposes are described.

—W. A. C. N.

Further Notes on the Suitability of Metals for Dyeing Machinery. J. G. Grundy (*J. Soc. Dyers Colourists*, 1935, 51, (11), 377-384; *C. Abs.*, 1936, 30, 617).—An investigation to determine the advantages of stainless steels for dyeing machinery as compared with wood, iron, copper, bronze, brass, Monel metal, &c. Tables show the behaviour of different metals under various treatments.—S. G.

Behaviour of Bare Conductors under Change of Stress. H. Leboutoux (*Conférence internat. Grands Réseaux Électriques à Haute Tension*, Reprint No. 229, 1935, 16 pp.; *Bull. B.N.F.M.R.A.*, 1936, (83)).—The "unsagging" of electrical overhead conductors after erection has often been observed, and various empirical practices have been recommended to guard against or obviate it. L. attributes the phenomenon to the fact that the modulus of elasticity of conductors is not constant except within certain well-defined limits. The variation of the modulus of elasticity, and a method of sag and tension calculation whereby increase in sag after erection may be calculated, are discussed.

—S. G.

Non-Ferrous Alloys Available for the Use of Industry. — (*Aluminium and Non-Ferrous Rev.*, 1935, 1, (2), 55-58; (3) 87-88).—The composition and properties of the following alloys are summarized: Ceralumin "B," "C," and "D"; aluminium alloys "L5," "L8," "L11," and "Y"; Alpha, Beta, and Gamma Alpac; Mazak Nos. 2, 3, 5, and 6; eleven Elektron alloys; and Sterling Metal Alloys S.M.82, S.M.101, and S.M.116.—J. C. C.

XXII.—MISCELLANEOUS

(Continued from p. 63.)

The Nickel Industry in 1935. Robert C. Stanley (*Met. Ind. (Lond.)*, 1936, 48, (1), 32-35; and *Found. Trade J.*, 1936, 54, (2), 36-39).—The developments in the nickel industry during the past year are discussed.—J. H. W.

Historical Summary of Platinum. C. Engelhard (*Japan Nickel Rev.*, 1936, 4, (1), 18-20).—[In English and Japanese.]—W. A. C. N.

The Platinum Industry in 1935. Charles Engelhard (*Amer. Metal Market*, 1936, 43, (3), 2).—A review.—L. A. O.

Early Chinese Metallurgy. E. A. Smith (*Met. Ind. (Lond.)*, 1936, 48, (1), 27-31).—Notes are given on the mineral resources of China; early antimony smelting and the casting of copper and bronze, which is considered to date from not later than 3000 B.C.; the working of gold and iron; the smelting of lead and the cupellation of auriferous lead; and the smelting of tin-zinc and complex ores. 3 references are given.—J. H. W.

Metallurgical Research at McGill [University, Toronto, Canada]. Alfred Stansfield (*McGill News*, 1935, 16, (4), 27-31; *C. Abs.*, 1936, 30, 413).—Results are reported of investigations on the penetration of gold, silver, platinum, and copper into lead cylinders, electrolytic production of magnesium, electric smelting of zinc and iron ores, and others not of non-ferrous metallurgical interest.—S. G.

Process Research and the Evolution of New Technique. R. S. Hutton (*Met. Ind. (Lond.)*, 1936, 48, (3), 55-58).—The direction in which modernization of existing processes is taking place is discussed.—J. H. W.

The Utilization of Production Methods. L. B. Hunt (*Met. Ind. (Lond.)*, 1936, 48, (3), 59-60).—The points of view of the user of non-ferrous metal products in the improvement in metal-working technique is set out.—J. H. W.

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[The statistics issued by the American Bureau will be found most valuable because of the obvious care that is taken in their compilation. They are clearly printed on large pages on good paper. The present volume, covering the year 1934, deals in the greatest detail with copper (33 pp.), lead (20 pp.), zinc (24 pp.), and gold and silver (10 pp.); the remaining 14 pp. deal with platinum, antimony, nickel, tin, aluminium, cadmium, brass, and bronze, and the metal consumption per person in the principal countries from 1912 to 1934, average prices of the principal metals (New York and/or St. Louis and/or London) from 1885 to 1934, and yearly average prices from 1882 to 1934. For the principal metals, the particulars given include world's production and consumption, refined metal production, mine production, producers, smelting and refining plants, smelter output, stocks, deliveries, ore reserves, imports and exports, metal available for consumption, use in U.S.A., and prices.]

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[See *Met. Abs.*, this vol. p. 86.]

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[The sections of special interest to members of the Institute of Metals are: "General Plant and Machinery," by H. W. Richards and J. N. Vowler (pp. 5–31); "Fuel," by L. E. Winterbottom and A. H. Raine (pp. 32–55); "Refractories, Ceramics, and

Cements," by J. H. Chesters and W. J. Rees (pp. 304-315); "Iron and Steel," by C. O. Bannister (pp. 316-343); "Non-Ferrous Metals," by A. R. Powell (pp. 344-368); "Electrochemical and Electrometallurgical Industries," by J. W. Cuthbertson.]

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Wirtschaftsgruppe Elektrizitätsversorgung. Herausgegeben von der *Industrielle Elektrowärme.* I Teil: *Entwicklung—Eigenschaften—Wirtschaftlichkeit—Bedeutung—Bauformen.* Pp. 63, with 99 illustrations. Berlin: Arbeitsgemeinschaft zur Förderung der Elektrowirtschaft.

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XXIV.—BOOK REVIEWS

(Continued from pp. 67-68.)

The Structure of Metals and Alloys. By William Hume-Rothery. (Institute of Metals Monograph and Report Series, No. 1.) Demy 8vo. Pp. 120, with 61 illustrations. 1936. London: The Institute of Metals, 36 Victoria St., S.W.1. (Cloth, 3s. 6d. net, post free.)

It has been said that mankind, like the number of motor-cars on our streets, progresses by leaps and bounds, and it is even more strictly true that leaps and bounds have been the means of progress of physical science during the past 20 years or so. Niels Bohr started it with his theory of the atom. Physical science then became a branch of mathematics and has remained so, in the main, to this day. Mathematical theory succeeds mathematical theory with almost breathless haste. A huge mathematical superstructure is built on a very slender base of solid or unsolid ascertained fact—it apparently does not matter much which it is.

So rapidly has science developed and so mutually contradictory are some of the views held—sometimes even by one and the same scientist—that the smaller fry of science do not know where they are. It is quite possible that recent experimental work by Shankland may bring the whole “leaps and bounds” theory of matter toppling to the ground, and then where are we, in the scientific sense? This is where the scientific societies can help us so much—I write as one interested in the progress of science generally. The Chemical Society and the Society of Chemical Industry have, over a long period, published annual reports of progress in pure and applied chemistry. The Physical Society started on somewhat similar lines last year, and now the Institute of Metals has set its hand to an even better and harder task; it has commenced the issue of a series of Reports and *Monographs* relating to metallurgy.

The first monograph—“The Structure of Metals and Alloys”—is by Dr. Hume-Rothery. The author is such a distinguished worker and recognized authority in this field that for me to commend this book were surely a work of supererogation. Rather would I thank the author for his clear, concise, and accurate account, not overlaid with detail, of “The Structure of Metals and Alloys” in the light of present-day science. It is just the book that I have been waiting for. More detailed books on the subject are obtainable—the German “Handbuch” type of book wearies me; the mathematical treatise on atomic structure scares me; with Dr. Hume-Rothery’s book I am at ease. The book is not easy reading throughout, but it is as easy as the subject permits. Bear in mind that what is at the back of the author’s mind in writing this book is to help to obtain an answer to the question “What is a metal or alloy?” Let me confess that even after reading Dr. Hume-Rothery’s monograph I don’t know. Is this to be wondered at? I think not. What is a metal? One will think of it in terms of its ductility, another of its conducting properties, a third of its malleability, its tensile strength, its lustre, its plasticity, and what not. Relatively few will think of a metal in terms of its crystalline structure. It is the belief of the physical metallurgist that all the different aspects and properties of a nickel are ultimately referable and explainable in terms of its crystalline structure, and here fundamental knowledge is provided in measure “without overflowing, full.”

The contents of the book may be briefly indicated. Sections are devoted to the electronic background of metallurgy, the crystal structure of the elements, atomic radii of the elements, primary metallic solid solutions, intermediate phases in alloy systems, and imperfections in crystals. These fairly round off the subject. Each chapter is provided with a bibliography of carefully-selected, selected references—the wheat has been winnowed from the chaff. An adequate index is provided, and the whole is enclosed in a limp linen cover.

The book contains no higher mathematics (knowledge of simple arithmetic, a little trigonometry and less algebra are all that are required of the reader); no use is made of crystallographic notations, wave-mechanical theory is merely mentioned and passed by, while thermodynamics are not even referred to. Thank heaven for these minor virtues of the book, for the higher flights of mathematics, applied to the discussion of metallic structure, would drive many metallurgists to the madhouse or the grave. Metallurgy, after all, is still very largely an *experimental* science.

I commend the book to all scientists, metallurgists, physicists, chemists, mineralogists, aye and to geologists and even biologists, first of all on account of its contents. Dr. Hume-Rothery has deserved well of his fellow scientists. I recommend the book secondly on account of its price: its costs only 3s. 6d. I don’t know how this has been made possible, but the Institute deserves well of science for its publication of this volume at so low a price. The book deserves the widest possible circulation.—J. S. G. THOMAS.

Métallurgie, Construction Mécanique et Électrique. (*Belgique et Grand-Duché de Luxembourg.*) Pp. 224. 1935. Bruxelles: D. Hallet, 42 Avenue Alexandre Bertrand (Forest). (30 Belgian francs.)

This is one of four “Guides Industriels Belges”; the others deal with the coal trade, the building materials, glass and ceramic trades, and the chemical industry. In the present

publication the metallurgical and engineering firms of Belgium and Luxembourg are classified geographically and according to products. There is also a list of professional trade and sales associations, and an index of traders and suppliers to the metallurgical and engineering industries.

Der Metallische Werkstoff. Seine Vervollkommnung durch Technik und Wissenschaft. Von W. Köster. (Deutsches Museum Abhandlungen und Berichte.) Demy 8vo. Pp. 77-107, illustrated. 1935. Berlin: V.D.I.-Verlag G.m.b.H.

This little paper-covered book contains a reprint of a lecture by the author to the Kaiser-Wilhelm Institute for the Advancement of Science covering in broad outline the development of the use of metals in technology and science from the early days to the present time. Modern methods of smelting and working metals are compared with those of the Middle Ages and of primitive man, and a brief account is given of modern methods of examining the structure and properties of metals and alloys.—A. R. POWELL.

Les emplois industriels du Gaz dans la Métallurgie. Par J. de Croes. (Extrait du Bulletin de l'Association des Gaziers Belges, Année 1934.) $8\frac{1}{2} \times 12$ in. Pp. 138, with 284 illustrations. 1934. Bruxelles: Électricité et Gaz de l'Agglomération Bruxellois (Électrogaz) S.A.

The competition between the various sources of heat for metallurgical purposes has resulted in widespread developments in their methods of application. The present volume summarizes in excellent fashion the many ways in which gas—coke oven, producer, blast furnace, water, or town's gas—is used in modern factories. It is divided into five sections which deal, respectively, with the application of gas in: (1) metal melting; (2) forging furnaces; (3) thermal treatment of metals and industrial alloys; (4) brazing, soldering, and welding; (5) the protection and decoration of metals. The discussion embraces both ferrous and non-ferrous materials, and is abundantly amplified by means of clear illustrations.

In large steel melting furnaces the use of producer gas results in a long clear flame which gives quick fusion and permits of heat regeneration at a cheap rate. Tests over a long period on crucible melting, using coke and gas as the fuels, indicate that the cycle with the former is twice that with the latter and that the cost is about 30% greater. An interesting type of crucible furnace has both internal and external recuperators. Descriptions are given of continuous and intermittent aluminium furnaces, galvanizing and tinning furnaces, and furnaces for melting type metals. In forging, gas is shown to be at least 50% cheaper than coke and much more convenient to use. Several types of furnaces are illustrated and described, and in many instances working costs, heat balances, and efficiencies under varying conditions are given. Of special interest are the gas furnaces for heating steel tyres in which the burners are situated within a casing which surrounds the tyre. In the summary of the thermal treatment of steel attention is paid to furnaces which employ special atmospheres or salt-baths to ensure the minimum of scaling. Similar consideration is given to the bright-annealing of non-ferrous metals. In connection with the latter mention may be made of unit pit-type furnaces similar to those which have been developed for heating electrically. The section dealing with protection and decoration includes information on the heating of electrodepositing vats, enamelling furnaces, and varnishing ovens.

The book is one of the most complete surveys of the application of gas to industrial furnaces. This review can give but an extremely brief indication of its scope. The value is considerably enhanced by the working data and efficiency figures which are included on a very liberal scale.—W. A. C. NEWMAN.

The Metal Cleaning Handbook. Equipment, Methods, and Materials with Practical Suggestions for Their Use. By Robert W. Mitchell. Med. 8vo. Pp. 213, with 287 illustrations. 1935. Garwood, N.J.: Magnus Chemical Co. (\$1.00.)

Although this book is in the nature of an advertisement for the products of the publishers and the machinery of various American manufacturers, its practical utility to the plater is very great since it contains a well-written and detailed description of all the modern methods of cleaning and degreasing metals for plating, and of the necessary plant. In addition, the principles underlying the operations of cleaning by detergents, by electrochemical means, and by organic solvents and vapours are carefully and thoroughly explained in simple language. The book is liberally illustrated throughout by photographs of modern apparatus, sectional diagrams showing the principles of their construction and use, and graphs showing the effect of various conditions on the efficiency and operation of the cleaning baths. Much information is also given on the composition of plating baths, the operation of silver, cadmium, zinc, nickel,

chromium, tin, copper, and brass plating baths, barrel plating and burnishing, and metal cutting, drawing, and extrusion with special reference to lubricants.

Altogether this is a valuable book for reference in any plating shop, at a remarkably low price.—A. R. POWELL.

Werkstoffnormen. Stahl, Eisen, Nichteisen-Metalle, Eigenschaften, Abmessungen. Herausgegeben vom Deutsche Normenausschuss. (DIN. Taschenbuch 4.) 9 Auflage. Pp. 164, illustrated. 1935. Berlin: Beuth-Verlag. (M. 4.)

This is the ninth edition of this extremely useful compilation of standards. There are a few minor alterations in seven of the specifications in order to bring them into line with recent information. In other respects the volume is similar to its predecessors.—W. A. C. NEWMAN.

Chromium Plating, with Special Reference to Its Use in the Automobile Industry. By O. Bauer, H. Arndt, and W. Krause. Translated from the German by E. W. Parker. With an Introductory Chapter on "Electroplating Practice and the Properties of Chromium and Nickel Deposits," by A. W. Hothersall. Med. 8vo. Pp. vii + 266 pp., with 194 illustrations. 1935. London: Edward Arnold and Co. (25s. net.)

In the course of the past 10 years the process of chromium plating has developed from the purely experimental stage to that of large-scale industrial application. Chromium deposits on suitable undercoats of nickel provide a unique finish by reason of their retention of a brilliant lustre under even severe corrosive conditions, and also their endurance due to their extreme hardness.

Increasing opportunities for service call for the display of properties which lead to the greatest usefulness in numerous applications. Many and varied are the methods of testing which have been devised and systematized. Hitherto these have not formed the basis of any special treatise, but the authors now cater for the needs of both the depositor and user and especially those in the realm of engineering in general and of the automotive industry in particular.

This is not a book on the processes of chromium plating. It strikes a new line in bringing together the methods of examination of such deposits and also those of the deposits upon which they are invariably made. On an extensive array of specimens drawn from the industry, tests have been carried out and the results summarized and surveyed to reveal the surface quality, hardness, adhesion, resistance to temperature and reversals of temperature, porosity, and corrosion-resistance.

A bibliography of nearly 600 papers only a few of which predate 1920 is by no means an inconspicuous feature of a worthy effort, which will render a service of inestimable value to those on whom devolves the task of devising specifications for the numerous types of electro-deposited chromium coatings.—S. FIELD.

Die Praxis der Verchromung. Von W. Birett. Sup. Roy. 8vo. Pp. 76, with 21 illustrations. 1935. Berlin: M. Krayn. (R.M. 3.50.)

The author of this little book sets out to provide a fairly comprehensive account of German chromium-plating practice to satisfy the needs of those who have no special qualifications to grasp the technicalities of the subject. The book deals mainly with the practical aspects of the process, and various sections are devoted to plant, electrolyte composition, the influence of operating conditions, and works control, while at the close of the volume, a list of faults likely to arise in chromium plating is tabulated together with suggestions for their rectification.

There is a considerable amount of useful information scattered through its pages, but the book is not well balanced, and the impression gathered is one of hasty construction. Thus, while it is now universally recognized that good-quality chromium plating is at least as much dependent on the deposition of a sound nickel undercoat as on the character of the chromium coating itself, the total space devoted by the author to the nickel-plating process does not exceed three or four pages, while preparatory and cleaning processes are allotted a single page. The self-cleansing properties of the chromium bath are evidently relied on for any deficiency in this respect. For further details respecting undercoatings for chromium plating, the author refers the reader to "Die Verchromung unter besonderer Berücksichtigung ihrer Anwendung im Automobilbau" ("Chromium Plating with special reference to its application in the automobile industry"), by Bauer, Arndt, and Krause. It is perhaps worth noting in parenthesis that this book has recently been translated into English (see review above).

It is interesting to note that German practice favours an electrolyte containing 350 gm./litre of chromic acid for general purposes, *i.e.* half-way between the low (250 gm./litre) and high (500 gm./litre) chromic acid electrolytes ordinarily met with in this country.

Reference is made in the preface to the Combine which is known to be exploiting certain

chromium plating patents in Germany, namely, the Elektrochrom-Gesellschaft, Langbein-Pfanhauser Werke A.G., and Siemens & Halske A.G.; while an interesting short statement on the patent position, which refers especially to the "acid radicle" patent (D.R.P. 448,526) of Dr. Liebreich and the "intermediate coatings" patent (D.R.P. 440,612) of Siemens & Halske A.G., concludes this somewhat indeterminate publication.—S. WERNICK.

Journal of the Electrodepositors' Technical Society. Volume X.—1934–1935. Pp. 202. London: The Society, Northampton Polytechnic Institute, Clerkenwell. (Members, 15s.; non-members, 21s.)

This volume contains 14 papers read before the Society or jointly with the Faraday Society, an account of the Annual Meeting and, at the end, discussions on some of the preceding papers and a description of the Electrodeposition Exhibition at the Science Museum. The papers on plating procedures refer to zinc-cadmium alloys, nickel, cadmium, tin, and chromium. There are also two papers dealing with specifications of electrodeposits and four papers on the structure of electrodeposits read at the recent Faraday Society's Symposium. The discussions on metal degreasing and on chromium plating troubles contain much useful information for the practical plater, in fact the whole of the volume contains so much of practical utility that no plating firm can afford to be without a copy for handy reference.—A. R. POWELL.

Principles of Experimental and Theoretical Electro-Chemistry. (International Chemical Series.) By Malcolm Dole. Demy 8vo. Pp. xiii + 549. 1935. New York: McGraw-Hill Book Co., Inc. (\$5.00); London: McGraw Hill Publishing Co., Ltd. (30s. net).

This volume introduces us to a new view-point of electro-chemistry. Hitherto the science has been regarded as a study of the mutual relations and transformations of electrical and chemical energy. In view of the fact, however, that there is a tendency to interpret all chemical reactions on an electrical basis, the author regards this former type of definition as altogether too vague, and he therefore applies a more restrictive definition by which the science becomes the organized body of chemical knowledge accumulated through the application of electric current or electric (or magnetic) fields in the solution of chemical problems, and through the measurement of electric currents or electric potentials flowing through or generated by chemical cells.

With this new definition a number of subjects, such for example as theories of indicators, of neutralization, of buffer solutions, of solubility and colligative properties of solutions, are not discussed, but in their place such aspects as dielectric-constant and dielectric-moment measurements, molecular ray experiments, high-frequency and high-voltage conductance phenomena, electrokinetic and electro-capillary phenomena and phase boundary and semi-permeable membrane potentials, usually omitted from former treatises, are mentioned and discussed. In simple terms the subject of electro-chemistry is treated rather from the physical than the chemical side. In this respect it provides a new departure in the literature of the subject, but nevertheless follows closely on experimental lines. Indeed the book opens in very simple terms with a simple discussion of the theory of Arrhenius and the methods employed in the study of the conductance and other properties of electrolytes, making it abundantly clear, however, that Arrhenius laid only one of the foundation stones of the science.

Many aspects of the subject, usually only briefly dealt with in the standard works on the subject are here treated in some detail, including the theory of strong electrolytes and the glass electrode, while the principles of quantum mechanics are applied to the study of the origin of electrode potentials, the abnormal mobilities of the hydrogen and hydroxyl ions, and the theory of over-voltage.—S. FIELD.

Elementary Craftwork in Metal. An Introduction for the Use of Teachers, Students, and Workers. By Alfred J. Shirley. Second Edition. Med. 8vo. Pp. viii + 126 + 30, with 32 illustrations. [1935.] London: B. T. Batsford, Ltd. (5s. net.)

Quality, but not quantity, will be found in this book, with its wide margins and open spaces, excellent printing, and pleasing illustrations. The author maintains a high standard of artistic design in the simplest of his examples and one can imagine few more pleasant tasks than those to which he sets his pupils. Metallurgists will take exception, however, to several details in the description of materials. The table of alloys on p. 8, for example, is of doubtful value (the composition given for Duralumin is amazing), and it is incorrect to state (pp. 14 and 15), that aluminium requires no flux for welding or that aluminium-bronze, German silver, manganese-bronze, Muntz metal phosphor-bronze, silver, and zinc cannot be welded.—H. W. G. HIGNETT.

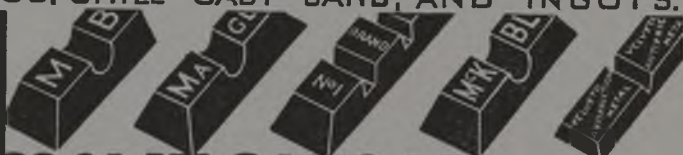


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