The Journal of the
INSTITUTE OF METALS
and
METALLURGICAL ABSTRACTS

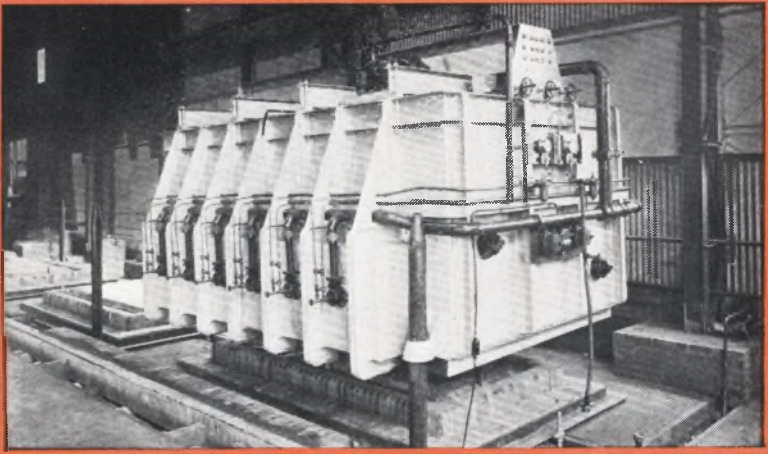
17

In this Issue:

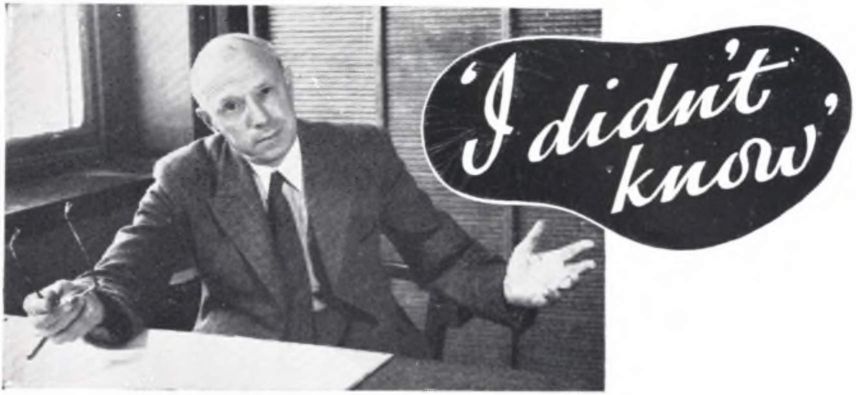
OCTOBER 1947

View of General Arrangement.

View showing Bell in operation on Base No. 1 and assembled charge on Base No. 2 with inner cover removed.



View showing Bell being lowered by crane on to Base.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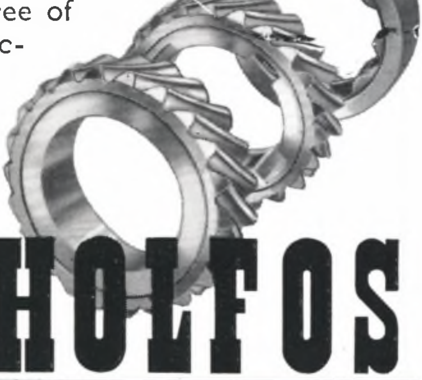

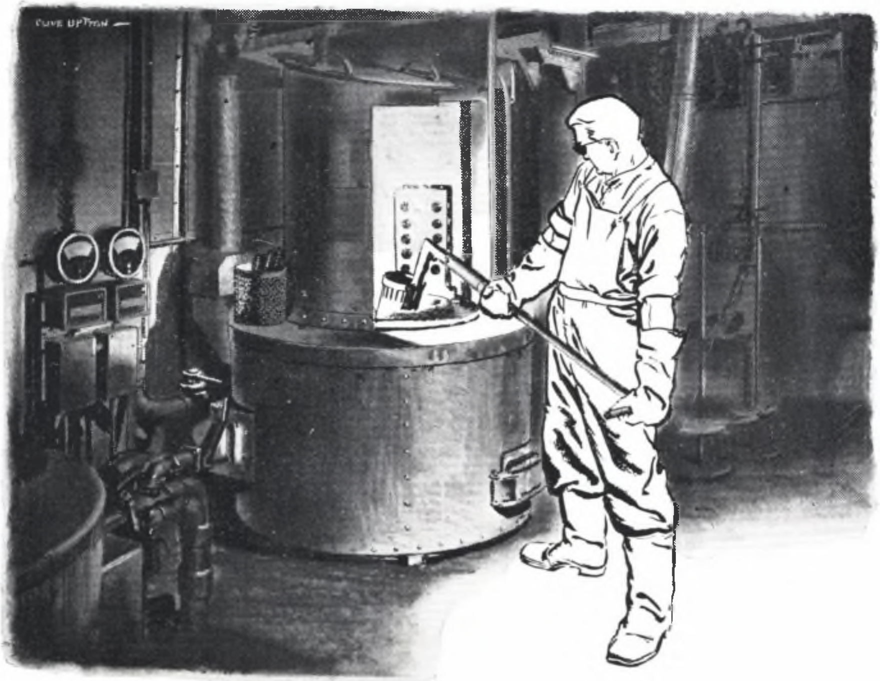
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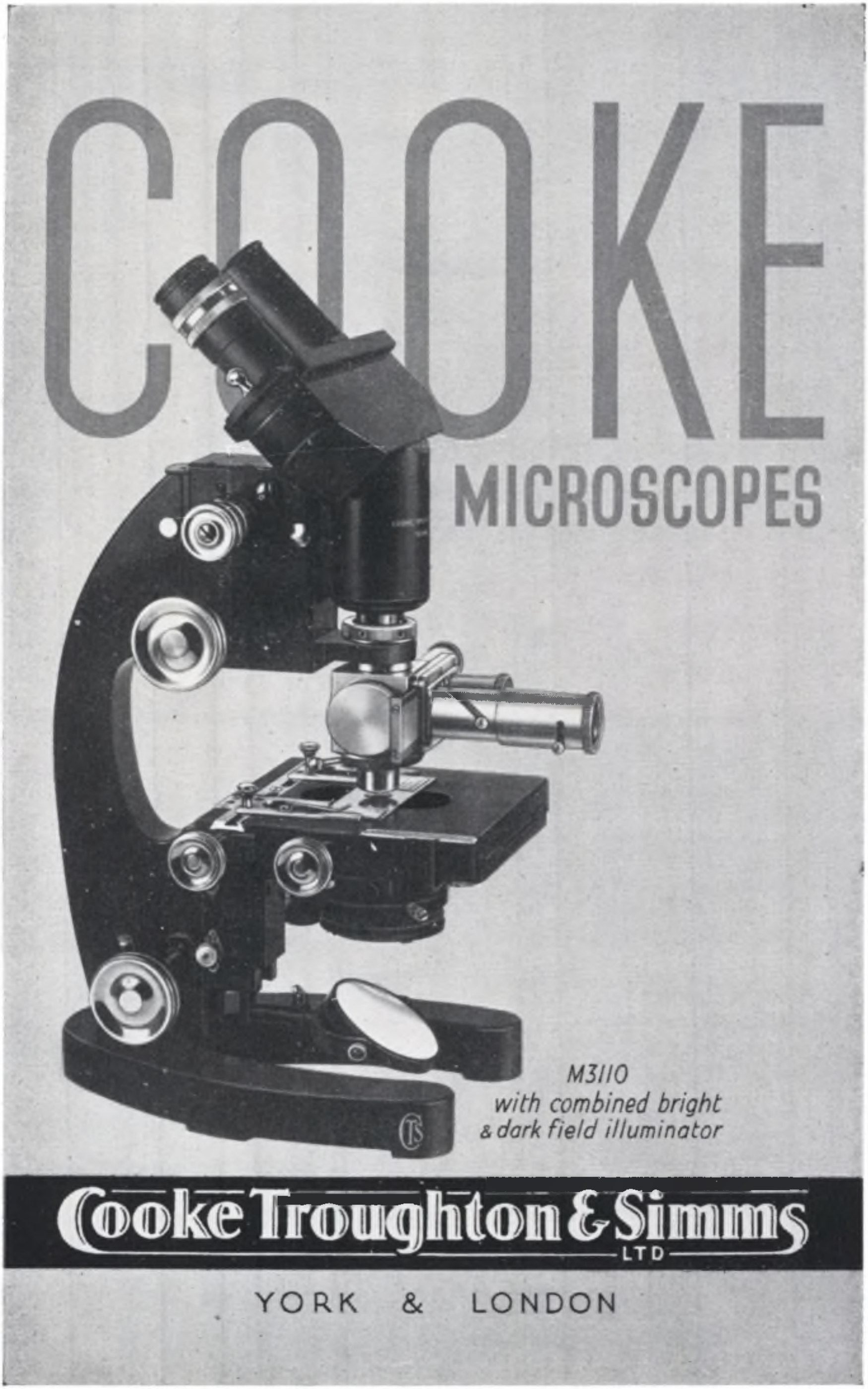


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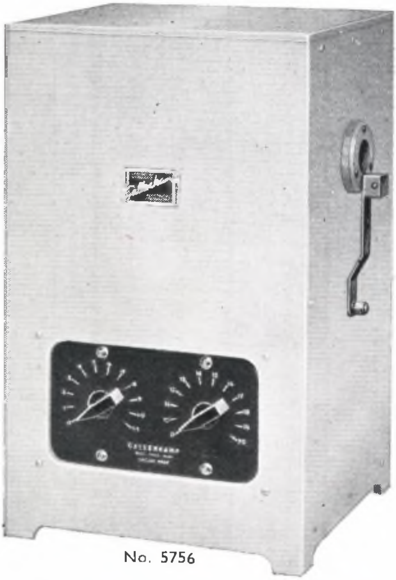

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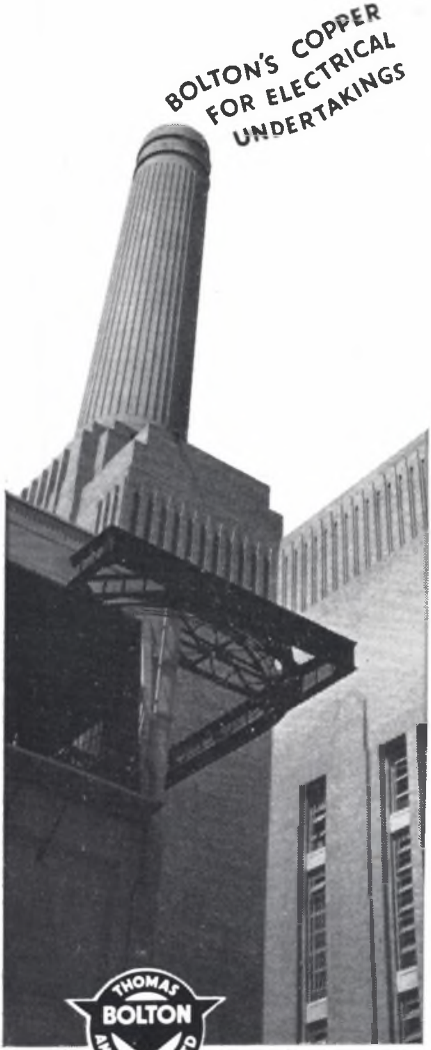
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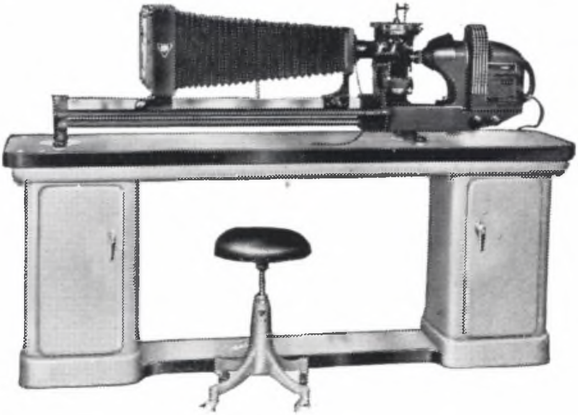

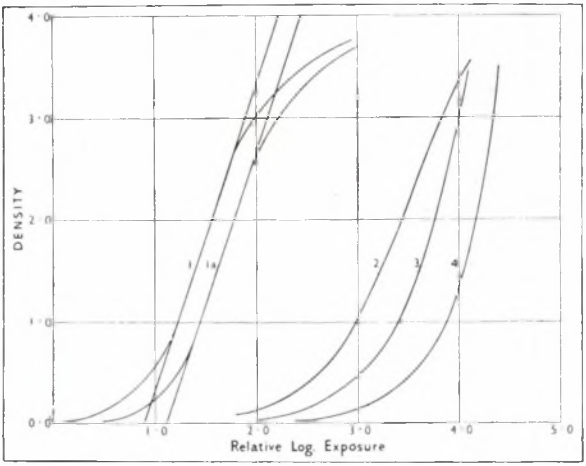
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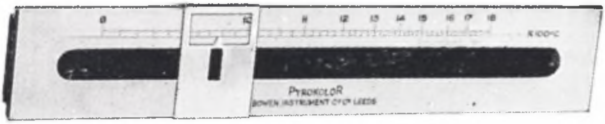
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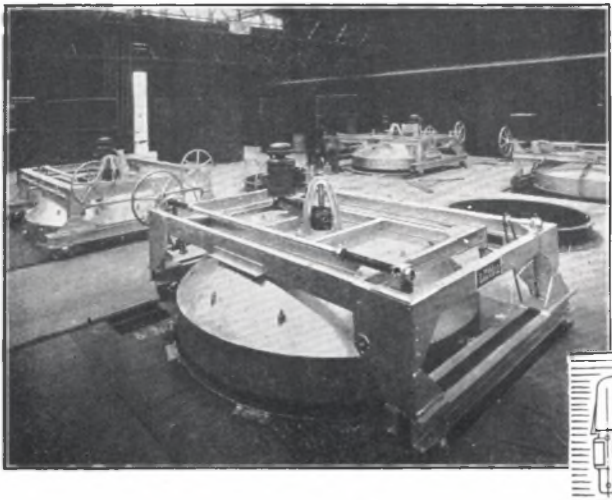

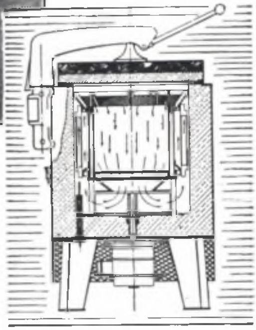

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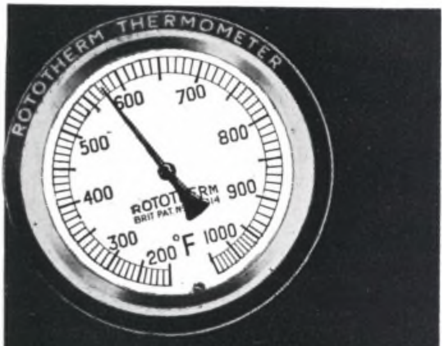

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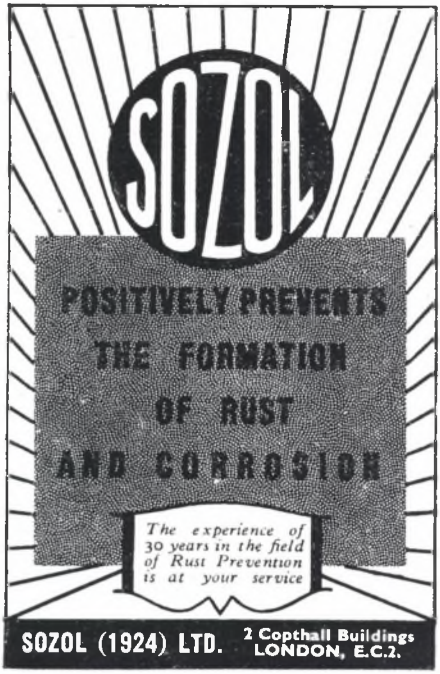


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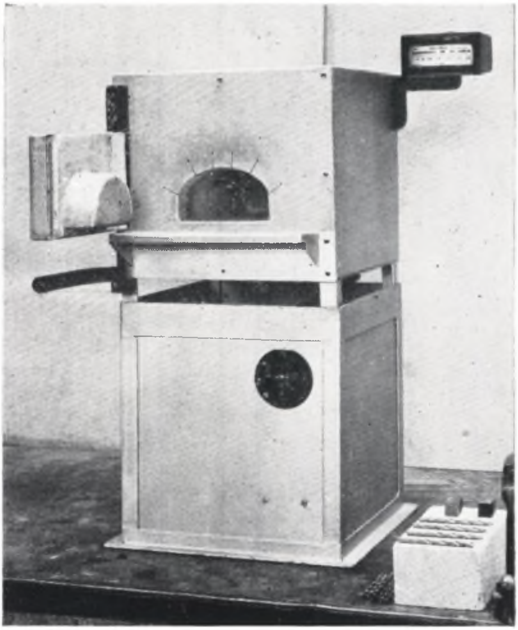

THE JOURNAL OF THE INSTITUTE OF METALS

OCTOBER 1947

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A finger on
the world's metallurgical pulse

October 1947.

THE INSTITUTE OF METALS

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Colonel P. G. J. GUETERBOCK, C.B., D.S.O., M.C., T.D., D.L., J.P., M.A., A.D.C.
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INSTITUTE NEWS AND ANNOUNCEMENTS

AUTUMN MEETING, GLASGOW

The Autumn Meeting, which took place in Glasgow from 23 to 26 September, was one of the most successful of its kind that has been held by the Institute. It was particularly remarkable for the very happy atmosphere which was created at the first social function and which was maintained throughout the meeting, for the care shown by the Reception Committee for members' comfort, the most generous hospitality offered to members and their ladies by the Scottish Local Section and others, and the interest of the works visited. The discussions of papers also maintained a high level.

Sir James Weir French, D.Sc., Honorary President of the Reception Committee.

The Institute owes a great debt of gratitude to the Committee of the Scottish Local Section for organizing so memorable a meeting, and particularly to Mr. Matthew Hay, the Honorary Secretary to the Reception Committee, on whom fell the greater part of the large amount of administrative work in connection with it.

The meeting opened on the evening of Tuesday, 23 September, with Sir James Weir French, D.Sc., Honorary President of the Reception Committee, in the Chair, when members heard official addresses of welcome from the Chairman (on behalf of the Reception Committee), Councillor Andrew Hood, J.P. (representing the Lord Provost and Magistrates of the City of Glasgow), Professor R. Hay (representing the Principal of Glasgow University), and Mr. W. H. Marr, President of the Glasgow Chamber of Commerce. The President briefly replied.

Under the chairmanship of the President, Professor G. Wesley Austin, O.B.E., M.A., M.Sc., then delivered the Autumn Lecture on "The Metallurgical Resources of Scotland", which will be

GLASGOW MEETING. THE PRESIDENT, COLONEL P. G. J. GUETERBOCK, C.B., D.S.O., M.C., T.D., D.L., J.P., M.A., A.D.C. (*above*), AND THE HONORARY PRESIDENT OF THE RECEPTION COMMITTEE, SIR JAMES WEIR FRENCH, D.SC. (*below*), SPEAKING AT THE DINNER HELD ON 25 SEPTEMBER 1947.

"The Professor"—Professor G. Wesley Austin, delivering the Autumn Lecture.

printed in an early issue of the *Journal*. Members and their ladies were then entertained to light refreshments and some Scottish songs [in the singing of the choruses of which they took part]. The welcome and this first social function struck the keynote of the very happy relations for which the meeting was so notable.

On the next day the morning was occupied by good discussions on papers by Mr. Ivor Jenkins on "Surface Effects During the Annealing of 70 : 30 Brass" and Dr. O. R. J. Lee and Dr. L. Northcott on "The Centrifugal Casting of Copper Alloy Wheels in Sand Moulds". At a luncheon that followed, the President thanked the Scottish Local Section for their invitation to hold the meeting in Glasgow, and Mr. A. Craig Macdonald, Vice-Chairman of the Section, replied. In the afternoon members visited the British Aluminium Company, Ltd., Falkirk; John Brown and Company, Ltd., Clydebank; Glenfield and Kennedy, Ltd., Kilmarnock; and Henry Wiggin and Company, Ltd., Thornliebank; while ladies visited the works of the Saxone Shoe Company, Ltd., Kilmarnock, or Burns' Cottage at Ayr.

In the evening members and their ladies were the guests of the Lord Provost (Sir Hector McNeill), Magistrates, and Corporation of Glasgow at a reception at the City Chambers. The Lord Provost, supported by the Magistrates, received the guests, and later made a brief address of welcome, to which the President replied. Sir James Weir French proposed a vote of thanks to the Institute's hosts. During the evening there was dancing (including Scottish dances) in the Banqueting Hall, and a concert.

On Thursday morning, very good discussions took place on a paper by Mr. P. G. Forrester on "Frictional Properties of Some Lubricated Bearing Metals", and a series of three papers on the corrosion of magnesium-rich alloys by Dr. F. A. Fox and Mr. J. K. Davies, Mr. C. J. Bushrod, and Mr. E. R. W. Jones and Mrs. M. K. Petch. Members were entertained by the Scottish Local Section to lunch, at which the Chairman, Mr. A. B. Graham, made a brief speech of welcome, to which the President replied. In the afternoon visits were paid to Albion Motors, Ltd., Scotstoun; Babcock and Wilcox, Ltd.,

Mr. A. B. Graham, Chairman of the Scottish Local Section.

GLASGOW MEETING. A GROUP OF MEMBERS AND LADIES OUTSIDE THE MEETING HALL.

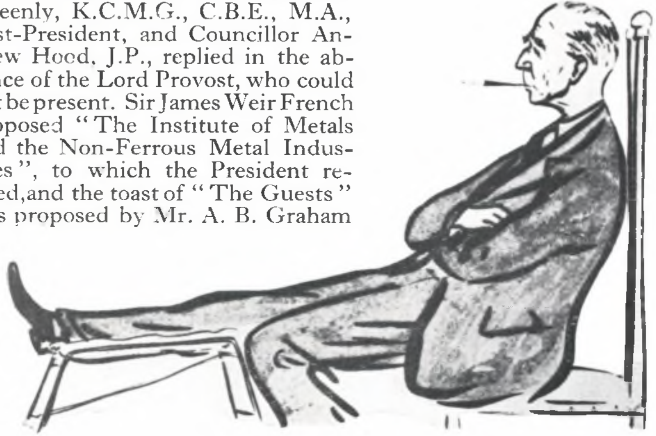
Renfrew; and Barr and Stroud, Ltd., Anniesland. The ladies had been the guests of the Reception Committee on an all-day tour of the Trossachs.

Mrs. Craig Macdonald.

"Scotland Forever."—Mr. A. Craig Macdonald, Vice-Chairman of the Scottish Local Section.

Mr. Matthew Hay, Honorary Secretary of the Scottish Local Section.

In the evening a dinner and dance was held at the Grosvenor Restaurant. The guests were received by the Chairman (Sir James Weir French), Lady French, and the President and Mrs. Gueterbock, and included many who are distinguished in science and industry in the Glasgow area. The toast of "The City of Glasgow" was proposed by Lieut.-Colonel Sir John Greenly, K.C.M.G., C.B.E., M.A., Past-President, and Councillor Andrew Hood, J.P., replied in the absence of the Lord Provost, who could not be present. Sir James Weir French proposed "The Institute of Metals and the Non-Ferrous Metal Industries", to which the President replied, and the toast of "The Guests" was proposed by Mr. A. B. Graham



"The Boss."—The President, Colonel P. G. J. Gueterbock (who, because of an injury, was glad to use a leg-rest specially made for him, at a few hours' notice).

and was acknowledged by Mr. W. H. Marr, President of the Glasgow Chamber of Commerce. There was dancing, and during the evening Mrs. Gueterbock made a presentation to Mr. Matthew Hay, Honorary Secretary to the Reception Committee, on behalf of the Council of the Institute.

The last day of the meeting, Friday, 26 September, was occupied by an all-day steamer trip on Loch Lomond. It was a beautiful day and the Loch was seen at its best. In the course of the trip the Reception Committee presented all ladies with a sprig of white heather, and in the afternoon the ship was stopped while Mr. A. B. Graham and Mrs. Craig Macdonald, respectively, presented the President and Mrs. Gueterbock with mementos of the meeting. A piper played the party on and off the boat, during the trip, and for reels which were danced by some of the members and ladies present.

All who contributed to the success of this meeting, including the Ladies' Committee which so ably cared for the comfort of the lady visitors, fully deserved the warm thanks expressed so frequently to their hosts by all who were present. Members were surprised that, in these days of austerity, so much could be achieved in so many ways to make the meeting so successful. Scottish hospitality had, once again, excelled itself.

The caricatures were drawn at the Glasgow Meeting by Mr. James Greenlees.

PHOTOGRAPHS TAKEN AT THE GLASGOW MEETING

A number of excellent photographs were taken at the Glasgow meeting, and it is desired to arrange for an album, which should be as complete as possible, that could be retained by the Scottish Local Section.

Will all members who took photographs on that occasion kindly send copies to the Secretary of the Institute for that purpose.

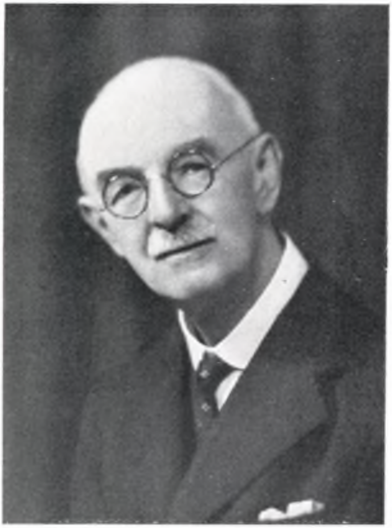
PERSONALITIES

Mr. H. H. A. Greer, J.P., Fellow.

Mr. H. H. A. Greer, J.P., who—as was announced in the August issue of the *Journal*—has been elected a Fellow in recognition of his outstanding services to the Institute for many years, was born in Belfast in 1875. He is well known in the metal trades of Scotland and has been connected with the metal industries for over 50 years.

For 20 years he was in business with his father, Mr. James C. Greer, and afterwards became the sole partner in the firm of James C. Greer and Son, Metal Merchants, of Glasgow, who have for many years been associated with Messrs. A. Cohen and Company, Ltd., of Great Dover Street, London. In 1918 Mr. Greer joined the Board of Directors of the latter Company, but retired some years ago.

An Original Member of the Institute, he took a large part in the formation of the Scottish Local Section in 1918. He was a member of the Committee of the Section from 1918 to 1944, Honorary Local Secretary from 1918 to 1928, and Chairman in 1931 and 1932. He was a Member of Council of the Institute from 1928 to 1936. Mr. Greer was a member of the Reception Committee of the Glasgow Meeting of the Institute in 1910, and



Honorary Secretary to the Reception Committee in connection with the Institute's very successful Autumn Meeting in Glasgow in 1925.

In the early days of the formation of the British Non-Ferrous Metals Research Association, he was its only member in Scotland, and acted as its Honorary Correspondent in Scotland. He is an Associate Member of the Institution of Engineers and Shipbuilders in Scotland, a Member of the Incorporation of Hammermen of Glasgow (founded in 1536), and a Member of the Incorporation of Gardeners, Glasgow (founded in 1605). He has held the position of Preses (Chairman) of the Weavers' Society of Anderston, Glasgow—a society founded in 1787, is a Justice of the Peace for the County of Ayr, and has been a member of the Parish Council of West Kilbride, Ayrshire.

Not only is Mr. Greer held in great esteem and affection in metallurgical and wider circles in Scotland, but his most attractive personality, his charm, and sense of humour have made him a very popular figure at the Institute's meetings—at home and abroad—which he very regularly attended until recent years.

PERSONAL NOTES

Dr. N. P. Antia was taken ill and admitted to hospital while on a visit to the United States. He was, in consequence, unable to return to England as planned, before returning to India.

Mr. B. L. Averbach, M.Met.Eng., has been awarded the degree of Sc.D. in Metallurgy of the Massachusetts Institute of Technology and has accepted an appointment as Assistant Professor of Metallurgy at that Institute.

Mr. H. J. Axon, B.Met., has left the Inorganic Chemistry Laboratory, University Museum, Oxford, and is now at the Metallurgy Section, A.E.I. Laboratory, Aldermaston Court, Aldermaston, nr. Reading.

Mr. H. R. Bleakney's correspondence should be addressed c/o National Research Council, 356 Booth Street, Ottawa, Canada.

Sir Lawrence Bragg, F.R.S., O.B.E., M.C., has had the honorary degree of LL.D. conferred on him by the University of St. Andrews.

Ir. B. E. Cankrien has retired from the post of Librarian of the Technical Nautical and Aeronautical Institute, Rotterdam, Holland.

Mr. A. L. Carr, B.Sc., has left University College, Cardiff, to take up an appointment with the Research and Development Department of The Mond Nickel Company, Ltd., Wiggin Street, Birmingham.

Mr. K. C. Choudhouri, M.Sc., Chemist and Metallurgist to the E.I. Railway, is now at the Metallurgical Laboratory, Locomotive Works, E.I.R., P.O. Jamalpur, Dt. Monghyr, India.

Mr. C. R. Cox, B.C.S., is now President of the Carnegie Steel Corporation, Carnegie Building, Pittsburgh 30, Pa., U.S.A.

Dr. D. W. Davison, B.Sc., sailed for Australia on 24 September. His address is now Research School of Metallurgy, The University, Melbourne.

Mrs. U. S. C. Ende has left the British Welding Research Association to take up an appointment in the Chemistry Department of the British Iron and Steel Research Association.

Mr. G. B. Evans has been appointed Senior Metallurgist to Airspeed, Ltd., Somerford Road, Christchurch, Hants.

Mr. Harold M. Gade is now at the College of Engineering, Rutgers University, New Brunswick, N.J., U.S.A.

Colonel P. G. J. Gueterbock, C.B., D.S.O., M.C., T.D., D.L., J.P., M.A., A.D.C., President, has been elected an Honorary Member of the Chemical, Metallurgical, and Mining Society of South Africa for the year ending 30 June 1948.

Mr. M. K. Haldar, M.Sc., has left the Research Department of the London, Midland and Scottish Railway Company, Derby, and is taking a special course in industrial and engineering radiography, held under the auspices of Kodak, Ltd., Harrow.

Mr. John C. Hannam has taken up an appointment as Research Assistant in the Chemistry Department of the British Iron and Steel Research Association.

Mr. Russell G. Hardy, B.S., has left the University of Notre Dame, Notre Dame, Ind., and is now Process Engineer at the Howard Foundry, 1700 N. Kostner St., Chicago, Ill., U.S.A.

Mr. John D. Haworth has been awarded the degree of B.Met. (First-Class Honours) and has also received the Mappin and Nesthill Medals at Sheffield University. He is now at the Inorganic Chemistry Laboratory, University Museum, Oxford.

Mr. J. L. Heselgrave, B.Met., has left his appointment at the Surbiton County Grammar School to take up a post as Mathematics Master at Tadcaster Grammar School, Tadcaster, Yorks.

Instructor-Lieutenant G. W. Horsley, R.N., has changed his address to: H.M.S. *President*, R.N. College, Greenwich, London, S.E. 10. He was recently awarded the B.A. degree of Cambridge University.

Mr. H. F. Johnson is now on foreign service. He should be addressed 8483 H. F. Johnson, S.Q. 8/1/4 Palm Grove, c/o A.I.O.C., Abadan, South Iran.

NEWS AND ANNOUNCEMENTS

MR. HENRY J. KOZLOWSKI, B.Sc., is on one year's leave of absence from the Bureau of Mines, Ottawa, Canada, to undertake post-graduate studies in the Department of Metallurgy of the University of Birmingham.

MR. P. J. LIPTROT, M.Eng., has left Avonmouth to take up an appointment as Works Metallurgist to the National Smelting Company, Ltd., Swansea Vale Works, Llansamlet, Swansea, Glam.

MR. HERBERT MEIER, Dipl.Ing., has left The George Fischer Steel and Iron Works, Ltd., Schaffhausen, and is now with George Fischer, Ltd., Schaffhausen, Switzerland.

DR. L. NORTHCOTT has been appointed Superintendent of Research, Armament Research Department, Ministry of Supply, Woolwich.

MR. JAMES PATRICK, A.R.T.C., has left Scotland and is now at The British Aluminium Company, Ltd., Salisbury House, London Wall, London, E.C.2.

MR. R. PEARCE, B.A., has left Oxford to take up a position in the Research Laboratories of the British Aluminium Company, Ltd., Chalfont Park, Gerrards Cross, Bucks.

DR. R. V. RILEY, B.Sc., has now taken up the post of Research Manager at the Staveley/Bradley and Foster Research Department, and correspondence should be addressed to him at the Staveley Coal and Iron Company, Staveley, near Chesterfield.

MR. J. SANDOR, D.I.C., has left the British Coal Utilization Research Association to take up an appointment as Research Metallurgist with Carbometals, Ltd., London.

MR. P. W. SMITH has recently joined the staff of the O. and F. Company, Hobart, Tasmania.

PROFESSOR E. C. R. SPOONER, D.Sc., B.E., D.Phil., has left England, and his address is now University of Adelaide, North Terrace, Adelaide, South Australia.

MR. ROBERT C. STANLEY has been awarded His Majesty's Medal for Services in the Cause of Freedom, in recognition of his valuable services to the Allies.

Mr. Stanley is Chairman and President of the International Nickel Company of Canada, Ltd., and, in over 40 years of service, has played a major part in the development of this important Canadian industry. He has been President of this Company since 1922 and, in addition, Chairman since 1937.

Besides his valuable work in the industrial sphere, Mr. Stanley was an active member of the British War Relief Society in America during the war, for which he collected over a quarter of a million dollars.

Mr. Stanley, who has been on his first post-war visit to England, left for New York on 26 September. On behalf of the Institute, a telegram of congratulation was addressed to him on the award of the honour bestowed on him by The King.

MR. L. J. STONE returned to Australia on 2 October 1947. His address now is Rollings Road, Upper Ferntree Gully, Victoria, Australia.

MR. V. SUBRAMANIAM, B.Sc., B.Met., has left Calcutta and is now at the Department of Metallurgical Engineering, 1218 John Jay Hall, Columbia University, New York 27, N.Y., U.S.A.

Mr. D. J. Leighton Thomas is now on the R.E.O. Staff, H.Q. Land North Rhine and Westphalia, Düsseldorf, Germany.

Mr. G. L. Turner has been awarded the degree of B.Sc. in Metallurgy of Birmingham University, has been elected a Graduate of the Institution of Mechanical Engineers, and has left the University to take up an appointment as Metallurgist at The Bridge Foundry Company, Ltd., Wednesbury. In October 1938 Mr. Turner commenced reading metallurgy at Birmingham University; he joined the Fleet Air Arm in January 1940 and was commissioned as a Lieutenant (A), R.N.V.R., in December 1940. In July 1941 he was taken prisoner and remained a prisoner-of-war until May 1945. He was released from the service in November 1945 and had resumed his studies at Birmingham during the previous month.

Mr. J. Walker, B.Sc., A.R.S.M., has been appointed to the Board of Directors of the Morgan Crucible Company, Ltd., London.

Mr. S. Walsh, A.M.T.C., is now employed in the Research Department of Taylor Bros. and Company, Ltd., Trafford Park Steel Works, Trafford Park, Manchester 17.

Mr. B. R. Warren has arrived in England from the Middle East Force, R.A.F. His address is Alma House, Great Hockham, Norwich.

Mr. N. G. Wright, B.Sc., has left the Manganese Bronze and Brass Company, Ltd., Birkenhead, to take up an appointment with Roan Antelope Copper Mines, Ltd., P.O. Luanshya, Northern Rhodesia.

DEATHS

The Editor regrets to record the deaths of:

Flying Officer P. J. **Danielsen**, who was reported missing on 28 May 1940, now presumed killed in action.

Mr. T. A. E. **Holdengarde**, O.B.E., on 4 August 1947.

Note: Will members (in addition to informing the Institute's administrative department of changes of address, occupation, &c.) kindly notify the Editor, separately, of all changes of occupation, appointments, movements, awards of honours and degrees, &c., as these are matters which interest their fellow members? Such notes should reach the Editor not later than the 23rd day of each month.

LOCAL SECTIONS NEWS

ASSOCIATED METALLURGICAL SOCIETIES

Members are reminded that, by special arrangement, members of the Institute of Metals may attend and receive notices of all meetings of the Leeds Metallurgical Society and of the Manchester Metallurgical Society, the Presidents and Honorary Secretaries of which attend meetings of the Institute's Local Sections Committee by invitation.

It is necessary for members to notify the Secretary of the Institute of their desire to be granted these facilities; the Institute then makes a payment to the two societies in respect of all such registrations.

Leeds Metallurgical Society

The officers and programme of the Society for the session 1947–48 are given below:

President:
A. Preece.

Past-President:
Major G. H. Kitson.

Vice-Presidents:
W. R. Berry.
J. Arthur Sykes.

Honorary Treasurer:
D. E. Catton.

Committee:
R. E. Campbell.
K. J. Irvine.
F. Lindars.
H. F. Poole.
H. D. Ward.
J. Wilkinson.

Honorary Secretary:
W. J. G. Cosgrave, 24 Wellhouse Road, Leeds, 8.

Programme of Meetings.

1947.	
Thurs., 2 Oct.	Mr. Edwin Davis: "Industrial Copper Alloys."
Thurs., 6 Nov.	Mr. R. G. Wilkinson: "Magnesium Alloys."
Wed., 3 Dec.	Mr. H. G. Warrington: "Aluminium Alloys."
1948.	
Thurs., 8 Jan.	Symposium on "Casting".
Thurs., 5 Feb.	Mr. C. P. Miller: "Investigation of Failures."
Thurs., 4 Mar.	Joint Meeting with members of the Iron and Steel Institute. Discussion of an Iron and Steel Institute paper.
Sat., 13 Mar.	Social evening.
Thurs., 1 Apr.	Mr. Ivor Jenkins, M.Sc.: "Controlled Atmospheres."
Thurs., 6 May.	Annual General Meeting and papers by Student Members.

The meetings are held in the Main Lecture Theatre, The Chemistry Department, The University, Leeds, at 7 p.m.

NEWS AND ANNOUNCEMENTS

Manchester Metallurgical Society

The officers and programme of the Society for the session 1947–48 are given below:

President :

L. C. Bannister, Ph.D.

Ex-President :

R. S. Brown, M.B.E.

Vice-Presidents :

D. Binnie, Ph.D.
A. H. Goodger, M.Sc.

Hon. Secretary :

J. A. Tod, B.Sc., I.C.I., Ltd., Metals Division,
Broughton Copper Works, Manchester.

Hon. Treasurer :

Norman Youatt.

Council :

H. Allison, B.Sc.Tech.
A. B. Ashton, M.Sc.
W. Cartwright, M.Sc.
E. J. Heeley, Assoc.Met.
N. S. Hubbard, B.Sc.
D. Menzies.
M. L. Meyer.
R. C. Stockton.
A. B. Winterbottom, M.Sc.
W. B. Wragg, B.Sc.Tech.

Programme of Meetings.

1947.	
Wed., 15 Oct.	Dr. L. C. Bannister, B.Sc. Presidential Address : "Conduction of Electricity."
Wed., 5 Nov.	Mr. E. Jones, M.Sc. : "Electrical Strain Gauges."
Wed., 26 Nov.	Mr. E. W. Colbeck, M.A. : "Some Metallurgical Problems in the Field of Atomic Energy." (Joint Meeting with the Iron and Steel Institute and the Institute of Metals.)
Wed., 10 Dec.	Mr. Ivor Jenkins, M.Sc. : "Controlled Atmospheres for Heat-Treatment of Metals."
1948.	
Wed., 28 Jan.	Mr. E. Davis, M.Sc. : "Some Metallurgical Aspects of Jointing Non-Ferrous Materials."
Wed., 11 Feb.	Mr. T. F. Russell, Assoc.Met. : "Isothermal Heat-Treatment of Alloy Steels."
Wed., 3 Mar.	Mr. E. Mills : "Metallurgical Problems Arising from the Use of Non-Ferrous Metals in the Telecommunication Industry."

Wed., 17 Mar. "Modern Heat-Treatment Furnaces." Discussion opened by Mr. R. S. Brown, M.B.E.
Annual General Meeting.

The meetings are held in the Engineers' Club, Albert Square, Manchester, at 6.30 p.m.

UNIVERSITY NEWS

DEPARTMENT OF METALLURGY, UNIVERSITY OF BIRMINGHAM

Dr. G. V. Raynor has been appointed Reader in Theoretical Metallurgy, and Mr. D. W. Wakeman, who is working on problems related to the thermo-chemistry of alloys, under the direction of Dr. Raynor, has been awarded the William Gibbins Fellowship.

The degree of D.Sc. was conferred upon F. A. Fox, J. H. Partridge, and W. T. Pell-Walpole at the last degree congregation. Dr. Pell-Walpole has been awarded an I.C.I. Research Fellowship in Metallurgy and is continuing to work in the Department on the melting and casting of tin bronzes.

UNIVERSITY OF MELBOURNE

A Rosenhain Club of Melbourne has been inaugurated at the University School of Metallurgy, consisting of physical metallurgists, engineers, physicists, and others interested in the physical properties of metals. The aims of the group are to perpetuate the memory of Dr. Walter Rosenhain, who was a graduate of the University, and also to form a meeting ground for a group of scientists who have common interests. The club meets monthly in Professor Greenwood's room at the University.

It is hoped to sponsor the Rosenhain Memorial medal annually.

Mrs. M. Kirsner (*née* Nancy Rosenhain) is a patron of the club, and Dr. J. L. Haughton and Dr. Marie L. V. Gayler are Honorary Members.

OTHER NEWS

METALLURGICAL REFRESHER COURSE

From 5 to 7 September 1947 the Institution of Metallurgists held its first Refresher Course for metallurgists, and it is hoped that such gatherings will become a regular feature of metallurgical practice.

In the beautifully appointed L.M.S. School of Transport in Derby some 70 members of the Institution, representing all grades of membership, lived and worked together over the week-end. The theme of the studies was "The Transformations in Solid Metals and Alloys", and the following lectures were given and informal discussion took place :

Lecture 1.—A general review of the subject, by Professor F. C. Thompson, M.Sc., D.Met. (Manchester University).

Lecture 2.—The Transformation of Austenite in Steels, by Professor J. H. Andrew, D.Sc. (Sheffield University).

Lecture 3.—The Determination of Time–Temperature–Transformation Curves in Steels, by E. H. Bucknall, M.Sc. (The Mond Nickel Company, Ltd.).

Lecture 4.—The Practical Aspects of Austempering, Martempering, and other Treatment for Steels, by J. Shaw, B.Sc., A.R.C.S. (Wm. Jessop and Sons, Ltd.).

Lecture 5.—The Formation of Graphite in Cast Iron and Related Alloys, by J. G. Pearce, M.Sc. (British Cast Iron Research Association).

Lecture 6.—Atomic Changes in Solid Solutions including Age-Hardening, by G. V. Raynor, M.A., D.Phil. (Birmingham University).

Lecture 7.—Order–Disorder Transformations in Solid Solutions, by G. V. Raynor, M.A., D.Phil. (Birmingham University).

While the newer physical methods of approach to problems of transformation received a good deal of attention, it was apparent that there is still room for further development and greater use of the more classical methods of the older school of metallurgists in the study of this subject.

All present were convinced that this type of meeting is likely in the future to play a most important part in the work of the Institution.

THE INSTITUTION OF HEATING AND VENTILATING ENGINEERS JUBILEE CELEBRATIONS

In view of the present national conditions, the Council of the Institution regretfully decided to cancel the arrangements to hold a Jubilee Banquet and Dance on Tuesday, 7 October. It was agreed, therefore, to confine the celebrations to technical meetings, and the final arrangements were :

Tuesday, 7 October, 5.30 for 6 p.m. Special Jubilee meeting in the Lecture Theatre, The Institution of Civil Engineers, Great George Street, London, S.W.1, when Mr. C. G. Carrothers, B.Eng., read a paper on "Practical Relations Between Heat and Electric Forms of Energy with Special Reference to District Heating".

Wednesday, 8 October, 5.30 for 6 p.m. Autumn Special Meeting in the Lecture Theatre, The Institution of Mechanical Engineers, Storey's Gate, London, S.W.1, when Mr. C. G. Vokes read a paper "Air Filtration in War as Applied to Peace Conditions".

THE PHYSICAL SOCIETY

Miss A. C. Stickland, Ph.D., has been appointed to the post of Secretary-Editor, and assumed her duties on 1 September 1947.

BRITISH WELDING RESEARCH ASSOCIATION

Dr. H. G. Taylor, D.I.C., has been appointed Director of Research in succession to Dr. A. Ramsay Moon.

NEWS AND ANNOUNCEMENTS

MECHANICAL ENGINEERING RESEARCH

Under the directorship of Dr. G. A. Hankins, the Government is setting up an organization to carry out research in mechanical engineering. It has been decided to do this through the Department of Scientific and Industrial Research, and the plan of the new organization will be based on the recommendations of a D.S.I.R. Committee on Mechanical Engineering Research.

Its purpose will be to meet and anticipate the needs of industry and government departments, and it is intended to supplement the research carried out in other organizations. The subjects which are to be investigated are:

(*a*) Properties and strength of materials.
(*b*) Mechanics of solids, stress, stability, and vibration of structures.
(*c*) Mechanics of fluids; aerodynamics, gas dynamics, and hydraulics in their mechanical and engineering applications.
(*d*) Lubrication, wear, and mechanical engineering aspects of corrosion.
(*e*) Mechanisms, engineering metrology, and noise control.
(*f*) Mechanics of formation of materials; machine shaping of materials.
(*g*) Heat transfer, heat exchange apparatus, and applied thermodynamics.

The location of the research station has not yet been decided, but for the time being the work will be carried out at the National Physical Laboratory and in the mechanical engineering laboratories of the Universities.

MACHINE TOOL & ENGINEERING EXHIBITION, LONDON, 1948

The 1948 Exhibition will open at Olympia on 26 August 1948, and close on 11 September 1948. It will be the largest show of machine tools, woodworking machine equipment, and accessories ever staged in Great Britain. The three halls at Olympia have been taken and the exhibition will occupy nearly a quarter of a million square feet of space.

The Exhibition will be international in scope. Foreign exhibits will be shown side by side with British equipment, and users will be able to compare the respective merits and observe the developments that have taken place.

WOMEN'S LEGION SCHOLARSHIP IN AERONAUTICAL ENGINEERING

The Women's Legion and the Women's Engineering Society announce the foundation of a new Scholarship for women, which will be awarded every two years. The winner will be enabled to train in any branch of aeronautical engineering. Girls who have passed the School Certificate examination and are aged between 15 and 20 will be eligible, and applications for the first Scholarship must be received before 30 April 1948.

NEWS AND ANNOUNCEMENTS

THE INDUSTRIAL FUTURE OF GREAT BRITAIN

A course of fifteen weekly lectures on the above subject is to be delivered, under the auspices of the University of London (Centre for Courses on International Affairs) and the Institute of Bankers, at the Beaver Hall of the Hudson's Bay Company, Garlick St., London, E.C.4 (near Mansion House Station). The course will be held on Tuesdays, at 6–7.30 p.m., commencing on 4 November 1947. The fee for the course is one guinea, and admission is by ticket only. As seating in the Hall is limited, tickets must be applied for in advance; none will be issued at the door.

Members of the Institute of Metals are invited to register for this course.

The lectures, each of which will be followed by a discussion, are: 4 *Nov.*, Professor T. S. Ashton, M.A.: "The Industrial Past"; 11 *Nov.*, Professor G. C. Allen, Ph.D., M.Com.: "Impact of the War"; 18 *Nov.*, Anthony Hurd, M.P.: "Agriculture"; 25 *Nov.*, Robert Stone, M.A.: "Iron and Steel"; 2 *Dec.*, Sir Jonah Walker-Smith: "Building"; 9 *Dec.* (speaker not announced): "Fuel and Power"; 16 *Dec.*, M. R. Bonavia: "Inland Transport"; 13 *Jan.*, F. W. Paish, M.C., M.A.: "Finance of Reconstruction"; 20 *Jan.*, Leslie Gamage, M.C., M.A.: "The Export Drive"; 27 *Jan.* (speaker not announced): "Shipping"; 3 *Feb.*, H. Haygarth Jackson, M.C.: "Textiles and Export"; 10 *Feb.*, S. R. Dennison, C.B.E., M.A.: "New Industrial Development and Export"; 17 *Feb.*, Albert Palache: "Long-Term Finance of Enterprise"; 24 *Feb.*, Professor Sir Arnold Plant, B.Com., B.Sc.: "Industrial Controls in War and Peace"; 2 *Mar.* (speaker not announced): "Industrial Change."

IRON AND STEEL INSTITUTE

Autumn Meeting, London

The Autumn Meeting of the Institute will he held at 4 Grosvenor Gardens, London, S.W.1, on Wednesday, 12 November (10 a.m.–1 p.m.; 2.30–5 p.m.) and Thursday, 13 November 1947 (10 a.m.–12.45 p.m.). On the first day of the meeting a buffet luncheon (price 6*s.*) will be served in the library.

Papers to be presented and discussed will be:

Wed., 12 *November*

(1) Jointly (10.15–11.45 a.m.): J. H. Andrew, H. Lee, K. H. Lloyd, and N. Stephenson, "Hydrogen and Transformation Characteristics in Steel"; and C. Sykes, H. H. Burton, and C. C. Gegg, "Hydrogen in Steel Manufacture".

(2) Jointly (11.45 a.m.–1 p.m.): W. Barr and C. F. Tipper, "Brittle Fracture in Mild Steel Plates"; W. Barr and A. J. K. Honeyman, "The Effect of the Manganese–Carbon Ratio on the Brittle Fracture of Mild Steel"; and W. Barr and A. J. K. Honeyman, "Some Factors Affecting the Notched-Bar Impact Properties of Mild Steel".

(3) Jointly (2.30–4.15 p.m.): J. E. de Graaf, "A Note on Variations in Producer Gas Quality"; M. L. Hughes, "The Distribution of Fuel in Gas Producers"; and M. L. Hughes, "Experiments on Gas Flow in Producer Fuel Beds".

(4) T. Land, "A Photoelectric Roof Pyrometer for Open-Hearth Furnaces" (4.15–5 p.m.).

Thurs., 13 *November*

(1) R. Jackson, D. Knowles, T. H. Middleham, and R. J. Sarjant, " The Fluidity of Steel " (10.0–10.45 a.m.).

(2) A. H. Jay, " The Mechanism of Carbon Removal by Oxidation from the Open-Hearth Furnace " (10.45–11.45 a.m.).

(3) W. L. Kerlie, " Some Aspects of the Refining of High-Phosphorus Iron " (11.45 a.m.–12.45 p.m.).

IRON AND STEEL ENGINEERS' GROUP

A meeting of the Group will be held at 4 Grosvenor Gardens, London, S.W.1, on Wednesday, 26 November 1947. A buffet lunch (price 6*s*.) will be served in the library.

Papers to be presented and discussed will be :

Morning (10.30 *a.m.*–12.45 *p.m.*)

" The Mechanical and Electrical Features of Primary Hot-Rolling Mill Auxiliaries." Section I.—" Mechanical Features ", by W. W. Franklin ; Section II.—" Electrical Features ", by P. F. Grove.

Afternoon (2.0–4.30 *p.m.*)

" Modern Small Rolling Mills ", by G. A. Phipps.

LOCAL SECTIONS MEETINGS

Birmingham Local Section.—Dr. G. V. Raynor, M.A. : " The Determination of Constitution Diagrams." (James Watt Memorial Institute, Great Charles Street, Birmingham, Thursday, 6 November 1947, at 6.30 p.m.)

Birmingham Local Section.—Mr. W. E. Ballard : Film on " Metal Spraying " and talk on " Protective Coatings." (James Watt Memorial Institute, Great Charles Street, Birmingham, Thursday, 27 November 1947, at 6.30 p.m.)

London Local Section.—Professor C. W. Dannatt, A.R.S.M., D.I.C. : " Some Aspects of Metal Refining." (Royal School of Mines, South Kensington, London, S.W.7, Thursday, 13 November 1947, at 7 p.m.)

Scottish Local Section.—Mr. A. Craig Macdonald, B.Sc. : " Commentary on a Visit to America." (Institution of Engineers and Shipbuilders in Scotland, 39 Elmbank Crescent, Glasgow, C.2, Monday, 10 November 1947, at 6.30 p.m.)

Sheffield Local Section.—Mr. A. J. Murphy, M.Sc. : " Magnesium Alloys." (Mining Lecture Theatre, Department of Applied Science, The University, St. George's Square, Sheffield, Friday, 21 November 1947, at 7.30 p.m.)

Swansea Local Section.—Sir Arthur Smout, J.P. : " The Place of the Metallurgist in Industry." (Guildhall, Swansea, Wednesday, 19 November 1947, at 6.30 p.m.)

OTHER MEETINGS

Diesel Engine Users' Association.—G. B. Fox : " Factors Affecting Piston Temperature." (Caxton Hall, Caxton Street, London, S.W.1, Thursday, 27 November 1947, at 2.30 p.m.)

Geological Society of London.—Ordinary Evening Meeting. (Burlington House, Piccadilly, London, W.1, Wednesday, 12 November 1947, at 5 p.m.)

Institute of Welding.—Presidential Address, by Mr. J. L. Adam, C.B.E. (Institution of Civil Engineers, Great George St., London, S.W.1, Wednesday, 29 October 1947, at 6 p.m.)

Institute of Welding, South London Branch.—R. R. Sillifant, "Argon Arc Welding." (Wandsworth Technical Institute, London, Thursday, 6 November 1947, at 6.30 p.m.)

Institute of Welding, West of Scotland Branch.—S. M. Reisser: "Welding of Structures." (Institution of Engineers and Shipbuilders in Scotland, 39 Elmbank Crescent, Glasgow, Thursday, 27 November 1947, at 6.45 p.m.)

Institute of Works Managers.—Mr. C. T. Melling: "Meeting the Industrial Power Crisis." (Waldorf Hotel, London, W.C.2, Wednesday, 29 October 1947, at 6.30 p.m.)

Institute of Works Managers.—Mr. G. Chelioti: "Some American Impressions." (Waldorf Hotel, London, W.C.2, Wednesday, 26 November 1947, at 6.30 p.m.)

Institute of Works Managers, Glasgow Branch.—Mr. C. A. Oakley: "An Industrial Survey of Scotland." (Institution of Engineers and Shipbuilders in Scotland, 39 Elmbank Crescent, Glasgow, C.2, Monday, 27 October 1947, at 7 p.m.)

Institute of Works Managers, Glasgow Branch.—Mr. M. McLachlan: "Industrial Relations: Employers, Employees, and the State." (Institution of Engineers and Shipbuilders in Scotland, 39 Elmbank Crescent, Glasgow, C.2, Monday, 24 November 1947, at 7 p.m.)

Institute of Works Managers, Liverpool Branch.—Miss A. G. Shaw: "Motion Study." (Exchange Hotel, Liverpool, Tuesday, 11 November 1947, at 6.45 p.m.)

Institute of Works Managers, Manchester Branch.—Mr. G. M. Davies: "Oil Firing." (Engineers' Club, Albert Square, Manchester, Friday, 14 November 1947, at 6.30 p.m.)

Institution of Engineers and Shipbuilders in Scotland.—J. A. Kilby and W. G. Cameron: "Steel Processing." (The Institution, 39 Elmbank Crescent, Glasgow, Tuesday, 4 November 1947, at 6.30 p.m.)

Institution of Mechanical Engineers.—Discussion on the Manufacture of Turbine Blades for the Whittle Engine, by Mr. T. A. Kestell. (The Institution, Storey's Gate, London, S.W.1, Friday, 31 October 1947, at 5.30 p.m.)

Institution of Mining and Metallurgy.—G. W. M. Eaton Turner: "Some Notes on the Bibiani Gold Mine, West Africa"; H. A. McGowan: "Treatment at the Bibiani (1927), Ltd., Gold Mine, West Africa." (Geological Society, Burlington House, Piccadilly, London, .W.1, Thursday, 20 November 1947, at 5 p.m.)

Iron and Steel Institute.—Autumn Meeting; for details see p. xlvi. (4 Grosvenor Gardens, London, S.W.1, Wednesday and Thursday, 12 and 13 November 1947.)

Iron and Steel Institute, Iron and Steel Engineers' Group.—Reading and discussion of two papers; for details see p. xlvii. (4 Grosvenor Gardens, London, S.W.1.)

Leeds Metallurgical Society.—Mr. R. G. Wilkinson: "Magnesium Alloys." (Main Lecture Theatre, Chemistry Department, The University, Leeds, Thursday, 6 November 1947, at 7 p.m.)

Manchester Metallurgical Society.—E. Jones, M.Sc.: "Electrical Strain Gauges." (Engineers' Club, Albert Square, Manchester, Wednesday, 5 November 1947, at 6.30 p.m.)

Manchester Metallurgical Society.—E. W. Colbeck, M.A.: "Some Metallurgical Problems in the Field of Atomic Energy." Joint Meeting with the Iron and Steel Institute and the Institute of Metals. (Engineers' Club, Albert Square, Manchester, Wednesday, 26 November 1947, at 6.30 p.m.)

North-East Coast Institution of Engineers and Shipbuilders.—Dr. T. W. F. Brown: "A Marine Turbine Research and Testing Station." Andrew Laing Lecture. (The Institution, Bolbec Hall, Newcastle-upon-Tyne, Friday, 31 October 1947.)

Royal Aeronautical Society.—Sir William T. Griffiths, D.Sc.: "The Problem of High Temperature Alloys for Gas Turbines." (Institution of Civil Engineers, Great George Street, London, S.W.1, Thursday, 23 October 1947, at 6 p.m.)

Sheffield Metallurgical Association.—R. B. Heywood: "Photoelasticity Applied to Design Problems." (198 West Street, Sheffield 1, Tuesday, 28 October 1947, at 7 p.m.)

Sheffield Metallurgical Association.—Dr. C. Sykes, F.R.S., H. H. Burton, and C. C. Gegg: "Hydrogen in Steel Manufacture"; Professor J. H. Andrew, Dr. H. Lee, H. K. Lloyd, and N. Stephenson: "Hydrogen and Transformation Characteristics in Steel." Joint Meeting with the Iron and Steel Institute. (198 West Street, Sheffield 1, Tuesday, 4 November 1947, at 7 p.m.)

Sheffield Metallurgical Association.—J. C. Williamson: "The Metallurgy of Musical Instruments." (198 West Street, Sheffield 1, Tuesday, 11 November 1947, at 7 p.m.)

Sheffield Metallurgical Association.—Professor Leslie Aitchison, D.Met., B.Sc. (title to be announced later). (198 West Street, Sheffield 1, Tuesday, 25 November 1947, at 7 p.m.)

Sheffield Society of Engineers and Metallurgists.—Sir Alwyn Crow, C.B.E.: "The Rocket as a Weapon of War." Thomas Hawksley Lecture. Joint meeting with the Yorkshire Branch of the Institution of Mechanical Engineers. (Royal Victoria Station Hotel, Sheffield, Monday, 24 November 1947, at 6.15 p.m.)

Swansea and District Metallurgical Society.—Mr. M. R. Hopkins, M.Sc.: "Metal Surfaces." (Royal Institution of South Wales, Swansea, Saturday, 15 November 1947, at 6.30 p.m. Members of the Institute of Metals are invited.)

West of Scotland Iron and Steel Institute.—Dr. C. Sykes, F.R.S.: "The Selection and Use of Steel for Steam Turbines." (Institution of Engineers and Shipbuilders in Scotland, 39 Elmbank Crescent, Glasgow, Friday, 21 November 1947, at 6.45 p.m.)

NEWS AND ANNOUNCEMENTS

APPOINTMENT REQUIRED

GRADUATE METALLURGIST (Member of the Institute of Metals), now in Polish Resettlement Corps, with good experience in metal testing and heat-treatment, and as University lecturer, seeks appointment research work or industrial testing of non-ferrous metals or steel. Box No. 215, Institute of Metals, 4 Grosvenor Gardens, London, S.W.1.

APPOINTMENTS VACANT

To conform to the requirements of the Control of Engagement Order, 1947, *these advertisements are published for the information of those who are classified as "excepted persons" under the Order, only.*

ANALYTICAL CHEMISTS required who should preferably be qualified and have experience in the assaying of non-ferrous metals, minerals, and by-products, including the rarer metals. Liberal salary will be paid. Apply to Derby and Co., Ltd., Cheyne House, 62–63 Cheapside, London, E.C. 2.

SENIOR METALLURGIST, aged 30–45, with degree or equivalent qualification and industrial experience, required by long-established heavy non-ferrous foundry in the North-West. Living accommodation available. Box No. 213, Institute of Metals, 4 Grosvenor Gardens, London, S.W.1.

THE MOND NICKEL COMPANY invites applications for the following posts in its Research Laboratory, Wiggin Street, Birmingham:

1. SENIOR WELDING INVESTIGATOR (30 to 38) with experience in metallurgical research, preferably in connection with the welding of alloy steels. Salary not less than £700 p.a.
2. ELECTRO-CHEMICAL AND CORROSION INVESTIGATOR (25 to 35). Salary according to qualifications and experience.
3. PHYSICAL CHEMIST (25 to 35) having thorough knowledge of chemical thermodynamics. Salary not less than £550 p.a.
4. RESEARCH ENGINEER OR ENGINEERING PHYSICIST (25 to 35) having thorough knowledge of modern theories of deformation and fracture of metals. Salary not less than £600 p.a.
5. JUNIOR RESEARCH METALLURGISTS (21 to 30), honours graduates, for work in steel, cast iron or non-ferrous sections of Laboratory. Salary not less than £400 p.a.

Salary figures refer to the lower limit of age and experience. All the above posts are of a permanent nature, offering opportunities for advancement. Candidates appointed will be eligible for membership of the Company's non-contributory pensions scheme. Apply to: The Manager, Development and Research Department, The Mond Nickel Company, Limited, Grosvenor House, Park Lane, London, W.1. Envelopes should be marked "R.L. Confidential".

UNIVERSITY OF THE WITWATERSRAND, JOHANNESBURG, SOUTH AFRICA. Applications are invited for a SENIOR LECTURER IN METALLURGY. Salary scale £800 × 40–£1000 per annum, plus a temporary cost of living allowance which at present amounts to £75 per annum for married men, or persons with dependents, and £46 16*s.* per annum for others. Membership of the University Teachers' Provident Fund Scheme is compulsory, and involves a contribution of 6% (which may shortly be raised to 7%) from the member's salary; the University and the Government together contributing an equal amount.

The duties of the post are concerned principally with Ferrous and Physical Metallurgy, and previous experience in these branches is therefore essential. Some industrial experience will be considered an advantage. Duties are to be assumed on 1 January 1948, or as soon as possible thereafter. Further particulars may be obtained from The Secretary, Universities Bureau of the British Empire, 8 Park Street, London, W.1. Closing date for receipt of applications is 17 November 1947.

ERRATUM

Journal, *August* 1947, p. xxxvii.

The entry regarding Mr. W. West is incorrect as regards his association with Leyland Motors, Ltd.; he still retains his seat on the Board of Directors. The remainder of the information given is accurate. The error is regretted.

No....................

Form A. (Membership Application) Recd....................

The INSTITUTE of METALS

4 Grosvenor Gardens, London, S.W.1.
Founded 1908. *Incorporated* 1910.

To the Secretary,
The Institute of Metals.

I, the UNDERSIGNED..

being..................years of age and desirous of becoming a*...
Member of the **Institute of Metals,** agree that if elected will be governed by the Regulations and Bye-laws of the Institute from time to time extant and observe the obligations imposed on Members under the Articles of Association of the Institute, and that I will advance the interests of the Institute so far as may be in my power ; and we, the undersigned, from our personal knowledge, do hereby recommend the said..for election.

Name of applicant in full..

Address ....

Business or Profession†..

....

....

Qualification ....

Degrees and/or honorific distinctions..

Dated this..................day of.., 19.......

....
....
....

Signatures of three Members.

The Council, having approved the above recommendation, declare the applicant to be duly elected as..
Member of the **Institute of Metals.**

....
Chairman.

To be filled up by the Council.

Dated this......................*day of*..19.......

* **For Qualifications of Members, see other side.** An applicant for Student Membership must state date of birth.

† Name and address of firm (or other body) should be stated as well as position held. (*It would be a convenience if the Candidate's Card were sent with this form.*)

OBJECTS OF THE INSTITUTE

The main objects for which the Institute was formed in 1908 are :

(*a*) To promote the science and practice of non-ferrous metallurgy in all its branches.

(*b*) To afford a means of communication between members of the non-ferrous metal trades upon matters bearing upon their respective manufactures, other than questions connected with wages, management of works, and trade regulations.

(*c*) To facilitate the exchange of ideas between members, and between members and the community at large, by holding meetings and by the publication of literature.

(*d*) To establish branches either in the United Kingdom or abroad.

A free copy of the Articles of Association may be obtained by prospective Members on application to the Institute.

MEMBERSHIP

Ordinary Members must be not less than 21 years of age, and either :

(*a*) persons engaged in the manufacture, working or use of non-ferrous metals and alloys, or

(*b*) persons of scientific, technical, or literary attainments connected with or interested in the metal trades or with the application of non-ferrous metals and alloys, or engaged in their scientific investigation.

Student Members are admitted and retained as such within the ages of 17 and 28 years of age. They receive the same privileges as members, except that they are not entitled to vote at meetings or to nominate candidates for ordinary or associate membership. They must be either :

(*a*) Students of metallurgy.

(*b*) Pupils or assistants of persons qualified for Ordinary Membership, whether such persons are actually members of the Institute or not.

SUBSCRIPTIONS

Ordinary Members : £4 4s. per annum ; entrance fee, £2 2s.

Student Members : £1 15s. per annum ; no entrance fee.

JOINT MEMBERSHIP WITH THE IRON AND STEEL INSTITUTE

Applicants for membership of the Institute of Metals may, when submitting their applications, also complete a form (obtainable from the Secretary, Institute of Metals) applying for oint membership with the Iron and Steel Institute.

The subscriptions and entrance fees of such Joint Members are :

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CALCULATION OF LOADS INVOLVED IN METAL STRIP ROLLING.*

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SYNOPSIS.

Various formulæ have been advanced for calculating the loads involved in the cold rolling of strip and sheet materials, but because of the several assumptions they contain, they are only of limited application and only very approximate. Moreover, in applying the formulæ, arbitrarily chosen values have to be adopted for the coefficient associated with the friction conditions in the roll throat, and it is necessary to determine experimentally the resistance to deformation as a function of the amount of reduction in thickness effected. Furthermore, none of the methods so far proposed makes any allowance for the effect of roll-face distortion.

Attention has, therefore, been directed to developing a method of computing rolling loads which dispenses with the need for the individual determination of the influence of these several factors, including roll-face distortion. The derivation of the method is based on the assumption that the magnitude of the pure work of rolling is independent of the number of passes used in effecting a given reduction in thickness, and the basic experimental data required consist only of a few measured values of the rolling loads developed in rolling one material under a series of different sets of rolling conditions. From these data, rolling loads can then be readily computed for practices involving any number of passes, or a sequence of reductions in thickness can be established for which a constant load is developed in each pass.

Results calculated by this method can be directly checked against measured values, and comparisons which have been made between calculated values and those obtained experimentally on steel and copper, in the course of investigations carried out by the British Iron and Steel Research Association, show good agreement over the range of reductions encountered in normal rolling-mill procedure.

I.—INTRODUCTION.

IN recent years several attempts have been made to derive a general formula for calculating the loads involved in flat rolling, i.e. strip or sheet rolling, and with the exception of that due to Ekelund,[1] these have been based on purely theoretical considerations of the mechanics of rolling. Von Kármán,[2] Trinks,[3] and Tselikov[4] have each advanced expressions from which it is possible to compute rolling loads, but because of the several assumptions which had to be made and the various mathematical simplifications which were introduced in the

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underlying mathematical treatment of the rolling process, these formulæ are only of limited application and very approximate.

The most comprehensive and exact analysis of the dynamics of rolling has been carried out by Orowan,[5] who did not assume that resistance to deformation was constant, but took into consideration work-hardening which takes place during cold rolling. In using this method of calculation, however, it is necessary to determine experimentally curves of resistance to deformation, and this may necessitate consideration of the effect of inhomogeneous deformation. It is also necessary to assume or establish an average value for the frictional forces developed in the roll throat, but it is open to question if such an average figure would be adequate, and, as in other formulæ, no allowance is made for the distortion of the roll face over the arc of contact.

In view of the doubts and difficulties associated with the determination of acceptably accurate values assignable to the influence of roll flattening, friction, and resistance to deformation, the authors have given their attention to the development of a method of rolling-load computation which avoids the necessity of determining values of the various factors individually, by any theoretical or practical procedures. The method is based on, and makes use of, a minimum of data in the form of initial rolling-load measurements. It is very simple to apply, and the accuracy of the results can be readily and directly checked with measured values of rolling loads.

II.—Derivation of Method of Calculation.

The method described for calculating rolling loads is based on the assumption that the magnitude of the pure work of rolling is independent of the number of passes used in effecting a given reduction in thickness. From Fig. 1, it will be appreciated that the pure work of rolling during one revolution of both rolls can be stated as:

$$W = 4\pi\beta e P$$

The meaning of these and other symbols used throughout the paper is indicated in Fig. 1.

The increase in kinetic energy of the material, associated with the difference in exit speed of the strip and the peripheral speed of the rolls, is negligible, and the values of these speeds have, therefore, been taken as identical. Hence, the number of revolutions of the rolls during the first pass can be written as:

$$N_1 = L_1/2\pi r$$

the total amount of pure work during the first pass being:

$$W_1 = 2P_1\beta_1 e_1 L_1/r.$$

Putting

$$e_1 = \sqrt{r(t_0 - t_1)} \text{ and } L_1 = t_0 L_0 / t_1,$$

the pure work, W_1, becomes :

$$W_1 = 2P_1 t_0 L_0 \beta_1 \sqrt{r(t_0 - t_1)}/rt_1 \quad . \quad . \quad . \quad \text{1st pass}$$

Similarly :

$$W_2 = 2P_2 t_0 L_0 \beta_2 \sqrt{r(t_1 - t_2)}/rt_2 \quad . \quad . \quad . \quad \text{2nd pass}$$

and

$$W_n = 2P_n t_0 L_0 \beta_n \sqrt{r(t_{n-1} - t_n)}/rt_n \quad . \quad . \quad . \quad n\text{th pass}$$

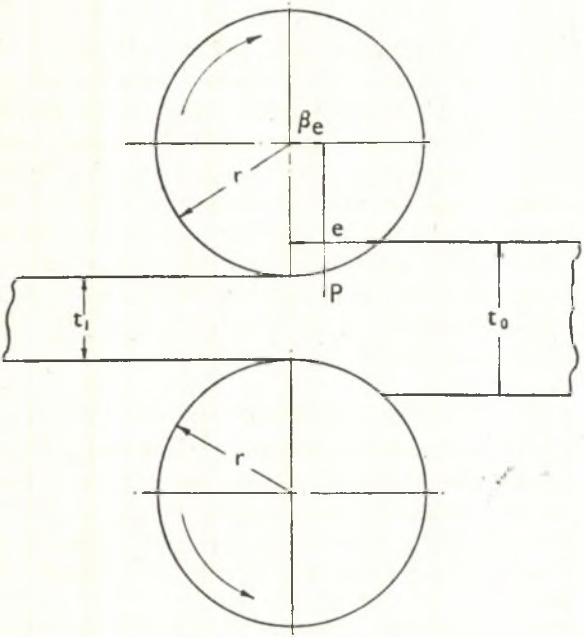

FIG. 1.

KEY.

W = Pure work of rolling.
e = Projected length of arc of contact.
L_1 = Length of strip after 1st pass.
t_1 = Thickness after 1st pass.
P = Rolling load.
L_0 = Length of strip before 1st pass.
t_0 = Thickness before 1st pass.
r = Roll radius.

The suffix (1) indicates conditions after the 1st pass.
" (2) " " " 2nd pass.
" (3) " " " 3rd pass.
" (n) " " " nth pass.
" (s) " " when a total reduction obtained in a number of light passes is achieved in one heavy pass.

If instead of n light passes, the total reduction made during these passes is effected in one heavy pass, then, using the suffix S to denote the condition of one heavy pass:

$$W_S = 2P_S t_0 L_0 \beta_S \sqrt{r(t_0 - t_n)}/rt_n.$$

The length βe in Fig. 1 is termed the lever arm and is defined as the horizontal distance between the vertical centre line of the rolls and the line of action of the resultant of the total rolling load. The moment of this force opposes the rotational motion of the rolls, so that if the pure torque which is needed to counteract the moment of the rolling load is divided by the product of the load and the length e, the value of β can be found. Consideration of experimental results, which are discussed later, justifies the decision to treat β as a constant.

Since it is assumed that the pure energy required to effect a given total reduction in one heavy pass is the same as the sum of the individual energies developed at each of a number of lighter passes, it follows that:

$$W_1 + W_2 + \ldots + W_n = W_S.$$

Hence:

$$P_1\sqrt{(t_0 - t_1)}/t_1 + P_2\sqrt{(t_1 - t_2)}/t_2 + \ldots + P_n\sqrt{t_{n-1} - t_n}/t_n = P_S\sqrt{(t_0 - t_n)}/t_n \quad . \quad . \quad (1)$$

the factor $2t_0L_0\beta\sqrt{r}/r$ being cancelled from both sides of the equation.

Since: $100\,(t_0 - t_1)/t_0 = R_1$

$100\,(t_0 - t_2)/t_0 = R_2$

and $100\,(t_0 - t_n)/t_0 = R_n$

equation (1) can be rewritten as:

$$P_1\sqrt{R_1}/(100 - R_1) + P_2\sqrt{(R_2 - R_1)}/(100 - R_2) + \ldots + P_n\sqrt{(R_n - R_{n-1})}/(100 - R_n) = P_S\sqrt{R_n}/(100 - R_n) \quad . \quad . \quad (2)$$

With this equation and an experimentally derived curve—later referred to as a first-pass basic curve—relating P_S to reductions effected in one pass on any one mill, the loads P_1, P_2, P_3, &c., developed when the same total reduction is effected in a number of smaller passes, can be determined. Conversely, if, for a series of individual passes, the loads P_1, P_2, P_3, &c., are known, then the load P_S, corresponding to one heavy pass, can also be computed.

The only means of checking the validity and accuracy of any method of calculation is, of course, by reference to actually determined load values where this is possible, as it is with this method. In all the other methods so far described, such a direct comparison cannot be made because it is not possible to assign accurate values to the coefficient of friction, variation in resistance to deformation by rolling, and roll-face distortion.

III.—Experimental Measurements of Rolling Loads.

All the determined load values which have been used for checking the method, and which are referred to more fully later, have been obtained by Dr. Hugh Ford [6] and his collaborators in the course of a very comprehensive investigation carried out at the Sheffield station of the British Iron and Steel Research Association. Some of the results of this work dealing with the cold rolling of a 0·11%-carbon silicon-killed steel, and a 0·07%-carbon rimming steel, have already been published, while those results relating to the other materials, a 0·2–0·25%-carbon steel and H.C. copper of three different initial thicknesses, have yet to be published. The authors are very grateful to the British Iron and Steel Research Association and to Dr. Ford for their kindness and courtesy in allowing them access to this information and for permission to make use of some of these results in the present paper. The curves in Figs. 2–4, the values recorded in Tables II–IV, and the measured loads plotted in Figs. 5–11 have all been obtained from this source.

All the cold rolling was carried out on the experimental two-high mill with 10-in.-dia. rolls under very accurately controlled conditions which have been described elsewhere.[7] In cold rolling the hot-broken-down 0·11%-carbon silicon-killed steel, 2·3 in. wide, at an initial thickness of 0·074 in., individual strips were reduced in thickness by 5, 10, 15, 20, 30, and 40% in one pass. Afterwards, the strips already reduced in thickness during the first pass by 5%, were subjected to a further 10 passes, each of 5% relative to the thickness before each pass. The material reduced in one pass by 10% was also given a further 13 passes, each of 10%, again relative to the thickness before each pass. Similarly, the 15, 20, 30, and 40% samples were further reduced in 8, 7, 3, and 2 passes respectively, the percentage reduction at each pass for each series being the same as for the first pass, but always with reference to the thickness before the pass. Each test was carried out at least in duplicate. During the whole of the rolling of this and other material referred to later, adequate lubrication was ensured by a liberal supply of Vacuum 40A rolling oil to the surface of the strip.

A set of corresponding data was also determined using an annealed 0·07%-carbon rimming steel, 3·3 in. wide, at an initial thickness of 0·064 in. For each of the various reductions obtained, the rolling load and roll torque were measured.

Similar comprehensive series of tests were also carried out on

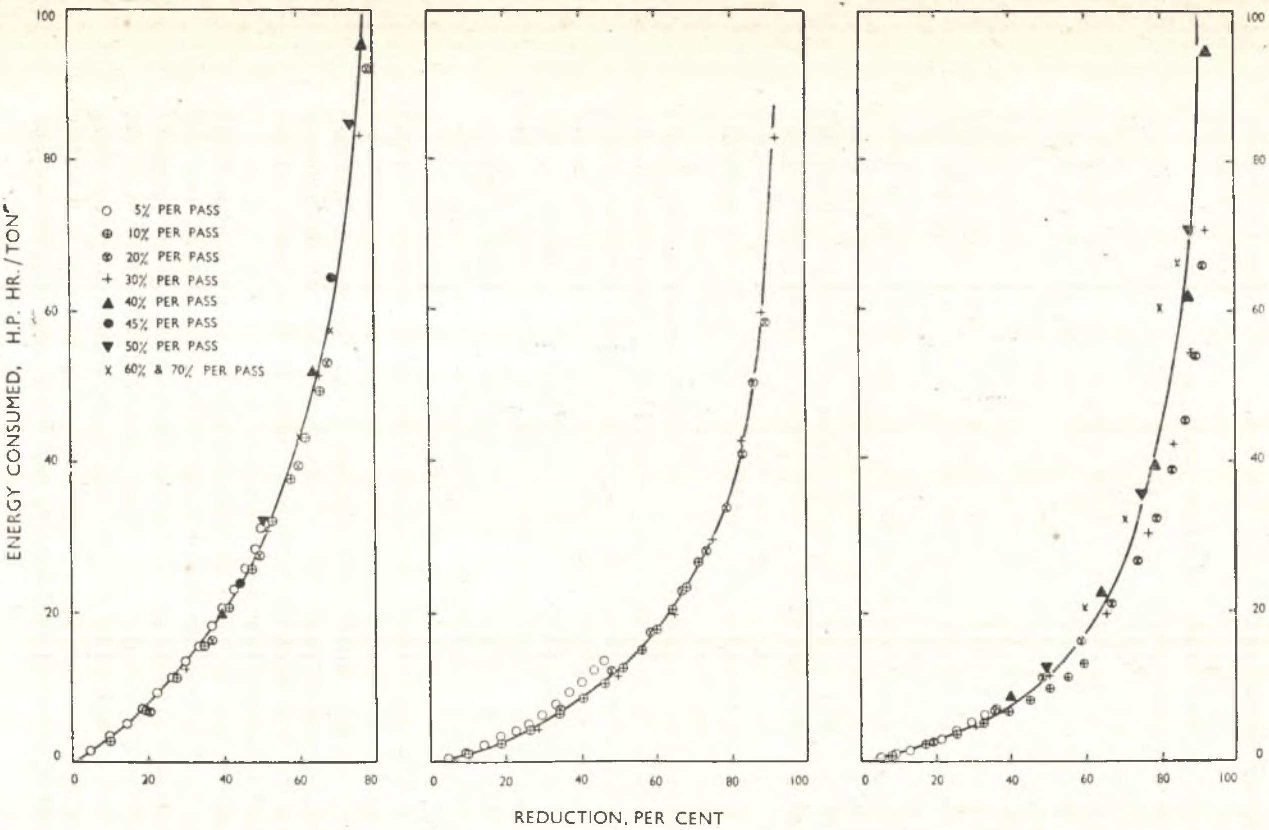

Fig. 2.

Fig. 3.

Fig. 4.

Total Pure Energy Values as Determined by Ford.

Fig. 2.—3 × 0·1 in. 0·2/0·25%-carbon steel. Roll surface: ground mirror finish.
Fig. 3.—3 × 0·1 in. annealed H.C. copper. Roll surface: ground mirror finish.
Fig. 4.—3 × 0·1 in. annealed H.C. copper. Roll surface: smooth, dull, matte finish.

annealed 0·2–0·25%-carbon electric-furnace steel 3 in. wide and 0·1 in. thick, and annealed H.C. copper 3 in. wide in three initial thicknesses, i.e. 0·1, 0·075, and 0·05 in. As before, the rolling load and energy consumption were recorded for each pass.

The measured energy consumption, in horse-power hours per ton, required to effect the reduction of the material only, i.e. the pure work of rolling, has been plotted against the total percentage reduction for one of the steels and one of the coppers, the results being shown in Figs. 2 and 3. From Ford's values, given in Table I, in which the reduction per pass is relative to the thickness before each pass, it will be seen that the total energy is the sum of the useful energy consumed at each pass; and these few results serve to show how the curves have been constructed.

The total-energy values in Table I are included in Fig. 2, where they all lie on a smooth curve. All the other values plotted in Fig. 2 but not included in Table I also lie on the curve, and the comparable results for the other two steels in turn follow similarly smooth curves.

TABLE I.

Pass No.	Reduction, %.		Useful Energy, h.p. hr./ton.	
	Per Pass.	Total.	Per Pass (measured).	Total.
1	20·3	20·3	6·86	6·86
2	20·6	36·7	9·46	16·32
3	20·3	49·5	11·35	27·67
4	20·7	60·0	11·95	39·62
5	19·8	67·9	13·45	53·07

The surface condition of the rolls used for this part of the research was described as a mirror finish, grinding having been carried out with a 400-grit wheel. This standard of finish was also operative during the rolling of the 0·1-in.-thick copper, and measured energy values for this material are plotted in Fig. 3. These plotted points also can be connected by a smooth curve.

After this phase of the investigation, the rolls were reground with a 180-grit wheel, the resultant surface finish being described as dull matte. Copper was then rolled at respective initial thicknesses of 0·1, 0·075, and 0·05 in. The energy values determined when rolling the 0·1-in. copper with this roll surface are plotted in Fig. 4, from which it will be seen that for this series of results there is a certain amount of scatter of the points relative to the smoothly drawn curve.

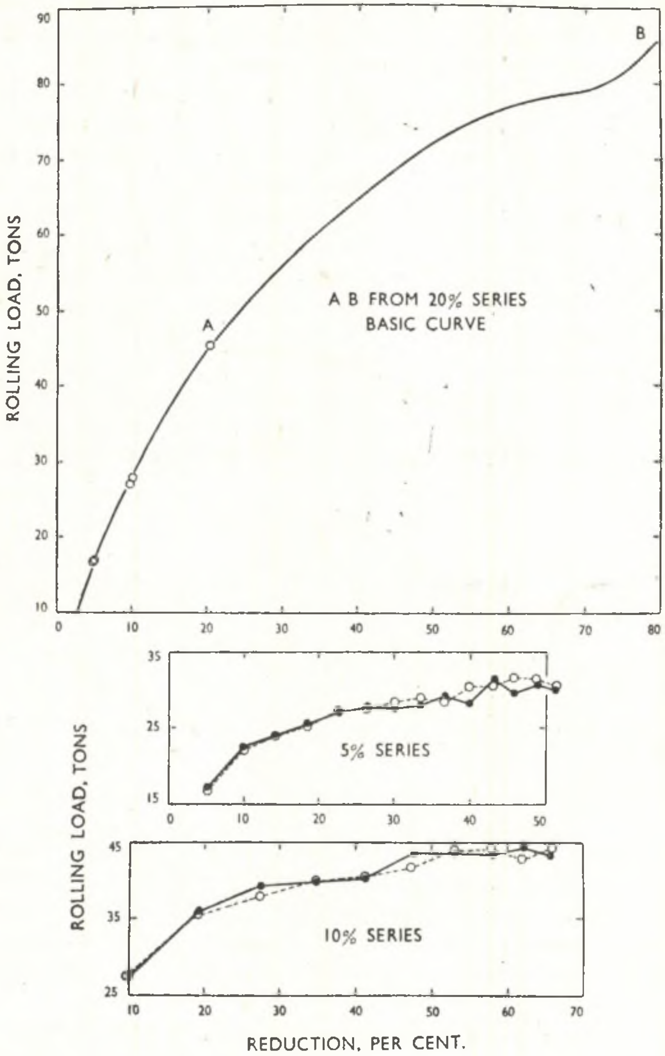

Fig. 5.—Annealed 0·2/0·25%-carbon Electric Furnace Steel, 3·0 in. Wide, 0·1 in. Initial Thickness. Roll surface : ground mirror finish (wheel grit 400).

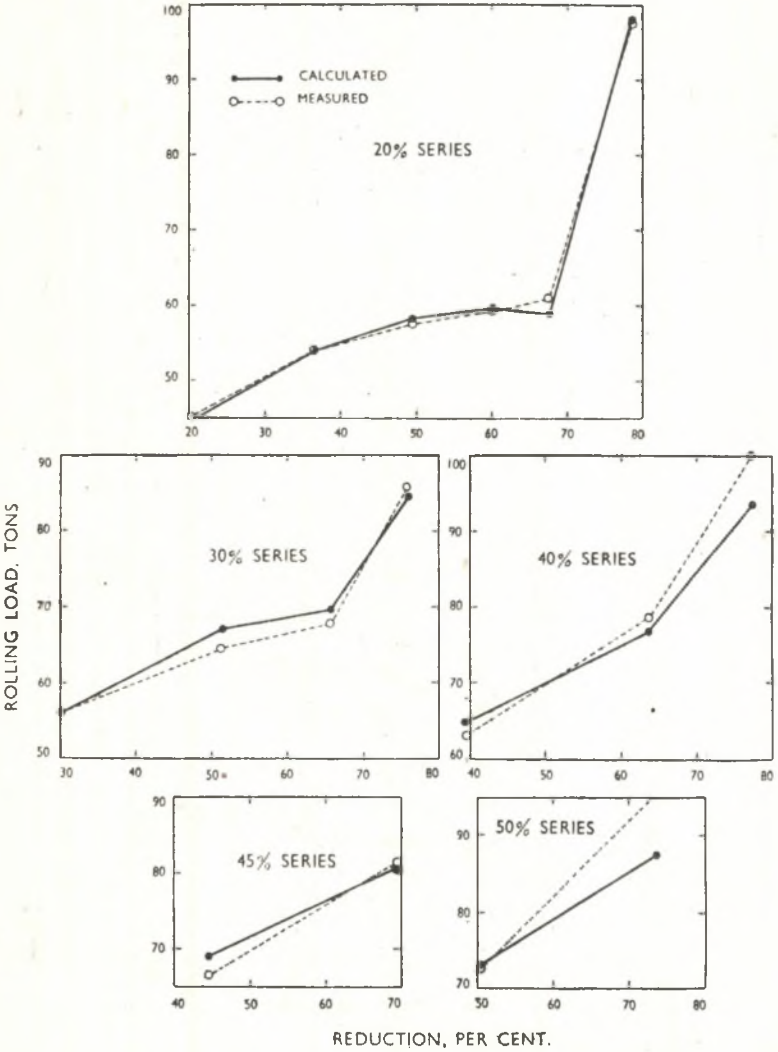

Fig. 5 (*continued*).

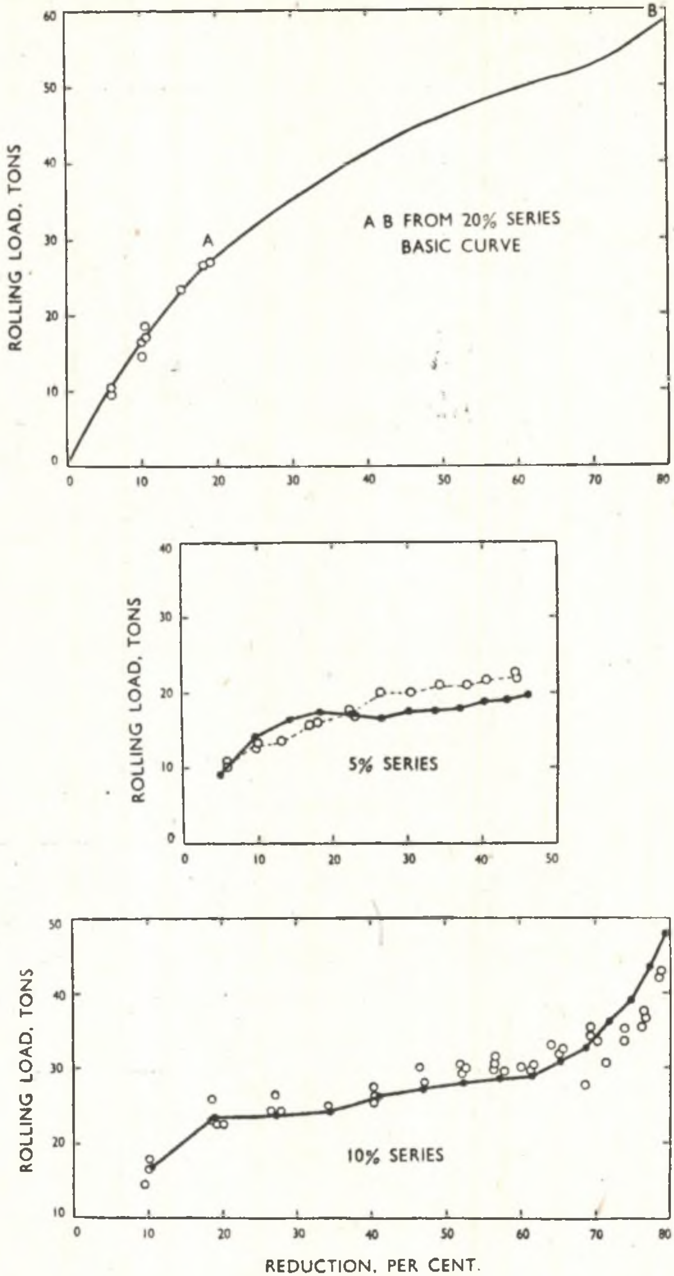

Fig. 6.—Annealed 0·11%-carbon Killed Steel, 2·3 in. Wide, 0·074 in. Initial Thickness. Roll surface: ground mirror finish (wheel grit 400).

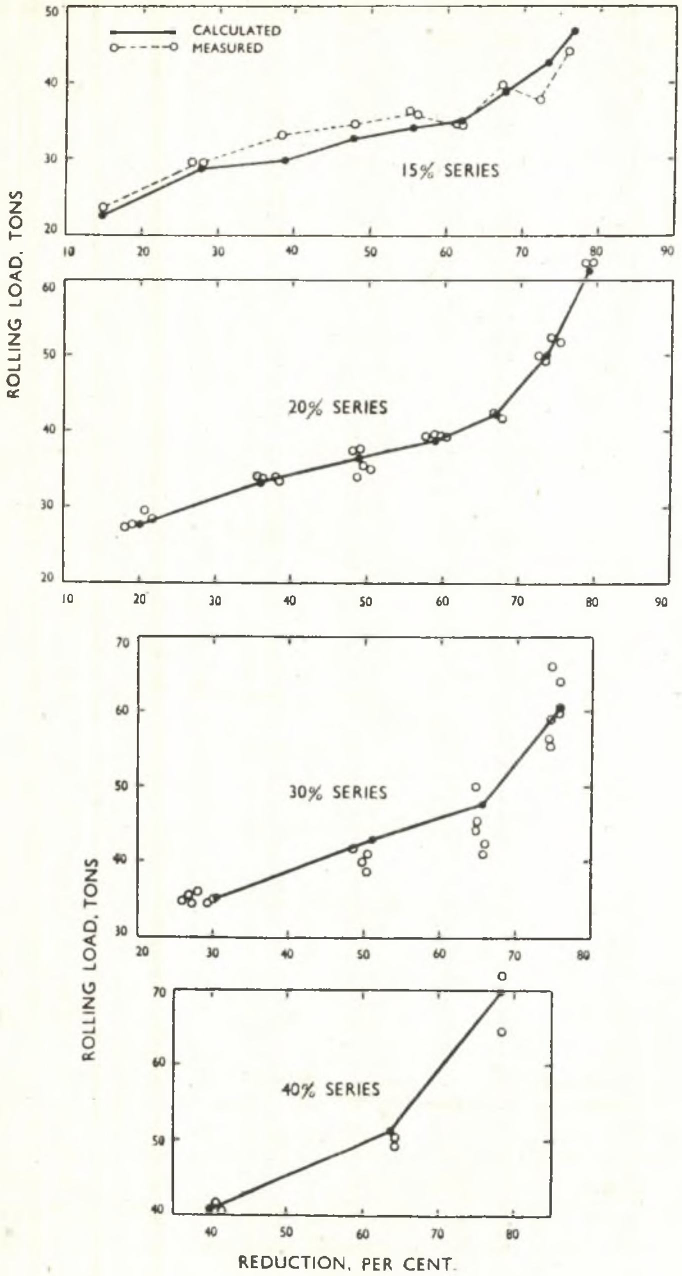

Fig. 6 (*continued*).

A similar scattering of the results was associated with the data for the 0·075 and 0·05-in.-thick copper.

The experimental data plotted in Figs. 2, 3, and 4 clearly show

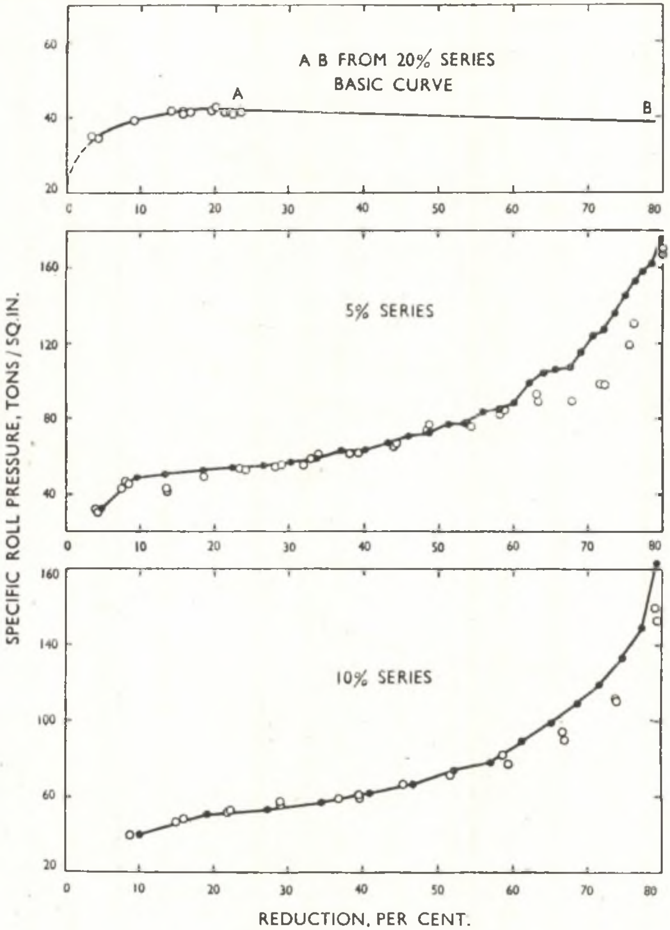

Fig. 7.—Hot-Rolled 0·07%-carbon Rimming Steel, $3\frac{5}{16}$ in. Wide, 0·063 in. Initial Thickness. Roll surface: ground mirror finish (wheel grit 400).

that, for the rolling conditions considered, the same amount of pure work of rolling is expended whether a given reduction in thickness is effected in one heavy pass or in a number of lighter passes. The only other assumption made in this method of calculation is that the ratio of the lever arm (βe in Fig. 1) to the horizontally projected length of the arc of contact (e) would be constant when rolling any one thickness of material under constant conditions. The justification or otherwise of this assumption can readily be established by experiment since,

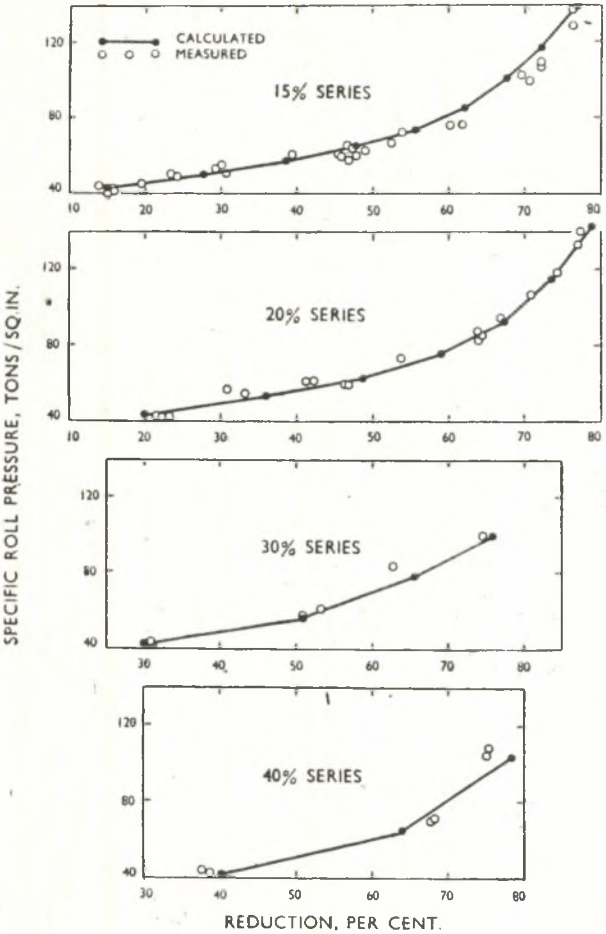

Fig. 7 (*continued*).

if the torque T required to effect the reduction of the material only and the corresponding rolling load are measured, then :

$$T = 2P\beta e$$

and

$$\beta = \frac{T}{2Pe}$$

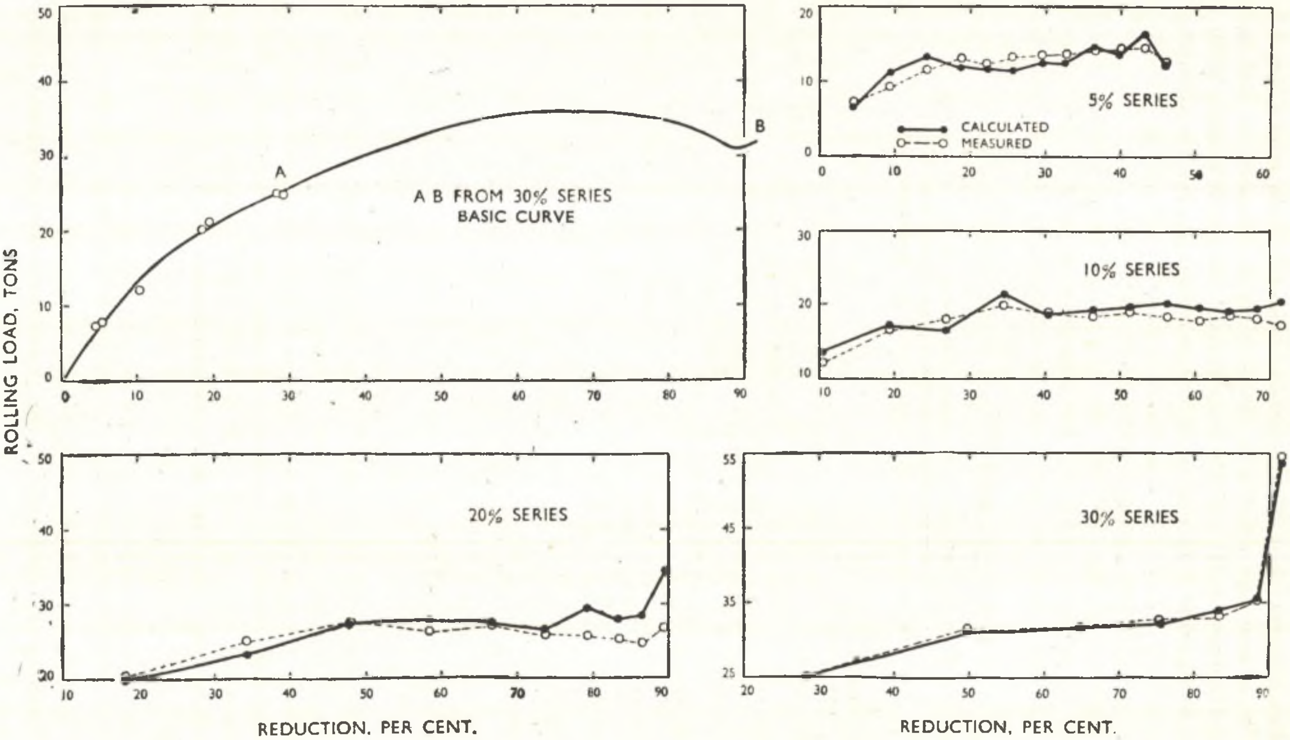

FIG. 8.—Annealed H.C. Copper, 3·0 in. Wide, 0·1 in. Initial Thickness. Roll surface : ground mirror finish (wheel grit 400).

Values of β for the measured results obtained when rolling the 0·2–0·25%-carbon steel and 0·1-in.-thick copper are recorded in Tables II and III respectively. It will be seen that, except for a slight drift, β can be considered constant, which accounts for the fact that the total-energy values plotted in Figs. 2 and 3 lie on smooth curves. In these tests, rolls having a ground mirror finish were used.

Table IV gives values of β for the 0·1-in. copper reduced on rolls with a ground matte finish. For this series of results, the constancy of β is not so good as that shown in Tables II and III, and accounts for the scattering of the points about the mean curve in Fig. 4. In spite of this, however, as will be seen later, when a comparison is made of the calculated and measured loads the above-mentioned assumption regarding the energy consumption and constancy of β is reasonable, even for rolls with a matte surface, because the agreement between calculated and measured loads is good for total reductions in one or more passes up to at least 60%.

TABLE II.—*Ratio of Lever Arm to Arc of Contact.*

0·2–0·25%-carbon electric-furnace steel, 3·0 in. wide × 0·1 in. thick.
Roll finish : ground mirror finish, wheel grit 400.
Calculated from Ford's torque and load measurements.

Reduction, %.	10.	20.	30.	40.	45.	50.	60.	70.
1st pass .	0·42 0·42	0·39 0·37	0·42 0·44	0·43 0·45	0·42 0·42	0·43 0·44	0·42 0·42	0·35 0·35
2nd pass .	0·43 0·45	0·39 0·39	0·43 0·42	0·42 0·43	0·45 0·44	0·45 0·43	... ...	... ...
3rd pass .	0·43 0·40	0·40 0·39	0·41 0·41	0·38 0·40	... ...	... ...	... ...	... ...
4th pass .	0·37 0·38	0·36 0·36	0·39 0·37	... ...	... ...	... ...	... ...	... ...
5th pass .	0·41 0·41	0·36 0·37	... ...	... ...	... ...	... ...	... ...	... ...
6th pass .	0·37 0·38	0·40 0·37	... ...	... ...	... ...	... ...	... ...	... ...
7th pass .	0·40 0·40	... ...	... ...	... ...	... ...	... ...	... ...	... ...
8th pass .	0·34 0·36	... ...	... ...	... ...	... ...	... ...	... ...	... ...
9th pass .	0·36 0·34	... ...	... ...	... ...	... ...	... ...	... ...	... ...
10th pass .	0·38 0·35	... ...	... ...	... ...	... ...	... ...	... ...	... ...

IV.—CONSTRUCTION OF BASIC CURVES FOR USE WITH EQUATION (2).

In order to calculate rolling loads from equation (2), it is necessary to establish experimentally a curve relating the load developed during

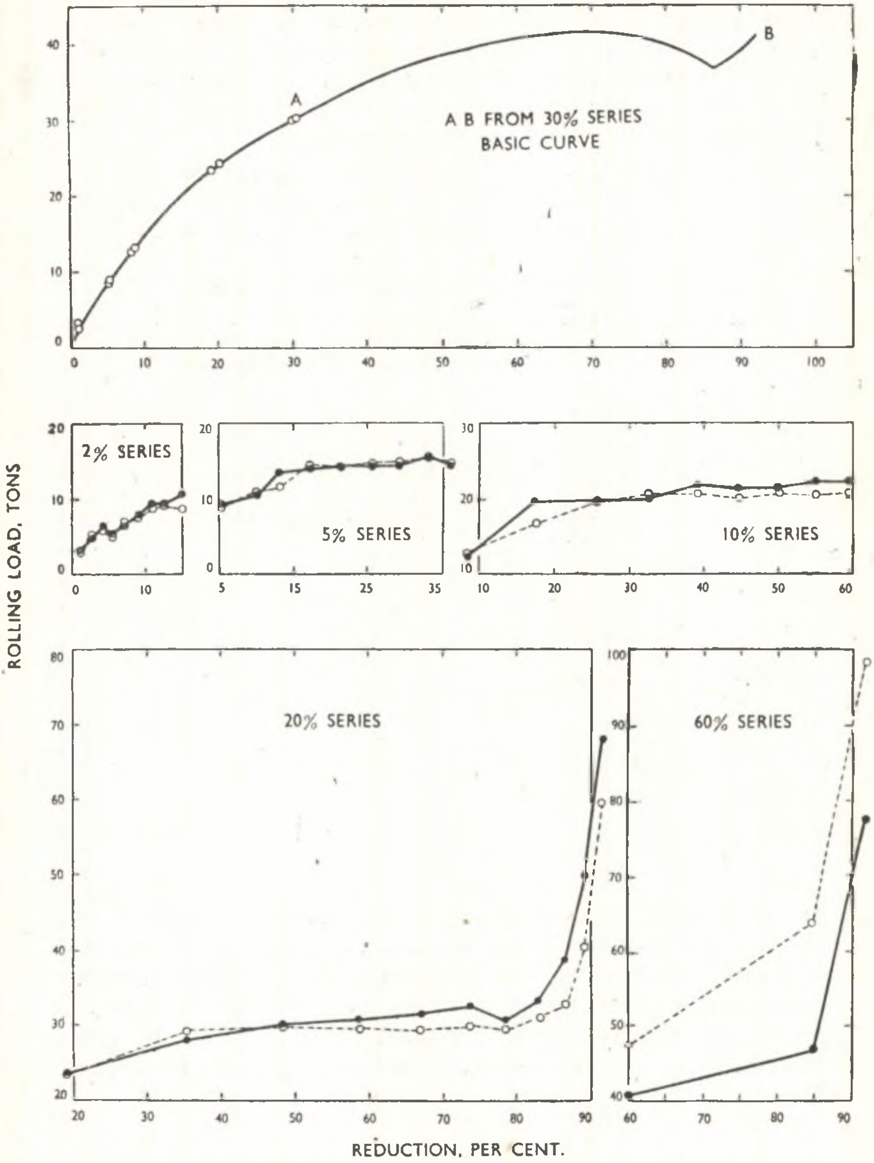

Fig. 9.—Annealed H.C. Copper, 3 in. Wide, 0·1 in. Initial Thickness. Roll surface: ground dull matte finish (wheel grit 180).

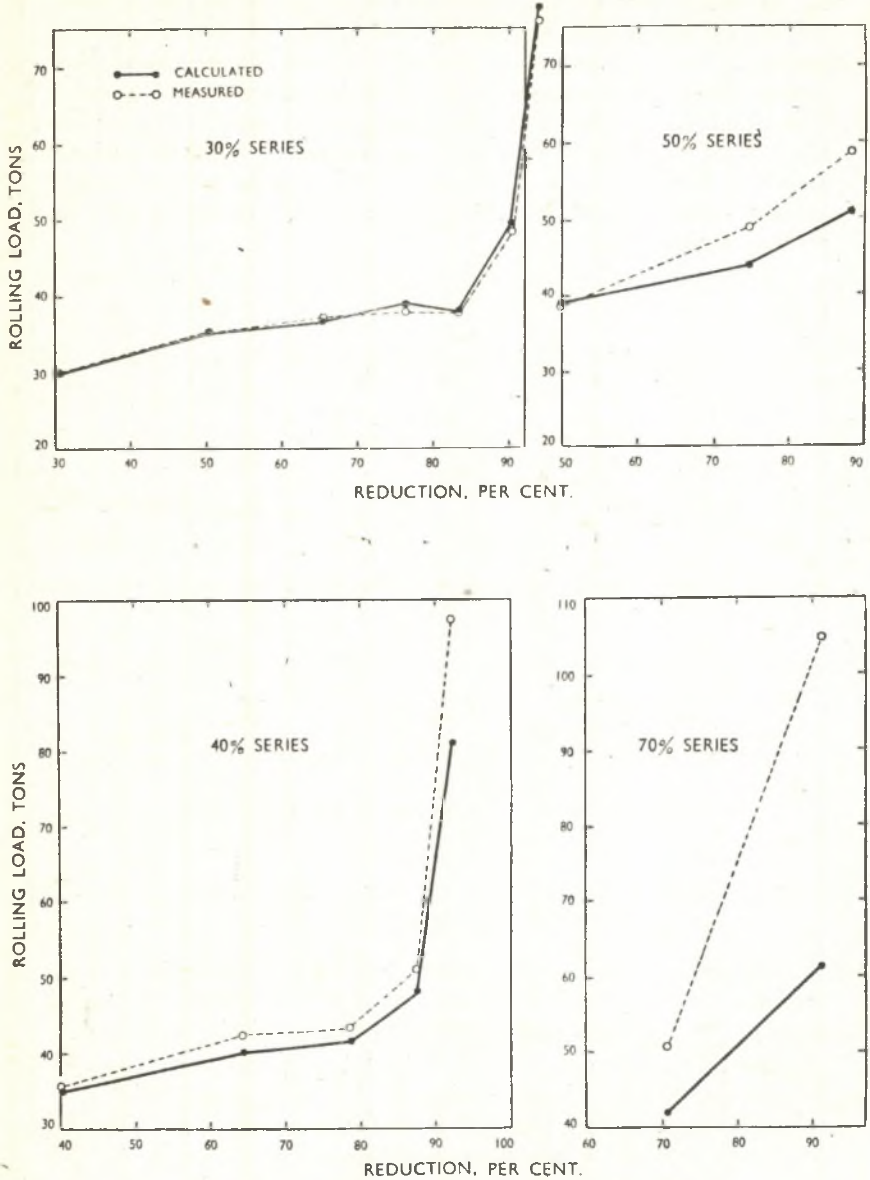

Fig. 9 (*continued*).

any one single pass to the percentage reduction in thickness effected. To be useful for practical applications, the first-pass basic curve should preferably cover reductions of 60–80%, for total reductions of this magnitude are not uncommon. Since, however, it is not usual to make such high reductions in one pass, it will be shown, by the use of equation (2), how the curve can be extended using experimental data determined from one particular series of progressive passes. The measured loads obtained when rolling 0·2–0·25%-carbon electric-furnace steel will serve to illustrate the procedure.

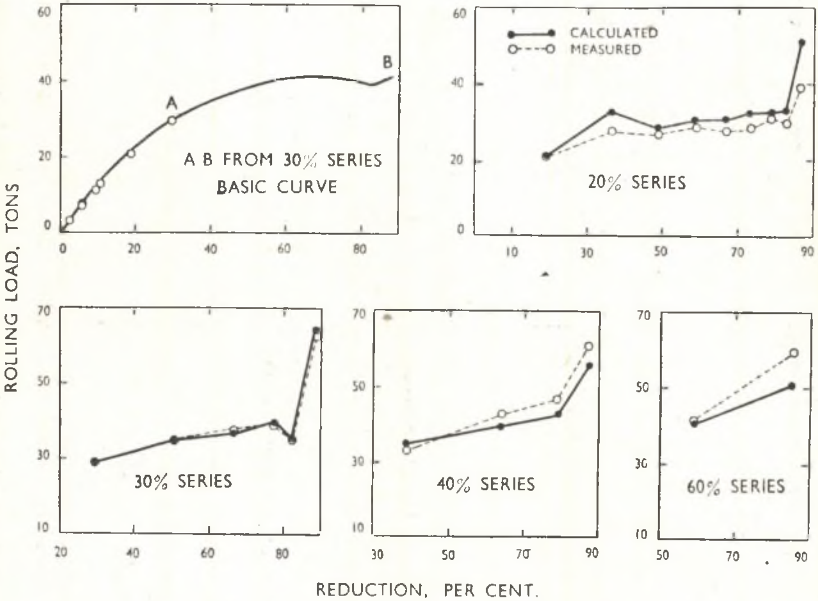

Fig. 10.—Annealed H.C. Copper, 3·0 in. Wide, 0·075 in. Initial Thickness. Roll surface: ground dull matte finish (wheel grit 180).

Although numerical values can be determined very quickly from equation (2) by the use of a slide rule or, preferably, a small calculating machine, and tables of square roots, the computations can be much simplified by the use of Table V, in which values of $\sqrt{R}/(100 - R)$ are recorded and used in illustrating the derivation of the basic curve shown in Fig. 5. The measured loads for first passes of 5, 10, and 20% were first plotted as shown in Fig. 5 and the extension of the abscissa of this curve to a percentage reduction of 76% was made by using the load and percentage-reduction data determined when submitting samples initially reduced by 20% to a further five passes, each approximately of 20% relative to the thickness before each pass. These results are recorded in the first four columns of Table VI.

With R_1 equal to 20·2, the value of the coefficient of P_1 in the first term of equation (2) can be read from Table V, i.e. when R equals 20·2 :

$$\sqrt{R_1}/(100 - R_1) = 0{\cdot}0563,$$

TABLE III.—*Ratio of Lever Arm to Arc of Contact.*

Annealed H.C. copper, 3·0 in. wide × 0·1 in. thick.
Roll finish : ground mirror finish, wheel grit 400.
Calculated from Ford's torque and load measurements.

Reduction, %.	10.	20.	30.
1st pass . . .	0·44 0·41	0·38 0·43	0·39 0·38
2nd pass . . .	0·38 0·43	0·46 0·44	0·40 0·40
3rd pass . . .	0·45 0·40	0·45 0·41	0·40 0·37
4th pass . . .	0·40 0·40	0·41 0·40	0·38 0·40
5th pass . . .	0·44 0·43	0·40 0·36	0·38 0·41
6th pass . . .	0·37 0·41	0·34 0·35	0·41 0·42
7th pass . . .	0·38 0·38	0·34 0·34	0·34 0·28
8th pass . . .	0·45 0·41	0·36 0·37	... ...
9th pass . . .	0·47 0·47	0·50 0·49	... ...
10th pass . . .	0·41 0·44	0·32 0·31	... ...
11th pass . . .	0·45 0·44	... ...	... ...
12th pass . . .	0·51 0·47	... ...	... ...

and since P_1 equals 45·0 tons, as measured, the first term on the left-hand side of equation (2) becomes :

$$P_1\sqrt{R_1}/(100 - R_1) = 2{\cdot}534,$$

i.e. W_{n-1} in Table VI. For the second pass, the coefficient of P_2, equation (2), must be computed. The values of R_2 and R_1 are 36·8 and 20·2% respectively, and with P_2 the measured load for the second pass equal to 53·8, the second term of equation (2) becomes

$$P_2\sqrt{R_2 - R_1}/(100 - R_2) = 3{\cdot}468,$$

i.e. W_{n-2} in Table VI. The value of P_S, i.e. the load which would be developed if the reduction R_2 of 36·8% had been accomplished in one pass, is derived by dividing the sum of the first two terms, i.e. $W_1 + W_2$, by the coefficient of P_S in equation (2), n in this right-hand term now signifying the second pass. The value of this coefficient is read from Table V against R equals 36·8, and is:

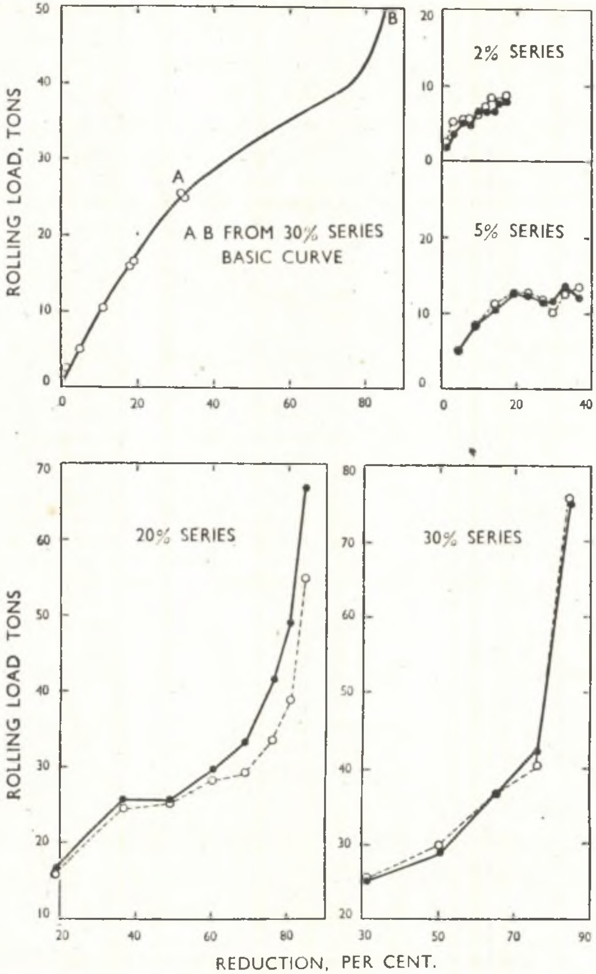

Fig. 11.—Annealed H.C. Copper, 3·0 in. Wide, 0·05 in. Initial Thickness. Roll surface: ground dull matte finish (wheel grit 180).

$$\sqrt{R_2}/(100 - R_2) = 0{\cdot}0960.$$

Hence:

$$ {}_2P_S = (2{\cdot}534 + 3{\cdot}468)/0{\cdot}096 = 62{\cdot}5 \text{ tons.} $$

For the third pass, the third term on the left-hand side of equation (2) is:

$$ W_3 = P_3\sqrt{R_3 - R_2}/(100 - R_3) = 4{\cdot}034, $$

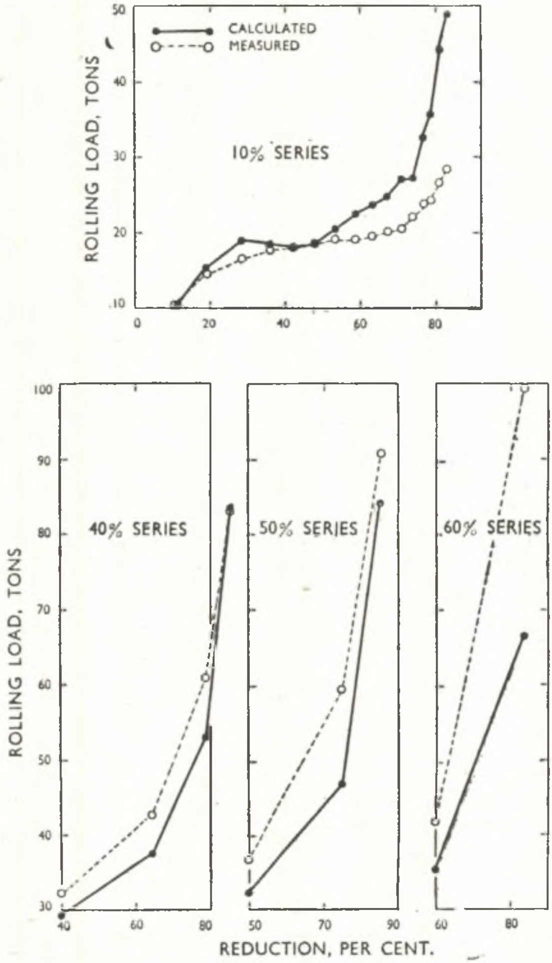

FIG. 11 (*continued*).

and the coefficient of the term on the right-hand side, as read from Table V for R equals 49·4%, is:

$$ \sqrt{R_3}/(100 - R_3) = 0{\cdot}1389. $$

Dividing the sum of W_n, i.e. $W_1 + W_2 + W_3$, corresponding to n equals 3 in Table VI, gives :

$${}_3P_S = 10{\cdot}04/0{\cdot}1389 = 72{\cdot}3 \text{ tons.}$$

The remaining values for the fourth, fifth, and sixth passes were computed in the same manner, the numerical results being given in Table VI.

TABLE IV.—*Ratio of Lever Arm to Arc of Contact.*

Annealed H.C. copper, 3·0 in. wide × 0·1 in. thick.
Roll finish : ground dull matte finish, wheel grit 180.
Calculated from Ford's torque and load measurements.

Reduction, %.	10.	20.	30.	40.	50.	60.	70.	80.
1st pass .	0·36	0·33	0·33	0·37	0·37	0·37	0·36	0·35
	0·31	0·35	0·33	0·38	0·38	0·36	0·36	0·39
2nd pass .	0·35	0·37	0·34	0·39	0·38	0·37	0·26	...
	0·35	0·39	0·33	0·40	0·39	0·35	0·26	...
3rd pass .	0·32	0·36	0·34	0·34	0·32	0·22	...	...
	0·31	0·35	0·33	0·37	0·32	0·20	...	...
4th pass .	0·28	0·35	0·35	0·31	...	...	...	...
	0·27	0·33	0·31	0·29	...	...	...	...
5th pass .	0·29	0·31	0·34	0·19	...	...	...	...
	0·31	0·33	0·29	0·20	...	...	...	...
6th pass .	0·26	0·32	0·22	...	...	...	...	...
	0·28	0·32	0·21	...	...	...	...	...
7th pass .	0·30	0·29	0·15	...	...	...	...	...
	0·24	0·29	0·16	...	...	...	...	...
8th pass .	0·24	0·28	...	...	...	...	...	...
	0·24	0·29	...	...	...	...	...	...
9th pass .	0·26	0·23	...	...	...	...	...	...
	0·26	0·25	...	...	...	...	...	...
10th pass .	...	0·22	...	...	...	...	...	...
	...	0·22	...	...	...	...	...	...
11th pass .	...	0·18	...	...	...	...	...	...
	...	0·20	...	...	...	...	...	...

The first-pass loads P_S were then plotted against the total percentage reduction, and thus the extension *AB* of the basic first-pass curve given in Fig. 5 was obtained.

V.—COMPARISON OF MEASURED WITH CALCULATED RESULTS.

The basic curves plotted in each of Figs. 5–11 were computed as described above; the values connected by full-line curves in the remaining diagrams in these figures have been calculated using the appropriate basic curves and equation (2). The results represented by small circles are Ford's measured loads. It will be realized that no

TABLE V.

% R	$\frac{\sqrt{R}}{100 - R}$.	For Each 0·1% R, Add :	% R.	$\frac{\sqrt{R}}{100 - R}$.	For Each 0·1% R, Add :	% R.	$\frac{\sqrt{R}}{100 - R}$.	For Each 0·1% R, Add:
0	0·0	0·00101	...	...	...	...	...	...
1	0·0101	0·00043	31	0·0807	0·00025	61	0·2003	0·00066
2	0·0144	0·00035	32	0·0832	0·00026	62	0·2072	0·00069
3	0·0179	0·00029	33	0·0858	0·00025	63	0·2145	0·00073
4	0·0208	0·00028	34	0·0883	0·00027	64	0·2222	0·00077
5	0·0236	0·00025	35	0·0910	0·00028	65	0·2303	0·00081
6	0·0261	0·00023	36	0·0938	0·00027	66	0·2389	0·00086
7	0·0284	0·00023	37	0·0965	0·00029	67	0·2480	0·00091
8	0·0307	0·00023	38	0·0994	0·00030	68	0·2577	0·00097
9	0·0330	0·00021	39	0·1024	0·00030	69	0·2680	0·00103
10	0·0351	0·00022	40	0·1054	0·00030	70	0·2789	0·00109
11	0·0373	0·00021	41	0·1085	0·00031	71	0·2905	0·00116
12	0·0394	0·00020	42	0·1117	0·00032	72	0·3030	0·00125
13	0·0414	0·00021	43	0·1150	0·00033	73	0·3165	0·00135
14	0·0435	0·00021	44	0·1185	0·00035	74	0·3308	0·00143
15	0·0456	0·00020	45	0·1220	0·00035	75	0·3464	0·00156
16	0·0476	0·00021	46	0·1256	0·00036	76	0·3633	0·00169
17	0·0497	0·00021	47	0·1294	0·00038	77	0·3815	0·00182
18	0·0518	0·00020	48	0·1332	0·00038	78	0·4014	0·00199
19	0·0538	0·00021	49	0·1373	0·00041	79	0·4233	0·00219
20	0·0559	0·00021	50	0·1414	0·00041	80	0·4472	0·00239
21	0·0580	0·00021	51	0·1458	0·00044	81	0·4734	0·00262
22	0·0601	0·00022	52	0·1502	0·00044	82	0·5035	0·00301
23	0·0623	0·00022	53	0·1549	0·00047	83	0·5357	0·00322
24	0·0645	0·00022	54	0·1598	0·00049	84	0·5728	0·00371
25	0·0667	0·00022	55	0·1648	0·00050	85	0·6150	0·00422
26	0·0689	0·00023	56	0·1701	0·00053	86	0·6622	0·00472
27	0·0712	0·00023	57	0·1756	0·00055	87	0·7173	0·00551
28	0·0735	0·00023	58	0·1813	0·00057	88	0·7814	0·00641
29	0·0758	0·00025	59	0·1873	0·00060	89	0·8576	0·00762
30	0·0783	0·00024	60	0·1937	0·00064	90	0·9487	0·00911

TABLE VI.

Pass No. = n.	Reduction, %.		Measured Load, tons = P_n.	Terms in Equation (2).		Basic One-Pass Load, tons = P_S.
	Per Pass.	Total = R_n.		Left Side W_n.	Right Side W_S = sum of W_n.	
1	20·2	20·2	45·0	2·534	2·534	45·0
2	20·8	36·8	53·8	3·468	6·002	62·5
3	20·0	49·4	57·5	4·034	10·04	72·3
4	20·7	59·9	60·0	4·848	14·89	77·2
5	20·4	68·1	60·2	5·405	20·30	78·4
6	32·6	78·5	96·5	14·475	34·78	84·5

physical significance attaches to the linking of these points by curves, which has been done only to facilitate comparison.*

For calculating the loads for passes subsequent to the first, equation (2) is used, and, as an example, the derivation of the points calculated for the 30% series, given in Fig. 5, is described below. The reductions obtained during the experimental rolling are included in Table VII.

The load corresponding to the first pass of 30% is read direct from the basic curve in Fig. 5, i.e. P_1 equals 56·0 tons. In order to determine the value of the first term W_1 in equation (2), it is necessary to evaluate the factor $\sqrt{R_1}/(100 - R_1)$, and this, as read from Table V against R equals 30, is 0·0783. Hence:

TABLE VII.

Pass No. = n.	Reduction, %.		$\sqrt{R}/(100 - R) = K$. Read from Table V.	Load Read from Basic Curve = P_S tons.	$P_S K = W_S$.	Difference of W_S.	Load per Pass = P_n tons.
	Per Pass.	Total R.					
1	30·0	30·0	0·0783	56·0	4·385	4·385	56·0
2	30·4	51·3	0·1471	73·2	10·778	6·393	67·4
3	29·3	65·6	0·2352	78·1	18·350	7·572	68·9
4	30·1	75·9	0·3604	82·0	29·600	11·250	84·6

$$W_1 = 56 \times 0{\cdot}0783 = 4{\cdot}385 = {}_1W_S.$$

If the total reduction obtained after the second pass, i.e. 51·3%, is effected in one pass, then the load ${}_2P_S$ which would be developed is 73·2 tons as read from the basic curve, and the coefficient $\sqrt{R_2}/(100 - R_2)$ of ${}_2P_S$ on the right-hand side of equation (2) is read from Table V against R equals 51·3. Hence:

$${}_2W_S = {}_2P_S\sqrt{R_2}/(100 - R_2) = 10{\cdot}778.$$

The load developed for the second pass, i.e. continuing a reduction of 30% to 51·3%, is, therefore:

$$P_2 = ({}_2W_S - {}_1W_S)(100 - R_2)/\sqrt{R_2 - R_1} = 67{\cdot}4 \text{ tons}.$$

When the total reduction effected in the three passes, i.e. 65·6%, is achieved in one pass, the load ${}_3P_S$ according to the basic curve is 78·1 tons, and the value of the term ${}_3W_S$ on the right-hand side of

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* In Fig. 7, the ordinate is plotted as tons per square inch since there were insufficient data to convert the measured values into tons. Both in the experimental work and in the calculation, the values in tons per square inch were obtained by dividing the load by the nominal projected area of contact.

equation (2) is $78{\cdot}1\sqrt{65{\cdot}6}/(100 - 65{\cdot}6)$. Against 65·6 in Table V, the value of the factor multiplying 78·1 is 0·2352. Hence:

$${}_3W_S = 18{\cdot}350.$$

The load P_3 developed when the reduction is increased from 51·3 to 65·6% is:

$$P_3 = ({}_3W_S - {}_2W_S)(100 - R_3)/\sqrt{R_3 - R_2} = 68{\cdot}9 \text{ tons.}$$

The load P_4 for the fourth pass is found in the same way.

The measure of agreement between the calculated and determined results is plainly shown in the various diagrams. In Figs. 5–7, in which the calculated and measured data for the three steels are plotted, it will be seen that the calculated values agree closely with all the experimentally determined results up to total reductions of 80%, even when this reduction is obtained by individual reductions each as high as 40%. The calculated and measured results recorded in Fig. 8 for the 0·1-in.-thick H.C. copper also show good agreement, except for some divergence at the last four passes in the 20% series, where the total reductions exceeded 75%.

The results for the three steels and the 0·1-in.-thick H.C. copper given in Figs. 5–8 were all obtained with rolls prepared with a mirror finish, and the good agreement between the calculated results and the measured values indicate the validity of the method for these rolling conditions.

In Fig. 9, details are given of the results obtained when rolling 0·1-in. copper on rolls with a dull matte surface, and it will be seen that the calculated results agree well with the measured results up to individual reductions per pass of 40%, even as far as total reductions of 90%. For the second and subsequent passes of the 50, 60, and 70% series, however, the computed results are lower than the measured values; but the calculated loads for the first pass of the same series are in better agreement. As for the 0·075 and 0·05 in. copper, Figs. 10 and 11 respectively, also reduced on rolls with a dull matte surface, agreement between the calculated and measured results is good until total reductions of 60% and individual reductions of 50% are exceeded.

VI.—APPLICABILITY OF THE METHOD.

It will be appreciated that any one first-pass basic curve will refer only to the particular conditions obtaining during the determination of the curve, i.e. roll diameter, friction, and the initial thickness of the material being rolled. However, it is not necessary to establish individual first-pass curves separately for all diameter of rolls, initial thicknesses, and friction conditions. It has been shown by the authors [8] that, for a given initial thickness and roll-surface condition, the relationship between the rolling load and the roll diameter is linear. If, therefore, basic curves are established for any given material for two widely different roll diameters, the data for any intermediate diameter can be interpolated. This conclusion is also supported by the experimental results of Emicke and Lucas [9] on the rolling of aluminium alloys.

The results of the computations already published,[8] and those of Emicke and Lucas, also show that, for any given roll diameter, the magnitude of the rolling load bears a linear relationship to the initial thickness within the range 0·5–0·1 in. For initial thicknesses less than 0·1 in. further experimental curves would be necessary, but the measurements of Emicke and Lucas and the authors' calculations referred to above indicate that two, or at the most three, curves would suffice for this range of initial thickness.

As the degree of roll-surface roughness, or smoothness, can be measured by methods developed in the last few years, it is possible that basic first-pass curves established for two- or three-roll finishes, representative of those used in normal rolling practice, could be used to construct curves for intermediate finishes. It is, however, realized that other factors as well as roll surface, such as lubrication and surface condition of the material being rolled, influence the frictional forces developed. In constructing a series of basic curves, advantage should also be taken of the principle of geometrical similarity, for if the ratio of the roll diameter to the original thickness of the material is constant, then the rolling load is directly proportional to the roll diameter or to the initial thickness, provided that the percentage reduction is constant and that the surface conditions in the roll throat are the same.

The basic curve for a given set of conditions covers not only the influence of the compressive characteristics of the material in its dependence on the frictional conditions, and thus of plane inhomogeneous deformation, but also that of roll-face distortion.

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THE EFFECT OF SINGLE- AND MULTI-HOLE DIE EXTRUSION ON THE PROPERTIES OF EXTRUDED ALUMINIUM ALLOY BAR.*

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Synopsis.

Longitudinal streaks on the surface of aluminium alloy components machined from extruded bar in BA 35 and D.T.D. 423A alloys were found to be associated with erratic circumferential strength. The streaks have been shown to be due to the flow structure originating in extrusion through multi-hole die plates, and the principles will apply to alloys generally. To investigate the problem fully, billets of the two alloys were extruded through die plates having 1, 2, 3, or 4 holes, all the multi-holes being symmetrically disposed about the centre. Transverse sections of bars extruded through multi-hole die plates showed a structure termed " radial flow ", converging to that portion of the surface marked by the streak; this structure was absent from bars extruded through single-hole die plates. Segregation of particle constituents was found near the periphery in the zone of radial flow and, consequently, the circumferential tensile properties of multi-hole material were inferior to those of single-hole bar. Small-scale experiments with lead–bismuth composites and coloured plasticine showed that the segregate originated from the axial zone of the billet; with a die plate having a single central hole, on the other hand, the axial segregate was confined to the axis of the single bar, where it is relatively harmless. Provision of a central hole in 3- and 4-hole die plates confined the segregate to the axis of the central bar, and this advantage has been confirmed by industrial trials.

I.—Introduction.

At one period in the mass production of a conical component which was machined from extruded aluminium alloy bar, large numbers of components were under suspicion owing to their having a fan-shaped, streaky appearance (Fig. 1, Plate XI). In service, these components rotate at extremely high speeds and, it was considered, would be subjected to a high circumferential tensile stress. It was feared that the streakiness might indicate low circumferential properties, and this was found to be so by work described below, under " Preliminary Tests ".

The cylindrical bars from which the components were made were extruded through single- or multi-hole die plates, and multi-hole die extrusion was suspected as being responsible for the streakiness and circumferential weakness, which in some components was very marked. It thus became clear that the original problem was part of the general

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question of the effect of extrusion through different types of die plates. An investigation was therefore initiated into the effect of extrusion, through die plates having 1, 2, 3, or 4 holes, on the mechanical properties of the bars. The experimental work showed that in many instances there was a variation in properties along the length of the bar; consequently, most tests were repeated many times (as an extreme instance nearly 150 drift tests were carried out), but only mean results are given in the present paper, and the question of scatter is dealt with separately, since it assisted in deciding the cause of the variable properties. To check the conclusions reached from this part of the work, laboratory extrusion experiments were carried out and were later extended to full-scale industrial trials.

II.—PRELIMINARY TESTS.

An anodized component having typical fan-shaped streaks is shown in Fig. 1 (Plate XI). The streaks were much more prominent after than before anodizing. Fig. 2 (Plate XI) shows that when a flat was machined on the side of the component parallel to the axis, the streaks revealed by etching were parallel to one another, and it was evident that the fanwise spread shown in Fig. 1 was due to the conical shape of the component.

To ascertain whether the streaks indicated any circumferential weakness, a group of 87 components in D.T.D. 423A alloy, some with and some without streaks, were " drift " tested by forcing a tapered and lubricated plug into their hollow interiors, thus expanding the component. At a particular load the component would burst with a longitudinal fracture; the fractures were either fibrous or laminated. Typical examples are shown in Figs. 3 and 4 (Plate XI). The bursting loads fell into two groups of high and low values, and Table I shows the connection with streakiness and type of fracture. It was not known which of the components were machined from single-hole bars and which from multi-hole bars.

TABLE I.—*Drift Tests on 87 Components.*

Group.	Number of Components.	Number with Streaks.	Number without Streaks.	Number with Laminated Fracture.	Number with Fibrous Fracture.
High bursting load 4–5·2 tons* . . .	46	5	41	7	39
Low bursting load 1–2·5 tons* . . .	41	40	1	41	0

* These figures are a function of circumferential tensile strength and ductility.

There is a clear connection between streaky appearance, low bursting load, and laminated fracture, but a few of the streaky components had high strength and broke with fibrous fractures, so that there was much scatter among the streaky components. The prominence of the streaks varied considerably from component to component, but bore little relation to the bursting load.

Transverse sections were prepared of seven of the above components and of four additional unbroken ones. Those which had the streaky surface appearance showed what will be referred to subsequently as "radial flow structure", but this was absent from the non-streaky bodies. Figs. 7 and 6 (Plate XII), respectively, show the structures of complete bars with and without radial flow. Micro-examination of the region of radial flow revealed segregation of particle constituents and, in unbroken components, sometimes also surface cracks (Fig. 5, Plate XI).

Longitudinal section through the streaks showed strings of particles of intermetallic compounds parallel to the pattern of streaks, which were evidently an etching effect occurring during anodizing and caused by the segregation. These tests established the association between the circumferential weakness, the radial flow structure, and the segregate near the surface; the responsible factor was concluded to be the employment of multi-hole die plates in the extrusion process.

1. *Examination of Bar Extruded Through* 1, 2, 3, *or* 4-*Hole Die Plates.*

Two alternative alloys were used for the component originating the investigation and, with the generous co-operation of the Northern Aluminium Company, Ltd. (D.T.D. 423A), and the British Aluminium Company, Ltd. (BA 35), bars of both alloys were obtained $1\frac{5}{16}$ in. dia., extruded through 1, 2, 3,* or 4-hole die plates and heat-treated to specification. For convenience in description, distinguishing terms such as 4-hole bar and 4-hole specimen will be used. The arrangement of holes in the die plates was similar to those shown in Figs. 12–15 (Plate XIII), referred to later; the significant feature was that the single hole was centrally placed, but in the multi-hole plates none of the holes was central. A set of bars $1\frac{3}{32}$ in. dia. was also supplied in BA 35 alloy, but, as the results of their examination were similar to those on the larger bars, only brief reference will be made to them. The specification compositions (%) are:

	Cu.	Mn.	Mg.	Fe.	Si.	Ni.	Sb.
D.T.D. 423A:	1	1	0·5–1·25	0·75	0·75–1·25	0·3	...
BA 35:	2·5–4	0·2	0·5–0·75	1·2		0·05	0·3–1

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* Only BA 35 was extruded through the 3-hole die plate.

The figures quoted represent maximum values except where a range is indicated.

TABLE II.—*Longitudinal Tensile Properties* (0·564 *in. dia. bar*).

Specimen from	BA 35 Alloy.				D.T.D. 423A Alloy.			
	Proof Stress, tons/in.².	Ultimate Tensile Stress, tons/in.².	Elongation, % on 2 in.	Reduction in Area, %.	Proof Stress, tons/in.².	Ultimate Tensile Stress, tons/in.².	Elongation, % on 2 in.	Reduction in Area, %.
1-Hole bar	11·0	19·7	24½	30½	25·6	27·5	11	24½
2-Hole bar	11·5	21·7	19	24	22·9	25·6	14	28
3-Hole bar	11·0	19·9	21	24½	...	...	...	...
4-Hole bar	12·5	19·8	18	28	22·3	25·3	12·5	18

The measured longitudinal tensile properties are given in Table II, which shows little difference between bars from different die plates. The BA 35 alloy has the lower strength and yield ratio, but greater ductility.

2. *Structure.*

The macrostructures of transverse sections cut from the middle of the BA 35 bars are shown in Figs. 6–9 (Plate XII). The D.T.D. 423A bars were similar, but of smaller grain-size. The 1-hole bar (Fig. 6) is characterized by a central segregate and a uniform structure away from the centre. The 2-hole bar (Fig. 7) shows, near the surface, the radial flow structure in which a radial segregate always occurred (cf. Fig. 5). The 3-hole bar (Fig. 8) shows two positions of radial flow, corresponding to the two adjacent holes in the die plate; the segregate lies between these two positions and spreads over an arc, and is therefore less concentrated than in the 2-hole bar. The structure of the 4-hole bar (Fig. 9) is similar to that shown in Fig. 8, but the angle between the two positions of radial flow is greater, corresponding to the greater angle subtended by the two nearest holes in the die plate (cf. Figs. 14 and 15, Plate XIII). These structures show how, in multi-hole extrusion, flow through each hole is affected by flow through neighbouring holes, and it is easy to picture how the central billet segregate appears at the surfaces of extruded bars, due to flow over the edges of the die holes at the positions nearest the billet axis. The later experiments with composite model billets confirmed this.

3. *Drift Tests.*

These tests were similar to those applied previously to the components. A lubricated conical steel plug, of 10° half angle, was forced into cylinders (1·5 in. long, 1·29 in. outside dia., 1·00 in. inside dia.) machined from the bar. The depth of penetration as well as the bursting load were measured. This load was sharply defined, and is a function of circumferential ductility as well as strength, since the former governs the depth of penetration which in turn governs the area of the test cylinder in contact with the plug and, hence, the total load sustainable. Six cylinders from each bar were tested, and mean results are given in Table III.

TABLE III.—*Drift Tests on Cylinders Machined from Bars.*

Specimen from	Load to fracture, tons.	
	BA 35 Alloy.	D.T.D. 423A Alloy.
1-Hole bar . . .	3·6	3·9
2-Hole bar . . .	1·7	1·8
3-Hole bar . . .	1·8	...
4-Hole bar . . .	1·8	1·7

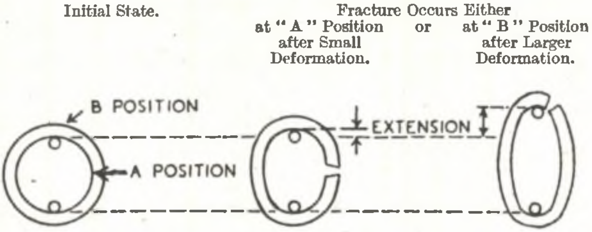
The circumferential properties of the 1-hole bar material are thus considerably superior to those of 2-, 3-, or 4-hole bars, between which there is little to choose. All the 1-hole cylinders had fibrous fractures, but all except one of the multi-hole cylinders (out of a total of 30) had laminated fractures, and all without exception broke in the region of radial flow. The similarity of the results as between the two alloys is due to the greater ductility of the BA 35 alloy counterbalancing the greater strength of the D.T.D. 423A alloy. There was a tendency for the bursting load to be lower for cylinders taken from the last part of the bar to be extruded. The 2-hole bar of BA 35 showed this effect the most. With the smaller bars, low results were obtained with cylinders from the rear part of the 1-hole bar; these results are referred to below.

4. *Ring Tests.*

Another convenient test which applied circumferential stress to the outer layers of the bar was to take rings machined from the bars and apply a load by means of two $\frac{1}{8}$-in. dia. pins placed inside the rings. To appreciate the results, some discussion of the test is necessary, and it may be helpful to refer to the diagrams in Table IV. Preliminary tests showed that the stress distribution was complex and changed during the progress of the test. From the strain markings on polished rings, it was evident that during the early stages of the test the maximum tensile stress occurred on the inner surface of the ring midway between the pins (" A " position). If fracture took place without much deformation, it always did so from the inside outwards at this position. In a more ductile material, the position of maximum surface stress changed during the later stages of the test to the outside of the ring above the pins (" B " position). Fractures at this position always started from the outside of the ring. Consequently, with rings having a weak spot the orientation of this spot in relation to the pins affected the results. As a standard position it was natural to choose that which gave the lowest results. With the D.T.D. 423A rings this was with the radial flow at the " A " position. The BA 35 rings, however, owing to their greater ductility, would sometimes break at the " B " instead of the " A " position, whatever the orientation of the radial flow position. In the main tests six or ten rings from each bar were tested, the D.T.D. 423A rings with the radial flow in the " A " position, but the BA 35 rings were tested in various positions. The extension measured over the pin positions was recorded, as well as the load to fracture. The mean results are given in Table IV.

TABLE IV.—*Ring Tests.*

Each result the mean of six or ten tests.



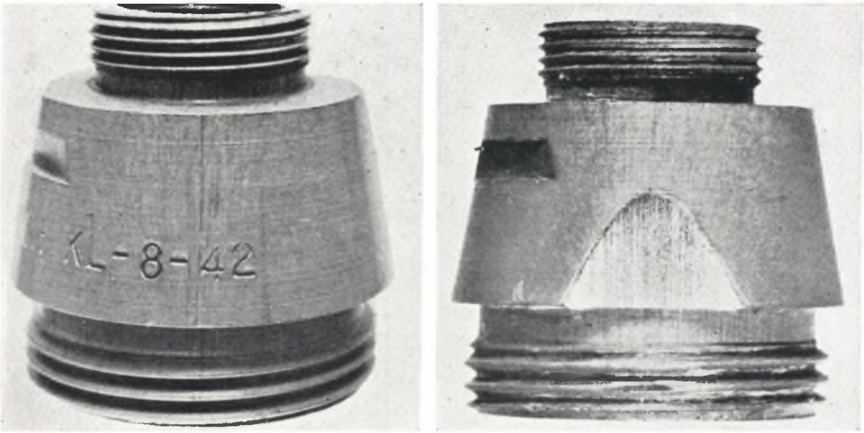
The loads to fracture and extensions are measures of circumferential strength and ductility.

Ring from	BA 35 Alloy.		D.T.D. 423A Alloy.	
	Load to Fracture, lb.	Extension, %.	Load to Fracture, lb.	Extension, %.
1-Hole bar	1230	51·7	3470	20·5
2-Hole bar	840	32·9	1790	3·8
3-Hole bar	830	47·0	...	...
4-Hole bar	795*	43·0	2040	12·4

* 865 if one very low value is omitted.

The marked superiority of the single-hole material is again shown. Among the results on multi-hole rings, those from 3- or 4-hole bar are

PLATE XI.



FIGS. 1 and 2.—Components Showing Fan-Shaped Streaks, Parallel on Machined Flat. × 1½.

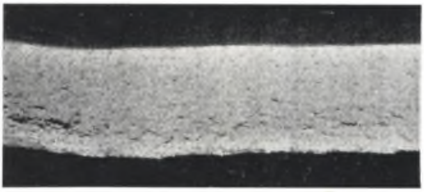


FIG. 3.—Fibrous Fracture of 1-Hole Cylinder. × 3.

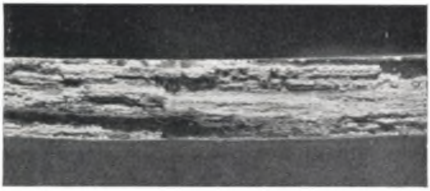


Fig. 4.—Laminated Fracture of 2-Hole Cylinder. × 3.

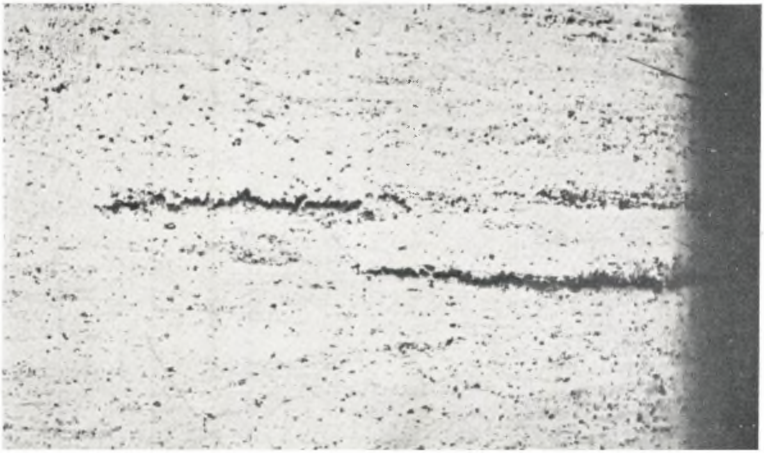


FIG. 5.—Transverse Section at Periphery of 2-Hole Bar in Radial Flow Position. Cracks and radial segregates. × 50.

PLATE XII.

Etched Transverse Sections of Extruded Bars. × 1½.

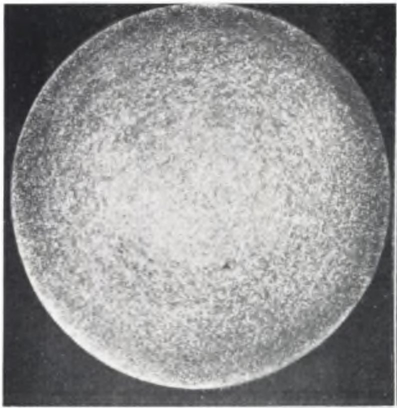


Fig. 6.
1-Hole.

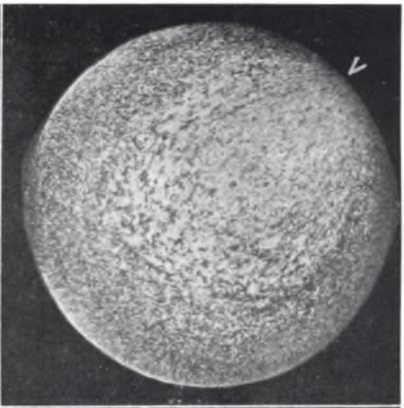


Fig. 7.
2-Hole.

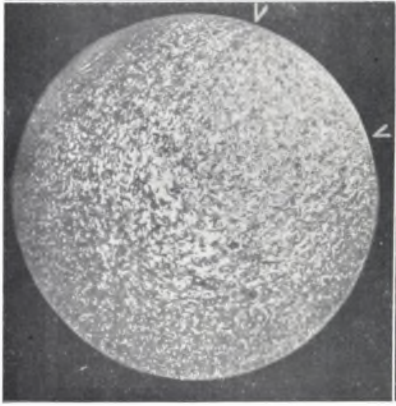


Fig. 8.
3-Hole.

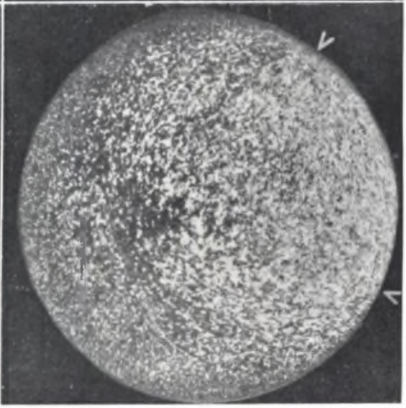


Fig. 9.
4-Hole.

Figs. 6–9.—BA 35 Bars Extruded Through 1- to 4-Hole Die Plates Similar to Those in Figs. 12–15.

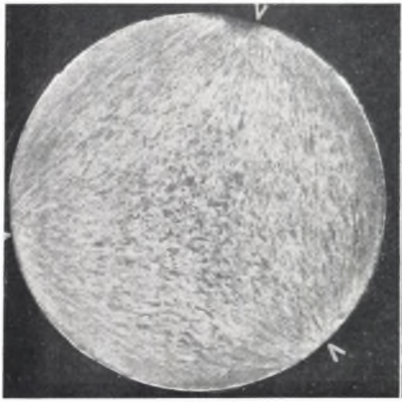


Fig. 10.

Centre Bar.

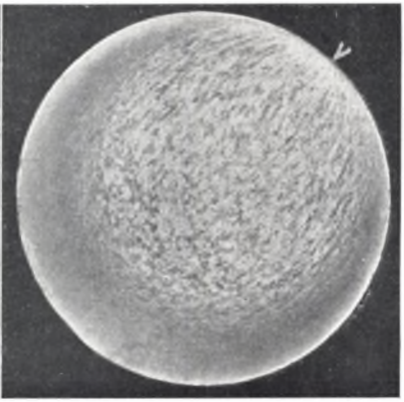


Fig. 11.

Outer Bar.

Figs. 10 and 11.—D.T.D. 423A Bars Extruded Through a 4-Hole Die Plate Similar to that in Fig. 17.

Extrusion of Plasticine Billets Through Various Die Plates.

Axial
Section of
Billet.

Plan View
of Die
Plate.

Axial
Section of
Rod.

Fig. 12.—1-Hole.

Fig. 13.—2-Hole.

Fig. 14.—3-Hole.

Fig. 15.—4-Hole.

PLATE XIII.

Extrusion of Plasticine Billets Through Modified Die Plates.

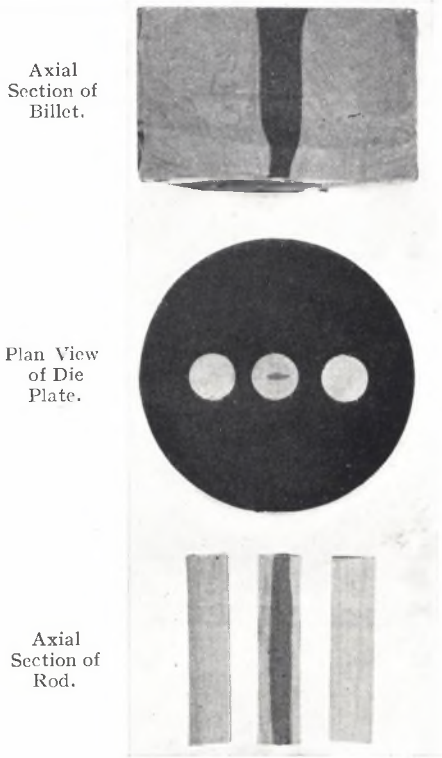


Fig. 16.—3-Hole with Central Hole.

Fig. 17.—4-Hole with Central Hole.

PLATE XIV.

superior to those from 2-hole bar, except for the fracture loads of the BA 35 rings.*

Out of 34 fractures through the radial flow, 25 were laminated, but all fractures which did not pass through the radial flow were fibrous.

5. *Tensile Tests on Circumference.*

Rings prepared as above from the 1-, 2-, and 4-hole bars in D.T.D. 423A alloy were cut through at one point, straightened out hot, and re-heat-treated (10 hr. at 525° C.; water quenched; aged for 12 hr. at 160°–170° C.). Straight tensile tests then measured the circumferential tensile properties of the outer layers of the original bar. By making the cut either through the radial flow position or diametrically opposite, the properties outside or inside the radial flow zone could be compared; average results are given in Table V.

TABLE V.—*Circumferential Tensile Tests* (0·1-*in. Square Bars of D.T.D.* 423A *Alloy*).

Specimen from	Radial Flow in Gauge-Length.	Ultimate Tensile Strength, tons/in.^{2}.	Elongation, %.	Type of Fracture.
1-Hole bar .	absent	24·3	9	fibrous
2-Hole bar	yes	22·9	4	laminated
	no	23·7	9	fibrous
4-Hole bar	yes	23·6	6	laminated
	no	24·6	10	fibrous

Two conclusions are obvious. Away from the radial flow position the circumferential properties of multi-hole die material are as good as those of single-hole die material, but in the radial flow position the properties, especially ductility, are inferior. In this position the 4-hole die material is superior to the 2-hole material. All fractures through the radial flow positions were laminated.

6. *Explanation of the Variation in Circumferential Properties of Multi-Hole Bars.*

The only peculiarities of the material in the radial flow position are the macrostructure (radial flow) and the segregate of intermetallic compounds near the surface; circumferential weakness in this position must consequently be explicable in terms of these two factors. Now the macrostructure was constant over long lengths of each bar, whereas

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* It is suspected, however, that the latter are affected by the possibility of breaking at either the " A " or " B " position since owing to the angular spread of the circumferential weakness in the 3- and 4-hole material (shown by the structures), with any given orientation, fracture has more chance of finding a weak spot.

the intensity of segregation varied, and a study of the circumferential properties showed that they also varied along the length of each bar. This is expressed in Table VI, in which are given the maximum and minimum values in the different tests and their ratios, including—for multi-hole material—only those tests where fracture occurred in the radial flow position. Results from 48 drift tests on finished components specially made from 1-, 2-, 3-, and 4-hole bars of BA 35 alloy are also included.

TABLE VI.—*Variation in Circumferential Properties.*

(For multi-hole material only, tests in which fracture occurred through the radial flow position are considered.)

Sample.		BA 35 Alloy.					D.T.D. 423A Alloy.			
		Ring Tests.		Drift Tests on Cylinders.		Drift Tests on Components.* Load, tons.	Ring Tests.		Drift Tests on Cylinders.	
		Load, lb.	Extn., %.	Load, ton.	Ductility, cm. Penetration.		Load, lb.	Extn., %.	Load. tons.	Ductility, cm. Penetration.
1-Hole bar	max.	1410	53	7·50	3·9	4·75	3850	21	4·84	2·2
	min.	970	50	3·02	1·7	3·25	3090	18	2·58	1·2
	ratio	1·43	1·06	2·5	2·3	1·4	1·2	1·2	1·9	1·8
2-Hole bar	max.	1260	50	2·62	1·7	3·45	2420	14	1·88	0·8
	min.	295	34	0·92	0·3	0·9	1660	3	1·86	0·5
	ratio	4·3	1·5	2·6	5·7	3·8	1·5	4·7	1·01	1·6
3-Hole bar	max.	1140	50	2·36	1·1	3·45	...	...	...	...
	min.	265	38	1·08	0·5	1·75	...	...	...	...
	ratio	4·2	1·3	2·2	2·2	2·0	...	...	...	...
4-Hole bar	max.	1100	49	3·77	1·8	3·15	2860	20	1·85	0·85
	min.	185	28	0·95	0·4	1·75	1660	8	1·65	0·6
	ratio	5·9	1·7	4·0	4·5	1·8	1·7	2·5	1·1	1·2

* Different samples from those covered by Table I, for which the individual extrusion practice was unknown.

In general, there is greater variability in multi-hole than in single-hole material, particularly with the BA 35 alloy, and this variability must therefore be due to the variation in segregation.

Table VI brings out the further point that, whereas in single-hole material the properties vary from moderate to good, for multi-hole material they vary from moderate to bad. Since, in an alloy free from an intergranular constituent, the tensile strength measured transversely across a columnar crystal aggregate is greater than that measured in the direction of growth,[1] the circumferential strength should be raised by the radial flow structure. On the other hand, the segregate would be expected to weaken the material. Consequently, both because the disturbing factor is erratic and because it weakens the material, the segregate must be held responsible for the variation in the circumferential properties of the multi-hole bars.

Micro-examination of multi-hole specimens showed a tendency for low loads to be associated with pronounced segregation of the particle constituents, but the correlation was not complete. This was not unexpected, since micro-examination covers only a two-dimensional surface whereas the mechanical properties are determined by the three-dimensional volume.

An opportunity to test the connection more conclusively and in the absence of the radial flow structure was provided, however, by the rear part of the smaller single-hole bar of BA 35 which, as previously mentioned, broke in the drift and ring tests at low loads, the fractures being mostly laminated. Micro-examination of these specimens revealed a dense longitudinal string of particles several inches long in the zone of fracture, but no radial flow. From an adjacent portion of the bar, two series of six rings were prepared of somewhat modified dimensions such that this segregate occurred close to the inside edge in one series, but in the other series the internal diameter was too great to include the segregate (the thickness of both series of rings being the same). Micro-examination after fracture confirmed that this intention was realized. For the tests, the rings were oriented so that the line of segregate was at the " A " position (see Table IV). Five of the six smaller rings broke at the segregate, the fracture being of the laminated type, but all six of the larger rings broke at the pin with a completely fibrous fracture. The fracture loads and ductilities of the smaller rings were much the more erratic :

	Loads, lb.		Extension, %.	
	Range.	Mean.	Range.	Mean.
Rings containing segregate .	175–1040*	845	30–54	46
Rings not containing segregate	910–1140	1070	48–59	56

* Or 1100 lb. if the ring which did not break in the segregate is included.

Bad segregation alone, without radial flow, can thus produce a drastic weakening of the material, confirming the previous conclusion that the surface segregate is the variable weakening influence in bars extruded through multi-hole dies.

7. *Depth of Circumferential Weakness.*

Tests on drift cylinders of different diameters, but of the same thickness, were made to discover how far below the surface of the bar the harmful effects of segregation were evident. Any multi-hole cylinder too small to include the surface segregate should have a bursting load equal to that of a single-hole cylinder of similar size. To avoid confusion in interpreting the results, it should be noted that in a homogeneous material, such as single-hole bar, the bursting load will decrease with decreasing cylinder diameter, since the maximum percentage circumferential extension increases for a given area of contact with the plug. Table VII shows results for 1-, 2-, and 4-hole bars of D.T.D. 423A alloy.

TABLE VII.—*Influence of Drift Cylinder Diameter on Bursting Load.*

Cylinders, all $\frac{1}{8}$ in. thick, from $1\frac{5}{16}$-in. dia. bar of D.T.D. 423A alloy.

Cylinder from	Load (tons) to Break Cylinders of Outside Diameters :				
	1·05 in.	1·12 in.	1·19 in.	1·25 in.	1·30 in.
1-Hole bar . .	1·4	2·3	2·15	4·0	3·0
2-Hole bar . .	1·0	1·05	0·8	0·85	0·9
4-Hole bar . .	1·25	1·25	1·3	1·6	1·7

Although the reduction in bursting load with diameter of single-hole cylinders is clearly shown, the relevant point is that with cylinders of 1·05 in. dia., multi-hole material has a breaking load almost as high as single-hole material. It will be seen that the weak zone penetrates to a depth of about $\frac{1}{8}$ in. below the surface and is more harmful in 2-hole than in 4-hole bar.

III.—EXPERIMENTAL EXTRUSION.

Laboratory experiments were made to investigate the process of extrusion flow more fully, with the final aim of eliminating any surface segregation in multi-hole bars.

In extrusion the type of flow is much the same for most metals and is unaltered by the temperature or rate of extrusion, although these, of course, affect the mechanical properties of the extruded rod. Composite billets of lead and bismuth, and later of differently coloured plasticine, were used. Both models gave the same results, so reference will be confined to the plasticine as the structures obtained could be readily photographed.

Billets $2\frac{1}{2}$ in. long by $1\frac{1}{2}$ in. dia. were prepared with a $\frac{1}{4}$-in. dia. cylindrical core of different colour extending the full length of the billet. These billets were then extruded through various dies containing from 1 to 4 holes, and the extruded rod and remaining unextruded part of the billet examined. Approximately 1 in. of the billet was left unextruded, and this portion was sectioned longitudinally; 1-in. lengths of the rods were also sectioned longitudinally in the same way as the billet and, finally, the rods were cut out flush with the face of the die and the die face, billet, and rods photographed (Figs. 12–15, Plate XIII).

Examination of the extruded rods showed that the size and shape of the portion from the core of the billet were the same over almost the full length of the rod; only at the front end of the rods was there any variation, a steady condition being reached within a few inches. With the 1-hole die, the central billet segregate was still central in the rod. With the multi-hole dies the billet segregate appeared near the surface of the rods, cutting through the surface at the position nearest the axis of the billet. Figs. 13–15 (Plate XIII) show that, as the number of die holes increases from 2 to 4, the segregate distribution changes from a radial to a peripheral form and, in addition, penetrates to a smaller depth below the surface of the bar. The segregate thus becomes more diffuse, and is likely to be less harmful in 4-hole than 2-hole bat. These results link up convincingly with the flow and segregation observed with the aluminium alloys.

Two other multi-hole die plates were tried with the plasticine model. The resultant photographs are reproduced in Figs. 16 and 17 (Plate XIV), which show the arrangement of holes. The significant feature is that one hole is central, and it is clear that the billet segregate is now concentrated in the core of the central rod. In this position it would be harmless for many applications and would be wholly removed in machining out hollow components.

This result prompted a similar experiment on an industrial scale, which was carried out by the Northern Aluminium Company, Ltd., using D.T.D. 423A alloy. A modified 4-hole die plate was used, similar to that in Fig. 17, i.e. 3 holes were at the corners of an equilateral triangle with the fourth hole in the centre. Lengths of the four $1\frac{5}{16}$-in. dia. bars extruded through this die plate were examined. A preliminary investigation showed the three outer bars to be similar, so a full examination was restricted to one outer bar and the central bar.

The macrostructures are shown in Figs. 10 and 11 (Plate XII), which reveal the radial flow structure in the expected positions. The microstructures, however, showed fewer intermetallic particles in these positions than in the previous multi-hole bars.

Drift tests were made on cylinders exactly as before with the following results:

Central hole bar . . .	2·1 tons bursting load.
Outer hole bar . . .	2·0 ,, ,, ,,

Comparison with Table III shows these results to be better than with the previous multi-hole material, but inferior to the single-hole material.

Tensile tests were also performed as before on sawn rings straightened out hot and heat-treated (1 hr. at 535° C., water quenched, and aged for 5 hr. at 160° C.). A $\frac{3}{4}$-in. gauge length of reduced section ($\frac{1}{8}$ in. × $\frac{1}{8}$ in.) was machined centrally to include the radial flow position in some specimens and exclude it in others. The results are given in Table VIII.

TABLE VIII.—*Circumferential Tensile Tests on Experimental Bars.*

D.T.D. 423A alloy extruded through die of type shown in Fig. 17 (Plate XIV). 0·125-in. square bars.

Bar.	Radial Flow in Gauge Length.	Ultimate Tensile Strength, tons/in.².	Elongation, %.	Type of Fracture.
Central	yes	24·9	8	laminated
	no	29·0	10	fibrous
Outer	yes	25·7	8	laminated
	no	26·3	10	fibrous

Comparison with Table V shows that the properties of these bars were more uniform around the circumference and were better in the radial flow position than the previous multi-hole bars. The properties in the radial flow position were, however, still inferior to those of the previous single-hole bar.

On the assumption that the billets extruded for this and the previous work were similar with regard to degree of casting segregation, this arrangement of holes in the die plate gives better circumferential properties than the usual one, although the improvement is not apparently as great as the plasticine model might indicate. The method is, however, considered promising.

IV.—CONCLUSIONS.

(1) The circumferential tensile properties of bar extruded through a die plate having a single central hole are superior to those of bar extruded through any multi-hole die plate.

(2) The explanation put forward is that the central segregate of the original billet remains central in the single-hole bar, but is extended radially and is displaced laterally to a position at the surface of multi-hole bars (Fig. 5, Plate XI), where, under circumferential strain, it causes laminated fracture after relatively small deformation.

(3) Extrusion through multi-hole dies causes radial extrusion flow (Figs. 7–11, Plate XII) at one or more positions on the circumference of

the bars, but this does not appear to be a serious matter in the absence of segregation.

(4) With multi-hole die plates, the holes are normally symmetrically disposed, but improvement is obtained by placing one hole at the centre of the die plate. The billet segregate then tends to be confined to the axis of the central bar.

(5) The structural features observed in the two aluminium alloys examined have been closely reproduced by materials having such different properties as lead–bismuth composites and plasticine, and should consequently apply generally to extruded materials.

ACKNOWLEDGEMENTS.

Thanks are due to the Northern Aluminium Company, Ltd., Banbury, and the British Aluminium Company, Ltd., Warrington, without whose co-operation the large-scale extrusion trials would not have been possible, and to Mr. S. Turner for help in the experimental work.

Permission to publish has been given by the Chief Scientist, Ministry of Supply.

REFERENCE.

1. L. Northcott, *J. Inst. Metals*, 1942, **68**, 189.

STRIATIONS: METALLOGRAPHIC EVIDENCE OF SLIP.*

By D. McLEAN,[†] B.Sc., Member.

Synopsis.

Regular criss-cross "striations" (Fig. 2, Plate XV) have been observed under the microscope in lightly deformed brass on sections electrolytically polished and suitably etched. It is shown that the "striations" are sections through glide planes that have slipped, and probably indicate non-uniform deformation on these planes. Failure to observe these markings before has probably been due to the imperfections of mechanical polishing.

I.—Introduction.

It is well known that slip lines can be seen on polished surfaces of a deformed metal if the metal is polished before deformation. Strain lines (Fig. 1, Plate XV) can also be seen on etched sections prepared after deformation when the deformation exceeds about 20%; the relation between strain lines and slip lines is uncertain. However, it seems to be believed that no evidence of slip or, indeed, of any microstructural change apart from slight elongation of the crystals, can be seen in a lightly deformed metal on a section polished and etched after deformation.[1, 2] This belief is shown in the present paper to be incorrect since markings which are evidence of slipped planes can be seen in brass when a suitable polishing and etching technique is adopted.

These markings differ observationally from strain lines (Figs. 1 and 12, Plates XV and XVI) in not being revealed by electrolytic etching, in being more numerous and practically straight, and, as appears later, in developing at much lower deformation.

Since the bulk of this research was completed, a paper by Jacquet[3] has been received describing, among other things, markings similar to those considered here and which Jacquet also ascribes to slip. The present paper gives further information on the nature of the markings, and deals mostly with brass instead of copper.

II.—Experimental.

The 70 : 30 brass used for this work was prepared from electrolytic copper and electrolytic zinc.

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* Manuscript received 5 June 1947.

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The criss-cross markings which are the subject of this paper are shown in Fig. 2 (Plate XV); they had previously been observed in electrolytically polished 70 : 30 brass after etching.[4] They are referred to subsequently as " striations ". They were revealed best by etching in alkaline copper ammonium chloride solution or in hot, very dilute orthophosphoric acid, poorly by etching in ammonium persulphate in ammonia solution, and not at all by electrolytic etching in the electrolytic-polishing solution of orthophosphoric acid.

After prolonged electrolytic polishing to remove a layer about $\frac{1}{4}$ mm. thick, the striations did not reappear on etching if the specimen had been furnace cooled, but sometimes did so if it had been water quenched. They sometimes did reappear, however, if the specimens were re-filed, polished, and etched, and could again be removed by prolonged polishing. This suggested that the striations were due to deformation during preparation and that this deformation penetrated to a depth of nearly $\frac{1}{4}$ mm.

After hand polishing instead of electrolytic polishing, the criss-cross pattern could only be detected in disordered fragments. It could be definitely observed under the microscope but did not reproduce well. The appearance differed from Fig. 2, much as a disorderly array of bricks differs from the regular array in a brick wall. It seems likely that this is evidence of the surface distortion produced by hand polishing.

1. *Connection Between Striations and Slip Lines.*

Small cubes (1 cm. side), ascertained to be free from striations, were polished, and reduced about 4% by cold hammering. Photographs of slip lines were taken at various positions. The surface was then electrolytically polished to a depth of 0·001 cm., etched, and the same positions re-examined. Compared with the number of slip lines, very few striations were found, but these were always parallel to the corresponding slip lines, and where they were few enough to be picked out individually, were the same distance apart as certain of the slip lines (see Figs. 3 and 4, Plate XV).

These specimens were reduced an additional 4% and the same fields re-examined without further preparation. In all fields, some lines parallel to the striations now stood out far more prominently. Fig, 5 (Plate XV) shows the original striations in one field, and Fig. 6 (Plate XV) is a photograph under the interference microscope of the same field after the further cold work. The sharp steps in the interference fringes at the prominent lines show that further slip has occurred there, for before the extra deformation the interference fringes were smooth at these points. The further slip has occurred on planes parallel to the striations.

From the foregoing it is concluded that striations mark the intersection of the polished surface with slip planes, and probably are thin regions along those that have actually slipped.

2. *Connection Between Striations and General Deformation.*

(*a*) Several cubes were annealed, furnace cooled, and reduced in thickness 2, 4, 8, 16, and 30% respectively by cold hammering. These samples, together with one unworked cube, were electrolytically polished, a layer ¼ mm. thick being removed to exclude surface deformation, and then etched. No striations were found in the undeformed specimen, but some were visible in the one deformed 2%, and their intensity and regularity increased to a maximum in the specimens deformed 4 and 8%; the striations were less distinct in the specimens deformed 16 and 30%, in which there were also strain lines.

(*b*) In a second experiment, a tapered specimen annealed and furnace cooled, was electrolytically polished and loaded in tension so as to produce 40% permanent elongation at the narrow end but none at the wide end. Transverse scribed lines permitted elongation determinations. The polished surface was then examined for slip lines, and a longitudinal section, after electrolytic polishing and suitable etching, for striations. Photographs of the latter are reproduced in Figs. 8–11 (Plate XVI). Starting at the wide end and moving towards the narrow end, neither slip lines nor striations were found in the undeformed region, Fig. 8. They were both first detected at the same point along the length of the specimen in the region of ¼% elongation (Fig. 9) : the striations were short wisps projecting from the crystal boundaries, whereas the slip lines extended across entire crystals. With increasing deformation, each striation became more complete but never seemed to traverse an entire crystal, and more striations appeared, at first parallel to the original ones, but later, at about 3% elongation and coincident with the appearance on the polished exterior surface of a second set of slip lines, in another direction (Fig. 10). The second set became complete in a small proportion of crystals at 9% elongation (Fig. 11), coincident with the completion of the second set of slip lines in a similar small proportion of crystals. At higher deformation, a third set of slip lines and striations formed, and some striations became more prominent and curved.

These experiments confirm that striations are caused by deformation and that they are connected with slip. The growing prominence and continuity with increasing deformation up to 9% is ascribed to repeated slip on the same plane.* For any degree of deformation, visible slip lines are much more numerous than striations.

3. *Connection Between Striations and Strain Lines.*

In the tapered tensile specimen, some striations became more prominent and curved with increasing deformation until they were ordinary strain lines; the structure in Fig. 11 gave way to that in Fig. 12 (Plate XVI). Definite strain lines were first seen at about 15% elongation. Examination of the cube deformed 30% showed no definite strain lines parallel to striations, but some instances were found of strain lines in one direction superimposed on a background of striations in two other directions. These might have been the remains of a third set of striations in the direction of the strain lines, but it is surprising that no other trace of such a set could be seen. The evidence about the connection between striations and strain lines is thus inconclusive, but the most likely hypothesis is that strain lines are an extreme form of striation, the atomic misalignment having become sufficient for the lines to be easily revealed by etching, and enough slip in other directions having occurred for the lines to be curved.

4. *Connection Between Striations and Crystallographic Orientation of the Plane of Polish.*

In all specimens examined and at all deformations some crystals could be seen containing no striations, although on the polished surface no crystals were free from slip lines at high deformation. Whether striations are revealed or not may depend on the crystallographic orientation of the plane of polish. It is perhaps significant that in Figs. 10 and 11 (Plate XVI), which were chosen at random, the angle between the two sets of striations is close to 60°. Since the slip planes of brass are the (111) planes, this angle would be obtained by sectioning along another (111) plane. Examination of other examples of two sets of striations showed a marked tendency for the angle of intersection to be close to 60°, 90°, or to be between 68° and 78°. These angles would be obtained by sectioning approximately along (111) (60°), (100) (90°), or (110) (71°) planes, respectively. It is possible, therefore, that only these planes etch suitably to reveal striations.

5. *Striations in Alloys Other than* 70 : 30 *Brass.*

Jacquet has observed similar markings in copper, as mentioned,[3] although in the present work they were not revealed in copper by a

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* i.e. the same plane within the limit of resolution by the microscope.

PLATE XV.

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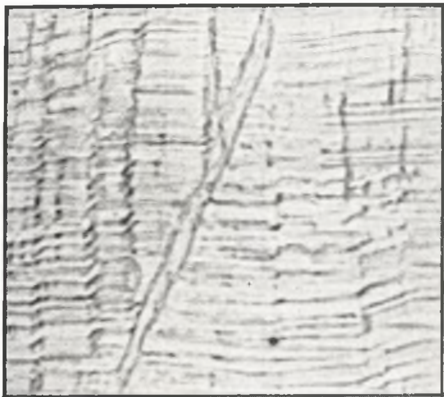

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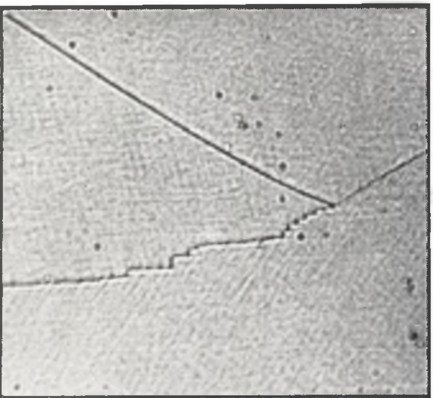

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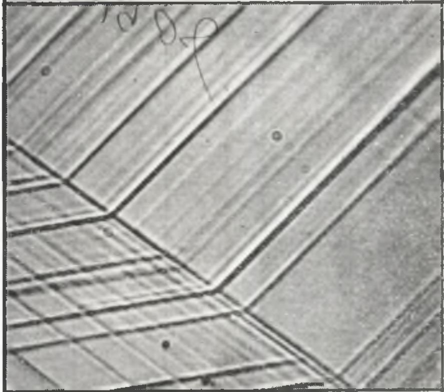

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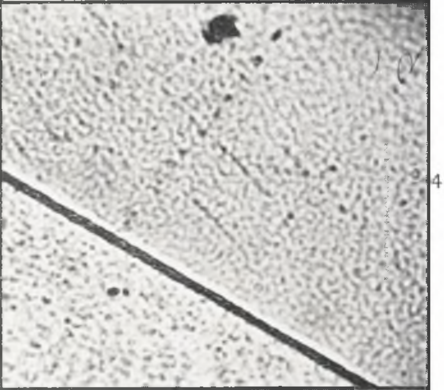

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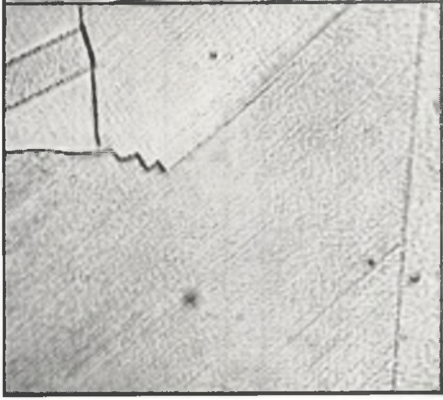

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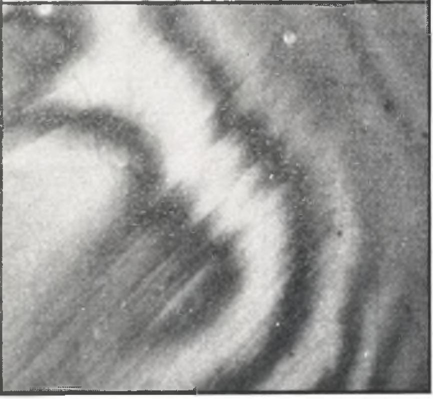
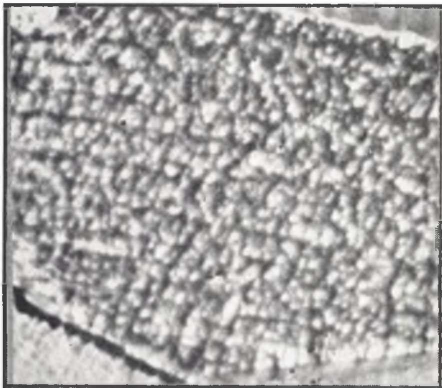


70 : 30 Brass.

FIG. 1.—Strain lines after 40% cold rolling, electrolytically etched. × 2000.
FIG. 2.—Striations after superficial deformation during preparation. × 750.
FIG. 3.—Slip lines after 4% deformation. × 1000.
FIG. 4.—Same area as Fig. 3, polished and etched, showing striations parallel to slip lines of Fig. 3. × 1000.
FIG. 5.—Striations after 4% deformation. × 1000.
FIG. 6.—Same area as Fig. 5 after further 4% deformation, under interference microscope. Slip lines parallel to striations of Fig. 5. × 1000.

[*To face p.* 98.

7



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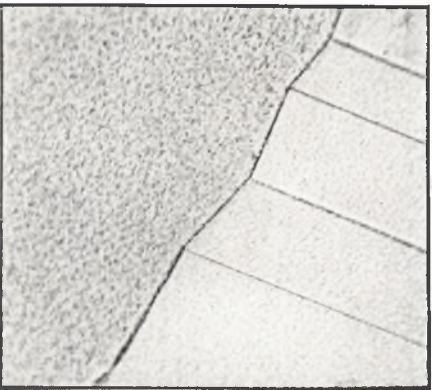

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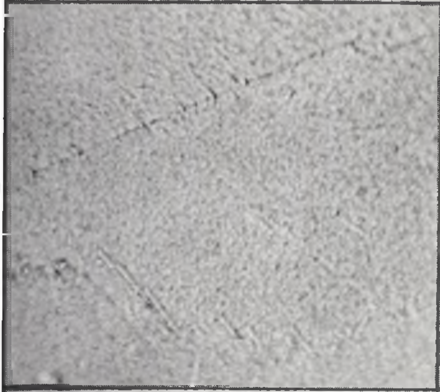

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12

70 : 30 Brass.

FIG. 7.—Striations after 8% deformation. Electron-microscope reproduction. × 7500.

FIGS. 8–12.—Striations in tapered tensile specimen. × 1250.

FIG. 8.—0% elongation. FIG. 9.—$\frac{1}{4}$% elongation. FIG. 10.—3% elongation.
FIG. 11.—9% elongation. FIG. 12.—35% elongation.

copper ammonium chloride etch. Nor could they be detected in zinc (99·99% pure), although several reagents were tried. They were, however, very prominent in copper–tin and were more prominent in antimonial 70 : 30 brass than in pure brass.

A range of brasses was examined. Alloys of nominal copper : zinc ratios of 90 : 10, 80 : 20, 70 : 30, and 60 : 40 were cast and forged. Annealed and furnace-cooled specimens ascertained to be free from striations were reduced about 4% by hammering, and polished. After etching in copper ammonium chloride solution, striations were much more prominent in the 60 : 40 alloy than in the 70 : 30, and faded with increasing copper content to become invisible with 90%. After repolishing and etching in hot dilute orthophosphoric acid, the position was approximately reversed; striations were more prominent in the 90 : 10 alloy than in the 60 : 40.

III.—NATURE OF STRIATIONS.

An electron-microscope photograph (Fig. 7, Plate XVI) of a 70 : 30 brass deformed 8% shows more detail than the optical-microscope photographs. The heavy striations are presumably those observed with the optical microscope; in addition many finer ones can be seen. The average fine spacing is about 0·2 μ, which is the order of magnitude usually given for mosaic blocks. Bearing in mind also the cellular structure in Fig. 7, it may therefore be that striations represent a row of mosaic junctions, coinciding with slip planes, which for some reason etch heavily.

The most probable reason is the setting up of strain by the slip, but there are two other possible reasons : (*a*) the existence of composition fluctuations similar to those found by Daniel and Lipson,[5] and (*b*) precipitation of β-brass along slip planes. (*a*) was tested by preparing two further tapered tensile specimens, annealing at 750° C., furnace-cooling one and water-quenching the other, and then proceeding as described in an earlier section. The incidence of striations was the same in both specimens. Since the 750° C. anneal would be expected to obliterate at least partially any composition fluctuation, and since this obliterated state would have been retained in the water-quenched specimen, it seems reasonable to conclude that (*a*) does not apply. Consideration of the results obtained with the brasses of 90 : 10 to 60 : 40 copper : zinc ratio, described in the preceding section, suggests that (*b*) does not apply either; for if it did, the striations would be at least as prominent in 90 : 10 as in 60 : 40 brass with both of the etching reagents tried, because of the greater difference between ground-mass and precipitate in the former alloy. It is therefore concluded that striations are probably regions of strain.

The first signs of striations appear at grain boundaries (Fig. 9, Plate XVI). This is to be expected, since slip in the adjoining crystal combined with grain-boundary irregularity presumably reduces the likelihood of atoms in the slipped plane near the grain boundary gaining correct lattice positions at the end of glide, so that the lattice becomes strained in these regions sooner than elsewhere.

Presumably the regions of strain revealed by striations account for some of the work-hardening during deformation. Since the striations are patchy, it follows that work-hardening of a given slipped plane is non-uniform over the area of the plane; and since the striations become longer and more pronounced with increasing external deformation, within limits, it seems reasonable to conclude that, when a plane that has already slipped slips again,* fresh areas of it are work-hardened. Repeated slip on the same plane * seems to occur without any obvious limit, but, since striations appear never to traverse an entire crystal, apparently does not succeed in work-hardening the entire plane.

ACKNOWLEDGEMENTS.

The author is indebted to Dr. L. Northcott for his encouragement and to Mr. F. W. Cuckow, National Physical Laboratory, for the electron-microscope photograph. Permission to publish has been granted by the Chief Scientist, Ministry of Supply.

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* i.e. the same plane within the limit of discernment of the microscope.

METALLURGICAL ABSTRACTS

AUTHOR INDEX TO ABSTRACTS

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METALLURGICAL ABSTRACTS

(GENERAL AND NON-FERROUS)

Volume 15 OCTOBER 1947 Part 2

I.—PROPERTIES OF METALS

***The Effect of Working on the Physical Properties of Molybdenum.** J. W. Marden and D. M. Wroughton (*Trans. Electrochem. Soc.*, 1946, **89**, 217–224; discussion, 225–228).—Properties of molybdenum after varying amounts of working are recorded in graphs, from which the following ranges have been taken: density, 9·8 for heat-treated ingot up to about 10·4 when reduced in cross-section from about 0·5 to 0·0001 in.^{2}; V.P.N. hardness, about 170 for ingot 1 in. thick to about 270 for sheet and wire about 0·02 in. thick; ultimate tensile strength, about 50,000 lb./in.^{2} for unworked metal to about 200,000 lb./in.^{2} for the finest wire or thinnest sheet; and elongation on 2-in. test length, a few per cent. to an average of about 17% (with lowest values of about 7% and highest of 50%) for the thinnest wires and sheets. Molybdenum with V.P.N. hardness of about 230 at room temp. showed a progressive decrease to about 100 at 1200° C. Hardness and bend tests on material annealed at various temp. showed that loss of hardness began at about 1000° C. and was rapid at 1200° C.—A. B. W.

***The Influence of Crystal Face on the Electrochemical Properties of a Single Crystal of Copper.** (Leidheiser and Gwathmey). See p. 47.

***Influence of Strain Rate and Temperature on the Mechanical Properties of Monel Metal and Copper.** (McAdam, Geil, and Woodard). See p. 35.

†The Separation of Gases from Molten Metals. Albert J. Phillips (*Metals Technol.*, 1947, **14**, (4); *A.I.M.M.E. Tech. Publ.* No. **2208**, 30 pp.).—The 26th Annual Institute of Metals Division Lecture of the A.I.M.M.E. The general principles underlying the absorption and evolution of gases from solid and liquid metals, and during the process of solidification, are outlined. The cases of oxygen, hydrogen, steam, sulphur dioxide, and carbon dioxide are discussed, and their effects in the solidification of copper are described in detail. The effects of each gas alone are discussed, and then their effects when present as binary or ternary combinations. The bearing of the results on copper-refining practice is then indicated, and a number of interesting conclusions and generalizations are reached. The author also deals with gases in brasses, bronzes, silver, silver alloys, and iron. The lecture gives an excellent review of one class of work, and shows the way in which the results may be applied.—W. H.-R.

Effect of Prior Tensile Strain on Fracture. Edward Saibel (*Metals Technol.*, 1947, **14**, (4); *A.I.M.M.E. Tech. Publ.* No. **2186**, 8 pp.).—Theoretical. In the thermodynamic theory of the fracture of metals (Saibel, *A.I.M.M.E. Tech. Publ.* No. **2131**; see *Met. Abs.*, 1947, **14**, 359), it was shown that a critical strain energy per unit vol. exists which is characteristic of the material and may be calculated from basic thermodynamic theory. According to Ludwig ("Elemente der Technologischen Mechanik", Berlin: **1909**), a material has two fundamental properties: (1) a resistance to flow and (2) a resistance to fracture. These ideas are used to analyse the method in which specimens are strained to varying degrees at room temp. and then pulled to fracture at a lower temp. The theory is in general agreement with the variation of fracture strength with prior tensile strain.—W. H.-R.

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* Denotes a paper describing the results of original research.

† Denotes a first-class critical review.

The Plasticity of Brittle Materials. —— (*Indust. Diamond Rev.*, 1946, [N.S.], **6**, (72), 339–344).—A summary of E. Ryschkewitsch, *Ber. deut. keram. Ges.*, 1941, **22**, 54, 363; and *Glastechn. Ber.*, 1942, **20**, 166.—R. W. R.

Friction and Lubrication. E. V. Paterson (*Mech. World*, 1947, **122**, (3157), 67–71).—P. describes the fundamental laws of solid, boundary, and fluid friction and current theories of lubrication, with particular reference to journal bearings. A discussion of bearing materials is included.—R. W. R.

A Comparison of the Mechanical Properties of Wood and Metals. —— (*Usine Nouvelle*, 1947, **3**, (4), 12).

II.—PROPERTIES OF ALLOYS

***Curved [Aluminium] Plates [Tested] in Compression.** —— (*Rep. Nat. Research Council Canada*, No. **MM180**; and (summary) *Aircraft Eng.*, 1947, **19**, (221), 230).—Tests on 155 curved and 24 flat aluminium plates were carried out; from the results empirical equations for critical buckling stress, reduced buckling stress after loads exceeding the initial buckling stress, and post-buckling behaviour or effective width are derived. These equations are compared with equations derived by other investigators. Modifications in testing technique and specimen dimensions are discussed.—J. L. T.

***Thermodynamic Activities and Diffusion in Metallic Solid Solutions.** C. Ernest Birchenall and Robert F. Mehl (*Metals Technol.*, 1947, **14**, (4); *A.I.M.M.E. Tech. Publ.* No. **2168**, 16 pp.).—Previous data on the vapour pressure of zinc in copper–zinc alloys at different temp. are used to deduce the activities and activity coeff. of zinc and copper in these alloys. The results are presented graphically and in the form of tables. Application of diffusion laws in the customary form to diffusion phenomena in alloys has shown that the diffusion constant varies with composition in all cases. The question arises as to whether the diffusion coeff. would become a constant, independent of concentration throughout a single phase if the concentration gradient in the diffusion equation were replaced by an activity gradient. The activities determined as described above are applied to previous data on diffusion in copper–zinc and iron–carbon alloys, and it is concluded that activity is more fundamental than concentration in the process of diffusion. The driving force is provided by a difference in free energy. The process of diffusion is examined in detail on these lines, and it is concluded that in binary substitutional solid solutions the results agree better with a direct exchange of atoms on adjacent lattice points, than with a process involving hole-diffusion mechanism. In general, chemical and radio-active methods for determining diffusion rates in substitutional solid solutions will not measure the same process.—W. H.-R.

***Interaction and Structure in Copper–Zinc Alloys.** C. Ernest Birchenall (*Metals Technol.*, 1947, **14**, (4); *A.I.M.M.E. Tech. Publ.* No. **2169**, 8 pp.).—The work of Birchenall and Mehl (see preceding abstract) indicates that, in so far as it is justifiable to speak of bond strengths between adjacent atoms in an alloy, the Cu–Zn bond is stronger than the Cu–Cu or Zn–Zn bonds, the last named being the weakest of the three. Assuming that this order of stability is the same in the different phases of the copper–zinc system, the stable phase should be that which provides for the greatest ratio of Cu–Zn to Zn–Zn pairs. At 50 at.-% zinc, the body-centred cubic lattice fulfils this condition with respect to the face-centred cubic lattice, while at a composition Cu_5Zn_8 the ordered γ-phase satisfies this condition better than the body-centred cubic phase.—W. H.-R.

Corrosion-Resistant [Hastelloy] Alloys. —— (*Steel*, 1946, **119**, (5), 70–75, 112).—The corrosion-resistance and working properties of four "Hastelloy" nickel-base alloys (exact composition unstated) are described. Recommended machining speeds and feeds and abrasives for grinding are given.—M. A. V.

Magnesium and Magnesium Alloys. Allen G. Gray (*Steel*, 1946, **119**, (17), 92–96, 112, 115, 116).—Magnesium alloys are described and the composition and properties of the commoner alloys tabulated. Capacities and production data and costs at a number of plants are given. Applications, and factors of importance to the designer are reviewed.—M. A. V.

***Rates of High-Temperature Oxidation of Magnesium and Magnesium Alloys.** T. E. Leontis and F. N. Rhines (*Metallurgia*, 1947, **36**, (213), 171).—Abridged from *Metals Technol.*, 1946, **13**, (4); see *Met. Abs.*, 1946, **13**, 350.—J. L. T.

***Influence of Strain Rate and Temperature on the Mechanical Properties of Monel Metal and Copper.** D. J. McAdam, Jr., G. W. Geil, and D. H. Woodard (*Amer. Soc. Test. Mat. Preprint*, 1946, (**54**), 49 pp.).—The conditions which may cause failure by intercrystalline cracking at the commencement of the third stage of creep are (contrary to the prevailing view) a sufficiently low rate of straining or a high testing temp. In a normal test, the creep rate increases in the third stage of creep owing to necking of the specimen. The result is that ductility increases, it being considered that then "the increase in the technical cohesive strength with the strain rate is rather greater than the increase in the flow rate". The effects of creep rate and temp. were studied by creep tests on cold-drawn Monel metal at 700°–1000° F. (370°–538° C.) and on cold-rolled, oxygen-free copper at 110°–375° F. (43°–191° C.), the strain rate being maintained approx. const. by repeatedly decreasing the load. By combining the results with previously published data, curves are derived showing the influence of temp. and strain rate on the strength and ductility of the metals over the whole range from −100° C. to the m.p.—J. C. C.

***Graphite Formation in Cast Irons and in Nickel–Carbon and Cobalt–Carbon Alloys.** H. Morrogh and W. J. Williams (*J. Iron Steel Inst.*, 1947, **155**, (3), 321–371; and *Iron and Steel*, 1947, **20**, (6), 241–257; discussion, 288–289).—The first part of this paper is mainly a critical review, at considerable length, of published information on the metallography and mechanism of solidification of cast irons, with particular reference to the mode of formation of the graphite; current theories are discussed in some detail. This section also contains a number of experimental observations made by the authors; it is shown that the graphite-refining action of titanium and zirconium is due to the presence of carbides of these elements, and the existence of two different kinds of inverse chill is demonstrated. The experimental work reported in the succeeding sections is concerned with the systems nickel–carbon and cobalt–carbon and the analogy between these and the iron–carbon–silicon system. Graphite formation in these systems was studied microscopically and by thermal analysis, and the structures of hypo- and hyper-eutectic alloys were shown to be closely similar to those obtaining in cast irons; graphite structures of both the normal flake and undercooled varieties were obtained, the eutectic temp. of the former being higher than that of the latter. The existence of the carbides Ni_3C and Co_3C was demonstrated. When eutectic and hyper-eutectic alloys in these systems solidify normally, coarse graphite separates directly from the melt and a eutectic of graphite and solid solution results, but if solidification is accompanied by undercooling, a eutectic of solid solution and carbide is formed which subsequently decomposes, yielding a fine dispersed eutectic structure of graphite in solid solution. The presence of sulphur in the alloys tends to prevent the formation of undercooled structures. The alloys are susceptible to inoculation by graphite. Spherulitic graphite is formed during the solidification of these alloys when calcium or magnesium is present; like undercooled graphite, such structures are thought to be formed by decomposition of the carbide, the effect of the calcium and magnesium being partially to suppress the transformation, which then takes place at lower temp., yielding spherulitic instead of undercooled graphite. Spherulitic structures are more easily produced in nickel–carbon alloys than in cobalt–carbon alloys; in the former they may be produced by rapid cooling. The authors confirmed the findings of Eash that undercooled structures in cast iron result from transformation of carbide eutectic. When specimens, 5–7 g. in weight, of irons which normally yield undercooled structures, were quenched immediately after solidification was complete, white-iron structures were obtained; the structure obtained in this way differed from a normal white-iron structure in that the carbide was plate-like. Spherulitic structures may, in certain conditions, be produced in cast irons without heat-treatment. Variations between the different systems, in the ease with which spherulitic structures may be produced, are ascribed to differences in the persistence of the carbides, Fe_3C being most and Ni_3C least persistent. A general discussion of undercooling phenomena is presented. Undercooling in cast irons, nickel–carbon, and cobalt–carbon alloys is compared with that occurring in modified aluminium–silicon alloys, and reference is made to the existence of metastable eutectics in the systems zinc–antimony, cadmium–arsenic, and iron–phosphorus, due to the suppression of peritectic reactions.—R. W. R.

***Thermodynamic Studies of Dilute Solutions in Molten Binary [Tin] Alloys.** John A. Yanko, A. E. Drake, and Frank Hovorka (*Trans. Electrochem. Soc.*, 1946, **89**, 357–371; discussion, 371–372).—See *Met. Abs.*, 1946, **13**, 248.

III.—STRUCTURE

(Metallography; Macrography; Crystal Structure.)

[For all abstracts on the constitution of alloy systems, including X-ray studies, see II.—Properties of Alloys.]

***X-Ray Studies of the Superficial Deformation of Single Crystals of Iron and Aluminium by Mechanical Polishing.** Jacques Bénard and Paul Lacombe (*Métaux et Corrosion*, 1946, **21**, (246), 30–31).—A note to the Académie des Sciences. The structure of single crystals of iron and aluminium after abrasion with No. 2 emery (5–10 μ grain-size) has been investigated, using the back-reflection technique, both directly and after removal of 20 μ and 60 μ layers by electrolytic polishing. The abraded surfaces gave diffraction rings indicating random orientation of crystal fragments, while at an intermediate depth the rings were incomplete, indicating a degree of preferred orientation. At greater depths from the surface, the Laue spots became progressively clearer, corresponding to the underlying crystal. The preferred orientation observed seemed principally related to the orientation of the underlying crystal and not to be influenced by the direction of abrasion.—A. B. W.

Back-Reflection Diagrams in X-Ray Crystallography, Technique and Applications. Jacques Bénard (*Métaux et Corrosion*, 1946, **21**, (247), 33–40).—The principles and advantages of the high-angle, back-reflection method with a calibration substance are briefly explained; suitable cameras are described and a number of examples of applications given. The latter include the determination of lattice parameters in solid solutions and the study of their variation in diffusion layers, and the study of superficial deformation caused by abrasion (see preceding abstract).—A. B. W.

***Interaction and Structure in Copper–Zinc Alloys.** (Birchenall). See p. 34.

***A New Method for Making Rapid and Accurate Estimates of Grain-Size.** Frederick C. Hull (*Metals Technol.*, 1947, **14**, (4); *A.I.M.M.E. Tech. Publ.* No. **2160**, 13 pp.).—The method is based upon a comparison of the image of the sample on the ground-glass plate of a metallograph with a grain-size standard transparency illuminated by transmitted light. The magnification of the image is varied by altering the extension of the bellows of the metallograph until the grain-sizes of the standard and of the specimen appear identical. This is more rapid than methods involving the taking of photographs, and is more accurate than methods in which an image is compared with standard photographic prints. Various other methods of measuring grain-sizes are described, and their errors are discussed.—W. H.-R.

The Diffraction of Electrons and Its Applications. J. J. Trillat (*Experientia*, 1947, **3**, (3), 85–95).—[In French]. The theory and technique of electron-diffraction methods are outlined. The application of this technique in the following fields is described: determination of crystalline structure and its modifications, and the study of deposited metals, superficial oxidation and adsorption, polished surfaces and the surface state, fatty substances and their application to lubrication, physico-chemical phenomena, and the internal structure of gaseous molecules.—S. J. K.

Conference on Industrial Applications of X-Rays, Prague, December 1945. J. Bénard (*Métaux et Corrosion*, 1946, **21**, (246), 25–27).—A brief review of the proceedings. The greater part of the conference was devoted to the consideration of applications to metals. Synopses of communications are given under these heads: deformation, precision determinations of parameters, identification of constituents of a mixture, and radiography.—A. B. W.

Determination of the Size of Sub-Microscopic Particles by X-Rays. A. Guinier (*U.S. Bur. Mines Inform. Circ.*, 1946, (**7391**), 17 pp.).—Translated from *J. Chim. Phys.*, 1943, **40**, 133.—J. L. T.

Applied Photography. George A. Jones (*Discovery*, 1947, **8**, (6), 184–188).—Among the uses of photography demonstrated at the Exhibition of Applied Photography recently held in London by Kodak, Ltd., were the reproduction of line drawings on sensitized metal, photo-elastic analysis for analysing stresses, and electron and X-ray diffraction.—J. L. T.

V.—POWDER METALLURGY

Carbides in Powder Metallurgy. James R. Longwell (*Steel*, 1946, **119**, (23), 130, 132, 159–160, 162).—The properties of parts made from hard metal carbides with metallic binders are summarized.—M. A. V.

Germans Failed in Search for Sintered Carbide Substitute. H. Crump (*Indust. Diamond Rev.*, 1946, [N.S.], **6**, (68), 205).—A summary of *Product. Eng. and Management*, 1945, **16**, 122; and *Chem. Age*, 1945, **53**, 577.
—R. W. R.

Copper-Base Powder-Metallurgy Parts. Herbert Chase (*Materials and Methods*, 1946, **24**, (6), 1439–1444).—Small machine parts are now made from porous bronzes, as well as bearings, flame arresters, and diffusers. Copper and brass powders are also used commercially. Some applications are described and illustrated.—J. C. C.

A Challenge: Powder Metallurgy. A. J. Langhammer (*Modern Metals*, 1947, **3**, (5), 13).—In L.'s opinion, progress in the powder metallurgy of aluminium will be impeded until an oxide-free powder has been produced.
—N. B. V.

VI.—CORROSION AND RELATED PHENOMENA

***Some Aspects of the Corrosion of Aluminium.** P. F. Thompson (*J. Council Sci. Indust. Research, Australia,* 1946, **19,** (2), 157–165).—Isothermal time–potential and also temp.–potential curves of aluminium micro-electrodes (0·05 mm.^{2}) immersed in various neutral glycol–water coolants are reported and discussed in relation to corrosion behaviour. Potentials of −1·18 and −1·31 V. on the saturated calomel scale have been observed during abrasion in such solutions, while the limiting potential necessary to produce hydrogen bubbles on aluminium is estimated at −0·96 V. In confirmation, hydrogen-bubble evolution has been observed with the microscope, at scratches during abrasion and for a few seconds afterwards, on aluminium surfaces immersed in neutral solutions.—A. B. W.

***Corrosion Tests of Multi-Arc-Welded High-Strength Aluminium Alloys [24S and 75S].** Loren W. Smith (*Trans. Electrochem. Soc.*, 1946, **89,** 83–103; discussion, 103).—Investigations are reported on the corrosion-resistance of welded aluminium alloys 24S (copper 4·2; manganese 0·6; magnesium, iron, silicon 1·5; and aluminium 93·7%) and 75S (zinc 5·5, magnesium 2·5, copper 1·6, chromium 0·27, manganese 0·20, and aluminium 89·93%), both with and without aluminium cladding. Bare alloy is susceptible to intergranular corrosion to a very marked degree in the as-welded condition, on either side of the weld bead. Heat-treated welds offer increased resistance to intergranular corrosion tests, but the overheated zone cannot be restored to the condition of the parent sheet by heat-treatment. Aluminium cladding protects the alloys very effectively. The rate of corrosion for Alclad 24S welded specimens is not greatly accelerated by the application of high stresses. With welded Alclad 75S in the heat-treated condition, stress-corrosion cracking was observed in chromic acid + sodium chloride + dichromate solution, but not in boiling 6% sodium chloride solution. Further laboratory work correlated with field-service data appears to be necessary.—A. B. W.

***Corrosion Studies on Electrolytic Chromium.** Norman Hackerman and Donald I. Marshall (*Trans. Electrochem. Soc.*, 1946, **89,** 195–204; discussion, 204–205).—See *Met. Abs.*, 1946, **13,** 252.

***Corrosion of Metals. Metals in Aircraft-Engine Cooling Systems [Copper, Iron, Aluminium].** P. F. Thompson (*Australian Council for Aeronautics, Report* No. **ACA24,** 1946, 54 pp.).—The mechanism of corrosion is described. The addition of triethanolamine phosphate (T.E.A.P.) to glycol renders it conducting; also, a condensation process occurs, producing a caramel-like substance. Pure de-aerated glycol has no effect on copper, iron, or aluminium (even at 170° C.), but aeration produces attack in the cold on copper and iron, in spite of the addition of T.E.A.P. Sodium mercaptobenzothiazole serves to inhibit the inhibitor T.E.A.P., and the addition of sulphonated oils is not really effective. A detailed study has been made of the corrosion of copper, iron, and aluminium, using small electrodes (0·05 mm.^{2} in area). *Copper:* the addition of T.E.A.P. to glycol results in complex ion formation and subsequent deposition of the copper elsewhere with consequent corrosion. The fact that glycol is hygroscopic ensures the presence of water. *Iron:* T.E.A.P. has no marked effect on the corrosion of iron in glycol solutions. It takes some time for a cathodic film to be built up on an iron surface. *Aluminium:* A more detailed study has been made in this case, including continuous abrasion of the surface produced by adding an abrasive powder to the liquid and passing a gas through it to secure the necessary scouring action. The existence of two potential–temp. zones is indicated, corresponding to stabilized and unstabilized films, the former calling for considerable abrasive action to expose a fresh surface. These two types of film may correspond to a different degree of hydration or involve the formation of a peroxide.—S. J. K.

A Review of Factors Affecting the Corrosion of Iron and Steel Used in Building. David W. James-Carrington (*Structural Eng.*, 1946, **24**, (9), 449–499).—The practically most important results of investigations of atmospheric corrosion and its mechanism, as well as combative measures at present available, are effectively reviewed.—A. B. W.

***Corrosion-Resistance of Magnesium and Certain of Its Alloys Under Various Accelerated Atmospheric Conditions.** R. R. Rogers, D. A. Tetu, and H. Livingstone (*Electrochem. Soc. Preprint* No. **90–25**, 1946, 315–322; and (summary) *Metal Ind.*, 1947, **70**, (1), 9–10).—Investigations of the corrosion-resistance of commercially pure magnesium and of the magnesium alloys AZ31X, AZ61X, and M-1 are reported. Accelerated tests were used, representative of the following conditions: (1) inland indoor atmospheric, (2) inland outdoor atmospheric, and (3) marine atmospheric. The accelerated corrosion procedures used were: (1) humidity cabinet with 100% relative humidity at 49° ± 1° C. and with air circulation, for 70 days, (2) exposure to ordinary air at about 38° C. in the radiation from an arc, with 3 min. tap-water spray out of every 20 min. throughout the test of 40 days actual running time, and (3) salt-spray cabinet at 35° ± 1·5° C. with 20% sodium chloride solution, maintained at *p*H 6·8–7·1, used for the spray, this test lasting from 24 to 60 days according to corrosion-resistance. The results indicate good resistance to corrosion in the first two conditions, but much less resistance in the third. It is pointed out that resistance to marine conditions should be satisfactory for most of these materials when properly protected with paint.—A. B. W.

***Tin–Zinc Coatings [Corrosion Properties].** —— (*Tin and its Uses*, 1946, (**17**), 5–8, 14).—Corrosion tests in salt spray, humidity chamber, and out-door exposure of tin–zinc, tin, zinc, and cadmium coatings of various thicknesses on mild steel are compared. The tin–zinc coatings showed outstanding corrosion-resistance, as is clearly apparent in colour reproductions of the test series. Two compositions are particularly attractive, the 80% tin–20% zinc, which has been applied to steel chassis of radio sets, and the 50% tin–50% zinc, which is preferable when a considerable degree of sacrificial action is desirable, as when a coating is required to withstand mechanical damage. Both alloys are easily solderable. Other possible applications are also envisaged, such as underlay for nickel–chromium automobile plating.
—A. B. W.

Corrosion of Galvanized Hot-Water Storage Tanks. J. M. Bialosky (*J. Amer. Water Works Assoc.*, 1946, **38**, (9), 1012–1017; discussion, 1017–1020).—The various internal and external factors having a bearing on the corrosion of galvanized hot-water storage tanks are discussed, as well as the different views held by various authorities on the relative importance of these factors, especially in seeking to explain the apparent diminution of tank service life in some circumstances in recent years. *Owen Rice*, discussing the paper, puts the conflicting requirements of soft-water supply and tank life very clearly, and cites interesting observations on the corrosion of steel and zinc, both coupled and separately, by Pittsburgh water (*p*H 6·7) at 176° F. (80° C.) to which varying " Calgon " additions had been made.—A. B. W.

The Mechanism of Oxidation and Tarnishing. U. R. Evans (*Electrochem. Soc. Preprint* No. **91–5**, 1947, 73–96).—Various relations between film thickness and time are observed: rectilinear, logarithmic, and parabolic. Outward migration of cations and electrons through an adherent film, normally by lattice defects, gives rise to parabolic film growth, but mechanical break-downs due to compressional stresses may lead to other time relations. Blistering, which is likely if adhesion is poor and cohesion good, should lead to rectilinear or logarithmic thickening according as the rifts in the blister wall do or do not admit tarnishing gas. Flaking should lead to periodical recommencement of rapid attack. Shear cracking, which is likely if cohesion is poor and adhesion good, may produce parabolic, rectilinear, or intermediate forms of growth. The theory is applied to interpret the results of Vernon and others, and particularly to explain why conditions obtaining at the time when a specimen is first exposed decide the corrosion rate, which often continues unchanged even if conditions subsequently alter.—A. B. W.

Corrosion Fatigue. G. T. Dunkley (*Mech. World*, 1947, **122**, (3160), 137–141).—An elementary discussion of the mechanism of corrosion fatigue and of the corrosion-fatigue properties of ferrous and non-ferrous alloys; means of minimizing corrosion-fatigue failures are described.—R. W. R.

***The Chemical De-Scaling of Boilers.** R. H. Burns (*J. Inst. Heating Ventilating Eng.*, 1947, **14**, (139), 376–392; discussion, 392–403).—The effect of adding inhibitors to the acid (hydrochloric acid, 31 wt.-%, diluted 1 : 7 and 1 : 10 with cold and hot water, respectively) has been investigated. Preliminary tests showed that hexamine and glue are the most effective organic inhibitors and that the addition of copper sulphate is not advantageous. Finally, using $1\frac{1}{4}$–$1\frac{1}{2}$% of size or 0·3% of hexamine (less effective in hot solutions), the attack on mild steel was found to be negligible, on wrought iron only little, and on cast iron considerable (though less with hexamine). Copper alloys were but slightly attacked, and inhibitors were of little value. There was a tendency to the removal of about 0·00001 in. of the metal before the inhibitor became effective. Details of recommended procedures are described for the treatment of (i) Lancashire type, (ii) hot-water supply, and (iii) water-tube boilers, aimed at ensuring the proper mixing and circulation of the acid, together with simple control tests.—S. J. K.

Glossary of Terms Used in Corrosion. (*Electrochem. Soc. Preprint* No. **90–12**, 1946, 8 pp.).—This glossary was prepared for inclusion in the forthcoming Corrosion Handbook, sponsored by the Electrochemical Society and to be published by John Wiley and Sons, Inc., New York. It is the result of the joint efforts of the Editorial Advisory Board of the Corrosion Handbook and Sub-Committee V of the American Co-Ordinating Committee on Corrosion.

—A. B. W.

VII.—PROTECTION

(Other than by Electrodeposition.)

The Hardness of Anodic Coatings on Aluminium. W. Schwan (*Indust. Diamond Rev.*, 1946, [N.S.], **6**, (63), 51).—See *Met. Abs.*, 1945, **12**, 186.

—R. W. R.

***Surface Hardening of Aluminium.** K. G. Robinson and B. W. Mott (*Product Eng.*, 1947, **18**, (7), 133–134).—Condensed from *Metallurgia*; see *Met. Abs.*, 1947, **14**, 323.—J. L. T.

Calorizing. B. J. Sayles (*Corrosion and Material Protection*, 1946, **3**, (7), 11–12).—The original calorizing process for steel parts was a single treatment of 4–6 hr. at 1800° F. (982° C.) in aluminium-containing powder, producing surface alloying to a depth of about 0·0008 in. containing about 60% aluminium. Such coatings were brittle and the bond weak. A second-stage diffusion treatment of about 48 hr. at the same temp., but in absence of cementation material, was developed later, and this enables the aluminium content to be distributed through a depth of 0·030–0·040 in., with an aluminium content of 20–25% at the surface. Such coatings have some ductility, and articles can be bent after treatment providing the bends are not too sharp and the temp. is not below a red heat. Information on costs of treatment and economic applications is included.—A. B. W.

The Treatment of Magnesium in Chromic Solutions. Jean Frasch (*Métaux et Corrosion*, 1946, **21**, (245), 11–18).—The nature of the action of various solutions on magnesium is correlated with the electrode potential assumed by the metal in the solution, viz. pickling, less than 0·8 V.; chemical coating, more than 1·35 V.; and galvanic anodic coating, 0·8–1·3 V., all potentials being referred to the saturated calomel electrode. In the galvanic process, the magnesium object is connected to a graphite cathode immersed in the bath through an external resistance. The process is stated to have the following advantages compared with chemical coating: (1) less attack and hence preservation of dimensions; (2) control of porosity and thickness of coating by variation of electrical conditions, bath composition, and time of treatment; (3) a single bath composition serves for all magnesium alloys; (4) this type of bath does not attack iron, aluminium, or copper, or alloys of these metals, and it is thus possible to treat assemblages of these metals with magnesium; (5) the baths are easily maintained, and the chromic acid consumption per unit area treated is quite low; and (6) the protection afforded by anodic coatings is superior to that of chemical coatings and may be further improved by sealing with paraffin or by painting. The baths used range about the following composition: CrO_3 10, $MnCO_3$ 6, and H_2SO_4 1·7–5 g./l., with *p*H 2·8–4·5.—A. B. W.

***Magnesium as a Galvanic Anode: Some Factors Affecting Its Performance.** H. A. Robinson (*Electrochem. Soc. Preprint* No. **90–4**, 1946, 49–71; and (summary) *Metal Ind.*, 1946, **69**, (21), 426).—Performance characteristics of the magnesium anode have been studied in the laboratory under carefully controlled conditions. The methods and apparatus used are illustrated and discussed. The general conclusions derived from this work are as follows: (1) The potential of the magnesium anode is ample for cathodic-protection purposes in most naturally occurring electrolytes. (2) Both anode current efficiency and the uniformity of anode consumption improve with increasing c.d. Efficiencies of 50–60% (approx. 500–600 amp./hr./lb.) are obtained with magnesium alloy anodes for c.d. in excess of 50–100 m.amp./ft.^{2} (5·4–10·8 m.amp./dm.^{2}). (3) The high-purity magnesium–aluminium and magnesium–aluminium–zinc alloys operate much more efficiently than pure commercial magnesium at c.d. up to about 700 m.amp./ft.^{2} (75 m.amp./dm.^{2}). Of the various compositions tested, the magnesium–6% aluminium–3% zinc–0·2% manganese alloy exhibits the best over-all performance characteristics. (4) Saturated aqueous solutions of either $CaSO_4$ or $MgSO_3$ provide the most generally satisfactory electrolytes for magnesium anode operation. An electrolyte *p*H of 9·5–10·5 is best. Higher *p*H values produce polarization, and lower *p*H values reduce current efficiency by stimulating local corrosion.—A. B. W.

***Advancements in Nickel-Dipping Practice.** G. H. McIntyre (*Bull. Amer. Ceram. Soc.*, 1946, **25**, (9), 333–337).—Experimental data are presented to substantiate recommendations for good nickel-flash practices. These are particularly adaptable to surfaces for one-coat white application directly on steel, but are also advantageous for regular ground coat. Procedures for large-scale production as well as research studies have shown that the following conditions and sequence of operations give an effective nickel coating on steel without the dangers attendant on the use of iron salts: (1) after acid pickle, 5 min. rinse in sulphuric acid (*p*H 3·0–3·5) at room temp.; (2) nickel dip, $\frac{3}{4}$–$1\frac{1}{2}$ oz. single nickel salts per gal. (preferably 1 oz./gal.), *p*H 3·0–3·5 (adjusted by sulphuric acid or caustic soda additions but no boric acid or ammonium salts), maintained at 155° F. (68·3° C.), and time of dipping chosen to suit plant conditions; (3) rinsing should be avoided if possible, but where necessary should be sulphuric acid (pH 3·0) with minimum time lag between nickel dip and subsequent neutralizing dip; (4) two neutralizer tanks should be used, the first fairly strong and the second weaker. The solutions should be operated at 140° F. (60° C.) and free from carbonates. Two alternative compositions are: (*a*) 0·4 oz. sodium cyanide and 0·2 oz. sodium hydroxide per gal. for 1½ min., and (*b*) 0·12 oz. sodium cyanide and 0·10 oz. sodium hydroxide per gal. for 2½ min.—A. B. W.

Nickel–Zinc Corronizing. L. C. Conradi (*Corrosion and Material Protection*, 1946, **3**, (7), 12–13).—Nickel–zinc diffused coatings are produced by heat-treatment at 700° F. (371° C.) of objects previously electroplated with nickel (next to basis metal) and zinc. The resultant coating consists of some residual nickel, nickel–zinc alloys, and possibly some free zinc at the outside. Comparative salt-spray corrosion tests of specimens with zinc and nickel–zinc electrodeposited coatings and nickel–zinc diffused coatings are reported, and show considerably less corrosion for the diffused coats. Applications and costs are briefly discussed.—A. B. W.

Hot-Dip Galvanizing Practice. William H. Spowers, Jr. (*Steel*, 1946, **119**, (7), 108–110, 130–131; (9), 100, 103–104, 106; (10), 127–128; (11), 136–138, 140, 155; (12), 122, 124; (13), 149–150, 152; (14), 74, 76, 78, 102, 105; (15), 134, 137, 172–174; (17), 118, 121, 137–141; (18), 114, 116, 126, 128, 130; (19), 118–120; (21), 112–114; (22), 88–90, 92; (23), 123, 126, 129.—W. G. A.

Full Automatic Hot Zinc Galvanizing of Tanks. Raymond F. Lodford (*Iron Age*, 1947, **160**, (5), 56–60).—L. explains the advantages of fully automatic methods of hot zinc galvanizing and describes several examples of "conveyorized" tank-galvanizing installations, including the make-up and other characteristics of baths for mechanical operation.—J. H. W.

Zinc Spraying. John Howat (*Corrosion and Material Protection*, 1946, **3**, (7), 8–10; and (abridged) *Products Finishing*, 1947, **11**, (6), 74, 76).—The capabilities of this method of zinc coating are listed and examples of applications and performance in service given.—A. B. W.

Zinc-Coating Structural Members. —— (*Steel*, 1946, **119**, (10), 122).—Structural members of bridges have been zinc sprayed to improve corrosion-resistance.—M. A. V.

***The Use of Metallic Pigments in the Preparation of Protective Paints [Zinc, Magnesium, Aluminium].** J. E. O. Mayne (*J. Soc. Chem. Ind.*, 1947, **66**, (3), 93–95).—Incorporation of zinc dust in a polystyrene lacquer produced a paint film with appreciable conductivity, while magnesium and aluminium powders did not do so. Measurement of the electrode potential of a steel specimen coated with the paint and having a scratch on the surface to expose the iron, partly immersed in sea water, showed that with zinc the potential was similar to that of zinc whereas with magnesium and aluminium it differed little from that of iron. Even after 3 months' exposure, the zinc specimen was free from rust at the scratch. These differences in behaviour may be attributed to variations in the properties of the respective oxide films.—S. J. K.

Preparation of Metals for Painting. R. E. Gwyther (*Corrosion and Material Protection*, 1947, **4**, (2), 8, 10–11).—Presented at the symposium on "Modern Metal Protection" held in Cleveland, September 1946, by the local sections of the American Chemical Society, the American Institute of Chemical Engineers, and the Electrochemical Society.—J. L. T.

Anti-Corrosive Protection of Metals by Phosphatization. J. H. Frydlender (*Rev. Produits Chim.*, 1946, **49**, (19/20), 171–175).—The use of phosphate coatings for the protection of metals is briefly reviewed with reference to patents and recent British and German articles under the heads: fundamental principles; surface preparation; bath composition, time, and temp.; phosphating non-ferrous metals; phosphate coatings to promote lubrication; and legal aspects.—A. B. W.

Formation and Application of Phosphate Coatings. Van M. Darsey and Walter R. Cavanagh (*Electrochem. Soc. Preprint* No. **91–1**, 1947, 1–14; and (summary) *Products Finishing*, 1947, **11**, (5), 66, 68).—The evolution of the phosphate coating of metals is outlined, and the theory of their formation is discussed. The applications of such coatings (i) for corrosion prevention, (ii) as a base for paint, (iii) to reduce wear, and (iv) as an aid in deep drawing, are reviewed for ferrous materials, zinc and zinc alloys, and aluminium and aluminium alloys.—A. B. W.

Temperature-Resistant Ceramic-Base Coatings for Metals. W. J. Plankenhorn and Terry F. Newkirk (*Indust. Heating*, 1947, **14**, (2), 296–297).—A summary of Section VI of Report No. 16 of the Department of Ceramic Engineering of the University of Illinois.—W. G. A.

New Coatings and Applications Expand Use of Porcelain Enamels [for Melting Pots &c.]. (——) See p. 56.

VIII.—ELECTRODEPOSITION

Electroplating on Aluminium. E. G. West (*J. Electrodepositors' Tech. Soc.*, 1946, **21**, 211–226; discussion, 290–293; and *Metal Ind.*, 1946, **69**, (11), 224–226; (13), 264–266, 268).—The cleaning and special surface treatments applied to aluminium as a preliminary to deposition of coatings are surveyed and discussed in detail. Surface treatments may be summarized as follows: (1) mechanical roughening, (2) chemical etching, (3) simultaneous chemical etching and formation of an immersion deposit, (4) anodic oxidation, followed by modification or complete removal of the anodic film, and (5) anodic oxidation to produce a porous film which permits direct plating and anchoring of the deposit. At present, the immersion deposits have given satisfactory results industrially, especially the zinc immersion process. Anodic treatments are promising, but not widely accepted yet. References to technical literature and to patents are included.—A. B. W.

***Routine Control of Brass-Plating Processes. Polarographic, Electrochemical, and Chemical Analysis of Plating Solutions and Deposits.** (Zentler-Gordon and Roberts). See p. 50.

***Electrochemical Jet Method for Determining the Local Thickness of Metallic Electrodeposits [Chromium, Nickel, Copper, Tin, Zinc, and Cadmium].** A. Ogarev (*Metal Ind.*, 1947, **70**, (19), 338–340).—A translation of *Zhur. Priklad. Khim.*, 1946, **19**, (3), 311–315; see *Met. Abs.*, 1947, **14**, 117.—J. L. T.

***Distribution of Current Along a Cylindrical Anode Inside of a Concentric Tube.** Arnold Weisselberg and Staff (*Electrochem. Soc. Preprint* No. **90–1**, 1946, 1–8).—The potential and current distributions derived on the assumptions of uniform solution resistance, finite anode resistance (current entering at one end), negligible cathode resistance, and electrode polarizations independent of c.d., have been compared in a practical case with direct determinations of potentials and (converting c.d. into thicknesses of deposit, making use of the known bath c.d.–current-efficiency characteristics) with the distribution of deposit. The case in question was internal chromium plating of gun barrels, and agreement was satisfactory.—A. B. W.

***The Electrodeposition of Cobalt and Nickel from Co-Ordination Compounds.** Margaret Davis Kramer, Sherlock Swann, Jr., and John C. Bailar, Jr. (*Electrochem. Soc. Preprint* No. **90–27**, 1946, 339–345).—Deposition on copper cathodes for periods of 5–15 min., from cobaltic, cobaltous, and nickel ammines with various co-ordinating groups at a concentration of 0·5%, has been studied. The results suggest that the nature of the co-ordinating groups, as well as the stability of the complex ions, are important in determining the character of the deposit. In the case of cobaltic ammines, the quality of plate deteriorated on passing from complexes with ethylenediamine to propylenediamine, and further on passing to those with butylenediamine and stilbenediamine.—A. B. W.

***The Protective Value of Lead and Lead–Tin [Electro-] Deposits on Steel.** A. H. DuRose (*Trans. Electrochem. Soc.*, 1946, **89**, 417–428; discussion, 429–432).—See *Met. Abs.*, 1946, **13**, 256.

***The Control of *p*H in Nickel-Plating Solutions.** H. Bandes (*Electrochem. Soc. Preprint* No. **90–34**, 1946, 423–437).—Equations are given for computing the amount of acid or base addition necessary to lower or raise the *p*H of nickel-plating solutions of the Watts type. The equations are derived from glass-electrode titration curves of a series of solutions in which nickel salt (sulphate and chloride) and boric acid concentrations were systematically varied. Families of iso-*p*H curves are plotted relating one of the concentrations as variable, y, with the addition of standard acid to 1 l. of solution, x, necessary to reduce the *p*H from a datum value of 5·35 to the value pertaining to the particular curve. These curves are approx. linear, $y = mx + b$, and tables are given of the parameters m and b for nickel sulphate, nickel chloride, and boric acid concentrations varied singly with other concentrations const. The addition of acid, Δx, necessary to produce a desired change in *p*H from $p\mathrm{H}_1$ to $p\mathrm{H}_2$ is evidently the difference of the abscissæ at the concentration y to the two iso-*p*H curves involved; or, in terms of the parameters, with subscripts 1 and 2 corresponding to the two *p*H's, $\Delta x = [(y - b_1)(m_1 - m_2) + m_1(b_1 - b_2)]/m_1 . m_2$. In the rare cases when an increase of *p*H is desired, Δx is negative, and the equivalent addition of nickel carbonate or hydroxide of known titration value is made. Nickel sulphate acts as a buffer over the *p*H interval 3·25–4·0, while boric acid acts as a buffer above *p*H 4·0.—A. B. W.

Nickel Baths Containing Sodium Sulphate. A. Pollack (*Galvano*, 1947, **16**, (120), 9–11).—A translation from *Oberflächentechn.*; see *Met. Abs.*, 1945, **12**, 117.—J. L. T.

***The Electrodeposition of Speculum.** R. M. Angles, F. V. Jones, J. W. Price, and J. W. Cuthbertson (*Galvano*, 1947, **16**, (124), 10–12; (125), 11–13).—From *J. Electrodepositors' Tech. Soc.*, 1946, **21**, 19–44; see *Met. Abs.*, 1946, **13**, 175.—J. L. T.

Continuous Electro-Tinning of Steel Strip in the Manufacture of Tinplate [" Ferrostan " Process]. C. Frenkel (*J. Electrodepositors' Tech. Soc.*, 1946, **21**, 129–139; discussion, 143–148).—The plant developed by the Carnegie–Illinois Steel Corporation for the electro-tinning of steel strip by the " Ferrostan " process is described. Eleven such plants are in operation in U.S.A., and a plant of this type is under construction in S. Wales. It is pointed out that though most electro-tinplate produced during the war had 0·5 lb. tin per base box, coatings of any thickness can be produced by this process. Further, electro-tinplate was developed before the war, and, though applications were greatly accelerated by the war, it was far from a war-time expedient. The operating data for a " Ferrostan " line are briefly as follows: (1) speed, 300–1000 ft./min.; (2) annual output, about 1,000,000 base boxes; (3) strip: 30–36 in. wide, 30–32 gauge, length per coil 1–2 miles, weight 4·5–10 tons; (4) line consists of: coil holder, double shear, welder, looping pit, pinhole detector, electro-limit gauge, alkali cleaner, washer, pickle, scrubber, plating, scrubber, drier, pinhole detector, emulsion oiling, flying shear, branner, and pilers; (5) plating: stannous sulphate electrolyte, c.d. about 200 amp./ft.^{2}.—A. B. W.

Electrical Equipment for Continuous Strip Electro-Tinning Lines. P. F. Grove (*J. Electrodepositors' Tech. Soc.*, 1946, **21**, 139–142).—The handling, plating, reflowing, and inspection equipment are briefly surveyed. The handling is divided into three main sections for control: entry end, plating zone, and finishing end. Variable-speed drives are operated in groups from variable-voltage generators. For plating-current supply, the advantages and disadvantages of motor generators and rectifiers of copper oxide and selenium types are compared. Selenium rectifiers are most efficient, and being oil-immersed are protected from corrosion, but are expensive. Motor generators were, however, specified for the S. Wales plant built under war conditions. Reflowing, i.e. the melting of the tin coat, can be carried out by several methods. The electrical ones are considered to be the best. They are: conduction, and high frequency. In the former, current is passed through the moving strip from conductor rolls, and, by suitable location of quenching, pick-up of tin on the exit conductor roll is avoided. In H.F. reflowing, the strip passes through an inductor supplied with H.F. current at about 200,000 c./s. from a valve generator. Initial cost and replacements are considerable for the H.F. equipment, and conduction heating is likely to be pre-eminent for some time.—A. B. W.

***Electro-Tinplate. II.—The Influence of Coating Thickness on the Porosity and Resistance to Corrosion of Electro-Tinplate.** R. Kerr, R. M. Angles, and K. W. Caulfield (*J. Soc. Chem. Ind.*, 1947, **66**, (1), 5–7).—When subjected to porosity tests (thiocyanate, hot-water, humidity-chamber, salt-spray, and outdoor-exposure), no appreciable difference in behaviour was observed between the deposits obtained in stannous sulphate and sodium stannate baths. In the range studied (corresponding to 2–133 oz. of tin per basis box), there was a marked falling off in the protection afforded below 8 oz., and with outdoor exposure only the thickest coatings gave a long-term resistance. —S. J. K.

***Electro-Tinplate. III.—The Influence of Pickling Conditions on the Porosity and Corrosion-Resistance of Electro-Tinplate.** K. W. Caulfield, R. Kerr, and R. M. Angles (*J. Soc. Chem. Ind.*, 1947, **66**, (1), 7–11).—Cf. preceding abstract. The relative effects of pickling in sulphuric, nitric, phosphoric, hydrochloric, and mixtures of sulphuric and perchloric and of phosphoric and chromic acids, and of anodic etching and pickling, on plates tinned in acid and alkaline baths (8 oz./basis box) have been studied. On the basis of these tests it is recommended that: (1) alkaline bath deposits be pickled for 20–30 sec. in 6% sulphuric acid, inhibited with "Stannine", at 85° C.; (2) acid bath deposits be given anodic treatment in 42% sulphuric acid at room temp. with a c.d. of 200 amp./ft.^{2}; and (3) 1 : 1 hydrochloric acid be used for either type of deposit, pickling for 30 sec.–5 min. at room temp., this treatment giving slightly poorer results but being simple to carry out. —S. J. K.

Electrodepositing Tin–Zinc. J. W. Cuthbertson (*Tin and its Uses*, 1946, (**17**), 13).—The conditions recommended for deposition of tin–zinc coatings on mild steel are:

	80 : 20 Tin–Zinc.	50 : 50 Tin–Zinc.
Tin content of bath, g./l.	30	30
Zinc content of bath, g./l.	2·5	8
Free sodium hydroxide, g./l.	4–6	6–8
Sodium cyanide, g./l.	25	50
Cathode c.d., amp./ft.^{2}	15–30	15–30
Temp.	70° C. (158° F.)	70° C. (158° F.)
Anodes	80% tin–20% zinc	50% tin–50% zinc

Iron tanks are satisfactory. It is important for all tin to be in the stannate form. This is achieved by maintaining the anodes in a filmed condition, as in tin plating from a stannate bath. At 15 amp./ft.^{2}, deposits of about 0·0005 in. thickness are obtained from the above-mentioned baths in ½ hr.—A. B. W.

***Co-Deposition of Tungsten and Nickel from an Aqueous Ammoniacal Citrate Bath.** Luther E. Vaaler and M. L. Holt (*Electrochem. Soc. Preprint* No. **90–9**, 1946, 151–162; and *Metal Ind.*, 1946, **69**, (21), 434–436).—Deposits containing 10–35% tungsten were obtained from a bath containing sodium tungstate, citric acid, nickel sulphate, and ammonium hydroxide. The max. tungsten content was obtained from a bath with low nickel content, high tungstate concentration, *p*H of about 7, high temp., and a fairly high c.d. The most satisfactory bath contained 20 g. $NiSO_4,6H_2O$; 50 g. $Na_2WO_4,2H_2O$; and 66 g. citric acid per litre, with sufficient ammonia to give a *p*H of 8. At 70° C. with a c.d. of 7–15 amp./dm.^{2}, bright shiny deposits containing about 35% tungsten were obtained with a cathodic efficiency of 40–45%. The tungsten content of deposits and the current efficiency were lower at lower temp. Cobalt and iron were also co-deposited when their sulphates were substituted for the nickel sulphate in this bath.—A. B. W.

Electroplating of Zinc. Leo Schmidt (*Corrosion and Material Protection*, 1946, **3**, (7), 10–11).—The advantages and disadvantages of the acid and cyanide zinc baths are briefly compared, and minimum thicknesses suitable for various types of exposure recommended. Chromate treatment of coatings is advocated to prolong useful protection, or as a preliminary to painting. —A. B. W.

Bright Zinc Plating Cuts Costs at Philco Plant. Clarence W. Smith (*Iron Age*, 1947, **160**, (2), 46–50).—S. describes the equipment and procedure for bright zinc-plating sheet-metal radio and television parts, giving a step-by-step description of the plating cycles, and detailing solutions, times, and temp. It is claimed that a great economy is effected by the substitution of bright zinc plating for cadmium plating.—J. H. W.

The Adhesion of Electrodeposits.—IV. A. L. Ferguson (*Monthly Rev. Amer. Electroplaters' Soc.*, 1946, **33**, (7), 760).—Additional references to a paper by F., *Monthly Rev. Amer. Electroplaters' Soc.*, 1946, **33**, (6), 620–629, 632–635; see *Met. Abs.*, 1947, **14**, 117.—J. L. T.

Defects in Plating Solutions and Their Remedies. P. Berger (*J. Electrodepositors' Tech. Soc.*, 1946, **21**, 195–209; discussion, 289; and *Metal Ind.*, 1947, **70**, (11), 171–173; (13), 206–208).—The remedies given are those which a practical man with the usual facilities of a plating shop at his disposal can reasonably be expected to employ. The following types of solutions are covered: brass, cadmium (cyanide), chromium, copper (acid and cyanide), lead (fluoborate and sulphamate), nickel (Watts' type and bright), silver, tin (stannate), and zinc (cyanide).—A. B. W.

Analysis of Electroplating " Strike " Solutions. —— (*Steel*, 1946, **119**, (6), 124–125, 141, 144).—A dip-type cell is recommended for the electrolytic analysis of silver and copper " strike " baths for routine control. The experimental procedure is described.—M. A. V.

Periodic Reverse-Current Electroplating. —— (*Mech. World*, 1947, **122**, (3159), 122).—In this method, which may be used with normal plating baths, the current is briefly reversed at frequent intervals; these reversals have the effect of deplating any unsound or inferior metal deposited during the previous plating period. A typical cycle consists of a plating period of 2–40 sec. followed by a reversal lasting ½–5 sec. Greater smoothness, brightness, and density of the deposit, increased plating speed, and other advantages accrue from use of the method.—R. W. R.

Specifications are Essential to Electroplating Finishing Operations. C. E. Heussner and Carl O. Durbin (*Products Finishing*, 1947, **11**, (6), 68, 70, 72, 74).—A paper presented at the second annual symposium on " Modern Metal Protection ", at Cleveland, U.S.A.—J. L. T.

Some Impressions of Electroplating in U.S.A. A. W. Hothersall (*J. Electrodepositors' Tech. Soc.*, 1946, **21**, 171–179; discussion, 283–286; and (condensed) *Metal Ind.*, 1946, **68**, (23), 456–458).—Specifications for nickel and chromium plate are compared with corresponding British ones. American electrodeposition practice is then surveyed under the following heads: bright nickel, pyrophosphate copper, pattern and colour plating, corronizing, silver plating of bearings, chromium plating of cylinder bores, tin and zinc plating of steel strip, miscellaneous (covering brass immersion deposition on aluminium, anodic cleaning, agitation, Hull-cell thickness testing, and training), and research and development. Selected references to American technical literature are given.—A. B. W.

Military Applications of Electroplating in World War II. William Blum (*Electrochem. Soc. Preprint* No. **90–32,** 1946, 403–410; also *Metallurgia*, 1947, **35**, (209), 246–248; and *Metal Finishing*, 1947, **45**, (1), 66–68).—In this brief survey, consideration is given to electroplating of eight different metals or classes of deposit, viz. hard and porous chromium, nickel, copper, zinc and cadmium, lead, tin, silver, and platinum-group metals.—A. B. W.

IX.—ELECTROMETALLURGY AND ELECTROCHEMISTRY

(Other than Electrodeposition.)

Electrolytic Cobalt: A Commercially Feasible Process. F. K. Shelton, Ruth E. Churchward, J. C. Stahl, and C. W. Davis (*Electrochem. Soc. Preprint* No. **91–4,** 1947, 55–71).—A method of electro-winning cobalt from cobaltite ores (arsenical sulphide) is described which has been successfully operated in a pilot plant producing 5 lb. (2·3 kg.) cobalt per day. The process comprises: (i) roasting; (ii) caustic leach to remove over 80% of the arsenic; (iii) acid leach of residue with an over-all cobalt recovery of above 98%; (iv) ferric arsenate precipitation from leach liquor in the *p*H range 4·0–4·5, followed by treatment with H_2S under pressure at *p*H 2·0 to remove acid sulphide group metals and zinc; (v) a final iron precipitation by aeration at 70° C. with *p*H adjusted to between 4 and 5; (vi) precipitation of cobalt carbonate from the purified solution at 25° C. in the *p*H range 6·48–7·2 with purified soda ash solution; (vii) recovery of the less-pure carbonate from the filtrate in the *p*H range 8·5–8·8; and (viii) electrodeposition of cobalt from cobalt sulphate or fluoborate electrolyte (prepared from the pure $CoCO_3$) operated at 60° C. at 25 amp./ft.^{2} using lead anodes, and in the case of the $CoSO_4$ electrolyte in the *p*H range 1·2–1·5. The $CoSO_4$ appears to be preferable on account of more economical maintenance. Spectrographic analyses of cobalt metal produced in two campaigns showed 99·2 and 99·1% cobalt, 0·74 and 0·81% nickel, and traces of aluminium, calcium, copper, iron, lead, magnesium, silicon, and zinc. —A. B. W.

***The Influence of Crystal Face on the Electrochemical Properties of a Single Crystal of Copper.** Henry Leidheiser, Jr., and Allan T. Gwathmey (*Electrochem. Soc. Preprint* No. **91–6,** 1947, 97–108).—Experiments are described and discussed in which spherical single crystals were subjected to various electrochemical treatments in a typical acid copper sulphate electrolyte (containing 205 g./l. of $CuSO_4,5H_2O$ and 48·8 g./l. conc. sulphuric acid). On simple immersion in the aerated electrolyte, (111) faces were greatly attacked and (100) faces were unattacked. Anodic treatment converted the sphere into an octahedron with faces parallel to (111), these being most rapidly attacked and the (100) faces most slowly. On cathodic treatment at low c.d., the initial rate of deposition was greatest on (111) faces and least on (100) faces; at higher c.d., the deposit on (100) faces became polycrystalline, but that on the (111) faces remained monocrystalline. A.C. (60 c./s.) at high c.d. led to the development of faces parallel to (100). Cathodic treatment at a low c.d. with superimposed A.C. gave results varying from those obtained without A.C. for low superimposed c.d. to those obtained with A.C. alone when this c.d. was high. Replacement reactions with dilute silver nitrate and gold chloride varied with crystal face as revealed by patterns obtained on dipping crystals in such solutions. When two specimens prepared to expose only (100) and (111) faces respectively were immersed in aerated electrolyte, the (100) was 0·0065–0·0057 V. positive with respect to the (111); when immersed in boiled electrolyte the difference was 0·0022 V. of the same sign but rose to 0·0059 V. on bubbling air through the solution.—A. B. W.

Electrolytic Production and Use of Lithium. —— (*J. Four Elect.*, 1947, **56**, (2), 24).—Reprinted from *Echo Mines Mét.*, **1946,** p. 194.—J. L. T.

***Electrolysis of Manganese Into a Metal Cathode from Suspensions of Manganese Oxide and Carbon in Molten Manganous Chloride.** Burke Cartwright and S. F. Ravitz (*Trans. Electrochem. Soc.*, 1946, **89,** 373–382; discussion, 382).—See *Met. Abs.*, 1946, **13**, 257.

***The Transference Number of Nickel in a Nickel Sulphate Solution.** C. J. B. Zitek and H. J. McDonald (*Trans. Electrochem. Soc.*, 1946, **89,** 433–441; discussion, 441–442).—Determinations were made at 40° ± 0·1° C. in a $0{\cdot}1N$-$NiSO_4$ solution by the gravimetric (Hittorf) method, using a modified Findlay cell. Extrapolation to zero hydrogen evolution, i.e. 100% cathode efficiency, gave an average value for the transport number of 0·366.—A. B. W.

***An Electrolytic Method for Pointing Tungsten Wires.** W. G. Pfann (*Metals Technol.*, 1947, **14**, (4); *A.I.M.M.E. Tech. Publ.* No. **2210,** 4 pp.).—The problem of forming points on tungsten wires from 0·002 to 0·010 in. dia. arose in connection with the use of silicon and germanium point-contact rectifiers in micro-wave radar. The method described involves electrolytic pointing in an aqueous solution (38 wt.-%) of potassium hydroxide, to which a little cupric chloride is added. The method is flexible, and differences in wire size, or in the shape of the point desired, involve only changes in the value of the shut-off current.—W. H.-R.

Rectification and Power Supply for the Electrolytic Industry. T. R. Rhea and B. R. Connell (*Electrochem. Soc. Preprint* No. **90–5,** 1946, 73–93).—The conversion equipment installed in the U.S.A. and Canada for the electrolytic industry (aluminium, magnesium, chlorine, copper, and zinc) is surveyed industry by industry, paying attention to size and type of equipment, i.e. whether rotating or rectifier. Of the grand total of approx. 4·5 million kW., about 3·5 million is mercury-arc rectifier equipment. A discussion of the advantages and disadvantages of rotating apparatus and rectifiers is given.
—A. B. W.

Electric Metering of Electrolytic Pot Lines. E. L. Kirk (*Electrochem. Soc. Preprint* No. **90–8,** 1946, 139–150).—The requirements of adequate metering are stated, a typical (magnesium) pot-line metering installation is described, typical metered load data are presented, methods of improving the accuracy of metering are suggested, and the economic value of adequate metering is emphasized. Metered D.C. data have not such a high assurance of accuracy as A.C., and yet it is of the greatest importance for operating adjustments on the plant. Checking D.C. meters directly is difficult, and a procedure based on calculated conversion losses has proved useful in the daily checking of D.C., kWh., and indicated D.C. ampere readings. An instance is given of such checking, enabling discrepancies in the operation of two pot lines to be explained and eliminated with consequent improvement in efficiency.
—A. B. W.

X.—REFINING

The Production of Beryllium Compounds, Metal, and Alloys. Henry C. Kawecki (*Trans. Electrochem. Soc.*, 1946, **89**, 229–245; discussion, 258–261).—See *Met. Abs.*, 1946, **13**, 241.

The Production of Beryllium Oxide and Beryllium Copper. Bengt R. F. Kjellgren (*Trans. Electrochem. Soc.*, 1946, **89**, 247–258; discussion, 258–261; and (condensed) *Metal Ind.*, 1946, **68**, (20), 385–388).—See *Met. Abs.*, 1946, **13**, 247.

The Production of Metallic Calcium by Thermal Reduction. C. C. Loomis (*Trans. Electrochem. Soc.*, 1946, **89**, 207–224; discussion, 225–228).—See *Met. Abs.*, 1946, **13**, 241.

Lead Refining. W. T. Isbell (*Metal Ind.*, 1947, **71**, (3), 47–48).—Abridged from *Metals Technol.*, 1947, **14**, (3); see *Met. Abs.*, 1947, **14**, 392.—J. L. T.

***Laboratory Preparation of Lithium Metal by Vacuum Metallurgy.** W. J. Kroll and A. W. Schlechten (*Metals Technol.*, 1947, **14**, (4); *A.I.M.M.E. Tech. Publ.* No. **2179**, 9 pp.).—Lithium metal was produced readily by the reduction of Li_2O–CaO mixtures with silicon or aluminium in a vacuum of less than one micron at 950°–1000° C. Recoveries of better than 75% of the lithium content of the charge were obtained with silicon, and better than 80% with aluminium as reducing agent. Magnesium–lithium alloys can be prepared by reducing Li_2O–CaO mixtures with magnesium at 950° C., but the magnesium is too volatile for the method to be used for the preparation of pure lithium. The lithium prepared by these methods is very pure. Other less successful or unsuccessful methods, and further possibilities, are discussed.—W. H.-R.

***Ductile Zirconium from Zircon Sand.** W. J. Kroll, A. W. Schlechten, and L. A. Yerkes (*Trans. Electrochem. Soc.*, 1946, **89**, 263–275; discussion, 275–276; and (summary) *Chem. Eng. Min. Rev.*, 1946, **39**, (2), 5).—A process is described for making ductile zirconium, using zircon sand as starting material. The operations are as follows: (1) production of a mixture of zirconium and silicon carbides by reduction of zircon sand in a carbon resistance furnace (carborundum-type furnace) with 100% zircon and 83% silicon recovery; (2) chlorination of mixed carbides, which commences at 500° C. and is strongly exothermic, with condensation of zirconium chloride in a condenser maintained at 80° C. to give a product containing only 0·05–0·3% silicon; (3) sublimation of chloride at 500° C. in hydrogen to eliminate iron which remains as $FeCl_2$ (boiling point 1024° C.); (4) reduction of purified $ZrCl_4$ vapour with magnesium in a helium atmosphere; (5) elimination of excess magnesium, magnesium chloride, and most of the hydrogen by distilling off *in vacuo* (1 micron mercury) at 800°–900° C., at the same time sintering the zirconium somewhat, followed by further degassing and sintering *in vacuo* in a high-frequency furnace; (6) re-melting of irregular lumps of metal in a vacuum-arc furnace with a low pressure of helium. The ingots thus obtained have a bright smooth surface, a Brinell hardness number as low as 197, and can be rolled if the Brinell hardness is less than 300, at first hot (700° C.) and thereafter cold with annealing after several passes. The resulting sheet can be bent cold 180° without cracking. Solid zirconium can be heated to 700° C. in air without burning. The process and equipment described is not limited to the production of zirconium, but can be used for the reduction of $TaCl_5$, $CbCl_5$, $BeCl_2$, and UCl_4, which have boiling points ranging from 233° to 618° C. Other metals such as calcium, lithium, or sodium could also be used as reducing agents, but magnesium is the most convenient.—A. B. W.

Zirconium Metal. D. B. Alnutt and C. L. Scheer (*Metal Ind.*, 1946, **68**, (18), 343–345).—Condensed version of a paper read to the Electrochemical Society. See *Met. Abs.*, 1947, **14**, 392.—W. G. A.

XI.—ANALYSIS

Chemical Analysis of Aluminium Alloys. F. H. Smith (*Light Metals*, 1947, **10**, (112), 255).—A letter giving the results of the analysis of a standard sample of " Y " alloy, prepared by the Light Metal Founders' Association and analysed independently in the laboratories of some of the members of the Association. These results are compared with those obtained by members of the Association of Light Alloy Refiners. The figures are in close agreement. —J. L. T.

Determination of Small Amounts of Copper in Metallic Aluminium by Means of Internal Electrolysis. N. A. Suvorovskaya (*Metallurgia*, 1947, **36**, (212), 110).—Abridged translation from *Zavod. Lab.*; see *Met. Abs.*, 1946, **13**, 327.—M. A. V.

***Contribution to the Study of an Inorganic Semi-Quantitative Method of Analysis: Analysis of Chromium and Nickel.** Paul E. Wenger, D. Monnier, and Y. Rusconi (*Anal. Chim. Acta*, 1947, **1**, (3), 190–200).—[In English]. The first part of the paper is a general discussion of a new semi-quantitative method of analysis, in which the unknown element is determined by spot reactions with specific organic reagents. The solution of the unknown element is progressively diluted until the limit of detection of the spot reaction is reached; the percentage of the element present in the original solution is then estimated, with the aid of a calibration curve, from the dilution required to reach the limit of detection. In general, several reagents are employed with one solution, to increase accuracy, and, where other ions interfere, a preliminary separation may be necessary. In the succeeding sections of the paper, the authors present methods and calibration curves for the analysis of Cr and Ni, and describe the steps in the analysis of a Cr–Fe alloy, a Ni–Fe alloy, and the determination of Cr and Ni in a steel. Reagents recommended for the estimation of Cr are gum guaiacum, strychnine, and diphenyl carbazide, while, for Ni, the authors suggest *cyclo*hexanedionedioxime, rubeanic acid, and diammonium tetrathiocyanatomercurate.—R. W. R.

***On a Spot-Reaction of Cobalt.** Clément Duval (*Anal. Chim. Acta*, 1947, **1**, (3), 201–204).—[In French]. A study is described of the reaction between Co^{++}, a bicarbonate, and H_2O_2, which gives rise to a green coloration and which may be used as a microchemical test for Co. The green compound has been isolated and shown to be Co carbonatocobaltate. In the spot-test, two drops of the Co solution are placed on a tile, a drop of saturated $NaHCO_3$ solution and a few crystals of Na_2O_2 are added, and, after the reaction has subsided, the colour is stabilized with a crystal of mannitol or a drop of glycerol. The limit of detection is 0·43 μg./ml., and the test is satisfactory in the presence of Ni. Other ions of the Co group do not interfere.—R. W. R.

***Note on the Spot Reaction of Cobalt as Potassium Hexanitritocobaltate.** Clément Duval and Colette Soye (*Anal. Chim. Acta*, 1947, **1**, (3), 205–206).—[In French]. A drop of glacial acetic acid, a drop of conc. potassium nitrite solution, and a drop of the Co solution are placed on a tile; after about 2 min. a yellow coloration, or precipitate of potassium hexanitritocobaltate, appears. The absolute sensitivity of the reaction is 0·04 μg. of Co. Ni does not interfere; interference by Cu^{++}, V^{5+}, CrO_4^{--}, and other ions is discussed. —R. W. R.

***Routine Control of Brass-Plating Processes. Polarographic, Electrochemical, and Chemical Analysis of Plating Solutions and Deposits.** H. E. Zentler-Gordon and Eric R. Roberts (*Electrochem. Soc. Preprint* No. **90–2**, 1946, 9–22; also (condensed) *Metal Ind.*, 1946, **69**, (19), 392–394; (21), 433–434; and (summary) *Metal Finishing*, 1947, **45**, (4), 66–69).—Satisfactory bonding between rubber and brass depends on both composition and structure of the latter, and necessitates rigid control of the electroplating process. Effectiveness of control depends in turn on rapid and accurate analyses of solutions and deposits. The determinations required are Cu, Zn, CN, Fe, and (CO_3) in the plating solution and Cu and Zn in the deposit. Polarographic methods have been applied to the determination of Cu and Zn in the solution and also the ratio Cu : Zn in deposits. In the case of the plating solution, a filtered or centrifuged sample is taken to dryness with an equal vol. of conc. HCl on a water bath, taken up with a few drops of HCl, and made up to a suitable vol. (e.g. 100 ml.), aiming at concentrations of approx. 100 mg. Cu and 40 mg. Zn/l. An aliquot portion with an equal vol. of a base solution, 4*N* with respect to both ammonia and ammonium chloride and containing 2% xylose, is then polarographed over the range 0 to −2·1 V., or, in the case of a non-recording polarograph (e.g. a voltamoscope), readings are taken at −0·25 V., between the Cu steps, at −0·9 V., between the Cu and Zn steps, and at −1·25 V., beyond the Zn step. The ratio of copper to zinc is obtained by multiplying the ratio of polarographic steps by the inverse ratio of the atomic weights, since the diffusion coeff. are identical. Individual Cu and Zn concentrations are obtained by the use of calibration charts in the usual way. As a check on the polarographic method, it was applied to a series of synthetic plating solutions made up from analysed salts, and the results showed agreement with gravimetric values within 1%. Brass deposits are stripped for analysis by the use of an ammoniacal ammonium persulphate solution (containing $(NH_4)_2S_2O_8$ 75 g.; ammonia (sp. gr. 0·880) 335 ml.; and water 660 ml.) and the solution obtained acidified with HCl and treated as for the plating solution. Determinations of Cu can also be made electrolytically, in which case the solution sample is acidified with HNO_3 and H_2SO_4 and treated in the usual way. Zn may be determined volumetrically on the Cu-free solution remaining after the electrolytic Cu determination, using 0·05*N*-potassium ferrocyanide solution and diphenyl benzidine indicator. Total CN is determined by distillation of a filtered sample with dil. HCl, collecting the distillate in 10% NaOH, and titrating with 0·1*N*-$AgNO_3$, using iodide indicator.—A. B. W.

Analysis of Electroplating "Strike" Solutions. (——) See p. 46.

Polarographic Determination of Zinc in Aluminium Alloys. W. Stross (*Metallurgia*, 1947, **36**, (214), 223–225).—S. discusses details of the technique used in applying the method described in a previous article (*Metallurgia*, 1947, **36**, (213), 163; *Met. Abs.*, this vol., p. 18).—M. A. V.

Electrolytic Methods for Microchemical Analysis. A. J. Lindsey (*Metallurgia*, 1947, **35**, (209), 267–268).—Summary of a paper presented to the Society of Public Analysts.—W. G. A.

Electrographic Methods of Analysis. Eric A. Arnold (*Electrochem. Soc. Preprint* No. **90–37**, 1946, 469–473; and (summary) *Steel*, 1946, **119**, (24), 88–89).—In this technique, which affords a useful means for qualitative and quantitative examination of metals and alloys, the test specimen is made the anode against an inert cathode, the electrolyte and necessary reagents being carried by a piece of bibulous paper clamped between the electrodes. Typical applications are: (1) qualitative: the examination of coatings for pinholes, e.g. Cr–Ni–Cu electroplate on steel with paper saturated with a solution containing 1% dimethylglyoxime and 1% barium hydroxide, which reveals pinholes in the nickel as red spots; (2) quantitative: the determination of alloy metal content by comparison with standards, electrographing at various known c.d. for various known periods and matching the stains.—A. B. W.

The Direct Reading of Spectral-Line Intensities. A Review of Some Recent Applications to Spectrographic Analysis. J. H. Oldfield (*J. Iron Steel Inst.*, 1947, **156**, (1), 78–80).—O. reviews the literature relating to the direct measurement of spectral-line intensities by means of photo-multiplier tubes, and describes the " Quantometer ", a commercial instrument, comprising a source unit, a spectrometer, and a recording unit capable of determining eleven elements in an alloy. The principal advantage of the direct-reading method lies in its speed, but it possesses the disadvantages (1) of requiring a more stabilized source, and (2) of dependency on the characteristics of the photo-cell, which are highly individual; replacement of a photo-cell necessitates complete recalibration of the instrument. The method is likely to find its greatest use in rapid routine analysis; it is not at present suitable for qualitative work.—R. W. R.

XII.—LABORATORY APPARATUS, INSTRUMENTS, &c.

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

The Electron Microscope and Its Applications in Metallography. P. Grivet, H. Brück, and F. Bertein (*Métaux et Corrosion*, 1946, **21**, (245), 1–10).—An exposition of the principles of electron microscopy and of emission and transmission instruments is followed by a description of the microscope manufactured by Compagnie Général de T.S.F. (Paris) and by some examples of its applications to metallographic subjects. The specification of the microscope is as follows: electrostatic lenses; objective, 5·4 mm. focus (magnification 62), projection lens, 4·7 mm. focus (magnification 111), giving a total magnification of 6500; resolution, about 8 mμ; field size, 5 μ for 24 × 36 mm. picture or 10 μ for 60 × 60 mm. picture; field depth, 10 μ; object carrier hole, 0·1–0·2 mm. dia.; high-tension supply, max. 75,000 V., 300 μamp., normal 65,000 V., 25 μamp.; photographs, 36 exposures 24 × 36 mm. or 12 exposures 60 × 60 mm.; time of exposure, 1 sec.; time for change of object, 3 min.; time for change of film, 10 min. Both intermediate and final images can be examined on fluorescent screens swung into position for this purpose. The electron micrographs reproduced to illustrate applications are: profile of tungsten wire 0·0003 mm. dia., before and after electrolytic polishing; magnesium and zinc oxide smokes; and technical and high-purity aluminium oxide replicas. Techniques for the production of synthetic resin and silica replicas are described, and reference is made to the possibility of using glancing reflection directly in examining metal surfaces. The paper concludes with a *bibliography* containing some 15 references to the literature from 1940 onwards, most of which are German.—A. B. W.

***Simple Device for Preventing the Formation of Hard Deposits in Laboratory Stills Fed with Water Partially Softened by Base-Exchange Treatment.** U. R. Evans (*Chem. and Ind.*, 1946, (49), 434–435).—A copper–zinc couple, immersed in the boiler but insulated from it, ensures deposition of loose, non-adherent sludge, apparently as a result of cathodic precipitation on the couple, though zinc dissolved anodically may modify the character of the deposit by protective colloid action or by the provision of suitable nuclei.—A. B. W.

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

Correlation of Diamond Pyramid and Magnetic Hardness. —— (*Machine Tool Rev.*, 1946, **34**, 50; and (summary) *Indust. Diamond Rev.*, 1947, [N.S.], **7**, (77), 120).—R. W. R.

Modern Hardness-Testing Machines. —— (*Indust. Diamond Rev.*, 1946, [N.S.], **6**, (70), 263–267).—A composite abstract of articles by K. Meyer, *Festigungstechn.*, 1943, (1/77), 232; 1944, (1/78), 17, 47; and W. Ermlich, *Metallwirtschaft*, 1942, **21**, 306.—R. W. R.

New Hardness Tester. T. Dobry (*Hutnické Listy*, 1946, **1**, 177; and (summary) *Indust. Diamond Rev.*, 1947, [N.S.], **7**, (81), 244).—R. W. R.

Specifications for Knoop Indenters. —— (*U.S. Bur. Stand. Letter Circular* **819**, 1946; and (summary) *Indust. Diamond Rev.*, 1947, [N.S.], **7**, (77), 119). —R. W. R.

Micro-Hardness Testing Fine Wire and Small Parts. G. E. Shubrooks (*Indust. Diamond Rev.*, 1947, [N.S.], **7**, (74), 10–11).—See *Met. Abs.*, 1947, **14**, 397.—R. W. R.

The Automatic Sonigage; A New Ultrasonic Testing Instrument. Wesley S. Erwin and Gerald M. Rassweiler (*Iron Age*, 1947, **160**, (4), 48–55).—E. and R. describe an improved ultrasonic testing device for rapid non-destructive tests of flat metal parts and tubes.—J. H. W.

***The Detection of Cracks in Steel by Means of Supersonic Waves.** C. H. Desch, D. O. Sproule, and W. J. Dawson (*Iron Steel Inst. Preprint*, **1946**, 23 pp.; and (summary) *Aircraft Prodn.*, 1946, **8**, (92), 259–265).

Magnetic-Particle Testing. —— (*Engineering*, 1946, **161**, (4185), 302; and *Tech. Moderne*, 1947, **39**, (1/2), 25).

Photographic Projection: Inspection and Lay-Out [of Castings]. C. J. Kettle (*Iron Age*, 1947, **160**, (5), 45–49).—K. describes a new, simple, and rapid method of inspecting and laying-out intricate castings, involving essentially the accurate projecting of lay-out drawings on to the surface of the casting by optical means. This method differs in many respects from previously described photographic methods, particularly in the use of a light wand for establishing a base line for the castings to be inspected.—J. H. W.

RADIOLOGY

Interpreting Spot-Weld Radiographs [in Aluminium Alloys]. Robert C. McMaster (*Steel*, 1946, **119**, (16), 104–107).—Typical radiographs of spot welds in 24S-T and 75S-T aluminium alloys are reproduced and explained. Common defects are illustrated.—M. A. V.

Safety X-Ray Code Protects Workers. —— (*Steel*, 1946, **119**, (14), 81).—A safety code has been published by the American Standards Association to protect workers in X-ray and radium industrial testing.—M. A. V.

XIV.—TEMPERATURE MEASUREMENT AND CONTROL

The Selection and Installation of Thermocouple Extension Lead-Wires. C. C. Roberts and C. A. Vogelsang (*Indust. Heating*, 1947, **14**, (3), 370–372, 374, 376, 378, 380, 382; and (summary) *Iron Age*, 1947, **159**, (10), 82–84).—The authors outline the various factors governing the selection of the proper kind of lead-wire, and give a few simple rules to be followed to ensure accurate measurement and control.—J. H. W.

XV.—FOUNDRY PRACTICE AND APPLIANCES

Melting Practice for Sand Casting [Aluminium Alloys]. Fred Carl, Walter Bonsack, W. E. McCullough, Wm. Rogers, and H. J. Rowe (*Modern Metals*, 1947, **3**, (2), 24–27).—An authoritative review in which are discussed gas absorption, dross formation, furnace equipment, temp. measurement, melting precautions, alloying, and the use of grain refiners. See also abstract below. —N. B. V.

Aluminium Fluxing and Melting Practice. Fred Carl, Walter Bonsack, W. E. McCullough, Wm. Rogers, and H. J. Rowe (*Modern Metals*, 1947, **3**, (3), 18–23).—Cf. preceding abstract. Methods of fluxing using solid fluxes, chlorine, and nitrogen; melting equipment and procedure for pressure and gravity die-casting; and methods of charging are described.—N. B. V.

Fluxes—Degasifiers and Grain Refiners [for] Aluminium Casting Alloys. James D. Kline (*Amer. Foundryman*, 1947, **11**, (4), 123–124; and *Metal Ind.*, 1947, **71**, (4), 71–72).—A general review, in which fluxing alloys, salt fluxes, and gaseous fluxes are briefly described.—J. E. G.

Theory and Practice of the Aluminium Sand Foundry. Present-Day Role of the Metallurgist. F. Raybould (*Found. Trade J.*, 1947, **81**, (1594), 171–176; (1595), 197–202; discussion, (1594A), 223–225).—Read before the London Branch of the Institute of British Foundrymen. A detailed account is given of the application of metallurgical control in the foundry. Particular topics discussed include the control of moulding and core sands, mould facings, chills, alloy melting, and the influence of design and alloy composition on solidification characteristics.—J. E. G.

Aluminium Sand Castings. —— (*Steel*, 1946, **119**, (7), 80–82, 84).—A brief illustrated description of equipment and operations in the foundry of Aluminum Industries, Inc., of Cincinnati, U.S.A.—M. A. V.

Aluminium Casting. R. E. Paine (*Amer. Foundryman*, 1947, **11**, (7), 48).—A summary of a paper presented at the Western Metals Congress, Oakland, Cal.—J. L. T.

Technology of Aluminium and Magnesium [Casting]. L. W. Eastwood (*Metals Rev.*, 1947, **20**, (2), 7–8, 51).—New aluminium–beryllium alloys for casting, and studies on the dimensional stability of aluminium castings, are briefly described. Recent work on (i) the corrosion and stress-corrosion characteristics of aluminium, (ii) aluminium bearings, and (iii) the centrifugal casting of aluminium, is discussed. The reduction of microporosity in magnesium alloys, and the grain refinement of magnesium casting alloys, are described.—J. L. T.

***Unsoundness in Cast Light Alloys.** J. C. Dehaven, R. F. Hauser, Walter Bonsack, L. W. Eastwood, C. E. Nelson, and W. E. Sicha (*Amer. Foundryman*, 1947, **11**, (1), 24–40; (2), 35–47).—The report of an A.F.A. Sub-Committee (Aluminium and Magnesium Division) on shrinkage and porosity. In light alloys, the type of defect caused by shrinkage and/or gas evolution depends chiefly on: (1) the composition of the alloy, (2) the gas content of the melt, and (3) the nature of the solidification process, as determined by such factors as casting design, method of gating, and section thickness of the casting. Depending on the magnitude and combination of these factors, localized shrinkage merges into microporosity. Similarly, gas porosity also merges into microporosity.—J. E. G.

The Effect of Melting Conditions on Light Alloys. A. J. Murphy, S. A. E. Wells, and R. J. M. Payne (*Fonderie*, 1947, (**18**), 708–710).—See *Met. Abs.*, 1940, **7**, 266.

The Founder and His Clients [Casting Light Metals]. E. Carrington (*Light Metals*, 1947, **10**, (111), 193–200).—C. deals with the advantages of the casting process as compared with the production of parts by mechanical-working methods, and discusses various procedures in relation to available aluminium alloys. Applications are also briefly described.—F. A. F.

Difficulties Encountered When Using Recovered Light Alloys for Casting. Jean Duport (*Fonderie*, 1947, (**14**), 527–538).—After reviewing chemical methods of analysing light alloys, D. tabulates the tensile properties of the most important French alloys; methods of testing the properties of castings are also considered. Impregnation of moulds is very important, the best results having been obtained with (1) lamp-black produced from acetylene, and (2) a solution containing: Spanish white 2·5, graphite 0·4, sodium silicate 0·2 kg., and water 10 l.—M. E.

Casting Magnesium Alloys. Allen G. Gray (*Steel*, 1946, **119**, (19), 92–95, 130, 132, 134, 136, 139–140).—Magnesium alloy sand-casting technique is described generally. Details are given of the compositions, characteristics, mechanical properties, and uses of magnesium alloy castings, and of the compositions and characteristics of suitable fluxes.—M. A. V.

Removing Dissolved Gases from Molten Metals. P. M. Hume (*Steel*, 1946, **119**, (15), 108–111, 160, 163; (16), 110–111, 122, 125–126, 128).—A general review of present knowledge and practice, in which published work is summarized. A short *bibliography* is appended.—M. A. V.

Practical Procedures for Reducing Gas Porosity in Non-Ferrous Castings. A. E. St.John (*Iron Age*, 1947, **160**, (1), 46–48).—St.J. outlines simple and practical means for reducing gas porosity in tin bronzes, aluminium bronzes, silicon bronzes, yellow brasses, and manganese brasses. He discusses the effects of fuel-fired and electric-furnace melting, atmosphere control, melting practice, superheating, stirring, deoxidizing, and pouring.—J. H. W.

Introduction to the Study of Foundry Defects. François Boussard (*Fonderie*, 1946, **1**, (12), 431–434).—67 causes of failure in the foundry are enumerated. —M. E.

Foundry Control in Aviation. René Buquet (*Fonderie*, 1946, **1**, (12), 453–454; discussion, 454).—An account of non-destructive testing methods for castings (X-ray, supersonic, and magnetic).—M. E.

†**Mare Island's Accurate Method of Propeller Manufacture.** Milton M. Metcalf (*J. Amer. Soc. Naval Eng.*, 1947, **59**, (1), 33–42).—The historical development of methods of casting ship propellers at Mare Island Naval Shipyard (California, U.S.A.) from 1890 to the present day is described with the aid of 22 photographs. The modern method of manufacture involves the use of metal patterns and sectional mould boxes, and produces propellers which require only a small amount of finishing in order to satisfy the specifications.—H. J. A.

Core and Moulding Sands for Aluminium Foundries. C. E. Heussner, Donald M. Bigge, Harvey J. Cole, Gordon Curtis, Harry Dietert, Robt. E. Schenck, and Norman Smith (*Modern Metals*, 1947, **3**, (5), 21–25).—A review dealing with moulding sands, binders, sand testing, reprocessing moulding sands, core sands and binders, core washes and spraying, inhibitors, core baking, and reclamation of core sand.—N. B. V.

Magnesium Foundry Core Practice. George W. Kurachek (*Foundry*, 1946, **74**, (9), 76–77, 162, 164, 166, 168, 170; and *Metal Ind.*, 1946, **69**, (16), 323–324, 330).—A review.—W. G. A.

Electronic Core Baking. R. W. Crannell (*Foundry*, 1947, **75**, (7), 66–69, 420).—A review of dielectric-heating methods of core baking as practised at a large American foundry. The principles of core manufacture are explained and the modifications in composition of the core-binding materials outlined. Photographs illustrate some of the production operations and the types of high-frequency ovens in use.—D. M. L.

***Moulding Sand Binders.** L. Jenicek (*Amer. Foundryman*, 1947, **11**, (4), 132–140).—From theoretical considerations, it is submitted that those bonding materials which behave as solids up to the greatest possible shear stresses possess the best properties for the development of max. green compressive strength in moulding-sand mixtures. These conditions are approached most closely by sodium bentonite. The characteristics of sodium bentonite are approached by certain organic substances which exhibit swelling in the presence of water. Other bond clays are characterized by less-favourable characteristics. J. also discusses the development of strength after " drying ", and the strength of sand mixtures at elevated temp.—J. E. G.

The Use of Mixed Sands in the Foundry. Ladislav Jenicek (*Fonderie*, 1946, **1**, (12), 462; discussion, 463).—A list of sands in common use is given. —M. E.

Drying of Foundry Sand Cores by Dielectric Heat. J. R. Calhoun, L. E. Clark, and H. K. Salzberg (*Found. Trade J.*, 1946, **80**, (1583), 405–406, 410).—Reprinted from *Industrial Ovens.*—W. G. A.

Foundry Sand Laboratories. O. Jay Myers (*Amer. Foundryman*, 1947, **11**, (4), 117–122).—A summary of the objects of sand control and a description of the chief methods of sand testing.—J. E. G.

Patterns for Production. John E. Gill (*Amer. Foundryman*, 1947, **11**, (4), 127–128).—A brief review.—J. E. G.

Pattern-Making. A New Machine for Cutting Irregular Shapes. B. Levy (*Found. Trade J.*, 1947, **81**, (1595A), 239–244; discussion, (1596), 271–272).—Read before the London Branch of the Institute of British Foundrymen. An illustrated account is given of a new, mechanically-operated machine primarily suited for cutting irregular shapes, such as foundry patterns, in wood and in very soft metals.—J. E. G.

New Coatings and Applications Expand Use of Porcelain Enamels [for Melting Pots &c.]. —— (*Steel*, 1946, **119**, (20), 154, 156, 218, 220, 222).—Recent industrial uses of porcelain-enamel coatings include heat-resistant coatings for melting pots, and marine and aircraft exhaust systems. Good results have been obtained by spray application.—M. A. V.

Speeding Production in the Foundry [Moulding Machines]. P. Peel (*Mass Prodn.*, 1946, **22**, (6), 277, 279, 281, 283).—P. describes various kinds of moulding machine, and discusses the ways in which combinations of the different types of machine are employed so as to secure max. production rates.—R. W. R.

Foundry Mechanization. C. O. Bartlett (*Amer. Foundryman*, 1947, **11**, (4), 82–90).—A general illustrated survey.—J. E. G.

The Handling and Transport of Materials in a Modern Factory. W. L. Beeby and W. Symes (*Manchester Assoc. Eng. Preprint*, **1946–47**, 15 pp.).—A general review of the problems involved in materials-handling processes in an engineering works. Topics discussed include the handling of raw materials, scrap, and swarf; and the use of hand- and mechanical trucks, cranes, and mechanical conveyers.—J. E. G.

Uses of "32" Alundum Abrasive in the Foundry. C. A. Carlson (*Grits and Grinds*, 1946, **37**, (9), 12–13).—A brief summary of the use of grinding wheels in this material for fettling castings.—R. W. R.

Foundry Dust-Control Systems: Hoods and Piping. E. A. Carsey (*Amer. Foundryman*, 1947, **11**, (3), 42, 46–47).—A review.—J. E. G.

Foundry Dust-Control Systems: Maintenance. Kenneth M. Smith (*Amer. Foundryman*, 1947, **11**, (3), 43–45).—A general illustrated account.—J. E. G.

Foundrymen Survey Vocational School Facilities. —— (*Amer. Foundryman*, 1946, **10**, (2), 77–79; and *Nassau*, 1946, **8**, (9), 3–9).

Centrifugal Casting. L. Northcott (*Found. Trade J.*, 1947, **81**, (1591), 151–155; discussion, (1594), 177–178).—Read before the London Branches of the Institute of British Foundrymen and the Institute of Metals. A review is given of the chief production methods of centrifugal casting and the factors involved therein.—J. E. G.

The Present Position of Centrifugal Casting. Jacques Boucher (*Fonderie*, 1946, **1**, (12), 435–437; discussion, 437).—An illustrated account of methods of centrifugal casting. The dia. of tubes which can be cast can vary from 1·25 to 18 mm. and the thickness from 2 to 100 mm.—M. E.

Centrifugal Casting. —— (*Usine Nouvelle*, 1947, **3**, (16), 12).—A brief elementary review.—J. L. T.

Centrifugal Casting in Germany. —— (*Steel*, 1946, **119**, (17), 100–101, 130, 132).—A summary of the investigations of the U.S. Technical Field Information Agency on the status of centrifugal casting in Germany. The works visited included Kupfer und Drahtwerk, Osnabrück, where large brass and bronze tubes were cast.—M. A. V.

Continuous Casting. H. Kästner (*Metal Ind.*, 1947, **71**, (5), 83–85; (6), 106–108; (7), 131–132).—A translation of *Stahl u. Eisen*, 1947, **67**, (1/2), 10–19; see *Met. Abs.*, 1947, **14**, 175.—J. L. T.

New Continuous-Pouring Induction Melting Furnace. (——) See p. 58.

Recommended Practices for Aluminium and Magnesium Permanent-Mould Castings. Alfred Sugar (*Aluminum and Magnesium*, 1946, **2**, (8), 12–14, 32–33; (10), 8–9, 16–17).—S. discusses mould design, types of mould, manufacture of mould, cores, venting, gates, runners and risers, the melting, degassing, and casting of aluminium and magnesium alloys, and the control of temp. of the moulds. The finishing of both types of alloy is described.
—E. C. E.

Permanent-Mould Aluminium Castings: Operations at Alumicast. —— (*Indust. Gas Times*, 1947, **10**, (112), 110, 112, 114, 116).—See *Met. Abs.*, 1947, **14**, 273.

Making Permanent Moulds [for Aluminium]. Vincent J. Sedlon (*Amer. Foundryman*, 1947, **11**, (2), 49–54).—An illustrated account, in which an outline is given of the chief factors to be kept in mind in the production of gravity die-casting moulds (permanent moulds) for aluminium alloy castings.
—J. E. G.

An Engine Without Valves Cast Under Pressure [Use of Aluminium–12% Silicon Alloy]. V. Boghossian (*Rev. Aluminium*, 1947, (**130**), 57–61).—Aluminium–12% silicon alloy (A.S. 13) is used by Jack and Heintz for the die-castings in their four-stroke, six-cylinder, 75 h.p. Skinner engine.—M. E.

German Die-Castings Made by Hot-Shot Goose-Neck Method. J. R. Townsend (*Product Eng.*, 1946, **17**, (7), 81–83).—Captured German telephone and wireless equipment contained aluminium and magnesium die-castings which were remarkable, not only for their size and intricacy, but also for their freedom from blow-holes and surface defects. Very small gates had been used, and high pressure and velocity probably ensured that the metal completely filled the mould before freezing began.—H. V.

Brass Die-Casting. Herbert Chase (*Steel*, 1946, **119**, (15), 112–114, 164, 166, 169–170).—Brass die-casting equipment and technique are described, and properties of brass die-casting alloys tabulated.—M. A. V.

Production of Magnesium Alloy Castings. Gravity and Pressure Die-Castings Technique. G. B. Partridge (*Metallurgia*, 1947, **36**, (211), 7–12; correspondence, (212), 82).—Cf. *Met. Abs.*, 1947, **14**, 400. The difficulties and advantages of the die-casting process for magnesium alloys are summarized, and the technique described generally. The latest method of counteracting oxidation is the addition of small quantities of beryllium, but this has the disadvantage of increasing grain-size.—M. A. V.

Production of Magnesium Alloy Castings. Some Commercial Applications. G. B. Partridge (*Metallurgia*, 1947, **36**, (213), 125–132).—Cf. preceding abstract. The design and application of magnesium alloy castings are discussed from the points of view of engineering properties and costs. Illustrated examples of Elektron castings are given.—M. A. V.

Die-Casting Magnesium Alloys. Allen G. Gray (*Steel*, 1946, **119**, (20), 150–152, 212, 214, 217).—A general account of magnesium alloy die-casting practice. Limitations in design are considered.—M. A. V.

1,000,000 Pounds of Small [Zinc] Die-Castings. Herbert Chase (*Steel*, 1946, **119**, (26), 56–58, 99–100).—Details are given of zinc alloy die-casting practice at one of Fisher Body's Ternstedt plants.—M. A. V.

A Small Die-Casting Machine for Zinc-Base Alloys. —— (*Machine Tool Rev.*, 1946, **34**, (201), 23–24).—The machine is suitable for casting zinc-base alloys up to 5 oz. in weight. It is a light-weight, hand-operated machine, and 400–500 shots per hr. can be maintained without undue fatigue. Automatic or hand-operated side cores can be arranged when required, and only the fixed half of the die is water-cooled. Dies can be quickly changed, reducing idle machine time. Dies are hand-operated by lever and toggle mechanism, giving a pressure of 6 tons. The melting pot has a capacity of 70 lb. and is heated by atmospheric burners using town gas. No air equipment is required, and gas consumption is 100–120 ft.^{3}/hr. The nozzle does not require independent heating.—H. V.

Timer for Die-Casting Machine. Gerald DeLong (*Electronics*, 1947, **20**, (3), 110–112).—An illustrated description of an electronic timer for die-casting machines for automatically controlling the time interval between the filling of the mould and opening for ejecting the casting. This time interval has been found to be critical for all types of die-castings in zinc and aluminium alloys. Each die-casting machine requires its own timer. The instruments for the whole shop are mounted together in a control rack only accessible to a foreman for adjustment.—D. M. L.

***A Study of the Hazards of Exposures to Metallic Fumes and Dust in Brass Foundries.** William W. Stalker (*J. Indust. Hyg. Toxicol.*, 1947, **29**, (2), 96–112).—S. describes atmosphere tests carried out during the melting and casting of brass in 5 foundries. The max. figure found for lead concentration was 8 mg./10 m.^{3}, while the max. figure for zinc concentration was 1824·7 mg./10 m.^{3}; these figures are the mean of several determinations. Medical tests on the urine and blood of 94 foundrymen were also carried out. Lead contents above the safe maximum were found in both the urine and blood of one-third of the workers, but it was not found possible to correlate this with either foundry atmosphere or with abnormal ill-health. About half the workers examined did, however, exhibit symptoms of mild alimentary lead poisoning. Recommendations are made with regard to the control of fumes in brass foundries.—R. W. R.

Experiences with Polarographic Methods in Controlling a Lead Hazard in Brass Foundries. Herbert J. Wheeler (*J. Indust. Hyg. Toxicol.*, 1947, **29**, (3), 158–167).—W. describes rapid polarographic methods for the estimation of lead in urine and blood, which are sufficiently accurate for controlling lead hazard in brass foundries.—R. W. R.

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

Reclaiming Brass Scrap. —— (*Steel*, 1946, **119**, (8), 100).—A brief account of the separation of brass machine-shop scrap from iron and steel, for subsequent reclamation.—M. A. V.

Treatment of Galvanizing-Bath Residues. A. Gordet (*Galvano*, 1947, **16**, (123), 15–17).—Answers to correspondence.—M. E.

XVII.—FURNACES, FUELS, AND REFRACTORY MATERIALS

New Continuous-Pouring Induction Melting Furnace. —— (*Iron Age*, 1947, **160**, (4), 55).—A brief description of a new design of melting furnace for aluminium, brass, and zinc. There are two chambers, one for charging and the other for pouring, connected by straight-line melting channels. An illustration shows the furnace in operation.—D. M. L.

***Experiments on High-Frequency Heating.** L. Hartshorn and E. Rushton (*Trans. Liverpool Eng. Soc.*, 1946, **67**, 111–132; discussion, 133–136).—The general principles of induction heating are outlined and illustrated by reference to: (1) the bonding of laminated wood, (2) the dehydration of vegetables, and (3) the sterilization of meat. A table of the dielectric properties of representative materials is given.—H. J. A.

Heat-Treating Furnaces in Foundry Work. Victor Paschkis (*Indust. Heating*, 1946, **13**, (10), 1612, 1614, 1634).

Heat-Treatment Furnaces. Some Recent Installations. —— (*Metallurgia*, 1947, **36**, (211), 31–38).—Illustrated descriptions are given of some newly installed furnaces, including a Wellman continuous reheating furnace for nickel–chromium and other non-ferrous billets, an Efco–Lindberg Cyclone tempering and heat-treatment furnace, a Birlec belt-conveyor bright-annealing furnace for copper sheets, and a Wild-Barfield bell-type bright-annealing furnace.—M. A. V.

Infra-Red Heating by Gas: Its Development and Practice To-Day. J. B. Carne (*Metallurgia*, 1947, **36**, (214), 193–196).—Infra-red radiant heating is a comparatively recent industrial application, having been first used by the Ford Motor Company in 1933 for stoving car bodies. Its use was greatly extended in World War II. Infra-red gas units are briefly reviewed, and the basic principles and advantages of the process (mainly higher temp. and greater speed) are discussed.—M. A. V.

Drying with Infra-Red [Rays]. Jean Maisonneuve (*Rev. Aluminium*, 1946, (**128**), 377–383).—Rays between 7600 and 30,000 Å have given the best results. The rays are emitted from lamps, the filaments of which are at 2450° K., and the efficiency of the process reaches 73%. Drying starts close to the metal, and thus the risk of cracking is diminished; this is especially useful when the rays are used for drying transparent plastic coatings on metals. —M. E.

Special Finishing Installation Eliminates Production Problem [Use of an Infra-Red Oven]. E. L. Verhagen (*Products Finishing*, 1947, **11**, (5), 70–72).—V. describes briefly the use of a "dual-heat" electric infra-red oven for stoving ivory enamel finish on can-openers. Rows of lamps set at criss-cross angles give an even and const. heat.—G. T. C.

†Fuel Economy. Leslie Aitchison (*Metal Ind.*, 1946, **69**, (17), 339–342; (18), 364–366; (19), 385–386).—Read at the Ministry of Fuel conference on "Fuel and the Future".—W. G. A.

XVIII.—HEAT-TREATMENT

Advancements in the Art of Heat-Treating Aluminium. James F. Carland and P. R. Watson (*Aluminum and Magnesium*, 1947, **3**, (4), 9–11, 19, 22).—A practical review of some factors in the heat-treatment of the strong alloys, dealing briefly with pit-quenching, standardization of quenching procedure, and temp. variations in the furnace. A 600 kW. furnace installed in 1944 in the St. Louis plant of the Curtiss and Wright Corporation, which is said to solve heat-treatment problems, is then described in some detail. The furnace had special ("Reactrol") temp.-control equipment, and an automatic quench mechanism.—F. A. F.

Heat-Treating Aluminium.—I, —II, —III, —IV, —V. G. W. Birdsall and O. L. Mitchell (*Steel*, 1946, **119**, (8), 98–99, 156, 159–162; (9), 78–79, 127–128, 130–131; (10), 103–104, 106, 108; (11), 118–120, 122, 124, 126; (12), 103–104, 106, 148–149).—(I.—) A popular exposition of the changes which take place in aluminium alloys when they are heat-treated, in particular, differential freezing, precipitation, segregation, and homogenizing are surveyed. (II.—) The physical metallurgy of the heat-treatment of aluminium–copper alloys is explained by reference to the phase diagram. The mechanism of quenching and ageing is described. (III.—) The heat-treatment characteristics of wrought aluminium alloys are described, and the effect of previous cold work, and the necessity of annealing (to remove the effects of plastic deformation), explained. (IV.—) A detailed discussion of the annealing and solution heat-treatment of aluminium alloys, illustrated by photomicrographs. (V.—) Precipitation-hardening, equipment, furnaces, and salt baths are discussed, and details are given of heat-treatment cycles for solution heat-treatment and age-hardening. —M. A. V.

***Controlled Annealing of Strain-Hardened Aluminium Alloys** [**52S and 3S**]. P. W. Boone and David Lewis, Jr. (*Aluminum and Magnesium*, 1947, **3**, (4), 8, 20).—A brief description of annealing tests and procedure applied to batches of half-hard aluminium alloy sheet (52S and 3S) to bring them to a condition equivalent, from the tensile-strength point of view, to quarter-hard sheet. The use of an electrically heated re-circulating type of furnace is stated to be satisfactory; non-circulating air furnaces are not suitable. The treatments used were ½ hr. at 600° F. (316° C.) for both alloys, and the temp. variation in the furnace was less than 10° F. (6° C.). Material equivalent to quarter-hard 52S sheet could be obtained by annealing the half-hard alloy for ½ hr. at 550° F. (288° C.); a similar change for 3S sheet required ½ hr. at temp. between 600° and 650° F. (316° and 343° C.). The authors recommend pilot tests on each lot of sheet before annealing the batch, so as to allow for variations in initial properties.—F. A. F.

Ageing Heat-Treatments of 75S Aluminium [**Alloy**]. F. R. Kostoch (*Iron Age*, 1946, **158**, (7), 49).—Summary of an address to the Aviation Section of the American Society of Mechanical Engineers. K. describes three classes of ageing treatment for Alcoa 75S, and the advantages of each.—J. H. W.

Controlled Atmospheres for Magnesium Alloy Heat-Treatment. F. A. Allen (*Light Metals*, 1947, **10**, (111), 169–172).—A. points out that oxidation of magnesium alloys is not necessarily very rapid, and discusses the amount of sulphurous material needed in the heat-treatment furnace to inhibit oxidation. Brief mention is made of the use of atmospheres of carbon dioxide, of dried, partially burnt town gas, and of water vapour and oxygen. The latter is claimed to be particularly successful, and is a patented process. —F. A. F.

Developments in the Applications of Controlled Atmospheres. I. Jenkins (*Metallurgia*, 1947, **36**, (211), 23–27).—Modern controlled-atmosphere practice is reviewed from the technical and economic viewpoints, and a table of characteristics of atmospheres for various purposes is given. This includes burnt ammonia for bright annealing and hardening of non-ferrous metals, completely burnt fuel gas for bright annealing copper and brass and copper brazing, and charcoal gas for bright annealing and melting copper.—M. A. V.

Heat-Treatment of Steels and Various Alloys.—I. — Sourdillon (*Tech. Moderne*, 1947, **39**, (5/6), 73–80).—A good general survey of the heat-treatment of ferrous and non-ferrous alloys.—M. E.

High-Frequency Induction Heating. E. May and T. G. Tanner (*J. Inst. Prodn. Eng.*, 1946, **25**, (12), 331–352; and (summary) *Engineer*, 1947, **183**, (4753), 178–180).—An illustrated account of the theory, modern industrial equipment, and applications of induction heating.—W. G. A.

High-Frequency Industrial Heating. —— (*Electronic Ind. and Instrumentation*, 1947, **1**, (3), 5).—A series of photographs is given, showing some uses of high-frequency generators in textile manufacture, plastics production, and metallurgical industries. Illustrations show equipment for high-temp.

melting, brazing operations on shafts and carbide-tipped tools, through heating of bars and tubes for forging, and high-speed hardening of steel gears. —D. M. L.

Induction Heating. M. Gourod (*Tech. Moderne*, 1947, **39**, (11/12), 206–208).—A summary of the principles, equipment used, and the diverse applications of induction heating using frequencies from 50 c./s. to 5 Mc./s. Equations for current penetration and heating intensity are given in the discussion of skin effect.—D. M. L.

Current Transformers in Induction Heating. R. A. Whiteman (*Radio News*, 1947, **37**, (4), 16–19, 31).—Current transformers, usually known in Britain as "concentrators" are assuming some importance for the production of very high-intensity H.F. fields for hardening operations and also for matching low-impedance loads, e.g. copper or brass, to the high-impedance output circuits of R.F. heating generators. W. analyses the design of current transformers and reports the results of tests carried out on transformers of various sizes. —D. M. L.

Induction Heating with Electronic Generators. —— (*Steel*, 1946, **119**, (14), 84, 87).—A brief description of R.C.A. 2 kW. and 15 kW. H.F. generators. —M. A. V.

Electronic Heating Units Show Economy, Speed. —— (*Electronic Ind. and Electronic Instrumentation*, 1947, **1**, (3), 2–3).—A review of the present uses of induction and dielectric heating. The advantages of radio-frequency heating over normal methods are discussed.—D. M. L.

Some Notes on Radio-Frequency Heating. —— (*Mass Prodn.*, 1946, **22**, (11), 566–567).—A brief review, including some metallurgical applications. —R. W. R.

Radio-Frequency [Heating] Aids Mass Production. —— (*Mass Prodn.*, 1947, **23**, (3), 42–47).—An account of the industrial uses of radio-frequency dielectric and induction heating, including certain metallurgical applications such as soldering, brazing, and surface hardening.—R. W. R.

The Tocco "Heat Gun". —— (*Machinery* (*Lond.*), 1947, **70**, (1808), 653).—An illustrated description of the "heat gun" developed by the Tocco Division of the Ohio Crankshaft Company. The portable inductor, working at a frequency of 10,000 c./s., actually generates heat within the conducting work-piece, giving heating speeds more than twice that of the oxy-acetylene flame. The gun takes 11 kW. from the motor-generator set. There is no electrical danger to the operator, and safety goggles are not required. The gun has been applied to lap brazing of steel boxes using silver-solder foil, local hardening and annealing of steel bars, brazing of carbide tips to lathe tools, and for solder melting in automobile-radiator assembly.—D. M. L.

***Some Experiments on Quenching Media.** F. W. Jones and W. I. Pumphrey (*J. Iron Steel Inst.*, 1947, **156**, (1), 37–54).—In an attempt to devise a standard test for the comparison of the (steel-) hardening properties of various media, the authors measured the cooling rates at the centre of a silver cylinder $\frac{3}{4}$ in. dia. × 3 in. A silver–platinum thermocouple was used, and the temp. was recorded with the aid of a D.C. amplifier and a high-speed milliammeter pen recorder. Results are presented in a table showing the time taken to cool to various temp. for the following quenching media: agitated water at 20° and 80° C., stagnant water at 80° C., and 5 oils, all agitated. The fastest rate of cooling was obtained with the cold water (2·0 sec. to 100° C.); the oils and agitated hot water all gave times of cooling to 100° C. in the range 12·8–15·5 sec., while the stagnant hot water yielded the much longer time of 26·5 sec. An attempt was made to correlate the hardnesses of cylinders of nickel–chromium–molybdenum steels with the cooling rates afforded by the different media, but no such correlation was found. Further experiments of a similar nature using $\frac{3}{4}$, $1\frac{1}{2}$, and $3\frac{1}{2}$-in. cylinders of 18 : 8 stainless steel were carried out, and it was found possible to relate qualitatively the cooling rates obtained with the hardnesses of the alloy steel specimens. It is shown that the heat-transfer factor varies considerably with temp. The "effective" value of this factor was found to decrease with increase of specimen size. Some of the experimental cooling rates found for the stainless-steel cylinders are compared with those predicted by calculation using Schmidt's method for the solution of problems in unsteady heat flow. This method and its application to the case of the cylinder are described in two Appendices.—R. W. R.

XIX.—WORKING

Upsetting Aluminium [18S] Heads. Harry G. Howell (*Steel*, 1946, **119**, (13), 108–111, 176–177).—A description of the forging, heat-treatment, quenching, and finishing of cylinder heads of 18S aluminium alloy for radial aircraft engines.—M. A. V.

Tolerances for Impression Die Forgings. —— (*Materials and Methods*, 1947, **25**, (6), 125).—Engineering File Facts No. 143.—J. L. T.

Impact Extrusion. The Application of the Process to the Production of [Aluminium] Radio-Condenser Components. —— (*Machinery* (*Lond.*), 1947, **71**, (1810), 3–11).—The production from 99·5% aluminium of trimmer-condenser stators and rotors, electrolytic condenser anodes, and other components of complicated shape by impact extrusion at the Mitcham Works of the Philips organization is described and illustrated.—J. C. C.

Achievements and Trends in the Copper and Brass Industry. Clement Blazey (*Australasian Eng.*, **1946**, (Dec.), 61–69; **1947**, (Jan.), 37–41).—A paper read before the Australian Institute of Metals, Sydney Branch. B. describes in detail the production of wire bars, wire drawing, the production of billets for tubes, piercing and extrusion of tubes, extrusion of rods and sections, and rolling of sheet and strip. 29 references are given.—N. B. V.

***The Effect of Speed of Rolling in the Cold-Rolling Process.** H. Ford (*J. Iron Steel Inst.*, 1947, **156**, (3), 380–398).—F. describes the results of measurements of roll torque made during the strip rolling, at various speeds up to 300 ft./min., of two mild steels, containing 0·2 and 0·07% carbon respectively, and of H.C. copper. With pass reductions up to 60%, the roll pressure required for first passes was independent of the speed of rolling, thus confirming the results of previous researches. When the material was thin and strongly work-hardened, a marked dependence of roll pressure on speed was found, the pressure required being least at high speeds and apparently approaching a limiting value at 300 ft./min. This effect first appears, in material which does not work-harden rapidly, at a thickness of about 0·017 in. using 10 in.-dia. rolls (i.e. dia. : thickness ratio = 590) and a pass reduction of 30%. With greater pass reduction, the critical thickness is greater and *vice versa*. A high rate of strain-hardening causes the effect to appear at greater thicknesses. In the case of the H.C. copper, some anomalies were found, the pressure/speed curve showing a hump at about 100 ft./min.; a theoretical explanation is given for this. Energy consumption also depended upon speed, but to a less extent and in a more complex manner; the energy required was usually least at medium speeds. Variation of speed during rolling, the setting of the rolls being unchanged, caused considerable variations in the thickness of the resulting strip, the thickness varying inversely with rolling speed; this effect was most marked with work-hardened thin strip. It is apparent from the experimental results that it is possible to roll thinnest at high speeds. F. concludes by discussing the results of his experiments from the point of view of deformation theory, suggesting as possible causes, dependence of yield stress on rate of deformation, temp. rise due to work of deformation, roll flattening, and frictional variations. These factors are not regarded as providing a complete explanation.—R. W. R.

The Rolling of Metals, Theory and Experiment. XIV.—Methods Used in Practice for the Calculation of Rolling Load and Horse-Power. L. R. Underwood (*Sheet Metal Ind.*, 1947, **24**, (243), 1352–1360, 1366).—Cf. *Met. Abs.*, 1947, **14**, 406. U. explains the method of calculating the rolling load and horse-power of a non-reversing cold breaking-down mill fitted with a fly-wheel between the motor and the stand. Examples of mills frequently fitted with a fly-wheel on the drive are brass and copper ingot cold breaking-down mills, the roughing stands of rod and bar mills, and any non-reversing mill in which the length of material rolled is short and the energy required for rolling relatively great. The methods of calculating roll loads and rolling horse-powers described are capable of giving satisfactory results in practice provided curves are used which refer to conditions closely resembling those of the calculation. Otherwise, the success of the methods is dependent on judgment gained from experience.—R. Gr.

***Fluctuations of the Distribution of Torque Between Rolling-Mill Spindles.** E. A. W. Hoff (*J. Iron Steel Inst.*, 1947, **155**, (1), 51–54; and *Iron and Steel*, 1947, **20**, (6), 216–217).—H. describes the results of strain-gauge measurements of the variations in the torques acting on the connecting spindles of a two-high mill, during the rolling of mild steel, H.C. copper, aluminium, and tellurium-lead strip. Two kinds of fluctuation were observed: (1) a periodic fluctuation, in step with the roll revolutions, which is ascribed to mechanical imperfections of the driving gear, and (2) irregular variations of shorter period, thought to be due to variations in the surface condition of the material being rolled. It is shown, in an Appendix, that none of the fluctuations could have been caused by the universal joints.—R. W. R.

Synthetic-Resin Bearings [for Rolling Mills]. F. W. Jones (*J. Iron Steel Inst.*, 1947, **155**, (4), 602–606).—J. describes the use of synthetic-resin bearings for rolling mills, and discusses various engineering considerations. The use of synthetic-resin bearings in place of bronze bearings resulted in a power saving of 19%.—R. W. R.

B.C.H. Bearings. —— (*Trans. Inst. Marine Eng.*, 1945–46, **57**, 66–67).—B.C.H. bearing material was used originally for roll-neck bearings in rolling mills. It now has uses in marine engineering for stern-tube bearings, " A " bracket bearings, rudder-post bearings, davit bearings, pump bearings, and eye rings, and for the surfacing of slides for cross-head slippers. It can be machined in a similar manner to aluminium.—J. L. T.

Carbide Drawing Dies [for Aluminium]. Daniel Mapes (*Steel*, 1946, **119**, (5), 84, 86).—A brief account of the advantages of changing from steel to " Carboloy " cemented-carbide dies for deep drawing steel and aluminium alloys.—M. A. V.

Drawing, Stretching, Stamping of Aluminium. Harry L. Smith, Jr. (*Steel*, 1946, **119**, (4), 88–90, 92, 130).—The technique of drawing, stretch-forming, and stamping aluminium alloys and Alclad is described generally. A table of tensile properties and hardness of the alloys is included.—M. A. V.

Panel-Beating Aluminium. —— (*Modern Metals*, 1947, **3**, (3), 24–25).—A description of the process, reprinted from *Aluminium News Bull.* (*Australia*).
—N. B. V.

Fabricating Aluminium Radiators. —— (*Steel*, 1946, **119**, (25), 102).—A brief description of three German shaping machines.—M. A. V.

Some Facts About Spinning Aluminium. —— (*Modern Metals*, 1947, **3**, (5), 16–17).—N. B. V.

Press Forms 4-Part Magnesium Canoe. Chester S. Ricker (*Machinist* (*Eur. Edn.*), 1947, **91**, (15), 480–481).—The manufacture of the canoe from sheets, extrusions, and castings is briefly described.—J. H. W.

Finishing Aluminium Pistons on Heald Borematics. —— (*Machine Tool Rev.*, 1947, **35**, (209), 67–68).—Heald Borematics are ideal machines for turning pistons, either cylindrical or oval, or for boring the gudgeon-pin holes, as they possess the desirable characteristics of smooth running and uniform traverse. The cutting should be done dry, but the model should be smeared with vaseline or lanoline. The required smooth wall surface can be obtained in many ways, but the two-way boring process is generally recommended.
—H. V.

Special Machine Tools for the Machining of Light Alloys. G. Laval (*Machines et Métaux*, 1947, **31**, (344), 115–120).—English and American machine tools are described.—M. E.

Free-Machining Copper. —— (*Indian Eng.*, 1946, **120**, (4), 225–226).—Reprinted from *Distribution of Electricity*.—W. G. A.

Machinability, Tool Life, and the Machine Tool. G. Schlesinger (*Machinery* (*Lond.*), 1946, **69**, (1774), 463–467; correspondence, 1947, **70**, (1795), 296).—Cf. *Met. Abs.*, 1947, **14**, 29.—J. L. T.

Cutting Action of Reamers. T. F. Githens (*Trans. Amer. Soc. Mech. Eng.*, 1946, **68**, (8), 867–876; and (summary) *Machinery*, 1946, **69**, (1779), 624).

Chatter and Its Causes. G. Holman (*Amer. Machinist*, 1946, **90**, 100–101; and (abridged) *Mécanique*, 1946, **30**, (340), 296).

Materials Used in America for the Cutting Edge of Milling Tools. J. Doumenach (*Machines et Métaux*, 1947, **31**, (344), 121–124).—A review.
—M. E.

Grinding Carbide Milling Cutters. E. T. Larson (*Grits and Grinds*, 1946, **37**, (3), 1–7; (4), 1–7).—L. describes recommended procedures for grinding carbide-tipped milling cutters for machining ferrous and non-ferrous materials.
—R. W. R.

Limitation of Sintered Carbide [for Machining]. R. B. Scheffer (*Indust. Diamond Rev.*, 1946, [N.S.], **6**, (73), 372).—A brief discussion of the uses of carbide tools in the machining of metals.—R. W. R.

Wet-Belt Machining. William F. Schleicher (*Steel*, 1946, **119**, (2), 94–95, 114, 117).—Wet-belt machining, which is applicable to non-ferrous metals, is a method of grinding, surfacing, and stock removal by an abrasive belt passing at high speed over a hardened steel platen. The abrasive is bonded to the belt with a plastic impervious to the liquid. The method avoids generation of heat and consequent probable weakening of structure.—M. A. V.

Notes on the Hand Engraving of Metals with Diamond Tools. —— (*Indust. Diamond Rev.*, 1947, **7**, (81), 229–234).—The various techniques are discussed, and the relative merits of diamond and steel tools are compared.—R. W. R.

Finishing with Diamond Tools. Paul Grodzinski (*Mech. World*, 1947, **121**, (3154), 615–616).—A brief discussion of the use of single-point diamond tools for the production of fine-turned finishes on metal surfaces.—R. W. R.

XX.—CLEANING AND FINISHING

Surface-Treating Aluminium with Alodine. —— (*Modern Metals*, 1947, **3**, (2), 23).—Cf. *Iron Age*, 1946, **158**, (23), 64; see *Met. Abs.*, 1947, **14**, 106.
—N. B. V.

Protective and Decorative Finishes for Cast Aluminium. John J. Stobie, Jr. (*Modern Metals*, 1947, **3**, (4), 14–19).—S. reviews the mechanical, chemical, electrochemical, and organic finishes available for cast aluminium. 27 references are given.—N. B. V.

Pre-Welding Treatment for Aluminium [Diversey Process]. (Button). See p. 69.

Finishing Copper by Oxidation with Sodium Chlorite. Walter R. Meyer and G. P. Vincent (*Metal Finishing*, 1947, **45**, (3), 61–63, 71).—A procedure, patented under U.S. Patent No. 2,364,993, for copper and copper alloys is described. It is applicable to pure copper, either cast, rolled, or electrodeposited, and to alloys containing more than 60% copper. For alloys with less than 90% copper, a pre-treatment is needed. Details of cleaning procedure and acid dipping are given, but the composition of the salts used is not given. The finish is claimed to improve the corrosion-resistance of the metal and to form an excellent basis for paints, lacquers, and enamels. Coloured finishes can also be obtained by carefully controlling the time of immersion. The temp. of operation is between 210° and 220° F. (99°–105° C.). Care is needed to prevent the solution touching the skin, and there is risk of fire if the salts come into contact with organic materials.—G. T. C.

Preparation of Magnesium for Painting. R. E. Gwyther (*Products Finishing*, 1947, **11**, (5), 56, 58).—A report of a paper read at the second annual symposium on " Modern Metal Protection ", held in Cleveland, Ohio.—J. L. T.

Shot Peening. R. King (*Mass Prodn.*, 1946, **22**, (9), 442–443).—An elementary account of the technique of shot peening, and of its effectiveness in increasing the fatigue strength of metal parts.—R. W. R.

Soft Grit Blasting. E. C. Lathrop and S. I. Aronovsky (*Steel*, 1946, **119**, (4), 102, 104, 107–108).—A description of a method of blasting with corncob or rice hull grit, under 80–90 lb./in.^{2} pressure, for cleaning metals or removing paint or surface finishes.—M. A. V.

Vapour Blasting. —— (*Mass Prodn.*, 1946, **22**, (12), 602–603).—A short description of a new (American) process for the production of fine finishes on metal surfaces. An abrasive emulsion (containing Novaculite as abrasive) is blown by compressed air on to the surface at a speed of 3000 ft./sec. The process is useful in preparing metal surfaces for painting or plating, removing machining marks, reducing friction between surfaces, and honing machined surfaces.—R. W. R.

Precision Tumbling of Metal Parts. R. M. Lord (*Grits and Grinds*, 1946, **37**, (6), 1–5).—L. describes the uses of precision tumbling, using Alundum Tumbling Abrasive, for deburring, descaling, and for the production of uniform radii on small metal parts.—R. W. R.

Barrel Finishing of Metal Products. VI.—Continuation of the Discussion on the Tubbing Machine. H. Leroy Beaver (*Products Finishing*, 1947, **11**, (5), 74–76, 78, 80, 82, 84).—The importance of renewing the burnishing liquid after each run is emphasized as being the only way to ensure satisfactory results. B. says diagonal-polishing steel slugs in tubbing machines are more effective than round balls.—G. T. C.

Barrel Finishing of Metal Products. VII.—Research in the Development of an Abrasive Bond Barrel Grinding Procedure. H. Leroy Beaver (*Products Finishing*, 1947, **11**, (6), 80, 82, 84, 86, 88, 90, 92).—Cf. preceding abstract. A discussion in very general terms of the properties required in liquids used in barrel grinding. High viscosity and rinsability are particularly important. It is suggested that glucose solutions and glycerine have the desired properties. No actual results are given.—G. T. C.

Barrel Finishing of Metal Products. VIII.—Some Things You Can Do to Help Yourself. H. Leroy Beaver (*Products Finishing*, 1947, **11**, (7), 62, 64, 66, 68, 70, 74, 76).—Cf. preceding abstract. In view of the current shortage of burnishing materials, the possibility of burnishing articles without the addition of such materials is worth considering. Whether or not parts are self-burnishing will depend largely on their shape and nature. A number of cases are mentioned where self-burnishing has been successfully carried out. Slight modifications in design (e.g. the avoidance of unnecessarily deep recesses) will often ensure that components are self-burnishing.—G. T. C.

Finishing Operations at Chrysler's Dodge Division. Bryant W. Pocock (*Products Finishing*, 1947, **11**, (7), 30–32, 34, 36, 38, 40, 42, 44, 46, 48, 50, 52, 54, 56, 58).—A description of the methods and equipment used for finishing motor cars. The specifications and operating details for the plating of brass, cadmium, bright zinc, copper (acid and cyanide), nickel (Watts' bath and hard nickel), chromium, and tin are given.—G. T. C.

Current Status of Protective and Decorative Coatings, and Future Possibilities. S. P. Wilson (*Products Finishing*, 1947, **11**, (5), 50–52, 54, 56).—A report of a paper read at the second annual symposium on " Modern Metal Protection ".—J. L. T.

A Surface-Active Agent for the Cleaning of Metals [Nacconol NR]. O. M. Morgan (*Monthly Rev. Amer. Electroplaters' Soc.*, 1947, **34**, (4), 430–441).—M. describes the use of an alkyl aryl sodium sulphonate, marketed as " Nacconol NR ", which improves the cleaning efficiency of both acids and alkalis. Treatment time, operating temp., and concentration can be reduced if this material is used. It is unaffected by hard water. A new method of evaluating metal-cleaning compounds is also described, based on the fact that mineral oil fluoresces brightly under ultra-violet radiation. The fluorescence is capable of being photographed, giving a convenient method of detecting and recording oil residues on metal surfaces. The article includes a large number of photographs illustrating the effect of varying concentrations of the surface-active agent.—G. T. C.

Water-Soluble Buffing Compound May Offer Advantages. —— (*Products Finishing*, 1947, **11**, (7), 92, 94, 96).—Buffing compounds have been developed which are water-soluble. They are easy to apply to the buffing wheel and adhere to it well. They can be removed from the work in many cases by a dip in hot water, though in general it is necessary to follow this water dip with a 2–3% sulphuric acid dip at room temp. The time in the water is, on the average, 2 min. and in the acid up to 30 sec. Unlike other buffing compounds, they do not " set-up " if there is an interval between application and removal.—G. T. C.

Wheels and Compounds for Buffing and Polishing. John E. Hyler (*Steel*, 1946, **119**, (25), 93–117).—H. enumerates recommended abrasives, buffing compounds, and types of wheels for various purposes, including the buffing and polishing of non-ferrous metals.—M. A. V.

Supplementary Equipment for Buffing and Polishing. John E. Hyler (*Steel*, 1946, **119**, (26), 62–63, 104).—Cf. preceding abstract. A discussion of wheels, other than set-up types, and electric motors.—M. A. V.

Machines and Auxiliary Equipment for Buffing and Polishing. John E. Hyler (*Steel*, 1946, **119**, (27), 68–69, 112).—Cf. preceding abstract. Buffing and polishing machines and dust-collecting systems are discussed.—M. A. V.

Polishing and Grinding Goes Modern. L. S. Sternal (*Metal Finishing*, 1947, **45**, (3), 51–54).—S. describes the advantages of using abrasive belts running over resilient contact wheels compared with the ordinary set-up polishing wheel and buff. Costs are considerably reduced, production is increased, and the finish obtained is more easily polished. Several types of contact wheel are described, including segmented cloth, segmented rubber, compressed canvas, and buff wheels. The importance of proper choice of wheel is stressed, and indications are given as to what each is suitable for.—G. T. C.

Grinding of Chromium-Plated Parts. F. J. Benn (*Grits and Grinds*, 1946, **37**, (5), 8–12).—Recommended procedures for the grinding of hard chromium plate are described.—R. W. R.

Cleaning-Room Practice. Milton P. Schemel (*Amer. Foundryman*, 1947, **11**, (2), 56–58).—A general review.—J. E. G.

***Note on a Convenient Method of Electropolishing Aluminium Alloys.** U. R. Evans and D. Whitwham (*J. Electrodepositors' Tech. Soc.*, 1947, **22**, 24–28).—An electrolytic-polishing bath, containing 144 c.c. ethyl alcohol, 10 g. anhydrous $AlCl_3$, 45 g. anhydrous $ZnCl_2$, 32 c.c. water, and 16 c.c. *n*-butyl alcohol, and operating at 20–24 V., is described. The method of polishing a small specimen is given in detail. After degreasing and etching, the specimen and cathode are fixed in a rigid frame, which is moved about in the solution during polishing. Polishing proceeds for about 1 min., after which the frame is exposed to the air, to break down the passivity, and then re-immersed. The cycle is repeated 6–12 times. The effect on the finish of departures from the optimum conditions is summarized in a table. Apart from aluminium alloys, zinc, tin, nickel, 18 : 8 stainless steel, cobalt, and chromium have been polished in the bath.—G. T. C.

***Electropolishing [Nickel] with Fluosulphonic Acid.** C. B. F. Young and Kenneth R. Hesse (*Metal Finishing*, 1947, **45**, (3), 64–67).—Solutions containing fluosulphonic acid 5–20, phosphoric acid 60–90, water 0–27, and chromic oxide 0·6–8·5% polished nickel, nickel silver, and 18 : 10 stainless steel fairly well. Additions of sulphuric acid produced no advantages over sulphuric–phosphoric acid mixtures. Fluosulphonic acid–acetic anhydride, fluosulphonic–perchloric acid, and fluosulphonic–sulphuric acid–water mixtures did not show promise. Several different anode materials were tried out in the various solutions.—G. T. C.

Electropolishing Silver. —— (*Steel*, 1946, **119**, (25), 110).—The Westinghouse Electric Corpn. have developed a process for electropolishing silver-plated articles in a silver cyanide bath.—M. A. V.

***Rapid Determination of Conditions for Electrolytic Polishing of a Metal.** François Bertein (*Métaux et Corrosion*, 1946, **21**, (247), 40–43).—Simple cells are described, in which the anode c.d. vary over a range of the order of 200 and which thus permit the rapid survey of the possibility of electrolytic polishing with a given metal with a series of electrolytes, temp., and times of treatment. The variation of c.d. over the anode surface is obtained by the interposition of an insulating screen, a plain or slotted cylinder, between the cylindrical anode and the annular cathode.—A. B. W.

Electropolishing: What Is Its Status To-Day? Charles L. Faust (*J. Electrodepositors' Tech. Soc.*, 1946, **21**, 181–194; discussion, 286–288; also (summaries) *Metal Ind.*, 1946, **69**, (25), 512–513; and *Product Eng.*, 1946, **17**, 449–451).—Industrial applications of electropolishing have been retarded by misconceptions and extravagant claims on the one hand and the complex patent situation on the other. F. lists pertinent patents in four pages of tables. The process can be used : (1) for finishing for appearance, e.g. usually as a final operation, though sometimes it may be preferable to combine electropolishing with a final loose buffing operation—an attractive satin appearance is obtained by electropolishing after abrasive blasting; (2) as a precision machining operation, e.g. for polishing screws, which are afterwards plated back to dimensions; (3) before deposition of iron, nickel, or chromium; and (4) before dyeing of aluminium or electro-colouring of copper. A variety of products are now electropolished commercially. The metals for which commercial methods are available are : stainless steels, carbon steels, low-alloy steels, high-speed steels, nickel–chromium–iron, nickel, nickel silver, Monel metal, Nichrome, Chromel, copper, brass, bronze, zinc, magnesium, and aluminium. The baths used on a significant industrial scale are limited to sulphuric–phosphoric, phosphoric alone, and sulphuric–citric acids. Baths may be divided into two classes from the maintenance viewpoint : (i) those of infinite life, in which plating or precipitation of salts prevents build-up of metal concentration, and (ii) those which have to be discarded when metal concentration reaches a definite limit. Typical D.C. requirements are :

12–14 V. and 100–300 amp./ft.^{2}, and 5–10 or 20 amp./gal. bath vol. Temp. are generally in the range 115°–150° F. (46°–65° C.) and times of treatment 8–30 min., with metal-removal equivalent to 0·0001–0·003 in. Electropolishing requires work-racking analogous to electroplating, and the same types of automatic, semi-automatic, or manual equipment can be used. Agitation is essential when the anodic efficiency is less than 100%, to avoid gas furrowing, and generally increases the rate and uniformity of polishing. It is considered that applications of electropolishing will increase, but the prospective user must be willing to design for electropolishing.—A. B. W.

The Possibilities and Limitations of Electrolytic Polishing. A. F. Brockington (*Sheet Metal Ind.*, 1947, **24**, (243), 1414–1416).—A brief review of the present position. Mop-polishing and electropolishing are compared.—R. Gr.

***Lime Treatment of Waste Pickle Liquor.** Richard D. Hoak, Clifford J. Lewis, Charles J. Sindlinger, and Bernice Klein (*Indust. and Eng. Chem.*, 1947, **39**, (2), 131–135).—The authors deal with the use of dolomitic lime for the treatment of acidic wastes. The lower rate of reaction of dolomitic limes as compared with high-calcium limes is illustrated graphically and the causes discussed, together with methods of increasing this rate. The lower reaction rate of dolomitic lime is balanced by its lower cost.—D. P. M.

XXI.—JOINING

Soft Soldering as a Production Process. R. G. Harper and R. S. Strauss (*Sheet Metal Ind.*, 1947, **24**, (238), 345–354; discussion, (240), 784–786).—Presented to the Sheet and Strip Metal Users' Technical Association. H. and S. discuss the soldering of components fabricated from sheet and strip from the point of view of efficient quantity production. Factors influencing the selection of a solder are dealt with and individual processes considered.
—R. Gr.

Continuous Soldering of Small Motor Rotors Using High-Frequency Heat. W. L. Tesch and Paul A. Greenmeyer (*Materials and Methods*, 1947, **25**, (6), 94–96).—An illustrated description of equipment developed by R.C.A.-Victor of Campden, N.J., U.S.A., for the rapid soldering of conductors to the end rings of small squirrel-cage motor rotors. The rotors are 1 in. dia., ¾ in. long and are soldered at the rate of 600 per hr. The high-frequency generator used has an output of 2 kW. at 400 kc./s.—D. M. L.

[**Discussion on R. H. Atkinson and G. P. Gladis's Paper:**] **"A Study of the Behaviour of Ruthenio-Palladium in Torch Flames, with the Object of Improving Soldering Technique".** F. E. Carter (*Metals Technol.*, 1947, **14**, (1); *A.I.M.M.E. Tech. Publ.* No. **2039**, pp. 15–16).—Cf. *Met. Abs.*, 1946, **13**, 341. C. states that, in commercial practice, annealing in helium is unnecessary, and R. H. A. and G. P. G. agree.—W. H.-R.

Lead Welding. Robert L. Ziegfeld and David M. Borcina (*Steel*, 1946, **119**, (6), 120–122, 162, 165–166, 168).—The history of welding lead to lead is briefly reviewed and the latest techniques described. A comprehensive list of corrosive chemicals and their effects on lead is appended.—M. A. V.

Fastening and Fastening Methods.—IV. J. R. Fawcett (*Mech. World*, 1947, **121**, (3154), 622–624).—F. discusses the joining of metal parts, (1) with low-m.p. fusible alloys of the bismuth–cadmium–lead–tin type, (2) by interference fits, (3) by swaging, (4) by rubber bonding, and (5) by plastic cementing.—R. W. R.

Copper-Brazing Intricate Parts. —— (*Steel*, 1946, **119**, (19), 108, 110).—Assembly-line technique for copper-brazing small parts of precision machinery is described. A G.E. brazing furnace is used with a Drycolene atmosphere generator.—M. A. V.

Silver Alloy Brazing. Adolph Bregman (*Steel*, 1946, **118**, (23), 94–95, 143).—Examples are given of the silver brazing of steel in army ordnance. —M. A. V.

Silver Alloy Brazing of Copper Tubing. J. C. Powers, Jr., and H. DeM. Lucas (*Steel*, 1946, **118**, (11), 112–114, 116, 118).—An illustrated description of technique. The brazing alloys recommended are " Easy-Flo " (50% silver) and " Sil-Fos " (15% silver).—M. A. V.

Induction Brazing. R. Baubie (*Metallurgia*, 1947, **36**, (213), 159).—Abridged from *Materials and Methods*, 1946, **23**, (4), 1007–1010; see *Met. Abs.*, 1947, **14**, 230.—J. L. T.

Brazing Tool Tips by Induction Heating. —— (*Steel*, 1946, **119**, (8), 101, 154).—A brief description of the technique of brazing tungsten carbide tips to cutting tools by induction heating.—M. A. V.

Brazed Sheet-Metal Automobile Engine. —— (*Sheet Metal Ind.*, 1946, **23**, (227), 533, 536).—Cf. *Met. Abs.*, 1946, **13**, 339.—W. G. A.

Braze Welding Damper Windings. Glenn Stangland (*Steel*, 1946, **119**, (13), 104–105, 170, 172).—Groups of non-ferrous bars in each pole piece of the amortisseur winding of a synchronous motor have their ends brazed to a copper ring. The welding alloy is copper–6% phosphorus, which flows at 1400° F. (760° C.) and is self-fluxing on copper, but requires a flux with some copper alloys. An oxy-acetylene torch is used.—M. A. V.

Use of Bronze Welding in Repairing a Draw-Bench Cylinder. —— (*Steel*, 1946, **119**, (14), 82, 105).—M. A. V.

Pre-Welding Treatment for Aluminium [Diversey Process]. B. B. Button (*Steel*, 1946, **118**, (11), 132, 137–138).—Methods of removal of oxide film from aluminium alloys preparatory to spot welding are discussed. The " Diversey " process is recommended, but compositions of the cleaning baths are not stated. —M. A. V.

Metallic Joining of Light Alloys.—I, —II. —— (*Light Metals*, 1947, **10**, (108), 20–32; (109), 103–108).—(I.—) The author surveys the available methods of joining thin-gauge light-alloy materials and considers in detail the metallurgical aspects of the problem of soft-soldering light alloys. (II.—) A detailed review of the many soft solders which have been suggested for aluminium. The lack of co-ordinated investigation and field-test results is stressed.—E. C. E.

Metallic Joining of Light Alloys.—III, —IV. —— (*Light Metals*, 1947, **10**, (110), 111–120; (111), 203–209).—Cf. preceding abstract. (III.—) Fluxes for soldering aluminium are briefly discussed and types of composition stated. Friction soldering without the use of flux shows the flux to give a much superior product as judged by a durability test according to W.T. Specification K110. Solders of the tin–zinc–lead and tin–zinc–silicon types are discussed and some test results quoted. For friction soldering, the 70 : 30 tin–zinc alloy solder is recommended. The use of resistance methods of heat supply for the soldering operation is described. Hard soldering is discussed generally and compositions given. The corrosion danger introduced by electrode p.d. between aluminium and the solder is considered; the potentials are no greater than exist between heavy metals and traditional solders, and consequently they do not rule out the use of solder with aluminium. (IV.—) A lengthy account is given of papers by E. C. Hartmann, G. O. Hoglund, and M. A. Miller (see *Met. Abs.*, 1945, **12**, 234) and A. E. Thiemann (see *Met. Abs.*, 1945, **12**, 19). A short digest of other literature is also given.—F. A. F.

The Welding of Non-Ferrous Metals. VIII.—The Welding of Copper and Its Alloys. E. G. West (*Sheet Metal Ind.*, 1947, **24**, (239), 618–622, 624; (241), 1017–1023, 1027; (243), 1425–1429, 1435).—Cf. *Met. Abs.*, 1947, **14**, 285. Various methods of arc welding of copper discussed include the metallic- and carbon-arc methods, with a reference to the Lessel multi-coated electrode.

The use of atomic hydrogen for welding has not as yet proved entirely satisfactory. The restricted uses of spot and seam welding and of butt and flash welding are referred to. Problems involved in the welding of copper-rich alloys are discussed and are stated to be less difficult than in welding copper itself. Copper alloy welding is not widely practised. The gas, arc, and resistance welding of copper–tin, silicon-bronze, and copper–aluminium alloys are considered.—R. Gr.

Multiple-Tip Torches Speed Stainless-Steel Welding. William P. Brotherton (*Iron Age*, 1946, **157**, (25), 70–73).—A description of the use of torches possessing two or three tips. In one application, one tip performs a cutting operation, the other subsequently welding the material. In another application, three tips are employed, the first preheating the metal, the second welding, and the third post-heating.—R. W. R.

***Observations on the Arc Welding of Aluminium and Its Alloys.** A. Schaerer (*Promotionsarbeit von der E.T.H. in Zürich zur Erlangung der Würde Eines Doktors der Techn. Wiss. Genehmigte*, **1946**, 72 pp.).—The theoretical principles involved in arc-welding aluminium and its alloys are briefly reviewed, and a comprehensive series of experiments on the subject reported, with particular reference to flux-coated electrodes. The welding behaviour of pure aluminium, Peraluman, Anticorodal, and Avional sheets, using different welding-rod alloys, was examined, and the corrosion-resistance and mechanical properties of the resulting welds investigated. Results are tabulated and illustrated graphically, and many photographs of the types of welds obtained under various conditions are given.—G. V. R.

Arc-Welding Equipment in War-Time Germany. F. W. Myers, Jr. (*Iron Age*, 1946, **157**, (17), 46–50).—M. describes a number of arc- and spot-welding machines, mostly of the automatic or semi-automatic type.—R. W. R.

Arc Welding Electrode Coatings. H. P. Zade (*Welding*, 1946, **14**, (3), 127–131; and *Iron Age*, 1946, **157**, (15), 46–49).—R. W. R.

Inert-Arc Welding. D. W. Puffer (*Steel*, 1946, **119**, (21), 80–82, 116, 118).—The advantages and technique of arc welding in inert atmospheres are outlined. Special reference is made to aluminium and magnesium and their alloys, copper, and nickel–chromium alloys.—M. A. V.

Production Applications for Inert Gas-Shielded Arc Welding. H. T. Herbst (*Weld. J.* (*J. Amer. Weld. Soc.*), 1947, **26**, (5), 410–418; and *Modern Metals*, 1947, **2**, (12), 26–28).—H. describes the Heliarc process, explains its development, and outlines various production applications for light metals.—N. B. V.

Automatic Welding. —— (*Mass Prodn.*, 1946, **22**, (8), 367).—A brief description of a new automatic shielded-arc process developed by the American Lincoln Electric Company.—R. W. R.

British Welding Research Association Symposium on the Welding of Light Alloys. —— (*Metallurgia*, 1946, **34**, (204), 321–324; *Sheet Metal Ind.*, 1946, **23**, (235), 2189–2191, 2198; and *Metal Ind.*, 1946, **69**, (18), 361–363; (19), 381–383).—Reports of the proceedings at the symposium (see abstracts below).
—W. G. A.

The British Welding Research Association Symposium on the Welding of Light Alloys. —— (*Sheet Metal Ind.*, 1947, **24**, (240), 823–824).—A report of the introductory speeches to the symposium.—J. L. T.

Industrial Practice for Spot-Welding Light Alloys. —— (*Sheet Metal Ind.*, 1947, **24**, (240), 824–828, 830; discussion, (244), 1650–1654, 1656).—A paper prepared by the L.R.4 Committee of the British Welding Research Association and presented at the symposium.—J. L. T.

Spot Welding of Light Alloys: Present Trends in American Machine Design. T. M. Roberts (*Sheet Metal Ind.*, 1947, **24**, (241), 1028–1032, 1034; discussion, (244), 1650–1654, 1656).—Read at the British Welding Research Association Symposium on the Welding of Light Alloys.—R. Gr.

Methods of Surface Preparation of Light Alloys for Spot Welding. F. C. Dowding (*Sheet Metal Ind.*, 1947, **24**, (242), 1232–1236, 1238; discussion, (244), 1650–1654, 1656).—First progress report of the L.R.3 Committee of the British Welding Research Association and presented at the symposium.—R. Gr.

Spot Welding of Some Aluminium and Magnesium Alloys. H. Brooks (*Sheet Metal Ind.*, 1947, **24**, (243), 1436–1440, 1442; discussion, (244), 1650–1654, 1656).—Read at the British Welding Research Association Symposium on the Welding of Light Alloys. MG 5, MG 7 (D.T.D. 182A), Alclad (D.T.D. 390), D.T.D. 118, and D.T.D. 120A are considered.—R. Gr.

Resistance Welding of Light Alloys. R. Bushell (*Machine Shop Mag.*, 1947, **8**, (7), 66–71).—B. deals with the fundamental technical differences between the spot welding of aluminium alloys and the spot welding of ferrous materials. He also discusses the best equipment for spot welding, seam welding, and butt welding.—H. V.

Some Fundamental Principles for the Resistance Welding of Sheet Metal. H. E. Dixon (*Sheet Metal Ind.*, 1947, **24**, (239), 607–617, 624; (240), 813–820; (242), 1221–1226, 1230).—Presented to the Sheet and Strip Metal Users' Technical Association. Spot, flash, and butt welding of aluminium-base alloys are discussed.—R. Gr.

Sciaky Resistance-Welding Machines. —— (*Mass Prodn.*, 1947, **23**, (4), 58–65).—A description of the principles, development, operating technique, and applications of the Sciaky welding machine.—R. W. R.

***The Development and Improvement of Spot-Welding Electrodes.** G. F. James (*Sheet Metal Ind.*, 1947, **24**, (238), 392–398; (242), 1227–1230).—Cf. *Met. Abs.*, 1947, **14**, 284. Experiments were carried out to determine the increase in tip dia. of some copper alloys under various welding conditions. The effect of temp. on the properties is discussed. Recommendations are made on the choice of suitable materials and conditions for the tips.—R. Gr.

Spray Welding [Hard-Facing Alloys]. —— (*Steel*, 1946, **119**, (26), 74, 77).—Hard-facing alloys are spray welded using 150-mesh powder and oxy-acetylene fuel gas, the deposited metal being bonded with an acetylene torch, or by induction heating, or in a controlled-atmosphere furnace at 1980° F. (1082° C.). The max. final thickness by this method is 0·06 in., i.e. 0·075 in. of deposited metal before bonding.—M. A. V.

Pressure Welding of Aluminium. H. Herrmann (*Metal Progress*, 1947, **51**, (6), 1004, 1008).—See *Met. Abs.*, 1946, **13**, 443.—J. L. T.

Welding Glass to Metal. —— (*Indian Eng.*, 1946, **120**, (3), 168).—Reprinted from *J. Council Sci. Indust. Research, India.*—W. G. A.

Metal–Rubber Assemblies. F. Sumner (*Mécanique*, 1946, **30**, (329), 9–11).—Translated from *Diesel Railway Traction.*—W. G. A.

Plastic Adhesive [Cycleweld]. —— (*Steel*, 1946, **119**, (27), 90).—Tests on 24S-T aluminium alloy plates bonded with "Cycleweld" plastic adhesive showed the adhesive to be stronger under bending stresses than the metal.—M. A. V.

The Selection of Welding Processes. W. J. Campbell (*Weld. J.* (*J. Amer. Weld. Soc.*), 1946, **25**, (8), 704–706; and *Australasian Eng.*, **1946**, (Nov.), 76–78).—N. B. V.

XXII.—INDUSTRIAL USES AND APPLICATIONS

Air Transport and Light Metal. Hedley S. Crabtree (*Light Metals*, 1947, **10**, (109), 78–86).—A review of trends in the use of aluminium and magnesium alloys in aircraft.—E. C. E.

Aluminium Aircraft Skis. —— (*Modern Metals*, 1947, **3**, (4), 20–21).—N. B. V.

The Seventeenth [French] Aircraft Show. Maurice Victor, Jean Blanchot, and Lucien Alff (*Rev. Aluminium*, 1946, (**127**), 363–369).—E. C. E.

Cable Sheathing in Aluminium. —— (*Light Metals*, 1946, **9**, (104), 474–498).—Based on accounts by W. Deisinger (*Z. Metallkunde*, 1939, **31**, (9), 305–310; and *Metallwirtschaft*, 1939, **18**, (48), 963–968; see *Met. Abs.*, 1940, **7**, 136, 180), F. Hanff, G. Hosse, and W. Deisinger (*Siemens Z.*, 1939, **19**, (8), 357–368; see *Met. Abs.*, 1940, **7**, 136), and A. Czempiel and C. Hasse (*Aluminium*, 1939, **21**, 17; see *Met. Abs.*, 1939, **6**, 383). The possibility of replacing lead by aluminium is examined critically in the light of economic and technical considerations.—E. C. E.

†Insulated Cables and Wire in Aluminium. —— (*Light Metals*, 1946, **9**, (107), 648–684).—A very comprehensive survey and summary of modern practice, in which particular attention is paid to the joining of aluminium cables.—E. C. E.

Nomographs for Calculating the Benefits of Reducing the Weight of Commercial-Vehicle Bodies [by Use of Light Alloys]. H. Colombier and Pierre de Lapeyrière (*Rev. Aluminium*, 1947, (**129**), 18–28).—The three types of nomograph described give: (1) the initial expense of the use of light alloys, (2) the decrease in daily load, and (3) the annual benefit.—M. E.

Coach Baggage Car Constructed of Aluminium Alloys. —— (*Product Eng.*, 1947, **18**, (7), 104–105).—A weight saving of 34%, as compared with conventional steel construction, is obtained in the car.—H. V.

Aluminium Ducts and Pipes [2S and 3S]. —— (*Modern Metals*, 1947, **3**, (3), 16–17).—Reprinted from *Amer. Artisan*. The practice of an American firm in fabricating ducts and pipes is described. The materials principally used are 2S (¼, ½, or ¾H) and 3S.—N. B. V.

Light Metals for Electronic Equipment. L. A. Hammarlund (*Modern Metals*, 1947, **3**, (5), 14–15).—N. B. V.

Light-Weight Gasoline Engines Made from [Aluminium] Die-Castings. R. P. McCulloch (*Iron Age*, 1947, **159**, (20), 52–57).—M. discusses the factors influencing the choice of die-castings in the design of a light-weight engine. Such factors are a substantial reduction in machining operations, lower scrap losses, use of light and inexpensive machine tools, and greater flexibility of design. He describes the major manufacture and assembly operations in the mass production of light motors largely of aluminium alloy.—J. H. W.

New Operation Builds Die-Cast [Aluminium] Engine in Mass-Production Style. —— (*Modern Metals*, 1947, **3**, (4), 26–27).—In the range of 2½–4 h.p. petrol engines described, all the main parts are high-pressure aluminium alloy die-castings with the exception of rods, crankshafts, and cylinder sleeves.
—N. B. V.

Gas Turbines and Jet-Propelled Engines. Maurice Victor (*Rev. Aluminium*, 1946, (**128**), 391–398).—An account of British and American jet-propelled engines and gas turbines.—M. E.

Four-Stroke Engines Have Won the War. Léonce Keuleyan, Jean Blanchot, and Lucien Alff (*Rev. Aluminium*, 1946, (**128**), 399–405).—M. E.

The Martin [Aluminium] Outboard Motor. G. E. Buske (*Modern Metals*, 1947, **3**, (2), 15–17).—Aluminium alloys in the form of stampings and die-castings are used to the max. possible extent in this American outboard motor, the construction of which is described in some detail.—N. B. V.

Four New Extrusions for Unit Furniture [Use of Light Metals]. George Fejer (*Light Metals*, 1947, **10**, (111), 184–188).—A discussion of the uses of specially developed extruded light-metal sections in the making of furniture (mainly wooden); the applications are in the form of door handles, sliding door channels, and drawer handles.—F. A. F.

[Use of Aluminium in] The Pinel "Hémo-Étaleur" for Counting Polynuclear White Blood Corpuscles. Emile Pinel and Marcel Lapoire (*Rev. Aluminium*, 1947, (**129**), 12–14).—An illustrated account of the apparatus, which is made of aluminium.—M. E.

The Light-Metal Home. —— (*Light Metals*, 1946, **9**, (105), 539–561).—A survey of the use of light alloys (principally aluminium) in the home. —E. C. E.

Aluminium Houses. —— (*Mass Prodn.*, 1947, **23**, (3), 52–57).—An account of the production of the "Airoh" House at the Bristol Aeroplane Company's works.—R. W. R.

Packaged [Aluminium] Houses. —— (*Steel*, 1946, **119**, (7), 86, 88).—A brief description of aluminium and steel prefabricated houses.—M. A. V.

Aluminium Roofing for Cincinnati's Union Terminal. —— (*Steel*, 1946, **119**, (6), 132, 149).—Details are given of the rebuilding of a dome-shaped roof, using preformed 14-gauge aluminium alloy sheet.—M. A. V.

[Aluminium] Roofs in Vercors. —— (*Rev. Aluminium*, 1947, (**130**), 41–43).—In Vercors, roofs of houses burnt by the Germans have been reconstructed in aluminium.—M. E.

How to Apply Aluminium Roofing and Siding. J. S. Pollack (*Steel*, 1946, **119**, (24), 107, 110).—Recommended erection methods are given.—M. A. V.

Aluminium Milk Cases. —— (*Modern Metals*, 1947, **3**, (2), 32).—N. B. V.

Aluminium Pallet Increases Flexibility, Lowers Handling Cost. T. O. Palmer (*Steel*, 1946, **119**, (1), 125–126).—A description of an aluminium pallet for industrial fork trucks, showing a considerable saving in weight over wooden units.—M. A. V.

Light-Weight Pallets for Easy Handling of Materials. T. O. Palmer (*Mech. Handling*, 1947, **34**, (2), 100–102).—Cf. preceding abstract. Reprinted from *Mill and Factory*.—J. L. T.

†Light-Alloy Piston Materials. A. Schofield and L. M. Wyatt (*J. Inst. Automobile Eng.*, 1947, **15**, (7), 251–293).—A comprehensive review of the aluminium alloys used for pistons, their fabrication and heat-treatment, and the thermal and stress conditions to which they are subjected in service. The mechanical, physical, and bearing properties of the piston alloys are described. —N. B. V.

The Precipitron Utilizes Aluminium. —— (*Modern Metals*, 1947, **3**, (4), 22–23).—The Precipitron, an electrostatic air-cleaning device, uses aluminium plates in the dust-collecting cell.—N. B. V.

Printing Industry and Light Alloys. —— (*Light Metals*, 1947, **10**, (109), 86–96).—A summary of current applications of aluminium alloys in printing plant and equipment and in printing processes. The theory and practice of the use of magnesium in photo-engraving are considered.—E. C. E.

Rockets. Maurice Victor (*Rev. Aluminium*, 1947, (**130**), 69–74).—An illustrated account of the manufacture of the V2 and of its performance. —M. E.

Aluminium and the Rubber Industry. —— (*Light Metals*, 1947, **10**, (109), 57–68).—A review of the use of aluminium in the production and processing of rubber. Particular attention is paid to those applications where the metal has shown superiority over alternative materials.—E. C. E.

Light Metals for Sculpturing. Lawrence Tenney Stevens (*Modern Metals*, 1947, **3**, (5), 18–20).—N. B. V.

Light Metals in Ship Construction. E. C. Goldsworthy (*Rev. Aluminium*, 1946, (**127**), 370–372).—Early experiences in the use of aluminium alloys for sea-going craft in Britain are reviewed. Between 1930 and 1934 many small craft were made from aluminium–magnesium alloy, and in 1944 one of these, the *Diana II*, was examined in detail with encouraging results. The Bristol Air–Sea Rescue launches are described, and the use of aluminium for the construction of containers for fish on fishing boats is mentioned.—E. C. E.

Light-Alloy Ships. —— (*Indust. Australian*, 1946, **101**, (2590), 906).—Reprinted from *Scope*.—W. G. A.

Small Craft in Light Alloy. —— (*Light Metals*, 1946, **9**, (103), 414–420).—An account of small rowing, sailing, and power-driven boats manufactured wholly or in part from light alloys.—E. C. E.

[Discussion on W. Muckle's Paper :] "Application of Light Alloys to Superstructures of Ships". —— (*Trans. N.-E. Coast Inst. Eng. Ship.*, 1945–46, **62**, D139–D154).—Cf. *Met. Abs.*, 1947, **14**, 34.—E. C. E.

Structural Uses of Aluminium Alloys. H. K. Hardy and C. G. Watson (*Mass Prodn.*, 1946, **22**, (5), 219).—A summary of *Structural Eng.*, 1946, **24**, (2), 65–112 ; see *Met. Abs.*, 1946, **13**, 272.—R. W. R.

Light Alloys in the Textile Industry. —— (*Light Metals*, 1947, **10**, (108), 33–53).—A review of the applications of aluminium and magnesium in the cotton, woollen, synthetic-fibre, and associated industries.—E. C. E.

New Toys in Aluminium. —— (*Rev. Aluminium*, 1947, (**129**), 15–17). —M. E.

Aluminium for Water-Works Structures. John M. Perryman (*J. Amer. Water Works Assoc.*, 1946, **38**, (12), 1327–1329).—It is pointed out that the reduced maintenance cost of aluminium equipment may more than off-set the greater initial cost of aluminium. A 500,000-gal. elevated water tank with an aluminium roof, ladders, and roof-supporting structure is described, and it is suggested that aluminium alloys could be considered as a substitute for steel filter gallery piping inside buildings and above the ground.—E. C. E.

Aluminium in West Africa. F. J. Erroll (*Light Metals*, 1947, **10**, (111), 178–183).—A review of the Gold Coast as a source of raw material and as a market for the aluminium industry. West African bauxite is low in silica, and a new project will make hydro-electric power available for the conversion of the ore, which is estimated to exceed 80,000,000 tons. Aluminium alloys are to be used in the construction of tropical-type bungalows and for river lighters, as well as for kitchen utensils.—F. A. F.

Aluminium Windows [63S]. —— (*Modern Metals*, 1947, **3**, (2), 18–19).—An American firm is mass-producing windows of the double-hung type in extrusions of 63S-5T alloy. The windows are transported to the site in the knocked-down state, and assembly, installation, and glazing take 23 min. —N. B. V.

Peace Demands for Aluminium Expand. Daisy L. Schooley (*J. Chem. Education*, 1946, **23**, (8), 399–401).—Reprinted from *Domestic Commerce*. A general review of some fields in which aluminium and its alloys may advantageously be used.—H. J. A.

Aluminium Seeks Home Market. —— (*Scope*, **1946**, (Sep.), 67–69).—An account of the changes which the war brought to the Swiss aluminium industry.—H. V.

Developments in the Aluminium Industry. E. G. West (*Metallurgia*, 1947, **36**, (211), 39–43).—Recent progress in the development and applications of aluminium alloys is reviewed.—M. A. V.

It's an Interesting Metal This Aluminium. —— (*Mass Prodn.*, 1946, **22**, (8), 403–404).—A brief account of the history and uses of aluminium. —R. W. R.

Beryllium Copper : Its Uses and Potentialities. H. G. Williams (*Steel*, 1946, **118**, (19), 88–91, 142, 144, 146).—Beryllium copper is non-magnetic, corrosion-resistant, and has high electrical conductivity ; it can be formed in a soft, ductile state, and then hardened to high strength (200,000 lb./in.^{2}) and a higher fatigue resistance than other copper alloys. The metallography, properties, and heat-treatment characteristics of the alloy are described. —M. A. V.

[Use of Brass in] Household Refrigerators. —— (*Non-Ferrous Forgings Digest*, 1947, **2**, (2), 1–3).

Diamond-Prepared Copper Tools in the Optical Industry. —— (*Indust. Diamond Rev.*, 1947, [N.S.], **7**, (77), 117).—A brief description of the uses of copper tools, charged with diamond grit, for lens grinding.—R. W. R.

***The Production of [Gold] Film-Type Bolometers with Rapid Response,** C. B. Aiken, W. H. Carter, Jr., and F. S. Phillips (*Rev. Sci. Instruments*, 1947. **17**, (10), 377–385).—In the type G bolometer, the sensitive element is constructed of a layer, 0·05–0·1 μ thick, of gold evaporated on a film of cellulose nitrate and covered by a layer of gold black to increase the absorption of radiation in the vicinity of 10 μ. Gold black, apparently a colloidal form of the metal, is produced by evaporation in an atmosphere of nitrogen, preferably in the presence of a small amount of tellurium. The resistivity of the gold black is dependent on the pressure of nitrogen, and by using a pressure of about 0·1 mm. it would probably be possible to deposit a conductive black strip directly on the cellulose film, omitting the first gold layer. The use of nickel, bismuth, antimony, cadmium, tin, tellurium, and selenium for bolometers has been briefly examined. None of these metals was so satisfactory as gold.—J. C. C.

Magnesium, the Metal of To-Morrow. T. R. B. Watson (*Canad. Metals*, 1947, **10**, (4), 13–17, 32).—Presented to the Essex–Kent Section of the Chemical Institute of Canada. A review of the history, manufacture, properties, and applications of magnesium and its alloys.—H. J. A.

The Alloys of Magnesium in Aeronautical Construction. Jean Gris (*Rev. Aluminium*, 1946, (**127**), 355–362).—A review of the growth of the use of cast and wrought magnesium alloys in aircraft. The mechanical properties of typical magnesium alloys are given.—E. C. E.

Photo-Engraving Plates in Magnesium. H. E. Swayze (*Light Metals*, 1947, **10**, (111), 188–192).—The magnesium alloy normally used for half-tone work contains aluminium 3, manganese 0·3, calcium 0·2, and zinc 1%, though for line work a special alloy (not specified) is used. Technical details, from the printer's point of view, are given, and the similarity to the processing of zinc is emphasized. Pictures indicating the clarity of reproduction from magnesium plates are given, together with further detailed comment on the peculiarities of magnesium alloys in processing as compared with zinc.—F. A. F.

Magnesium in Photo-Engraving. H. E. Swayze (*Modern Metals*, 1947, **3**, (2), 20–22).—Reprinted from *Photo-Engravers' Bull.*, Nov. 1946. The advantages of magnesium over other metals used for photo-engraving are enumerated, and a description is given of the processing of magnesium plates. —N. B. V.

***Characteristics of the Silver Chloride–Magnesium Water-Activated Battery.** J. B. Mullen and P. L. Howard (*Electrochem. Soc. Preprint* No. **90–33**, 1946, 411–422).—The positive electrode of each cell consists of silver foil 0·001–0·003 in. thick, coated with electrolytically formed silver chloride, electrochemically equivalent to 0·75–5·0 amp. min./in.^{2} according to requirements. The negative electrode consists of commercially pure magnesium foil. In the cell, electrodes are assembled with dry absorbent paper interleaved. At the time of use, the battery is removed from the sealed container and activated by immersion in tap water or sea water. The working voltage of single cells is 1·3–1·5. A summary is given of the preparation of materials, methods of construction, electrolytes, and discharge characteristics. A comparison of Wh./lb. with other types of batteries gives these average figures: lead–acid 10·5, dry cell 2·0, and silver chloride–magnesium 19·4.—A. B. W.

Pure Nickel Rupee. —— (*Sheet Metal Ind.*, 1947, **24**, (243), 1419).—A note to the effect that pure-nickel coins are now beginning to circulate in India. An illustration of the obverse and reverse of a coin is given.—R. Gr.

The Nickel Industry in 1945. Robert C. Stanley (*Queensland Gov. Min. J.*, 1946, **47**, (539), 276).—Condensed from *Min. Congr. J.*—W. G. A.

The Future of the High-Temperature Steam Piping Expansion Problem [Use of Inconel]. F. A. Scanlan (*J. Amer. Soc. Naval Eng.*, 1947, **59**, (1), 48–56).—A type of bellows expansion fitting, fabricated in Inconel, is described. Such fittings at present on the market will withstand a pressure of 1000 lb./in.^{2} at a temp. of 1600° F. (871° C.). It is suggested that these high-temp. expansion fittings will eliminate expansion loops and bends in high-temp. steam piping systems.—H. J. A.

Some Aspects of Gas-Turbine Development for Aircraft Propulsion [Nimonic Alloys]. S. G. Hooker (*Trans. N.-E. Coast Inst. Eng. Ship.*, 1945–46, **62**, 143–156; discussion, D47–D74).—A very brief account is given of some properties of modern materials for turbine blades, and the results of a number of tests on turbine discs are displayed. Turbine-blade stresses are designed up to the creep strength of Nimonic 80 at 700° C. for 300 hr. to fracture.
—E. C. E.

Metallurgy and the Gas Turbine. Frank T. Sisco (*Min. and Met.*, 1946, **27**, (473), 276–277; and (condensed) *Indian Eng.*, 1946, **120**, (3), 161–162).—A brief review.—W. G. A.

The Nimonic Series of Alloys. —— (*Indust. Australian*, 1947, **102**, (2603), 1097).—J. L. T.

***[Contact Materials for] Potentiometers [Palinoy No. 7].** L. A. Nettleton and Fred E. Dole (*Rev. Sci. Instruments*, 1946, **17**, (10), 356–363).—Methods of improving the performance of potentiometers are discussed. The only type of contact material which consistently gave long operating life on nickel–chromium wires (in size down to 0·002 in. dia.) was an alloy of platinum, palladium, gold, silver, copper, and zinc (Palinoy No. 7), used as a wire brush with a pressure of 40 g.—J. C. C.

The War Job of Tungsten and Molybdenum Products. M. H. McClement (*Steel*, 1946, **118**, (9), 141, 142, 144).—A brief account of the war-time production and applications of tungsten and molybdenum in the U.S.A.—M. A. V.

Forecast on New Metals and Alloys. Zay Jeffries (*Metals*, 1947, **17**, (9), 8–10, 16).—An address to the American Institute of Mining and Metallurgical Engineers.—J. L. T.

The Selection of Alloys for Use at Elevated Temperatures. B. H. Garnsey (*Australasian Eng.*, **1946**, (Nov.), 68–71; discussion, 71–72).—A lecture to the Australian Institute of Metals, Sydney Branch.—N. B. V.

***Marine Propeller-Blade Vibrations: Full-Scale Tests.** L. C. Burrill (*Trans. N.-E. Coast Inst. Eng. Ship.*, 1945–46, **62**, 249–270; discussion, D119–D138).—B. describes some experiments carried out with full-size marine propellers with a view to determining the modes and frequencies of the natural vibrations of the blades. The blades are excited by a vibrator, controlled by means of a beat-frequency oscillator, and the nodal patterns mapped out with the aid of a piezo-electric pick-up, used in conjunction with a cathode-ray oscillograph. Some examples are given of the nodal patterns and natural frequencies obtained from propeller blades designed to give pure flexural and pure torsional movement, i.e. without coupling, and also for other blades not so designed. Records are given for a typical propeller known to " sing " in service which exhibit several interesting features.—E. C. E.

The Use of Die-Castings in a Film Strip Projector. N. Field (*Machinery* (*Lond.*), 1947, **70**, (1809), 689–692).—J. C. C.

Collapsible Tubes. Frank T. Sisco (*Min. and Met.*, 1946, **27**, (475), 443; and *Indian Eng.*, 1947, **121**, (1), 41).—A review.—W. G. A.

Microscopic Electronic Parts by the Million. —— (*Steel*, 1946, **118**, (25), 95, 120, 127).—Examples are given of mass-produced small stampings and formed-wire components of phosphor bronze, beryllium copper nickel, nickel alloys, tungsten, steel, and copper-clad steel.—M. A. V.

New Methods of Radio Production [Use of Sprayed Metal]. J. A. Sargrove (*J. Brit. Inst. Radio Eng.*, 1947, [N.S.], **7**, (1), 2–33).—A technique for the mass production of light-current electrical apparatus is described. The method depends partly on the use of metal films sprayed on to a special base-plate (instead of soldered wires) to form the electrical circuit. The insulating base-plate is designed with recesses corresponding to the positions of the conductors; the whole base-plate is sprayed with metal and is subsequently surface ground, leaving metal in the recesses only.—H. J. A.

Future Trends in Instrument Bearing Design. J. H. Goss (*Product Eng.*, 1947, **18**, (2), 131–132).—Summary of a paper presented at the First National Instrumentation Conference of the Instrument Society of America.—W. G. A.

Metal-Coated Plastics. —— (*Steel*, 1946, **118**, (7), 92–95, 136, 138).—Applications of metal-coated plastics, e.g. as electrical conductors of intricate shape, or light reflectors, are becoming more numerous. Plating increases the heat resistance and tensile strength and decreases the water absorption of plastics; it is highly corrosion-resistant owing to the electrochemical inertia of the plastic base. Apart from electroplating, metal may be deposited by spraying, vacuum deposition, or chemical reduction. Special measures, e.g. roughening, must be taken to ensure good adhesion. Comparative tables of mechanical properties, corrosion-resistance, heat distortion, and water absorption of plated and unplated plastics are given.—M. A. V.

XXIII.—MISCELLANEOUS

[U.S.] Senate Small-Business Committee Report on the Future of Light Metals Industry. —— (*Modern Metals*, 1947, **3**, (2), 28–30).—A summary of a U.S. Senate Committee Report entitled: "Future of Light Metals and Government Plant Disposals".—N. B. V.

[Aluminium] 1939–1946. Jean Gillemin (*Rev. Aluminium*, 1946, **(127)**, 339–354).—A review of progress in aluminium technology in the war years, dealing in a general way with alloy development, continuous casting, continuous rolling on four-high mills, machines for the manipulation of sheet and tube, methods of joining including welding and riveting, foundry practice, and some novel uses of the metal.—E. C. E.

Technical Organization of the "Aluminium Français" in the Service of Industry. André Dumas (*Rev. Aluminium*, 1947, **(130)**, 62–67).—An illustrated account of the history, organization, and laboratories of the "Aluminium Français".—M. E.

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NEW JOURNALS

Instrument Practice. Covers the whole field of instrument technology and instrumentation. Published monthly by United Trades Press, Ltd., 24 Bride Lane, Fleet Street, London, E.C.4. First issue published in November 1946. (30*s.* per annum.)

Metalen. Published monthly [in Dutch]. Administrative Office, Scheepmakersstraat 1–3, Den Haag, Holland. First issue published 15 September 1946. (f. 10·50 per annum.)

Metallforschung. Contains original contributions on metallurgy, metallography, &c. Published monthly by Dr. Riederer Verlag, Stuttgart; edited by G. Masing, E. Scheil, and G. Wasserman. First issue published in July 1946. (9 R.M. per quarter.)

XXV.—BOOK REVIEWS

Practical Metallurgy, Applied Physical Metallurgy, and the Industrial Processing of Ferrous and Non-Ferrous Metals and Alloys.

By Georg Sachs and Kent R. Van Horn. Med. 8vo. Fifth printing. Pp. [xii] + 567, with 335 figures in the text and numerous constitutional diagrams. 1946. Cleveland, O.: American Society for Metals. ($5.00.)

There was a time, perhaps as recent as the later years of the eighteenth century, when a man might aspire to take all knowledge as his province; and if he had received a good education and was of a studious habit, he might justly expect to succeed. But those days are gone; and in these times nobody could even attempt to know everything, though he were to restrict himself to a single subject. As with men, so with books. When knowledge was scantier than it is to-day, a single book might set out to embrace a whole subject, and in the attempt might present all that could reasonably be expected. None, at the time of its appearance, could have quarrelled with "De Re Metallica" on the score of inadequacy; or, three hundred years later, with Percy's "Metallurgy". Coming still nearer our day, the standard work on "Metallography", when first it appeared in 1908, could cover, in an adequate manner, the field of knowledge as it then existed. In the 1940's it is doubtful whether any single book can be expected to deal satisfactorily with "metallurgy".

The degree by which metallurgical science has expanded; the extent to which it has inspired research and publication; the use it has made of physical and chemical discoveries; have brought metallurgy, as a subject, to dimensions that are almost frightening. Such advances have only been achieved by dividing the subject into a number of parts, none of them necessarily tied to any particular metal, on each of which many specialists have laboured. Metallographic studies have advanced in their own manner; mechanical metallurgy and production metallurgy have advanced with giant's strides, none proceeding independently, but all concurrently. In each branch of the subject, the process of probing and delving has gone on at a furious pace; and sufficient knowledge has emerged to justify a library of books, each written by a specialist dealing with one or other part of the enormous territory that has been cultivated. So considerable is the accumulation of results and discoveries that the regular appearance of monographs on separate topics seems the only way in which metallurgical knowledge can now be effectively presented.

Such are some of the thoughts engendered by a consideration of the latest printing of "Practical Metallurgy" by Drs. Sachs and Van Horn. Given the task of covering such a title, it is doubtful whether any would be likely to do better than these gifted compilers. Nevertheless, the result is an exasperating book; and the reader is constantly torn between admiration of the enormous amount of information provided, and disappointment at what is not to be found. Doubtless, this is the consequence of covering such a large syllabus, resulting occasionally in a treatment of some or other topic that is almost artistic in its brevity, though not in its illumination. There is a wealth of good things in this volume and no student of metallurgy should ignore it. Preferably he will have it available for ready reference, and will find himself consulting it time after time. Occasionally he may be misled [illegible] he reads if he leaves the matter as he finds it in this book; but more probably he will be stimulated to look further into the topic that interests him, and will be helped to do so by the voluminous references to original work provided page by page. Regarded as an introduction, this book can be of immense help in guiding the enquirer towards metallurgical truth. If it turns the seeking mind towards more specialized, detailed, or complete treatments, it will have justified itself.

That this book is to be commended goes without saying, but the appearance of a further reprinting calls for at least two particular comments. The first is that in certain respects the book is now almost out of date; or perhaps it would be fairer to say that gaps in the information provided are rather noticeable because of the numerous developments that have occurred since the book was written. This work, in its particular subject, is encyclopædic in outlook; and few things date so rapidly as an encyclopædia. The time seems ripe for something more than a reprinting, and it is earnestly suggested that a revision is now appropriate. If such were undertaken, the second point calling for comment, and which has always been noticeable about this book, might receive the attention it warrants. The illustrations are numerous and in many respects admirable, but many of them are too small, and some of them are virtually useless in consequence. This comment is particularly applicable to photographs of processes and plant; in fact one almost feels that some of them were originally made with the specific intention of hiding anything that might yield information. Surely the authors, with their obviously wide contacts, could have provided something better. Another matter on the illustrations that calls for remark is the frequent absence of dimensions, or of a human figure to act as a standard of reference. To the initiated, such aids may be unnecessary; but surely the book is not intended to be read only by those already well informed. This same assumption of prior knowledge could be urged against some of the diagrams intended to illustrate processes; and it cannot be pressed too strongly that, in any new edition of this book, the whole subject of illustration should receive particular attention.—LESLIE AITCHISON.

Cutting Tools for Metal Machining. Second, revised edition. By Max Kurrein and F. C. Lea. Med. 8vo. Pp. xii + 312, with 375 illustrations and 33 tables. 1947. London: Charles Griffin and Co., Ltd. (28*s.* 6*d.*, post free.)

The first edition of this book appeared in 1940. The objects remain the same as originally, namely to gather together in one volume the most important information regarding cutting speeds and the forces on modern tools; to provide those responsible for workshop practice, as well as designers, with an appreciation of the measurable quantitative values involved, to give guidance on the best methods of tooling for production; and to meet the need for a text book for teachers and students of the science and practice of the workshop.

The subject is dealt with in sixteen chapters. The first chapter, " Elements of the Tool ", gives definitions and describes the measurement of tool angles, cutting forces and speeds, cooling, and lubrication. Succeeding chapters deal with " Materials for Tools ", " Classification of Cutting Tools ", and there is a series of chapters each devoted to a single type of tool, e.g. turning and boring tools, drills, reamers, and milling cutters. Chapters XII, XIII, and XIV are concerned with tool grinding, grinding wheels and grinding machines, lapping, and honing. Chapter XV, of only five pages, deals sketchily with surface finish and its measurement, but an appendix, " Finishing Cutting Tools ", takes the subject further with an account of recent original work on a broad finishing tool. The final chapter, XVI, is entitled " Tool Hardening ".

The chapter headings show that a surprising range has been covered within the 312-pages compass of the book. Inevitably, some of the sections suffer from the limitation of space, and it might have been more useful to expand the more advanced sections, e.g. on thread-grinding tools, at the expense of the rather full treatment of elementary points on angle measurements and the like, with which most of the readers of this book will be already acquainted.

The book is clearly a text book for mechanical engineers, and a metallurgist reviewing it has different interests from the majority of those for whom it is intended. The present reviewer looked without success for any systematic account of the influence of the material being cut upon the selection of the form of tool. Where reference is made to non-ferrous materials the identification is of the vaguest description: " aluminium " is used indifferently for the pure metal and its alloys. The reproductions of photomicrographs as half-tone illustrations on ordinary paper are unsatisfactory in many cases.

The chapter entitled " Tool Hardening " is weak. The authors wisely refer the student to " standard text books on metallurgy ", and it would have been better to leave it at that and not to embark on an explanation of " certain points that are fundamental to the subject ". In the course of this section the terms " phase " and " solution " are used in senses which could understand the metallurgical aspects of tool steel. Examples only confuse the student seeking solid solution in any one of the regions (of the constitutional are: “the structure of t . . .”; “Pearlite is the eutectoid solution, composed of α-iron and diagram) is called a [illegible]ble phase is composed of cementite and pearlite. . . .” cementite”; “th[illegible]ts which naturally catch the eye of the metallurgically minded reader, but

These are [illegible]fair to over-emphasize their importance in relation to the book as a whole. As it would [illegible] on the mechanics of cutting processes and modern practice in the application of a ma[illegible] tools, the book should be valuable to those teachers and students who have felt the [illegible]eed for a more comprehensive treatise than has hitherto been available.—A. J. Murphy.

Metallic Corrosion, Passivity, and Protection. Second edition. By Ulick R. Evans. With an Appendix by A. B. Winterbottom. Med. 8vo. Pp. xxxiv + 863, with 144 illustrations. 1946. London: Edward Arnold and Co. (50*s.*)

No one who is interested in the production, fabrication, or uses of metals will need to be reminded of the economic importance of corrosion. It has increasingly come to be realized that the subject is amenable to scientific study, and that this can lead to advances not only in the field of pure science but in the efficient use of metals. Research on corrosion can yield large dividends in the economic as well as in the academic sphere.

Dr. Evans, who has made great contributions to advances in our knowledge of corrosion, continues in the second edition of his well known book the task of presenting and interpreting the accumulated contributions of many workers. The increasing number of these is illustrated by the inclusion in the new edition of references to the work of 1155 new authors! The general treatment adopted has naturally been influenced by Dr. Evans's own work, but a critical survey is given of researches in other laboratories. The Introduction, dealing with “Principles of Electrochemistry”, presents a readable and lucid summary of the electrochemical concepts necessary for a proper study of corrosion. An Appendix by Mr. A. B. Winterbottom gives an authoritative account of optical methods for the determination of films on metals, based on polarization and interference phenomena.

The book includes fourteen chapters with these titles: simple examples of corrosion and passivity; study of thin films; oxidation at high temperatures; corrosion in moist or polluted atmospheres; corrosion not involving the absorption of oxygen; corrosion of ferrous materials involving the absorption of oxygen; corrosion of non-ferrous metals involving the absorption of oxygen; influence of stress, strain, and structure; influence of contacts and crevices; protection by inhibitive treatment of water; protection by chemical and electrochemical treatment; protection by paints and enamels; protection by metallic coatings; and testing. Each chapter is divided into sections (*A*), (*B*), and (*C*) as in the earlier edition, dealing respectively with “The Scientific Basis”, “Practical Problems”, and “Quantitative Treatment”.

The advantages of segregating in section (*B*) an account of the more practical aspects of a topic are illustrated by the excellent review (pp. 375–384) of the corrosion of condenser tubes. In Chapter VIII a most readable account is given of the phenomena of intergranular corrosion and of corrosion fatigue.

Since the subject matter of the book is arranged according to the type of corrosive environment or to the methods of protection, the treatment of individual metals is distributed throughout all the chapters. A summary of the behaviour of typical non-ferrous metals in water and aqueous solutions is, however, given in Chapter VII, including a comprehensive account of “Non-Ferrous Metals in Contact with Water and Food” (pp. 388–410). The underlying principles and the practical application of protective methods are clearly and authoritatively discussed in Chapters X–XIII. The final chapter gives a brief survey of methods of testing, including in section (*C*) a stimulating and welcome account of the principles of statistics as applied to corrosion testing.

Although the text is considerably longer than the previous edition (xxxiv + 863 pp., compared with xxiii + 720 pp.), the book is easier to handle owing to the use of thinner paper. The author and the publishers are to be congratulated on the production of this valuable text book and work of reference.—F. Wormwell.

The Electron Microscope. An Introduction to its Fundamental Principles and Applications. Second, revised and enlarged edition. By E. F. Burton and W. H. Kohl. 23 × 16 cm. Pp. 325. 1946. New York: Reinhold Publishing Corporation. ($4.00.)

The possibilities offered by electron microscopy are very great, and have undoubtedly not yet been fully appreciated in this country. The present reviewer is, therefore, most glad to welcome a second edition of this book, which offers an easy and elementary approach to the underlying principles of the new methods. In the first 250 pages of the book, the reader is led gradually from the most elementary optics, electricity, and magnetism to the principles underlying the electrostatic and magnetic electron microscopes. The description is elementary, and should be followed by a schoolboy of Higher Certificate standard. The presentation is extremely clear, and the authors are to be congratulated on the way in which the elementary reader is led from the simplest concepts to an understanding of what is involved by electron microscopy. This part of the book can be whole-heartedly welcomed for those readers who require a really elementary approach to the subject.

The last 46 pages of the book deal with applications of the method, and are less satisfactory. Many photographs—only two refer to metals—are reproduced, and are described briefly, and often with quotations from the original papers of others. This results in the introduction of many technical terms which will be meaningless to the reader for whom the earlier pages are intended. The authors seem in fact to have changed suddenly from a book intended for the general elementary reader to one addressed to specialists in different branches of science. The book concludes with a very comprehensive ***bibliography*** of several hundred books and papers dealing with electron microscopy in one form or another. This will be of great value, but it is to be hoped that in the next edition the authors will indicate which papers are suitable for the elementary reader to whom their earlier pages are addressed.—W. HUME-ROTHERY.

Metals and Plastics: Production and Processing. By Thomas P. Hughes. Med. 8vo. Pp. xiv + 373, with numerous illustrations. 1947. Chicago, Ill.: Irwin Farnham Publishing Co., 332 South Michigan Ave. ($4.50.)

This is a well produced and well illustrated volume written for engineering students, with the professed aim of giving them a knowledge of the characteristics of the raw materials—metals and plastics—which they will need to use in the practice of their vocation. In its title and aim the book is, however, more ambitious than in its achievement. Essentially, the author has followed the pattern of many conventional elementary text books on " metallurgy for engineers " and has included, almost as an afterthought, just 20 pages on plastics. It would be pleasing to be able to report that the volume is a well balanced, freshly written account of ferrous and non-ferrous process and physical metallurgy; but in fact the matter is, in general, poorly selected, and the treatment is dull, often slip-shod, and sometimes obscure and misleading. The chapters on equilibrium diagrams and the iron–iron carbide diagram are so clumsily set out that any uninstructed reader would undoubtedly be in a state of complete bewilderment after reading them; and there are a number of serious mistakes. Thus, the illustration of a typical solid-solution diagram with superimposed cooling curves is fundamentally in error, and is calculated to mislead the most painstaking student. The best parts of the book are those dealing with mechanical working and welding; these include some good photographs of modern equipment.—J. C. CHASTON.

The Metallization of Plastics. By J. R. I. Hepburn. Cr. 8vo. Pp. 71, with 4 plates and 8 figures in the text. 1947. London: Cleaver-Hume Press, Ltd. (6*s*. net.)

This monograph contains a very brief account of the processes—deposition from solution, metal spraying, sputtering, and evaporation—which are said to have been employed for applying metal deposits to the surface of plastics. Unfortunately, the details of equipment or of operation which are given are extremely meagre and far from up to date, and are likely to be more misleading than helpful. A surprising omission is the absence of any account of the application of these methods for metallizing plastics. The normal methods of applying coatings to metals or glass are alone described; and the reader will look in vain for guidance on the choice of method for any given plastic or for advice on special precautions which may be necessary in operation.—J. C. CHASTON.

The Microscope: Its Theory and Applications. By J. H. Wredden. With an Historical Introduction by W. E. Watson-Baker. Roy. 8vo. Pp. xxiv + 296, with 298 illustrations. 1947. London: J. and A. Churchill, Ltd. (21*s*.)

This is a clearly written elementary introduction to the use of the microscope. After a short historical introduction, by W. E. Watson-Baker, there are two chapters on elementary optics and on the general construction of the compound microscope, after which the various components are considered in detail in separate chapters. The author is concerned with the use of the microscope in a works laboratory and includes in the last chapter notes on a few special techniques which he has developed for examining electrical insulating materials. The volume deals only with the standard forms of microscope using transmitted illumination; the metallurgical microscope is not considered.—J. C. CHASTON.

Handbook of Structural Design in the Aluminium Alloys. By J. E. Temple. Demy 8vo. Pp. 147, illustrated. 1947. Birmingham: James Booth and Co., Ltd., Argyle Street Works, Nechells. (21*s*.)

Quite frankly, your present reviewer does not feel altogether competent to comment in detail on the matter contained in this Handbook. As the publishers point out, it is intended for engineers and architects, and the metallurgy is quite incidental. However, designer colleagues are enthusiastic, and welcome the Handbook as a blessing to those involved in designing in light alloys.

The contents include a short introductory section on alloys available, their properties, and methods of fabrication. This is followed by the main part of the book, which covers structures, from simple bending and torsion through design of sections, struts, plates, and riveted joints to compound structures. The material is treated on the assumption that the reader is familiar with the design of steel structures, special emphasis being placed on the difference between these and light-alloy structures. It is interesting to note that Mr. Temple's theoretical deductions have recently been confirmed by Professor Baker's experimental work at Cambridge, results of which are included in the Handbook.

There is little doubt that the publication of this Handbook is most timely and should assist those engaged in applying light alloys to this very wide branch of engineering.

Designer friends consider the lay-out to be refreshingly straightforward and information readily accessible, despite the absence of an index.—W. K. B. Marshall.

Heat-Treating Aluminium Alloys. [Loose Leaf.] Demy 8vo. Pp. 144, illustrated. 1946. Louisville, Ky.: Reynolds Metal Co., Inc. ($1.00); **Finishes for Aluminium (Section One).** [Loose Leaf.] Demy 8vo. Pp. 108, illustrated. 1947. Louisville, Ky.: Reynolds Metal Co., Inc. ($2.00); **Finishes for Aluminium (Section Two).** [Loose Leaf.] Demy 8vo. Pp. 125. 1946. Louisville, Ky.: Reynolds Metal Co., Inc. ($1.00); **Welding Aluminium and its Alloys.** [Loose Leaf.] Demy 8vo. Pp. 90, illustrated. 1946. Louisville, Ky.: Reynolds Metal Co., Inc. ($1.00.)

The publishers have considered, quite correctly, that some knowledge of metallurgy is desirable for a proper appreciation of the various heat-treatment processes applied to aluminium alloys. In the initial part of their book on this subject they have, therefore, attempted to impart to the reader this essential metallurgy. The present reviewer finds it difficult to say definitely whether or not this attempt has been successful; whether or not in this case the process has been taken too far. However, allowing for necessary "popularization" of the presentation, the metallurgy is sound, and in any case the authors are to be congratulated on making a move in the right direction. The remainder of the booklet deals with the practice of heat-treatment, including, principally, annealing, solution and precipitation treatments, and the various types of equipment required. A defect is perhaps the constant reference to specification and proprietary alloys without giving compositions. Altogether, however, the booklet is a useful addition to those on this subject.

The booklets on "Finishes for Aluminium" are likely to be of interest to those engaged in using aluminium and its alloys in the multitude of new applications which have arisen since the end of the war. A bewildering number of treatments—including straight cleaning, mechanical, chemical, electrolytic, electroplated, organic, and inorganic finishes—are described, but, owing to somewhat uncritical presentation, the reader might find difficulty in choosing that most suited to his particular application. Section I describes the processes in a general way, while Section II gives comprehensive practical details. There is extensive reference to proprietary materials, but this does not detract seriously from the usefulness of the manuals.

The booklet on "Welding Aluminium and Aluminium Alloys" is perhaps a little more comprehensive than the average trade publication on aluminium welding in that it includes references to inert-gas-shielded arc welding, flash welding, and furnace brazing in addition to the more usual gas and metallic-arc, carbon-arc, and spot welding. It is strange, however, to find such praise for notched edges as a preparation for gas welding. This method of preparation is now no longer considered necessary in this country. Some confusion is caused by the failure to associate odd illustrations with the text in their immediate vicinity, but otherwise the subject is quite well presented.—W. K. B. Marshall.

Philips Resistance-Welding Handbook. Demy 8vo. Pp. iv + 210, with 184 figures. [1946.] London: Philips Industrial (Philips Lamps, Ltd.), Century House, Shaftesbury Ave., W.C.2. (10*s.* 6*d.*)

This book has been written to help the user of resistance-welding processes. It is essentially practical, although there is a useful proportion of supporting theory. The scope of the book covers the construction and principles of spot-, projection-, seam-, flash-, and butt-welding machines; applications of the processes (with special emphasis, of course, on steel and light metals); and certain specialist sections on subjects such as the metallurgy of resistance welding, timers, electron-tube control, electrodes, and production planning. Much of the text is anonymous, but there are some useful contributions from well known authorities, including Sinclair, Simmie, Hipperson, Higgins, and Tucker. In certain sections there are faint suspicions of special pleading, but these never obtrude: rival equipment and processes are given a fair hearing. Altogether the book serves a useful function in gathering together the various aspects of resistance welding. It is, incidentally, very well produced, although an index would have improved its usefulness.—W. K. B. Marshall.

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