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Grey Ironfounders' Productivity Report

The major lessons of the Report on "Grey Ironfounding,"* prepared by a team which visited America under the ægis of the Anglo-American Productivity Council, are:—(1) Mechanisation is not the complete solution to the problem. (2) A spirit of co-operation with productivity as the main objective must be engendered. (3) Incentives which the industry can offer will never be adequate without Government support. (4) This support involves the institution of conditions which will inculcate into everybody a desire to acquire goods and services now unattainable. (5) Suggestions are made, such as lower taxation and an increase in the supply of consumer goods and, finally, (6) more benefits should result from honest toil and enterprise and fewer from social services.

Obviously, much of this applies to all industries and we congratulate the team on their forthright statement, especially when the composition of the team is taken into consideration. The observation that old managers are living on capital and the younger element finds it virtually impossible to save are not ideal conditions for inducing personal enterprise. We recall that we once wrote editorially that we hoped that the Government would realise in their taxation policy that, if overdone, there would be no money left to support the artist and craftsman. Now, the Report calls attention to the notion that to-day the population is turning its leisure-time attention with zest and interest to outside activities such as repairing, decorating, and the like, which may exert a detrimental effect on the employment of craftsmen who have specialised in these activities. There is but little mention of the housing situation in the Report, beyond the statement that in the States men leave to take up jobs in other areas. In this country, the inability to find proper accommodation often prevents a man from making progress. This point might, if applicable, have been included as just one more feature in the appraisal of worthwhile incentives.

The Report rightly emphasises climatic conditions as a factor in productivity. We are unaware whether meteorological conditions have any influence in this country, but from personal observation it is possible to state that in some areas the whole of the personnel apply themselves with greater energy than in others. This aspect is well worth further investigation, as it is not related to mechanisation, amenities, wages, or any known incentive. Another important observation is the effect of racial heterogeneity on good production. We can confirm the truth of this from visits to foundries where two or more nationalities are employed. The Ardennes region in France is such a case, for there the staffs are a mixture of French and Belgians. References to an ample supply of consumer goods as being a good incentive was amply illustrated in Belgium, where moulders would continue working after finishing time, so long as the compressed-air supply lasted, in order to have as much money as possible to buy those little extras which make life worth living. We are sure the authors of the Report were wise to include views of a character similar to those we have outlined in order to paint an adequate picture of the fundamentals of incentives to production.

[Other aspects of the Report will be dealt with editorially in future issues.]

* Obtainable from the Anglo-American Council on Productivity, 21, Tothill Street, London, S.W.1. Price 3s. 6d.

Contents

Technical Aspects of Productivity

B.C.I.R.A. Conference, October 12 and 13

The following provisional programme has been arranged for the B.C.I.R.A. Productivity Conference to be held at Ashorne Hill, near Leamington Spa, on October 12 and 13. The purpose of the Conference is to discuss purely technical aspects of productivity arising from the recent report of the General Ironfounders' Productivity Team, which visited the United States earlier this year.

The accommodation at Ashorne Hill is limited to approximately 180 persons and rooms will be allocated in order of application, the closing date for which will be October 2, or earlier if the accommodation is fully taken up. Application should therefore be made to the Association as early as possible. The majority of the accommodation consists of single rooms. The Association may require to limit the number of individuals attending from any one firm.

Programme

Each of the subjects to be discussed is introduced by a member of the Grey Ironfounders' (General and Jobbing) Productivity Team.

Thursday, October 12.

1.0 p.m.: Luncheon, followed by a welcome to delegates by the President of the Association, Mr. P. H. Wilson, O.B.E.

3.0 p.m.: General aspects of American foundry practice, introduced by Mr. S. H. Russell, of S. Russell & Sons, Limited, Leicester, team leader.

3.30 p.m.: Sand practice, (*a*) general; (*b*) green- and dry-sand moulds, and (*c*) core sands, by Mr. W. B. Parkes (B.C.I.R.A.).

4.0 p.m.: Tea.

4.30 p.m.: Sand practice (continued), (*d*) handling and storage, by Mr. H. B. Farmer, of Rice & Company (Northampton), Limited, and (*e*) sand mixing and distribution, by Mr. M. Martin, of Markham & Company, Limited, Chesterfield.

5.15 p.m.: General metallurgical aspects, by Dr. H. T. Angus (B.C.I.R.A.).

5.15 p.m.: Melting practice, (*a*) the stockyard, by Mr. G. W. Nicholls, of Modern Foundries, Limited, Halifax, and (*b*) equipment and operations, by Mr. N. Charlton, of C. A. Parsons & Company, Limited, Newcastle-upon-Tyne.

7.15 p.m.: Dinner.

Friday, October 13.

9.0 a.m.: Training and education, (*a*) training for management, (*b*) training of apprentices, (*c*) U.S.A. educational system, (*d*) technical associations, by Dr. H. T. Angus. These will be followed by sections (*e*) efficiency of management, and (*f*) interchange of methods, by Mr. G. B. Judd, of Mann, Judd & Company, London, and finally by section (*g*), training of foremen, by Mr. N. Charlton.

10.0 a.m.: Plant and mechanical aids, by Mr. A. Kirkham, of Sir W. H. Bailey & Company, Limited, Patricroft, and Mr. W. R. Marsland, of Newman Hender & Company, Limited, Woodchester, followed by Transportation, by Mr. H. B. Farmer.

11.15 to 11.30 a.m.: Interval.

11.30 a.m.: Moulding operations and foundry layout, by Mr. G. W. Nicholls, Mr. A. Kirkham and Mr. E. J. Ross (the latter of G. & J. Weir, Limited, Glasgow).

1.0 p.m.: Luncheon.

2.0 p.m.: Coremaking, by Mr. M. Martin.

2.45 p.m.: Planning of operations: saving of time, by Mr. H. B. Farmer and Mr. H. Hendy (of Davey & United Engineering Company, Limited, Sheffield).

3.30 p.m.: Heating and ventilation, by Mr. N. Charlton.

4.0 p.m.: Tea.

4.30 p.m.: Comments on statistical information in the appendices, by Mr. G. B. Judd.

5.0 to 6 p.m.: General discussion.

In addition to the above, it is hoped that the following members of the team will also be present to take part in the discussion: Mr. C. Blackburn, of T. H. & J. Daniels, Limited, Stroud; Mr. R. M. Lumsden, of Fraser & Chalmers Engineering Works, Erith; and Mr. J. Stewart, of A. F. Craig & Company, Limited, Paisley.

There will be a cinema performance at 8.15 p.m. on both Thursday and Friday, with a change of programme on the second evening.

Forthcoming Events

SEPTEMBER 22.

Institute of British Foundrymen.

Birmingham Branch (Students' Section):—Address by the chairman, F. Dunn, followed by "Nickel and Some of its Alloys," by D. R. Wood, M.A., at the James Watt Memorial Institute, Great Charles Street, Birmingham, at 7 p.m.

SEPTEMBER 22 to 30.

International Commercial Motor Vehicle Exhibition.

At Earls Court, London, 10 a.m. to 9 p.m. daily (except Sunday).

SEPTEMBER 23.

Institute of British Foundrymen.

East Midlands Branch:—Visit to Parker Foundry, Derby. Presidential address, followed by Film "A1 at Lloyd's," in the works canteen at 2.30 p.m.

SEPTEMBER 23 and 24.

I.B.F. Annual Golf Meeting at Woodhall Spa.

SEPTEMBER 26.

Institution of Production Engineers.

Luton, Bedford and District Section:—Film, "Pattern for Progress," at the Town Hall, Luton, at 7.15 p.m.

SEPTEMBER 27.

Institute of British Foundrymen.

London Branch:—Presidential address by F. E. Tibbenham, followed by "Cast Iron Team's Visit to America," by S. H. Russell, at the Waldorf Hotel, Aldwych, London, W.C.2, at 7 p.m.

Birmingham Branch:—Presidential address by H. T. Angus, D.Sc., M.Sc., followed by "Steelfoundry Practice," by G. T. Hampton, at the James Watt Memorial Institute, Great Charles Street, Birmingham, at 7.15 p.m.

Institution of Production Engineers.

Lincoln Section:—"Mechanical Handling," by J. R. Sharp, at the staff canteen, Ruston & Hornsby, Limited, Boultham Works, Lincoln, at 7 p.m.

SEPTEMBER 28.

South Wales and Monmouthshire Section:—"Material Handling," by F. T. Dean, M.I.Mech.E., at the South Wales Institute of Engineers, Park Place, Cardiff, at 6.45 p.m.

Engineers' Guild.

Metropolitan Branch:—Annual general meeting, at the Lighting Service Bureau, 2, Savoy Hill, London, W.C.2, at 6.15 p.m.

SEPTEMBER 28 to OCTOBER 1.

Purchasing Officers' Association.

National Conference and "Minibition" (several foundries are among the exhibitors), at the Hotel Metropole, Brighton.

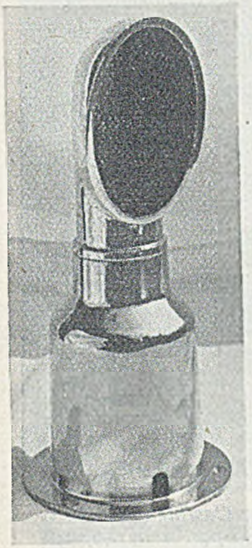
SEPTEMBER 30.

Institute of British Foundrymen.

Birmingham Branch (Students' Section):—Visit to the Patent Shaft and Axletree Company, Limited, Wednesbury, at 9.30 a.m.

Symposium on Gas Turbines Postponed

The Iron and Steel Institute has decided to postpone the Symposium on High-temperature Steels and Alloys for Gas Turbines and the Fifth Hatfield Memorial Lecture, which were to be held from October 17 to 19. The recent dispute in the printing trade has made it impossible to print advance copies of the Papers for discussion in time for the meeting. A notice will be issued when all the details for the later meeting and lecture have been settled.



Castings for River and Coastal Craft

By A. G. Thomson

Closely identified with Britain's industrial achievements are world-famous companies, operating on such a scale that production is very highly organised and large sums can be earmarked for development and research. Inevitably, the smaller firms tend to be overshadowed by the achievements of these large concerns. Yet efficiency is not necessarily governed by size and capital resources, and due credit for Britain's economic recovery belongs to countless small firms whose products are known only to a limited number of customers but whose aggregate output is extremely large. To the small industrialist with limited capital resources, the past 25 years have been a testing period in which survival was apt to depend on a combination of efficiency, business ability, and refusal to accept defeat.

A NOTABLE EXAMPLE of difficulties successfully surmounted is provided by the now well-established firm of Victor Moyle & Company at Hampton Wick, near Kingston-on-Thames, who specialise in castings for river and coastal craft.

This business was started by Mr. Victor Moyle, who served his apprenticeship at Mr. W. Lodder's foundry, Queenborough, Kent. After serving a period with the Air Force during the 1914-18 war, Mr. Moyle came to London in 1919. In 1926 he took over a derelict foundry of about 2,000 square feet of which only a very small part was usable. This building had been a foundry for about 60 years. It was originally the mews of the still existing house now in possession of the firm.

When Mr. Moyle took over this foundry, his predecessors had gone bankrupt, the equipment had all been sold, and the building was just an empty shell. All that remained were the chimney stacks, the connecting flue and the pits where the furnaces had been. The first thing, therefore, was to build a furnace and benches.

Selecting a Commercial Field

Since the foundry was near the river Thames, the orders received were mainly for marine castings and realising that huge tonnage productions were impossible, Mr. Moyle set out to make intricate and difficult castings, taking on jobs of a kind which the average foundry would turn down. As an example of the difficulties surmounted in these early days, a gunmetal casting weighing 84 lb. was cast from an 80 lb. furnace and an 80 lb. "Morgan" crucible. The casting was delivered to the customer two days after the pattern had been received, and this job put the foundry on the map. The company has been faced with the same sort of problem ever since. The foundry is now equipped with a 3-ton electric crane and a 3-ton per hour cupola, and yet castings have recently been delivered weighing just under five tons each.

The business was making very satisfactory progress till the 1930 slump, which set the company back so badly that it became virtually insolvent. At that time, about a dozen men were employed. These had all to be dismissed and Mrs. Moyle came to the foundry to help her husband in casting up. The finances were restored in a year. After the slump, Mrs. Moyle took over the office work and was made a partner when the freehold of the original premises and the rest of the present site were purchased.

War Work

During the early years, production was confined to non-ferrous castings, but about 1936 a small cupola of one-ton per hour capacity was installed. When concentration of the iron foundries was introduced during the recent war, however, this side of the business was temporarily discontinued. Shortly afterwards, an order was received from the Ministry of Aircraft Production for underwater castings in nickel-aluminium-bronze for air-sea-rescue boats. The foundry was so successful with this difficult metal that it was asked to step-up its output considerably. This necessitated extensions to the existing premises, and when the plans emerged from the various Government committees, etc., the firm was able to proceed with the erection of its main building, which now houses the iron foundry (Fig. 1).

Early in 1944, a visit was received from representatives of the Ministry of Supply, who required 300 pairs of 26-in. diam. manganese-bronze propellers within ten weeks. These were for amphibian tanks used in the assault on the Normandy coast on D-day. It so happened that the foundry was abreast of its orders and Mr. Moyle readily undertook to deliver 24 pairs per week, promising that he would also keep up his deliveries of castings for

The Gunmetal Casting illustrated at the head of this article is a Fairmile Waterproof Ventilator (Pat. No. 548334), cast at the Victor Moyle Foundry.

FIG. 1.—*Section of the Iron Foundry. In the Foreground are Moulds for Steam Valve Covers.*

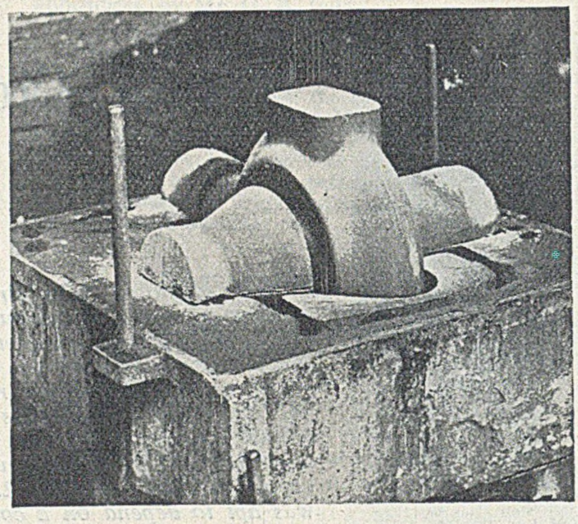


FIG. 2.—*Mould for Hydrovactor Casting for Dust-handling Equipment with Top-part removed to show the Intricate Core.*

air-sea-rescue boats and for naval craft. At this period of the war, the priority was for naval craft, but the need for these particular propellers had become very desperate. The officials from the Ministry chatted to the particular moulders concerned and emphasised the importance of rigid adherence to delivery dates. In actual fact, the foundry produced and delivered the entire order for 300 pairs of propellers within ten weeks and also helped the Ministry to arrange with firms to do the finishing.

Earlier in the war, when prototype castings for night-fighter aircraft were required, what would normally have been three days' work was done in one Saturday afternoon. No Government department or "back-room hush-hush man" ever made a call on this little firm in vain, and their calls were very frequent. Underwater castings for air-sea-rescue boats, submarine chasers, seaplane tenders and harbour launches, were in regular production during the war, besides a great number of propellers for various types of boats.

Post-war Re-equipment

After the war, a new cupola, an electric crane, a new fettling shop and a pattern store were added. Another business, one making marine fittings, was purchased and, owing to lack of space at Hampton Wick, the machine shop for this business was established at Woking, Surrey.

The pattern-shop is equipped with two lathes, a planer, circular and band saws, sander, etc. Among the patterns under construction was one for an order for 38 Hydrovactors (Fig. 2) in iron. Patterns are painted with the British standard colours, those not returned to customers being stored in a fireproof building 40 by 25 ft. built well above part of the foundry yard. The store is equipped with racks of the firm's own manufacture. This building also houses the foreman's office with windows looking down on the iron foundry.

In 1947, Mr. Moyle's son, Mr. C. E. Moyle, B.SC. (ENG.) MET., came into the business as a partner. He was trained at the Deptford foundry of J. Stone & Company, Limited. Mr. Moyle junior introduced to the company a high-strength, non-corrosive light alloy for marine castings, which has also been extensively used for "tailor-made" racing cars. Named "Vimarilite," this alloy is proving very popular with builders of aluminium boats. One of the original samples has been in brine for three years and is still in excellent condition. The company is also catering for an expanding demand for other non-ferrous alloys for marine use, which are marketed under the names of "Vimaritence" and "Vimarinel." These special alloys are first compounded and cast into ingots, which are placed with an appropriate code

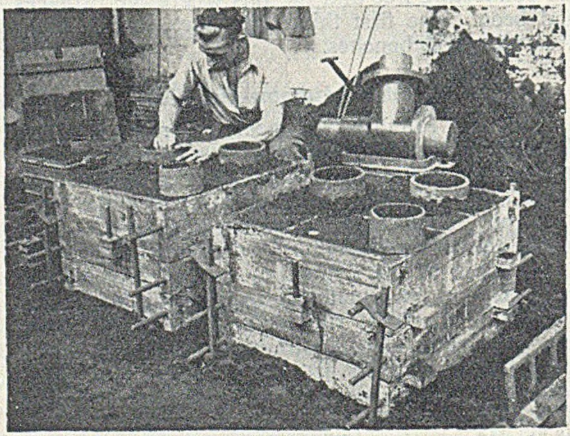
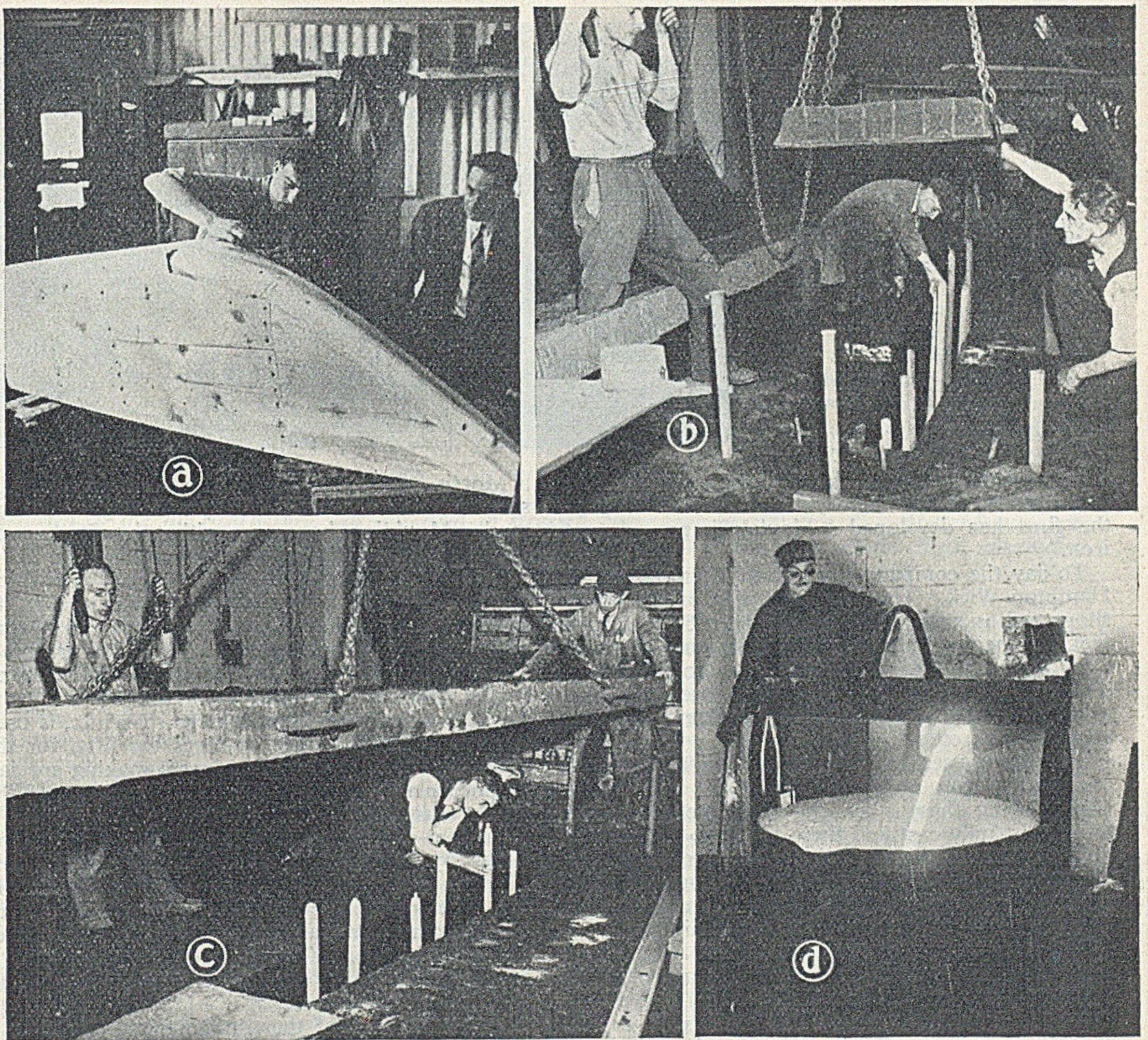


FIG. 3.—*Cast-aluminium Moulding Boxes made on the Premises. The Moulds are for Tee Castings for Hydrovac Equipment, Pattern shown in the Background. Note the Adjustable Box Clamps.*



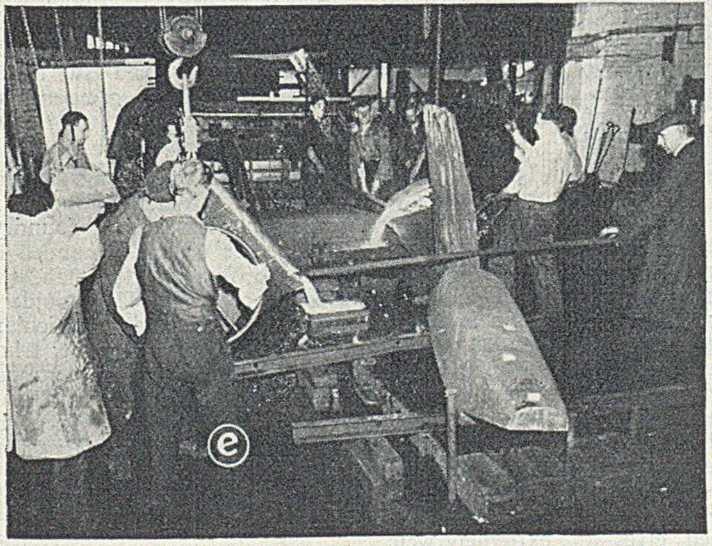


FIG. 4.—*Stages in the Production of Yacht Keel Castings in the Iron-foundry.*

(*a*) Pattern Construction for a 2-ton Keel destined for Hong Kong.

(*b*) Lowering the End Box-part of the Keel Mould.

(*c*) Closing the Main Top-part of the Mould. Note the Bolt-hole Cores, painted to resist Metal Penetration.

(*d*) Tapping Metal from the Cupola, which is Positioned behind the Wall of the Foundry with only the Spout protruding.

(*e*) Casting an Iron Keel, Two Ladles of Metal are Used.

(Illustrations (*b*), (*c*), (*d*) and (*e*) relate to a 3½-ton Keel for a Boat under Construction at Burnham-on-Crouch.)

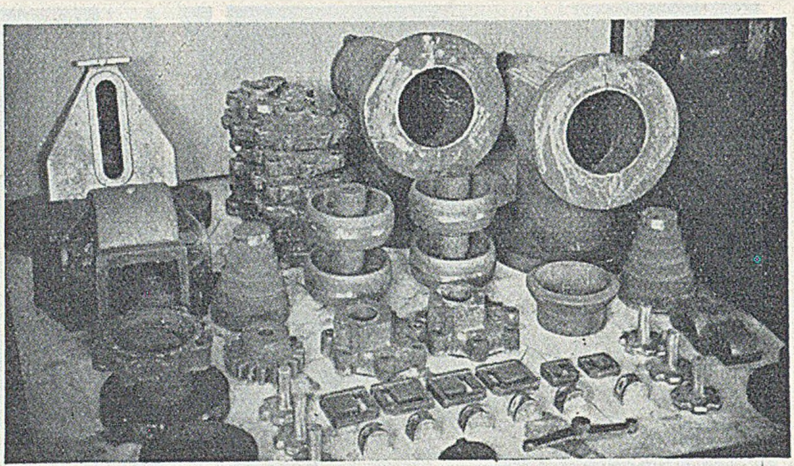


FIG. 5.—*Group of Miscellaneous Engineering Castings, Mainly Ferrous, produced at the Moyle Foundry.*

number into a bonded store until test-bars have been passed as satisfactory. For ferrous castings the firm has developed "Moyle's improved cast iron."

To-day the company has about 40 employees at Hampton Wick. The combined area of the workshops and ancillary buildings is about 5,000 square feet, the main shop being a lofty building of about 80 ft. long by 30 ft. wide with north roof lighting. The original house, built in 1814, is used partly as a residence by the two senior partners and the remainder as offices, stores, etc.

The sands used in the foundry are Bromsgrove and Erith loam and, for cores, Erith and Ryarsh silica. Using these silica sands, magnesium alloys are successfully cast and there has been a considerable output in this material. Rollers weighing about 25 lb. each were produced without difficulty in magnesium-alloy metal, after aluminium had been rejected on account of gas porosity.

The non-ferrous foundry is equipped with a one-ton travelling crane, carried on a monorail, a Pneulec "Royer" sand mixer, and a gyratory riddle by Cummings which serves the sand behind the bench moulders. This area originally consisted of a series of sheds which were destroyed by a fire in 1934 and were replaced by the existing building. The melting equipment comprises two Cumming furnaces each of 120-lb. gunmetal capacity, a Black-seam Midland Monolithic furnace of 400-lb. capacity, and a 120-lb. "Morgan" oil-fired furnace. The two Cumming furnaces gave excellent service during the war years.

Typical Production

Typical of the castings produced in the non-ferrous foundry (besides those in magnesium) are a shaft bracket and rudder log in manganese-bronze and a skeg in high-strength aluminium. Castings are also supplied for refrigerators, lifts, automobiles, etc. In order to speed-up the delivery time it was decided to use aluminium for a V-rope drive for a large refrigerator for marine use. The experiment proved so satisfactory that this job has been produced in aluminium ever since.

The iron foundry is served by a Paterson Hughes 3-ton electric crane equipped with a De Renzi-Holt special low-speed lowering device which gives a very wide range of lowering speeds. There is also a Morris half-ton jib crane which has given useful service. Two Pneulec "Royers" cope with the sand. Moulding boxes are either by Sterling or are made by the company in aluminium (Fig. 3).

The iron foundry produces keels for yachts which are usually made with a cheap-grade iron (Fig. 4). In addition to the keel castings of 2 tons and 3½ tons which were in production when Fig. 4 was prepared, the company is shortly to cast two 4-ton keels for British West Indies. Moyles improved cast iron, which is a hematite pig and scrap-steel mix, is used for toolmakers' castings, castings for lifts, for the optical industry, and for engineers making special-purpose machinery. Fig. 5 shows a group of the smaller castings.

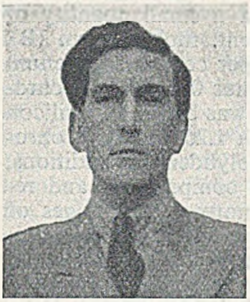
In the core shop there are two drawer-type stoves by August's and also a cabinet-type improvised core stove using the original 80-lb. pit fire, previously mentioned, as a heating unit. Straight cores are made on a "Green" rotary core-making machine. The bulk of the core sand is mixed within a Fordath mixer, and a semi-solid core compound is used.

The equipment of the trimming shop includes a "Mitchell" double-ended high-speed grinder with a dust exhaust, which latter also serves the scratch brushes. There are also a cutting-off machine by Coleman, a machine hack-saw, a band-saw, bench grinders, and three flexible-shaft grinders by Hopkins

Organisation

Careful attention has been devoted to the efficient organisation of production. When an order is received it is given a number and a foundry-capacity date. Copies of the order are handed to the despatch section, the foundry foreman, the moulder and the costing department. The moulder's name is entered on the cost sheet with particulars of any cores required, the piecework price, trimming, time and scrap risk. The costing department obtain the weight from the delivery note and thus have all the information they require. When the job is finished all sheets are destroyed except that of the costing, which is filed, so that in case of a repeat order all necessary information is available in convenient form. This system has worked extremely well.

(*Continued on page* 284)



Deformation Characteristics of Five Grey Cast Irons at 400 and 500 deg. C.*

By C. R. Tottle, M.Met., A.I.M.

Five grey cast irons, manufactured by the Meehanite† process, and incorporating alloying elements, have been critically examined at 400 deg. C., and incompletely at 500 deg. C. The deformation at these temperatures has been measured in short-time tensile tests, high-sensitivity creep tests of 2,500 hours' duration, and stress-to-rupture tests. The ductility has been shown to increase, in the rupture tests, as the stress is lowered, and the time to fracture increases. This increase in ductility occurs in the third stage of creep. Unstressed bars, inserted in the creep furnaces, showed no growth after 10,000 hours' exposure, and no breakdown of the microstructure was observed in stressed bars, even at 500 deg. C. Molybdenum was found to give the most effective resistance to deformation, compared with the basic composition, chromium-copper additions being second in order of merit.

THOUGH THE MECHANICAL properties of cast iron at elevated temperatures have been investigated for a number of test conditions, and various iron compositions, few results have been reported for creep tests. Short-time tensile strength has been covered by Donaldson,[1] Smalley,[2] Collins and Smith,[3] Moore and Lyon,[4] Harper and McPherran,[5] Bolton,[6] Paschke and Bischof,[7] Kanter and Guarnieri,[8] and others. The main conclusions of these workers, in each case, indicate a decrease in maximum stress between 100 and 300 deg. C., with a return to the original values, or even a slight increase, between 400 and 500 deg. C., followed by a gradual fall at higher temperatures. Ingeberg and Sale[9], using hollow test-cylinders in compression, found a gradual decrease in strength with rising temperature, although the fall up to 450 deg. C. never exceeded 20 per cent. of the original value.

Impact strength, measured by Dahle[10] on Charpy and tensile-impact machines, and by Rajakowicz,[11] Paschke and Bischof,[7] Kanter and Guarnieri,[8] on notched and unnotched bars, all point to a reasonably-steady value (fluctuating slightly above and below the strength at room temperature) up to 500 or 600 deg. C. Hardness appears to follow similar trends, although it commences to fall rapidly above 500 deg. C. Fatigue-strength investigations, by Moore and Lyon,[4] Collins and Smith,[3] showing similar trends to impact strength, seem to indicate little or no loss in test values up to 500 deg. C., but there is rapid reduction beyond that temperature.

Creep tests were first reported by Honegger,[12] Piwowarsky and Bornhofen,[13] though no truly systematic comparison appeared in the literature until Tapsell, Becker and Conway[14] showed the possibility of employing certain alloyed irons in the steam temperature range 375 to 600 deg. C. Criticism of this last work centred round the short times employed for test (1,500 hours as against the lifetime of a turbine of 15 years), the effects of oxidation and growth and the variability of composition expected between separately-cast bars of the same iron, or between cast-off bars and actual castings. However, it was obvious that cast iron showed low creep rates in the range studied, and reasonable total deformation before fracture, *i.e.*, that it became much more ductile at elevated temperatures than is apparent from normal-room-temperature tests.

Present Investigation

The present investigation was based on a complete survey of the deformation characteristics of grey cast iron at two temperatures, one just below, and one just above, the temperature at which the short-time tensile strength appeared to fall rapidly. Preliminary work indicated that this temperature varied little with small additions of alloying elements, and that 400 and 500 deg. C. would satisfy the test requirements. The properties of those irons, in the present series, which show the greatest creep resistance, have been examined thoroughly at 400 deg. C., but as yet incompletely at the higher temperature.

Short-time tensile tests were first carried out, to determine the limit of proportionality, modulus of elasticity, breaking strength and ductility. From these results, values of stress suitable for high-sensitivity creep tests and stress-rupture measurements were obtained. The creep tests were conducted for a maximum of 2,500 hours, since the creep rate was still decreasing after this period, but some of the rupture periods have now exceeded 10,000 hours' duration, and it is intended to continue these tests for several years if possible. The conclusions drawn from shorter times of stressing may then be compared with actual measurements over "life" involved in service applications.

* Paper presented at the Buxton Conference of the Institute of British Foundrymen. The Author is Lecturer in Metallurgy, The University, King's College, Newcastle-upon-Tyne. The investigations described have been extracted in part from a thesis submitted to, and approved by, the University of Sheffield, for the degree of M.Met.

† Meehanite is a registered trade name.

Deformation of Cast Iron at 400 and 500 deg. C.

The investigation of deformation formed part of a larger programme of research into heat-resisting properties at sub-critical temperatures, and growth and scaling were naturally measured under a variety of conditions. In atmospheres of air and of burned town's gas, growth (in the same irons) did not occur at any temperature below 600 deg. C., for periods of 300 hours, either in continuous heating or by cyclic heating in three-hour periods. Although this total test period is small, the rate of growth and of scaling can be plotted against time, and some estimation of results for tests of longer duration can

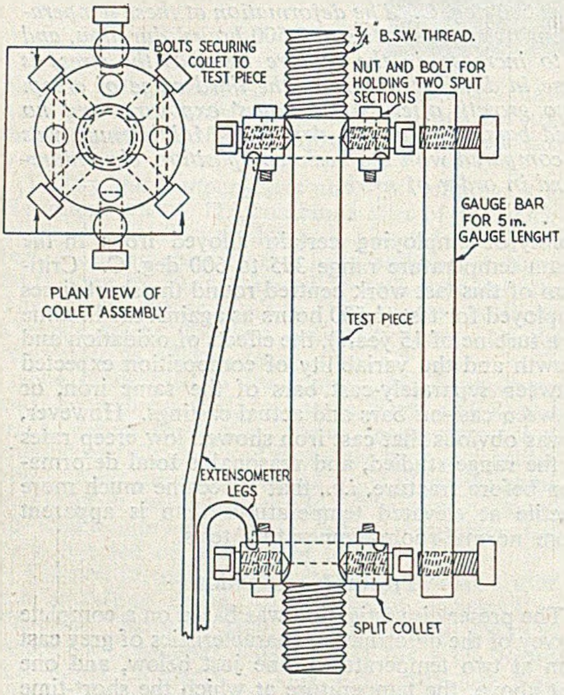


FIG. 1.—*Creep Test-piece and Split Collets.*

thus be made. In the present work, bars of each iron were inserted in the creep-test furnaces alongside the stressed bar and, by exposing these for the duration of four creep tests, a total test period of 10,000 hours (slightly more than one year) is possible. Comparison of the microstructures on stressed and unstressed bars also gives immediate indications of any changes likely to affect either deformation, oxidation, or graphitisation.

Materials

The materials chosen for this work were intended to cover a range of alloying additions, the first four embracing a basic composition to which was added one or more elements, the fifth being the result of an attempt to improve the mechanical properties of a high-silicon type of iron. All irons were cast into bars 12 in. long by 1-in. dia., in green-sand moulds, due precautions having been taken to ensure minimum variation in chemical and physical properties from one bar to another. To the basic iron composition (A), which contained a small quantity of copper, was added 0.5 per cent. molybdenum (B), 1.5 per cent. copper plus 0.4 per cent. molybdenum (C); and 1.4 per cent. copper plus 0.8 per cent. chromium (D). The fifth iron (F) was based on a silicon content of 4.25 per cent., with 1.25 per cent. chromium and 1.0 per cent. molybdenum additions. Iron, F, is, of course, only a compromise, and retains only a portion of the normal advantages of this type. The chemical composition and mechanical properties of the five materials are shown in Table I, from which it can be seen that only small variations occur from A to D in the common elements present.

Testing Procedure

The creep tests were made on two Denison 5-ton capacity machines, the test-bars being of 0.564-in. dia. for the gauge length of five inches, with screwed ends, to fit the machine grips, of ¾-in. B.S.W. threads. The extensometers were of the Martens mirror type, employing one fixed and one movable mirror on two assembly legs diametrically opposed on the test-pieces. The extensometer legs were located in grooves cut into split collets fixed to the test-bar by four screw pins at each end. A gauge bar of the required length was fitted to the collet assemblies when setting up the unit for test. Details of the split collets and test-bars are shown in Fig. 1. The furnaces attached to the testing machines were of 12-in. dia. and 18 in. in length, wound differentially in three portions, so that a uniform temperature was maintained over the central 9 in. embracing the test-piece and the machine grips.

Temperature Control

Control of temperature was achieved by a potentiometric controller and thermocouple on one furnace, and by a proportioning resistance thermometer controller on the other. Couples were also arranged at each end of the test-piece and in the centre, a multipoint recorder being employed to record continuously the temperatures of these three check couples on each furnace. The centre couple in each case could be further checked on a potentiometer by a switch incorporated in the circuit. The controlling platinum-resistance thermometer on the one furnace was situated with its coil alongside the metal sleeve placed inside the wound silica tube, but the control couple on the second furnace was placed between the wound silica tube and the central metal sleeve (fitted inside the silica tube to eliminate temperature variations). In each case, the windings on the furnaces were adjusted in conjunction with external shunts and ballast resistances, so that a current slightly less than that required to maintain the desired temperature was continuously present in the circuit, and an extra controlled current was superimposed upon this by switching out a portion of the total resistance in the control system.

Several checks were made on the control cycle achieved during each test, and in no case did the variations at the centre of the test-bars exceed ± 0.25

deg. C., the variations along the length of the test-piece being not greater than ± 0.5 deg. C. Due to the paucity of information on creep testing of cast iron, it was felt that such close control was a necessary precaution. The extensometers used were capable of measuring changes in length of the order of 2×10^{-6} in. per in., which, with the control of temperature, achieved an accuracy of the order of 10^{-6} in. per in. per hr. on the creep rate. (The movement of the extensometer mirrors was measured in the usual way, by means of telescopes and illuminated scales.)

Rupture Tests

To provide measurements on the ductility of the irons at elevated temperatures, stress-to-rupture tests were carried out, using smaller test-pieces of 2-in. gauge length. By making pock marks on the shoulders and measuring the length before and after test, figures for elongation were obtained, together with the test duration to the time of fracture. Initially, these tests were made on 0.564-in. dia. test-pieces in the creep machines, but the duration often reached such long periods, under high stress, that more machines were necessary to limit the total time for collecting results sufficient to provide useful information.

A six-unit battery of testing machines was therefore constructed, on simple lines. The framework was welded from heavy angle-iron, loading was provided by dead weights on levers of 40 to 1 ratio, acting on hardened steel knife-edges. The straining heads and grips were one-piece, heat-treated, 0.4 per cent. carbon steel bars of 1½-in. dia. threaded internally at one end to take the specimen. Strain was applied at the top of the machine by large steel nuts with machined spherical seatings and adjusting washers for ensuring axial loading and torsion bars for eliminating torque. The furnaces were simple resistance-wire wound tubes, arranged to give uniform temperature over the central 5-in. portion, and 9 in. in length and diameter. The furnaces were suspended from the frame, for ease in setting-up for the tests; each furnace was controlled by an energy regulator and checked by thermocouples and a potentiometer.

Ballast resistances were used on the adjustment of the furnaces, care being taken to construct them in identical manner to avoid excessive adjustment when in use. On this equipment, six test-pieces could be under test at any one time, and results could be obtained more rapidly. Temperature control was to ± 1 deg. C., and by limiting the weights used on the machine to 150 lb. maximum per unit, test-pieces of 0.399-in. dia. served to cover the necessary range. Checks made on bars of 0.564-in., 0.399-in. and 0.282-in. dia. (¼, ⅛ and 1/16 sq. in. cross-sectional area, respectively) proved that results were identical on each size in all irons except F., where the smallest test-piece gave low results compared with the other two.

Bars of the same length as the creep-test pieces, but of uniform diameter (¾ in.) were suspended in the furnaces alongside the creep bars, and their lengths were measured before and after periods of 2,500 hours' continuous heating (the duration of each single creep test). To eliminate errors due to scaling, ¼ in. dia. Nichrome studs were screwed into the ends of the bars for a depth of ¼ in., and the bar length was measured on a clock-gauge comparator between the machined parallel faces of these studs. After 10,000 hours' exposure (four creep-test periods) at both 400 and 500 deg. C., none of the irons showed any increase in length, and no visible or measurable signs of breakdown were found by microscopic or chemical methods of analysis. It was therefore concluded that continuation of these tests at 400 deg. C. would yield no further results, and that the measured creep at 400 deg. C. was probably entirely due to deformation. No signs of breakdown were found in the creep bars, so that stress probably has no effect on growth at this temperature and at the stress levels used, at least for the periods of test adopted.

Similar reasoning applied to the " growth " bars at 500 deg. C., but 10,000 hours may not have been sufficient to indicate incipient breakdown, and longer periods of exposure will be required to draw definite conclusions. It can be stated at present, however, that no growth has been measured in unstressed bars, and no breakdown has been found in stressed bars, at 500 deg. C., after periods of 10,000 hours and 2,500 hours respectively.

Short-time Tensile Tests

To investigate the breaking strength of the irons it was necessary to conduct short-time tensile tests, and thus supply information on the modulus of elasticity and limit of proportionality, together with levels of stress suitable for stress-rupture tests.

No apparatus fitted for these tests at high temperature was available, and one of the creep machines was, therefore, used for the measurements, with the creep extensometers attached in the same way as for long-time creep tests until rapid plastic deformation began, when the mirror systems were removed for safety. Rubber shock absorbers were inserted below the steelyard beam and the universal joint at the base of the machine grips, to prevent damage to the machine.

In an initial exploration, specimens of the same size as those used in creep tests were loaded to the

TABLE I.—*Percentage Composition and Mechanical Properties of the Materials Selected.*

	T.C.	C.C.	Gr.	Si.	Mn.	P.	S.	Cu.	Cr.	Mo.	Cast off tensile test-bar, dia. in ins.	Tensile strength, tons per sq. in.	Brinell hardness number.	Fracture.
A	2.91	1.06	1.85	1.34	0.93	0.08	0.11	0.31	—	—	1.0	21.0	235	Slight mottle.
B	2.92	1.26	1.66	1.24	1.00	0.10	0.10	—	—	0.51	0.875	24.8	255	Mottled.
C	2.80	0.84	1.96	1.17	1.01	0.07	0.11	1.51	—	0.41	1.2	28.6	269	Grey.
D	2.89	1.09	1.80	1.41	0.91	0.08	0.09	1.36	0.82	—	0.875	25.0	285	Slight mottle.
F	2.90	0.48	2.42	4.08	1.05	0.11	0.13	—	1.26	0.91	0.875	19.3	207	Grey.

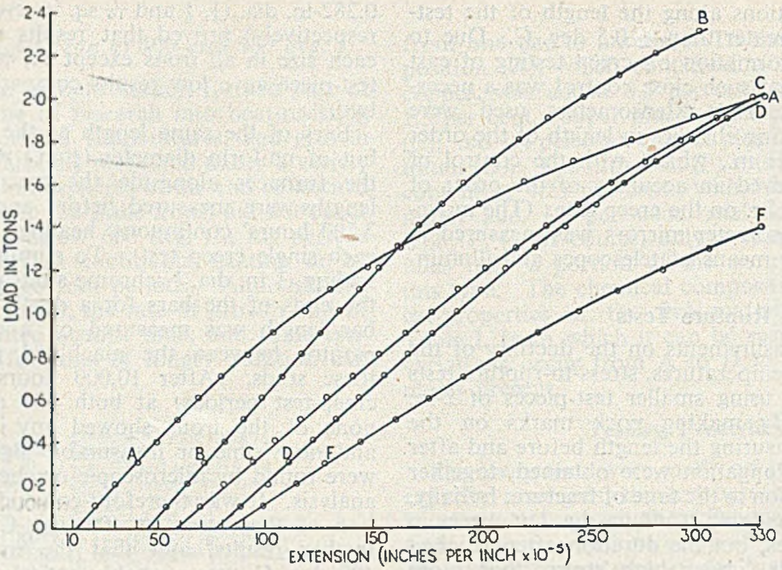


FIG. 2.—*Short-time Tensile Tests at* 400 *deg. C.*

full capacity of the machine, extensometer readings being possible up to four tons load. With specimens of ¼ sq. in. cross-sectional area, it was found impossible to break any of the irons, except F, under the full capacity of the machine (five tons), and the results were therefore repeated with the reduced cross-section given by a diameter of 0.399 in., all other dimensions being identical with the creep-test specimens. In this case, the extensometer mirrors normally were removed at two tons load, which point corresponded with rapid plastic deformation. The tests were carried out under the same conditions as the creep tests, allowing 24 hrs. soaking at temperature before commencement of loading, the temperature control being ± 0.25 deg. C. with not more than ± 0.5 deg. C. variation along the length of the specimen. Load was applied in increments of 0.1 ton, the rate of straining being such as to require 10 secs. to apply each increment, and the extension was measured after an interval of not more than 20 secs. By this means, the amount of creep occurring at each load increment was reduced to a minimum. After removal of the extensometer mirrors, the load was applied under the same conditions, with the same increments, until fracture occurred, *i.e.*, 10 secs., to increase the load by 0.1 tons, followed by 20 secs. delay before a further increment.

Results

The results are plotted in Fig. 2 and the computed figures for limit of proportionality, modulus of elasticity and breaking strength are shown in Table II. The limit of proportionality and modulus of elasticity were taken from the closest straight line which could be drawn to the lower points on the curve, which, in some cases, was found to be coincident with the actual points for a considerable number of load increments.

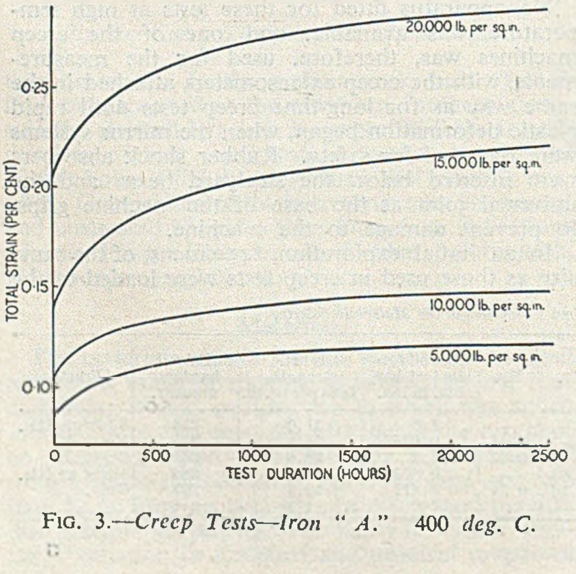


FIG. 3.—*Creep Tests—Iron* "*A.*" 400 *deg. C.*

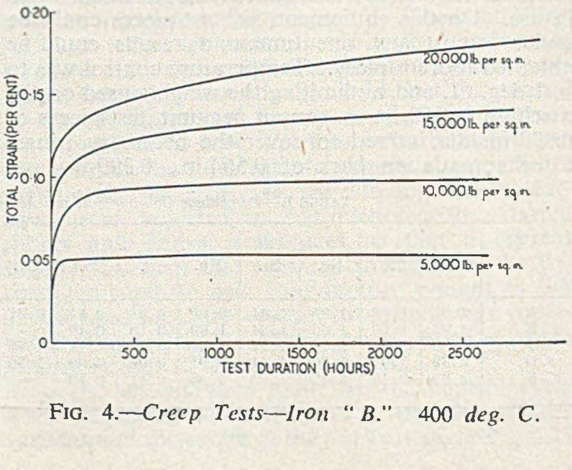


FIG. 4.—*Creep Tests—Iron* "*B.*" 400 *deg. C.*

TABLE II.—*Results of Short-Time Tensile Tests.*

Iron.	Limit of proportionality, tons per sq. in.	Modulus of elasticity, lb. per sq. in.	Stress at fracture, tons per sq. in.	Elongation at fracture, per cent. on 5 in.
Tested at 400 deg. C.				
A	5.0	18.1×10^6	22.4	0.63
B	11.5	19.9×10^6	23.0	0.62
C	8.6	15.0×10^6	22.4	0.94
D	10.0	16.5×10^6	23.36	0.63
F	6.4	11.3×10^6	16.72	1.8
Tested at 500 deg. C.				
B	5.4	12×10^6	15.2	0.92
C	3.6	8×10^6	13.6	1.3
D	4.9	10×10^6	15.8	0.87

Creep Tests

From the results of the short-time tests, stresses of 5,000 to 20,000 lb. per sq. in. at intervals of 5,000 lb. per sq. in were used for the long-time creep tests, and the results obtained for the five irons at 400 deg. C. are shown in Figs. 3 to 7, total strain per cent. being plotted against duration to include the initial extension. By re-plotting creep-strain only against time, on a larger scale, the curve of closest fit was obtained as accurately as possible for measurements of creep rate, shown in Table III. As a guide to the possible uses of these irons, the creep rate at 1,000 hours was plotted against stress, in the manner proposed by Bailey and other workers. By extrapolating the curve obtained to stimulate a creep rate of 10^{-3} inch per inch per hour, the stress value which might be expected to give 0.1 per cent. deformation by creep in 100,000 hours was obtained. Such extrapolated values have no value unless rupture tests of sufficiently long duration are also conducted under similar conditions, but they may serve as a possible comparison between different irons (Fig. 8.) Creep-tests at 500 deg. C. are as yet incomplete, and have therefore been omitted from the present Paper.

Stress-to-rupture Tests

The results obtained from stress-to-rupture are mainly limited to irons B and D (which are superior

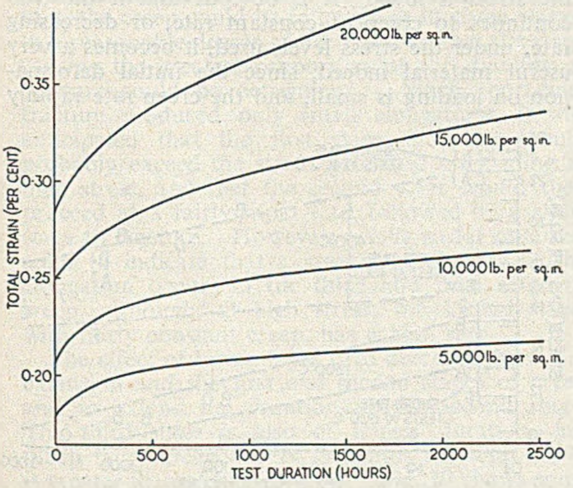


FIG. 5.—*Creep Tests—Iron " C."* 400 *deg. C.*

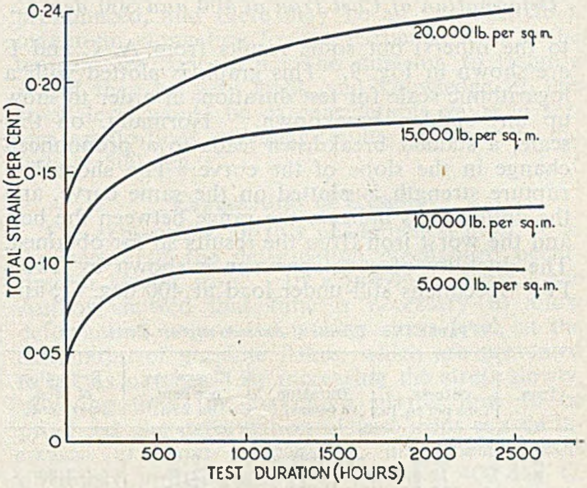


FIG. 6.—*Creep Curves, Iron " D," at* 400 *deg. C.*

TABLE III.—*Creep Rates at 400 deg. C. over Various Periods.*

Iron.	Stress, lb./sq. in.	Creep rate. Inch per inch per hour, $\times 10^8$ At 1,000 hrs.	At 2,000 hrs.	At 2,500 hrs.
A	20,000	20	10	7.0
	15,000	17	9.0	8.0
	10,000	11	4.5	4.5
	5,000	5.2	3.0	3.0
B	20,000	19	12	11
	15,000	8.0	5.5	5.0
	10,000	1.5	1.3	1.3
	5,000	0.2	0.2	0.2
C	20,000	45	24	22
	15,000	25	19	14
	10,000	14	8.0	7.0
	5,000	4.0	3.5	3.5
D	20,000	31	12.5	9.0
	15,000	20	7.25	4.5
	10,000	10	5.00	4.0
	5,000	0.75	0.7	0.7
F	20,000	25	22.5	20
	15,000	13	10	9
	10,000	4.5	2.8	2.6
	5,000	1.2	1.0	1.0

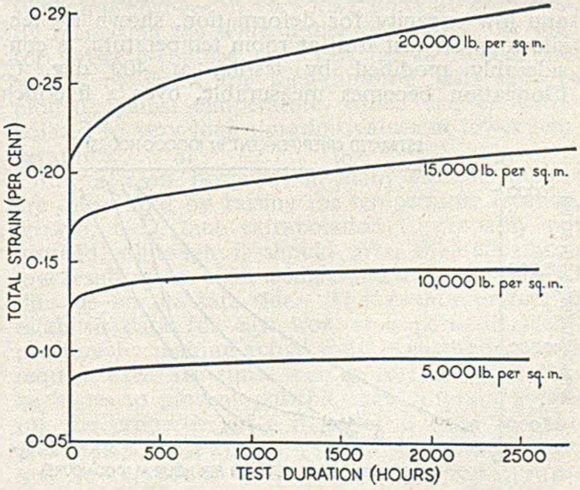


FIG. 7.—*Creep Curves, Iron "F," at* 400 *deg. C.*

Deformation of Cast Iron at 400 and 500 deg. C.

to the others) but some results from A, C and F are shown in Fig. 9. This graph is plotted with a logarithmic scale for test duration, in order to show up any sudden breakdown. Normally, on this scale, a sudden breakdown leads to a pronounced change in the slope of the curve. The short-time rupture strength is plotted on the same curve, and the dotted lines indicate the range between the best and the worst iron from the results so far obtained. The ductility of each specimen is shown by Table IV. Specimens still under load at 400 deg. C., and

TABLE IV.—*Results of Stress-to-rupture Tests.*

Iron.	Stress, tons per sq. in.	Duration, hours.	Elongation, per cent. on 2 in.	Reduction of area, per cent.
Tested at 400 deg. C.				
A	22.4	(Short-time)	0.63	—
A	17.5	1,075	2.79	3.20
A	16.5	5,900	3.80	—
B	23.0	(Short-time)	0.62	—
B	20.0	64	1.70	—
B	19.0	895	1.95	0.95
B	18.0	5,000	2.20	—
C	22.4	(Short-time)	0.94	—
C	16.0	10,050	3.40	2.00
D	23.4	(Short-time)	0.63	—
D	20.0	{ 23	1.70	2.40
		{ 25	2.10	1.60
	19.0	215	2.70	—
D	18.0	2,005	2.75	—
F	16.7	(Short-time)	1.80	—
F	15.0	1,875	3.00	—
Tested at 500 deg. C.				
B	15.2	(Short-time)	0.92	—
B	12.0	92	1.00	—
B	11.0	515	1.75	—
C	13.6	(Short-time)	1.30	—
C	10.0	275	1.90	—
C	9.0	3,009	2.30	—
D	15.8	(Short-time)	0.87	—
D	12.0	131	1.30	—
D	11.0	1,007	2.1	—

which have exceeded 10,000 hours duration, are not reported, but confirm the trend of results plotted in Fig. 9.

Discussion of Results Obtained from Deformation Tests

The normal conception of the "brittle" fracture and low capacity for deformation, shown by tensile tests on cast iron at room temperature, is considerably modified by testing at 400 deg. C. Elongation becomes measurable, over a five-inch gauge length, in short-time tests to fracture, and the rupture stress is only slightly lowered from the value obtained at room temperature.

The low value obtained on iron F is thought to be due to slight porosity in some of the bars, and to variations in the graphite content. Porosity would be magnified in its effect by using the smaller-section test-bar in the creep machines; this was probably the greatest factor in this instance. However, iron F shows remarkable elongation at 400 deg. C., this property being far greater than with the other irons in the short-time test. Iron C, also shows reasonable ductility (on the basis of cast irons in tension) and the remaining three are almost identical with each other. The limit of proportionality in B, and D, and more particularly the high modulus of elasticity of iron B, are noteworthy. The decrease in this modulus with rise in temperature is considerable, since the normal modulus at room temperature is of the order of 24×10^6 lb. per sq. in., on these materials.

In the creep tests, the alloying elements play a preponderating rôle, as for example as with iron F, which, in spite of its high-silicon content, shows low creep rates even with a stress of 20,000 lb. per sq. in. Iron D, is superior to iron F, at low stress, and iron B shows the greatest promise. The low initial extension on loading, combined with the short initial stage of creep and low creep rate, illustrate the rigidity of cast iron in tension, and there is some similarity to low-alloy steels, as regards the general slope of the creep curve, and the effect of increased stress. The scale of strain is reduced to small dimensions, compared with steels, but the matrix obviously behaves according to modern concepts, *i.e.*, visualising cast iron as a steel modified by "notches" filled with graphite, whose shape, size and distribution affect the iron to a remarkable degree. This has been demonstrated by the Author, at room temperature, and at elevated temperatures, by different methods of stressing.[15]

The creep rate at 400 deg. C. is still decreasing at 2,500 hours although to a very small extent when the stress is low. It is obvious that if the iron continues to creep at constant rate, or decreasing rate, under the stress levels used, it becomes a very useful material indeed, since the initial deformation on loading is small, and the creep rate rapidly

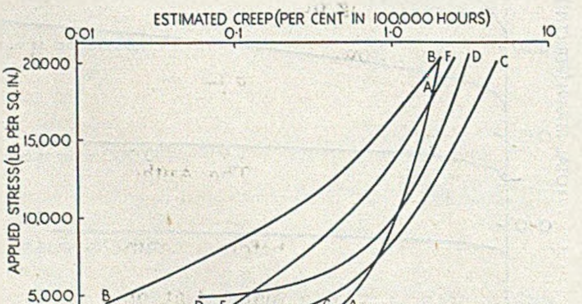


FIG. 8.—*Creep Rate v. Stress. 400 deg. C*

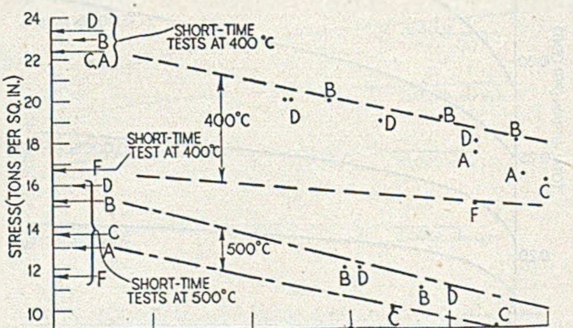


FIG. 9.—*Stress to Rupture Tests.*

reaches its constant or decreasing value. However, the results have been treated with caution throughout, and duplicate tests have been conducted, in some cases, to detect any variations in test-bar quality which might, by chance, magnify the properties. The creep curves so obtained have a remarkable degree of similarity, there being very little difference, even, in the strain produced by loading. The precautions taken in casting the original bars seem therefore to have been fully justified.

With the creep results available, the times necessary to rupture the irons at low stresses will obviously be great, unless breakdown to the third stage of creep becomes possible with changes due to oxidation of the surface, spheroidisation, or growth (or the effect of stress on these factors, particularly on growth). It has been recorded that stress-free bars showed no growth after 10,000 hours at 400 or 500 deg. C., in the creep-furnace chamber, so that this effect was not expected to influence the results. The stress-to-rupture tests were therefore planned to cause fracture in periods from 10 to 10,000 hours, as stress was lowered. Iron D was tested first at 400 deg. C., under 20 tons per sq. in., and fractured in 23 hrs. In a second test, conducted under the same conditions, the time varied by only two hours, the elongation was slightly increased, and, in both cases, the ductility was definitely much higher than in the short-time test.

Specimens of iron B, were then subjected to the same stresses as iron D, and the time to rupture was again high, being 5,000 hrs. for 18.0 tons per sq. in. at 400 deg. C. When the stress was reduced to 17 tons per sq. in. on iron B, the test-bar was still unbroken after 10,000 hrs., and creep is still occurring. The elongation of these specimens was greater than those of B, and D, at the higher stresses (Table IV), and it was, at this point, concluded that ductility appeared to increase as the time to rupture increased, that it, as the applied stress was lowered.

By attaching a clock gauge, reading to 10^{-4} in. per division, to the lever arm of the stress-to-rupture unit, the creep could be followed in its three stages, to a reasonable degree of accuracy, so that the stage causing the greatest proportion of the ductility at fracture could be determined. Since short-time fracture produced only small elongations, it was anticipated that the first stage of creep would probably exceed the strain produced on loading at high stress, and that the second stage would then proceed at a fairly rapid rate, followed by a short stage to fracture. However, results so far obtained seem to indicate that a greater proportion of the elongation occurs in the third and final stage of creep, although, at high stress, the second stage, with fairly constant creep, has a high rate.

The effect of lower stress is to decrease the initial extension and the first and second stages of creep and to extend the duration of the second stage. The third stage is also of longer duration, but much more creep occurs, and thus the total strain is greater than at higher stress. Fig. 10 shows some curves obtained with iron B. With further decrease of stress, the increase in elongation becomes less pronounced, and there may be an approach to a maximum elongation for the particular iron at the temperature concerned. The duration to fracture would then be very great, and knowledge of this stress level would be of considerable value in service applications. Similar results appear from the tests at 500 deg. C.

Explanation of Results

The explanation of this phenomenon must lie in the nature of the deformation mechanism occurring in a cast iron. In a previous Paper,[15] the Author showed that time is necessary to allow deformation to proceed, at any stress level, at the extremities of graphite flakes, which are presumed to act as notches. By increasing the stress slowly, allowing time for maximum plastic flow to be produced, the deformation of cast irons can be increased at room temperature, and these effects obviously, must be greatly increased at 400 deg. C. Thus, at high stress, the high temperature causes greater plastic flow, which eventually proceeds very rapidly, and there is no time to allow slow dissipation of the high-stress concentrations at the graphite-flake notches. When the stress is reduced, the effect is similar to allowing longer time, and thus there is slower propagation of flow in the matrix. Deformation has thus proceeded further before rupture finally results, although there must be a limit, where the effect described is opposed by the low level of stress being unable to propagate the flow in the time to the same degree.

Insufficient results have been obtained in the stress-to-rupture test, but the trend is certainly such as to confirm the creep-resistance implied by the creep tests themselves. Hence, the slow creep rate observed at low stresses would be expected to continue for the " life " required in many service applications, say for 100,000 hours or even longer. Stresses intermediate between those used in the creep tests and those in stress-to-rupture tests (*e.g.*, in the range 12 to 14 tons per sq. in. at 400 deg. C.) may give times before fracture of the order required, and thus confirm the susceptibility to structural changes in very long times at low stress. By increasing the temperature of testing, the time for stress-to-rupture tests can be shortened, and graphs of stress for long-duration tests can be plotted against temperature, which can be extrapolated to very long duration values at lower temperatures.

In cast iron, however, so many variable factors are introduced by raising the temperature (scaling, growth, etc.), that extrapolation is probably not justified, although it should give, theoretically, a low result rather than a high, and any error should thus be on the safe side. The Author prefers to establish data for cast iron at a particular temperature by making actual tests, even though these require excessive times before fracture, and thus he hopes to prevent possible inaccuracy in assessing the properties of a material at once so complex, and so little known. It will still remain necessary to reproduce castings with identical properties to individual batches of test-bars, and this may

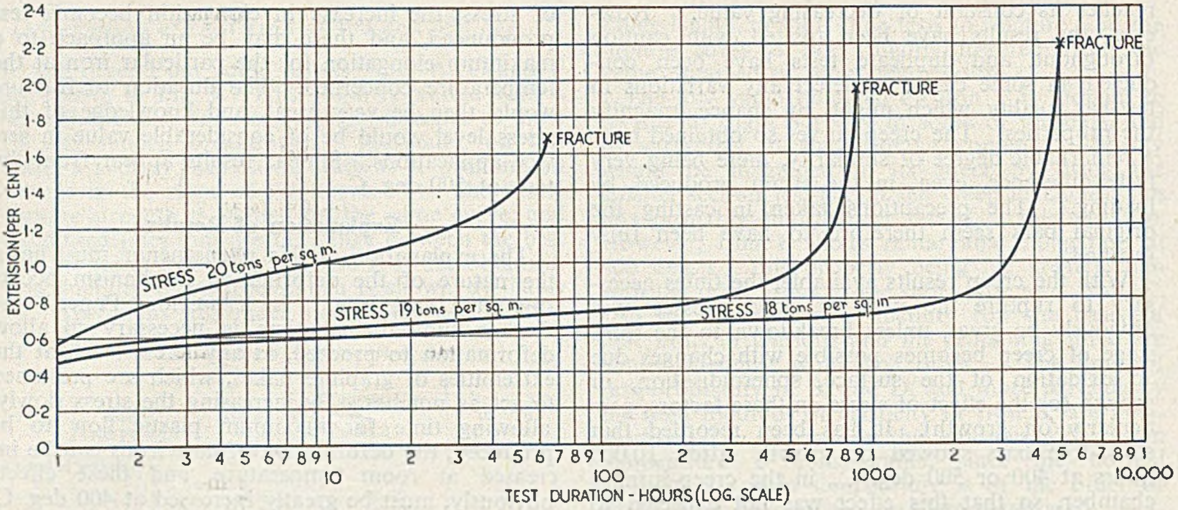


FIG. 10.—*Iron "B." Creep in Stress-to-Rupture Tests, showing Rise in Ductility, with increase in Rupture time.*

prove the deciding factor in applying cast iron to service at higher temperatures and stresses than have hitherto been used.

Microscopic Examination of Creep Specimens

Sections cut from all specimens fractured at 400 and 500 deg. C. were examined by the microscope to investigate the nature of the fracture and deformation with respect to the microstructure. In all cases, fracture appeared to follow a path between graphite flakes, and to show no unusual features. In some instances, a crack or cracks could be seen over part of the structure immediately behind the fracture proper, and this invariably followed the line of flakes, and with no other particular orientation so far as could be judged at the highest magnification and resolution of the microscope. No change in microstructure was ever observed in these sections, when compared with that of the original as-cast bar.

Conclusion

1. The ductility of the irons under test is much increased at 400 and 500 deg. C. from that at room temperature, as measured by short-time tensile tests. The modulus of elasticity is decreased at both temperatures, rupture strength is only slightly affected at 400 deg. C., though the effect is considerable at 500 deg. C.

2. The effect of increasing stress on the creep at 400 deg. C., gives a normal increase in total strain at any duration, and a slow rise in creep rate at the constant, or decreasing stage of the creep curve.

3. The normal creep tests at 400 deg. C. show extremely small values of deformation (either total or rate of change) compared with most materials used at high temperature, and the total strain after a life of several years, even for stresses of the order of 10 tons per sq. in. tensile, must be very low.

4. The duration before rupture at high stresses increases considerably with decrease in stress below the short-time rupture strength, and ductility appears to rise as duration is prolonged by lower stresses being imposed. This increase in ductility appears to take place in the final (tertiary) stage of creep.

5. Extrapolation of the creep rates, measured at 1,000 hours, against stress, shows that stresses of the order of 5 to 8,000 lb. per sq. in. tensile, could be applied at 400 deg. C., to limit the deformation to less than 0.1 per cent. after 100,000 hours duration. This extrapolation seems so far justified, on the duration of stress-to-rupture tests at much higher stresses, though insufficient factual results have been obtained in this connection. Extrapolation to total deformation of 1 per cent. at 100,000 hours, would indicate that stresses approaching 20,000 lb. per sq. in. may be possible.

6. No measurable growth occurred in the materials examined, after 10,000 hours at 400 and 500 deg. C., in unstressed bars. Microscopic examination of test-pieces stressed at both temperatures, and chemical analyses for graphitic carbon, indicate that no structural breakdown has occurred in any specimen at the conclusion of creep tests of 2,500 hours duration.

7. Molybdenum plays an important part in improving the creep resistance of an iron which basically has a high-duty composition. A chromium/copper addition is only slightly less effective, and silicon/chromium/molybdenum may have advantages for oxidation resistance, though it is inferior in creep.

Acknowledgments

The Author wishes to acknowledge the encouragement received from Professor C. E. Pearson, M.MET., F.I.M., during his tenure of the Chair of Metallurgy in the University of Durham. The provision by Qualcast (Ealing Park), Limited, and

Cameron & Roberton, Limited, of the materials used in this research is also acknowledged, together with the interest of Mr. P. Attenborough, chief engineer, International Meehanite Metal Company, Limited.

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DISCUSSION

[At the Buxton conference the Paper was presented by Mr. M. M. Hallett owing to the unavoidable absence of the Author.]

DR. R. V. RILEY, opening the discussion, asked whether the creep tests reported in the Paper had been made with the aid of apparatus similar to that generally employed for the carrying out of creep tests on steel. If not, was the accuracy to be expected equal to that obtained in the best conducted tests made on creep-resistant steels.

He wondered if Mr. Hallett could say whether Mr. Tottle intended to continue creep investigations, because if so some of the more heat-resisting types of cast iron could, with advantage, be tested, as for example, Silal or Nicrosilal.

MR. HALLETT said he was not sufficiently familiar with the investigation to reply to any criticism as to whether the tests were carried out under satisfactory conditions. Would Dr. Riley like to elaborate his question? He had hinted that the tests were unsatisfactory, but had not said in what way. The work, in spite of Mr. Tottle's imminent departure from Durham, would, he understood, be carried on, but that would have to be confirmed by Mr. Tottle.

He himself very much agreed with the desirability of extending that type of work to more heat-resisting materials. The possible uses of cast iron at high temperatures could only be extended by the provision of accurate data, and there were a number of fields concerned. The present investigation merely covered one of those fields—the use of low-alloy cast irons at slightly elevated temperatures, which were generally of particular interest to the designers of steam plant. For work at higher temperatures for furnace applications, or even gas-turbine parts, obviously one had to use much more highly-alloyed materials which were inherently much more heat resisting. Information on the creep behaviour of those would be of extreme value.

Accuracy Queried

MR. GRANT expressed surprise at some of the results obtained, particularly in the growth tests. Mr. Tottle referred to atmospheres of air and of burnt town's gas and said the growth did not occur at any temperature below 600 deg. C. That seemed to be an extraordinarily high temperature for no growth to be detected. Tests which have been done at the British Cast Iron Research Association's laboratories have shown a definite growth over long periods at 400 to 500 deg. C. Also, the results of Tapsell's researches on mildly-alloyed cast iron had shown considerable growth at 450 deg. C. He was wondering if the type of growth test which Mr. Tottle had used was sufficiently accurate to determine the order of growth which took place.

Also, the Author had made a remark about the considerable reduction in the modulus of elasticity and had quoted a figure of 24×10^6 lb. per sq. in. at room temperature. That was an extremely high modulus for irons of that type. According to the Paper it had decreased from 24×10^6 lb. per sq. in. at room temperature to values of the order of 15 to 18×10^6 lb. per sq. in. at 400 deg. C., and to 11×10^6 lb. per sq. in. at 500 deg. C. Whilst the drop from 400 to 500 deg. C. might be expected, the speaker felt that there was not usually an appreciable drop from room temperature to 400 deg. C. He thought it would have added to the value of the Paper if the actual modulus of elasticity at room temperature could have been included. The same remark applied to elongation. It was stated that it increased with increase of temperature, but the room temperature elongation was not included.

In referring to the microscopic examination, it was stated that there was no detectable change in the microstructure in the specimens tested for long periods at 500 or 600 deg. C. It might be that he had been examining the structure very close to the crack and had not paid much attention to the area near the surface of the test-piece. In some tests at Alvechurch it had been shown that there was a slight pearlite breakdown in an unalloyed iron after 30 days at 500 deg. C. Did the Author think that the introduction of a small amount of alloy, in one case a small copper addition, might have been responsible for preventing any pearlite breakdown? Also, in the same tests, a constituent which appeared to be associated with some oxidation effect, had formed an envelope around the graphite flakes at the extreme surface.

Mr. Grant referred to the third conclusion in which it was stated that "the normal creep tests at 400 deg. C. had shown extremely small values of deformation compared with most materials used at high temperature." This might give the impression that the cast irons exhibited less creep than heat-resisting steels and other heat-resisting alloys which, of course, was not true and it seemed to be a misleading statement.

Mr. Hallett agreed with nearly all Mr. Grant's comments. He regretted he had already not raised

Discussion—Deformation of Cast Iron

with Mr. Tottle the question of growth measurement. Certainly each set of creep curves shown by Tapsell, Becker and Conway was accompanied by a growth curve and the values were detectable even at temperatures down to 370 deg., let alone at 500 deg. C., where they were considerable. He agreed also that it would be desirable to incorporate in the Paper more details of the lower temperature measurements so as to have a standard of comparison for the higher temperature data.

The elasticity modulus of 24 × 10^6 lb. per sq. in. did seem extremely high. His own feeling on the rate of drop of modulus with increasing temperature was that up to about 400 deg. C., which was as high as he had gone, the rate of drop was something like 1½ to 2 per cent. for each 100 deg. and nothing like as great as the drop shown by Mr. Tottle.

He thought the effect of the alloy content on the change of microstructure with time was extremely important, and he was sure that the addition of molybdenum or chromium was very potent in delaying spheroidisation of the pearlite. He thought that Mr. Grant in his tests on unalloyed irons would have been able to detect spheroidisation before Mr. Tottle, working with molybdenum and chromium irons. Even something like 0.3 to 0.4 per cent. chromium definitely had an effect in reducing spheroidisation. For example, in the production of piston rings containing 0.4 per cent. of chromium, they were re-heated to about 640 deg. C. for about half an hour. Although the time was short, the temperature was relatively high, yet it was very difficult to detect spheroidisation, whereas single sand-cast, rings, high in silicon and low in chromium, showed much spheroidisation of the pearlite when heated in the same way. Chromium did definitely delay spheroidisation.

The graphite fringes referred to by Mr. Grant were obviously an oxidation effect due to the penetration of the gas preferentially along the openings between the graphite flakes and the matrix. His impression was that Mr. Tottle was not thinking of the surface or just below the surface, so much as of the general structure, but again confirmation would have to come from Mr. Tottle.

MR. J. CAMERON, JNR. added his thanks to Mr. Tottle for the additional light he had thrown on the problem. As far as continuity of the tests were concerned The International Meehanite Metal Company, Limited, were endeavouring to continue the matter, but, as they would appreciate, the time factor involved in the more extensive tests was a very serious problem, particularly from the point of view of maintaining continuity. That problem was being tackled and it was hoped that over the course of the next two or three years the really long-time test results should be available, still adhering, however, to that series of irons which had been dealt with in Mr. Tottle's Paper.

MR. HALLETT said he was sure everyone would be glad to hear that there was a prospect of the work continuing.

Conditions of Testing

THE CHAIRMAN referred to a point made by Dr. Riley—a criticism that the method of testing would not be accepted by the steel people—and asked if he had any further comment to make on that point.

DR. RILEY said he had had little practical experience of creep testing, but he believed there was a more or less standard apparatus, widely accepted, and that the apparatus itself should be housed in a room with precautions to keep a steady ambient temperature. Were the precautions that Mr. Tottle had taken as satisfactory in this respect?

THE CHAIRMAN pointed out that, on page 3, of the Preprint, Mr. Tottle gave the limits to which the temperatures were maintained:— ±0.5 deg. along the length of the bar.

MR. HALLETT remarked that again he would have to refer that question to Mr. Tottle. Dr. Riley was certainly right in saying that it was desirable for the ambient temperature to be kept as constant as possible. But if Mr. Tottle's statement was right, that he did maintain his temperature within ±0.5 deg. C., for that type of work, he thought he was doing well enough. There were not, he thought, very many creep-testing laboratories working with ambient temperature control on work of that class, and he would say that Mr. Tottle was doing not too badly.

He did not think it right to say that there was a standard apparatus; every laboratory had to make its own extensometer and every laboratory had its own ideas and there were, in fact, quite wide variations in set up and methods of temperature control, so that there was in fact nothing like a standard creep test which everyone used. The position was rather that the reverse condition held.

MR. GRANT asked Mr. Hallett to refer to the third conclusion in which Mr. Tottle said that the normal creep test at 400 deg. showed extremely small values of deformation compared with most materials. Taking the deformation on steel for instance, he had the impression that there were even greater deformations with cast iron than with steels. Was it true that in that case the values were smaller than when compared with steel? Certainly the initial strain was much greater.

Mr. Hallett thought Mr. Grant had raised an important point. The statement as it stood called for modification. He thought that what Mr. Tottle really had in mind was that with say materials of the gas-turbine blade class used under turbine conditions, the amount of extension which could be tolerated was relatively great compared with the extension which he was reporting under his tests. It was certainly true to say that turbine-blade materials of heat-resisting steel would show very little elongation at the temperatures and stresses used by Mr. Tottle and the original was rather a misleading statement as it stood.

His impression, comparing rates in the present Paper with those reported by Tapsell, Becker and Conway, on low-alloy cast irons, was that they were in the same order. It was difficult to com-

(*Continued on page* 286)

Running Iron Castings*

Use of Pencil Gates in a Ring Runner

By Pierre Rigaut

THE INTRINSIC PROPERTIES of the liquid iron poured into a mould are not the only factors governing the soundness of a casting. The laws of cooling are just as important. It is common knowledge that it is difficult to cast cylindrical jobs on the flat if the diameter exceeds 4 in. Despite all the precautions taken for feeding and despite the use of one or two filter cores in the running system so as to ensure clean metal, defects will show up on machining especially in the bore. Vertical casting is now the usual practice and may be carried out by bottom or top running or, as in some foundries, a combination of the two.

Bottom running at first sight suggests itself as being a method which brings about the regular filling of the mould. However, the heating-up of the lower part by the ingates is not trouble-free and, for many castings of circular form, experience has shown that it is best to cast from the top. Cooling then takes place from the bottom upwards. The constant supply of hot metal at the top does allow for the progressive feeding of the successive layers during the course of solidification—a favourable factor from the soundness point of view. If, moreover, the method used ensures a uniform distribution of the metal throughout the section, there will be a step-by-step cooling and the contraction will take place regularly from the bottom to the top, the parts solidifying in this way being fed by the influx of hot metal and thereby the runners and risers can be greatly reduced.

* Translated from *Fonderie*.

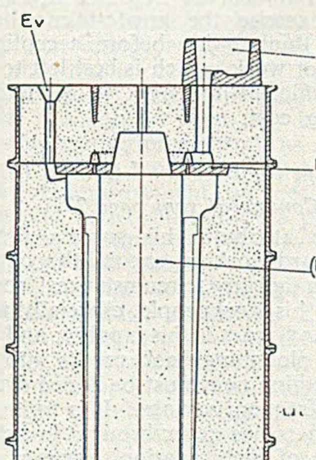

FIG. 1.—*Method employed for the Top Pouring of a Cylinder Casing, using Pencil Runners.*

Practical Layouts

The running system may consist of (1) a circular or flat wedge ingate—a method largely used for small castings and for air-cooled (ribbed) cylinders, or (2) by means of a ring runner carrying evenly-spaced pencil runners to be described later. [The French call this a shower collar—Editor.] Fig. 1 is a sketch of a method developed for the top pouring of a cylinder casing weighing 990 lb. It is 30 in. high, with an outside diameter 14.4 and inside 11.2 in. The pencil runners are so positioned that they are nearer to the core than to the outside wall of the mould. The pencil runners are spaced out circumferentially in a core cake (Ng). As a support for this cake, a print is provided both on the mould and on the central core (N-Cy). This method allows moulding to be carried up to the joint line and ensures the perfect centring of the main core in the mould. Core setting, being confined entirely to the drag part, completely eliminates any danger of a crush or of sand dropping in when closing the mould. The venting of the central core is effected by means of a hole in the top part. Gating is by means of circular runners with evenly-spaced pencil gates. The system of running is shown in more detail in Fig. 2.

[Actually, the French text says it is preferable to constrict the downcomer in relation to the circular runner ring as Figs. 1 and 2 show.]

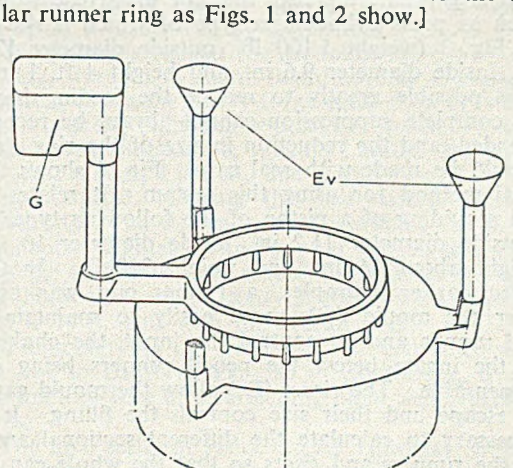

FIG. 2.—*Circular Runner Ring carrying evenly-spaced Pencil Gates.*

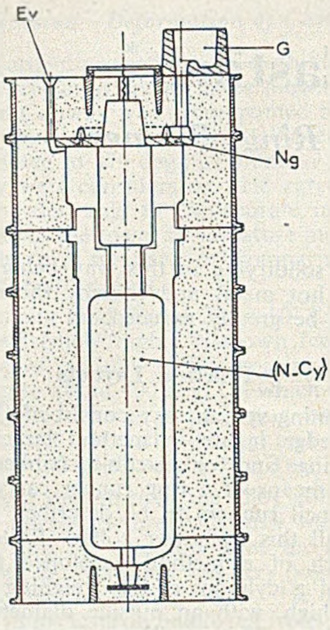

FIG. 3.—*Running System for a Large Press-cylinder Casting.*

To aid in venting of mould whilst the metal is rising, three "whistlers," Ev, are placed at 120 deg. centres located in the core cake. These "whistlers" serve the purpose of gas liberators but not the role of feeders. On the top part of the casting, it is wise to add on a bit of extra metal. With certain types of metal there is always a chance of small cavities showing up just underneath the pencil runners. Again a minimum allowance of at least an inch is needed for this ring riser. The sketch Fig. 1 shows a larger feeder because of the exceptionally severe inspection conditions of the job illustrated, which should be progressively reduced in normal practice.

It is germane to recall that for massive castings, such as press cylinders, a type of which is shown in Fig. 3 (weight 1,100 lb., outside diameter 12.4 in., inside diameter 9.6 in., and height 4 ft. 1 in.), it is possible greatly to reduce the feeding head. Its complete suppression cannot always be recommended, and the reduction in size of the ring riser should be made with real care. Fig. 4 shows the final method for using this system. It relates to the moulding of a piston of the following type:—Outside diameter 11.2 in., inside diameter 10 in., height about 16 in., and weight 330 lb. In the three earlier examples, a runner cup was used over the mould (G), more easily to maintain a full runner and so control the input, the choking of the ingate below the pencil runners being indispensable. The risers (Ev) allow the mould gases to escape and their size controls the filling. It is necessary to calculate the different sectional areas of the runners and risers so that the whole can be constantly choked, whilst yielding the condition that the runner can be kept full during the time of the filling of the mould.

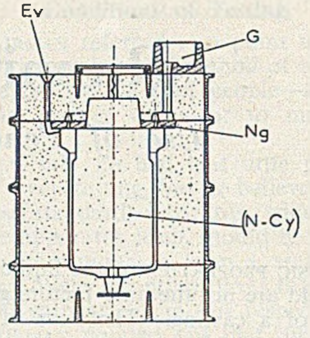

FIG. 4.—*Use of Pencil Gates in the Casting of a Piston.*

Pencil runners should drop exactly in the centre of the section to avoid the impingement of the streams either on the core or the mould wall. Thus steps should be taken to see that the mould stands truly vertical before being poured.

Conclusions

Recapitulating, the method of casting which has every appearance of being the most suitable for the types of casting described, is that which has been designated as the ring-feed-and-riser system. Bottom casting, if it reduces mould and core erosion to a minimum, does on the other hand set up "hot spots." When rising up the mould the liquid metal cools off and so eventually it is the coldest metal which fills the feeder.

The ring runner and feeder, which makes for simplicity in moulding, does create conditions favourable for feeding the casting. Moreover, the pencil runners split up the stream of the metal in such a manner as to rule out the risks of mould erosion.

There still remains the need when making such castings to exercise the greatest care, and it is necessary to think twice before accepting orders for this class of work, which is best left to founders who have sufficient tonnages to keep down the manufacturing cost.

Castings for River and Coastal Craft

(*Continuedf rom page* 272)

Mr. Moyle attributes his success first to the loyalty and hard-working capabilities of his wife, particularly in adverse circumstances; secondly to the loyalty of his workpeople, especially those who have been many years in his employ; and finally to the policy of ploughing back profits into the business. "Something new must be added every year" is one of his frequent sayings. It is to be observed that this business has never brought in new capital. The incidence of high taxation, however, has been burdensome in the extreme.

The new business, now known as Moyle Marine Products, was purchased primarily to feed the foundry and is now, in fact, its biggest customer. Through the activities on this side, yacht equipment, consisting mainly of castings, is being sent to all parts of the world.

Iron and Steel Institute

DELEGATES to a special conference of the Iron and Steel Institute met in Glasgow from September 12 to 15, at the invitation of West of Scotland Iron and Steel Institute, and in the evening of the first day attended a civic reception in the City Chambers, when they were received by Lord Provost Victor D. Warren, who expressed the view that there need be no fears about the future of the industry under private enterprise.

"If you are given the right to manage your own affairs, we need have no fears as to your future as a great industry," said the Lord Provost. Glasgow was a city much dependent on the heavy industries, and they recognised that it was through the initiative and inventive genius of the Institute that great strides had been made since the remnants of the Caledonian Forest were first cut down to make pig-iron.

Dr. C. H. Desch, past-president of the Iron and Steel Institute, said Glasgow had done wonderful work in repairing the errors of the Industrial Revolution and, by overcoming the handicaps imposed by rapid industrial development, had become a model to the municipalities of the world. About 500 guests attended the reception; it was the first time since 1927 that the Institute had met in Glasgow.

Doubtful Future

On the second evening, a dinner and dance was held in the Central Hotel. On this occasion, Sir Andrew McCance, proposing the toast of the Iron and Steel Institute, said Scotland to-day produces substantially more pig-iron from exactly one-quarter of the furnaces that she possessed 23 years ago. He was recalling the conditions which prevailed in the industry on that occasion of the last visit of the Institute to Glasgow in 1927. Those changes were the inevitable result of changes in conditions during the intervening years, he said. "Unfortunately, in the public controversy that has raged around our industry," he went on, "I cannot say that all the speakers in what they have said have used the simple criterion of truth as a standard of reference." Visitors would be able to see the present stage of improvement of the industry. In any living and active business the process of improvement was continuous, but how long it might continue in the steel industry was another matter.

With two social upheavals arising from two world wars, with the steadily advancing level of wages, and with the increasing cost of all those social frills that went to make up the Welfare State, everything was combining to make the building of a steel works a most prohibitively expensive amusement. Whichever way one turned, one found nothing but difficulties and depression. Those who managed to survive their apprenticeship were permanently cured of that complaint.

The toast was replied to by Mr. J. B. Menzies-Wilson, president of the Institute. Captain H. Leighton-Davies, vice-president, proposed that of the City of Glasgow, which was replied to by Lord Provost Victor D. Warren.

During the first technical session on September 12, four Papers were read and discussed—"Ingot Heat Conservation: Time Studies from Casting to Rolling," by A. V. Brancker, J. Stringer, and L. H. W. Savage, who described observations made at three works of the progress of hot ingots from the castings bay to the cogging mill in an attempt to find the causes of delays and their effects on soaking-pit operations. It was concluded that worthwhile savings were possible. "Reduction of Lump Ores," a Paper by R. Wild and H. L. Saunders, dealt with the overall rate of heat transfer to the centre of ore lumps and the penetration of gaseous reduction. Extent of penetration was shown to be closely related to the porosity of the ore. "Ingot Heat Conservation: Mould and Ingot Surface Temperature Measurements," by A. V. Brancker, showed significant differences between the temperatures on the faces of each mould for two different mould positions in a casting pit during two separate top-teeming operations. The fourth Paper was "Distribution of Temperature in Ingot Moulds and Its Relation to Ingot Structure," by L. M. MacKenzie and Audree Donald, which discussed, among other things, the factors controlling the rate of heat transfer to the mould, with particular reference to the early separation of the ingot skin from the mould wall.

On the morning of the second day, September 13, a film on the continuous casting of steel was presented by Mr. J. Savage, of the British Iron and Steel Research Association. The film was made at an experimental plant built at the Allegheny-Ludlam Steel Corporation, Watervliet, U.S.A.

Works Visits

The works visits arranged for the afternoon of the first day included parties to Stewarts and Lloyds, Limited, Clydesdale Works, Mossend, and alternatively to the steel foundry of Clyde Alloy Steel Company, Limited, Motherwell. At the latter foundry oxygen lancing of the electric-furnace charge is being carried out on a routine basis, though it was not seen by the visitors.

The parties arranged for the following day, Wednesday, were to William Beardmore & Company, Limited, where the heavy forge-press shop provided much interest; Lanarkshire Steel Company, Limited, Motherwell; Babcock & Wilcox, Limited, Renfrew; R. B. Tennent, Limited, and Lamberton & Company, Limited. During this last named visit to Coatbridge, the delegates saw workmen at R. B. Tennent's Whifflet Foundry pour the biggest castings the firm have ever made. Two ladles containing between them 50 tons of metal were used to cast a 14-ft. roll with an overall length of 21 ft. and diameter 44½ in. This visit was combined with the one to Lamberton's, also in Coatbridge, to see the manufacture of steel rolling plant and precision tools.

The final series of visits, on the Thursday, was to three works of Colvilles, Limited—Clyde Iron Works, Clydebridge Steel Works and Glengarnock Steel Works. At this works, the tapping of a blast furnace was a feature of the programme.

Deformation Characteristics of Five Grey Cast Irons at 400 and 500 deg. C.

(*Continued from page* 282)

pare one man's work with another's in relation to temperature, time and test materials and the most one could do was to say that the rates reported by Mr. Tottle were not completely incompatible with those reported by Tapsell, Becker and Conway.

Mr. Twigger said it occurred to him that the materials used in that investigation were extremely stable structurally. Mr. Tottle had mentioned that heat-treatment for 2,500 hours at 400 to 500 deg. C. had shown no measurable structural break down. He was connected with the Institute's sub-committee T.S.31, which was studying the subject of heat-treatment of cast iron, and they had evidence showing that it was common practice to anneal some castings at temperatures below 600 deg. C. for the purpose of improving their machinability, and that, of course, in a relatively short time, so that between temperatures of, for example, 575 deg. C. for a short time and 500 deg. C. for 2,500 hours there seemed to be a very wide gap indeed. That, he thought, was a point that the T.S.31 sub-committee should certainly take into account in their deliberations. It was, of course, fortunate from the point of view of the creep tests, with which the Paper was principally concerned, that those materials did not break down structurally, because that would have interfered very seriously with the validity of the creep tests.

Necessity for Further Investigations

He would add a plea for more work on the creep testing of highly-alloyed irons, because to be of any value in high-temperature service it was necessary to obtain a very high degree of stability obtainable only with special types of iron, commonly referred to as "heat resisting." Such materials, although perhaps not in large-scale production, had important applications in industry.

Again, said Mr. Hallett, he agreed with everything Mr. Twigger had said. His comments as chairman of the T.S.31 sub-committee were very much to the point. There was no doubt whatever that alloying elements, particularly molybdenum, had a potent effect in reducing the speed of spheroidisation. One could take a parallel from the case of steel. The pioneer work of R. W. Bailey showed very convincingly the strong effect of quite small quantities of molybdenum in reducing spheroidisation of the steels which they were employing in high-temperature-steam applications. He did not think it incompatible, as Mr. Twigger had pointed out, that ordinary cast irons were showing a relatively high rate of spheroidisation at 575 deg. C., and yet virtually none was shown in those high molybdenum irons at temperatures of 500 deg. C. He only hoped that continued pleas for more work on creep of high-alloy materials would eventually bear fruit somewhere or other.

The Chairman, closing the session, said thanks were due to Mr. Hallett for having studied the Paper so very carefully and for having presented it in such an admirable way. It must have taken time, because he had seen a long letter sent back by Mr. Tottle, and that no doubt meant a long letter written to start with. Much trouble had been taken on members' behalf, and he expressed their thanks for it.

AUTHOR'S WRITTEN REPLIES

The Author wrote saying how much he regretted his unavoidable absence from the meeting, and expressed his gratitude to Mr. M. M. Hallett for presenting the Paper and replying to the discussion. It was difficult to understand Dr. Riley's criticism, which was not directed to any specific objection. If Dr. Riley would refer to the British Standard Specification on long-time creep tests, he would find that the present work more than satisfied the requirements laid down in that instruction, and, in fact, very few creep laboratories could hope to work in the ideal conditions of a University laboratory. The testing procedure adopted was fully described in the Paper, except for the atmospheric temperature surrounding the furnaces. In actual fact, an old strong room housed the machines used, there being no windows or ventilators, very thick walls, and a tightly fitting thick oak door as the only means of access. Room temperature, measured daily for four years by an accurate mercury in glass thermometer, registered 25 deg C. ± 0.5 deg. over that period. The Author challenged Dr. Riley to reproduce superior creep-testing conditions.

Slight Surface Oxidation

In reply to Mr. Grant, the Author would refer him again to page 2 of the Preprint, where no growth at temperatures below 600 deg. C. was stated for periods of 300 hours only. These bars were measured in the same way as those exposed in the creep furnaces (page 3), and were therefore capable of detecting 0.01 per cent. increase in length over the test period. The growth results were required to detect any extension other than that due to creep, and had therefore to be made on separate bars. They were not designed to detect growth due to slight oxidation of the surface, and, as Mr. Hallett pointed out, the microscopic investigation was a general, though careful, survey to cover the possible effect of *deformation* on microstructure after subjection to stress at elevated temperature. Oxidation naturally occurred to a slight extent on the surface, air being present in the furnace chamber, but its effect was not noticeable in the microstructure. Mr. Grant mentioned 30 days as a long period at 500 deg. C., but the Author preferred to think in terms of 10,000 hours or longer, as had been achieved in this work.

The absence of figures for modulus of elasticity and elongation at room temperature was regretted, this being due to an attempt to shorten the total length of the Paper, as frequently requested by the Institute. The figure of 24×10^6 lb. per sq. in. applied only to Iron B, the remainder ranging down to 19×10^6 lb. per sq. in. for Iron C, and

(*Concluded on page* 288)

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(*Continued from page* 286)

14×10^6 for Iron F. Elongation at room temperature never exceeded 0.25 per cent. (Iron B), and was low for irons such as A and D. These figures were obtained in an identical manner to those at high temperature, using the same machines and extensometers. The Author supported Mr. Hallett's views on the effect of even small amounts of molybdenum or chromium.

Other Materials Compared

Mr. Grant's later comment on the comparison between these irons and "other materials" requires explanation. The Author wished to compare the two superior irons (B and D) at 400 and 500 deg. C. with the performance of mild or medium-carbon and low-alloy steels under similar conditions. There was definite evidence that some of these materials did in fact show greater deformation, both total strain and rate of change. It was not intended to suggest that cast iron could therefore replace these materials, but that in certain circumstances it could show equal or better performance in creep tests.

Mr. Twigger referred to lack of structural breakdown at 400 and 500 deg. C. in periods of 2,500 hours. As stated on page 3 of the Preprint, the bars were inserted in the creep furnaces for four periods, a total of 10,000 hours, before examination. Mr. Hallett had already pointed out the great difference in behaviour between ordinary grey iron and one containing a carbide-stabilising element such as molybdenum. Mr. Twigger's later statement on the "fortune" of this stability affecting the "validity" of the creep tests is challenged. Surely breakdown would have led to different results, not made the present ones invalid. The rupture tests for long duration to fracture were carried out for the very purpose of proving whether or not such changes occurred (Preprint, page 6). Microscopic examination was complementary, to detect any incipient breakdown not already evident from creep tests.

In conclusion, the Author was somewhat disappointed that no-one raised the question of apparent increase in ductility at a given temperature with decrease in stress and longer duration to fracture. He felt this to be important, and of considerable assistance in the wider adoption of iron castings, if and when the effect was fully investigated. The Author thanked his critics for their interest, and regretted that he must now relinquish this work, though he hoped others might continue to supply much-needed results of this kind.

Iron and Steel Prices

Under an order issued by the Ministry of Supply, the maximum prices of a limited range of iron and steel products are amended. The principal alterations are increases in the maximum prices of electrical sheets, wire and wire products. The order—the Iron and Steel Prices (No. 3) Order, 1950—came into force on August 29, and is obtainable from H.M. Stationery Office or any bookseller.

Latest Foundry Statistics

The production figures for the ironfounding industry for the second quarter of 1950 are now available. The quarter's total was 866,323 tons, made up of 833,984 tons of grey-iron and 32,339 tons of malleable-iron castings.. This output is equivalent to an annual production rate of 3.47 million tons, as against the level of 3.52 million tons recorded in the year's first quarter. (The level in the second quarter of 1949 was 3.38 million tons.) The output in the first half of the year stands at 1,747,066 tons, which is higher by 20,000 tons than last year's corresponding figure, and makes an annual rate over the first six months of this year of 3.49 million tons.

The output in the various sections of the industry during the second quarter, 1950, was as follows:—

	Tons.
Automobile	68,381
Building and domestic	127,483
Pipes	142,726
Engineering and jobbing	378,316
Ingot moulds	80,302
Railway equipment	69,115

Unanswered Questions

Experimentally, the Department of Scientific and Industrial Research, of Charles House, 5 to 11, Regent Street, London, S.W.1, has published the first issue of a bulletin, the object of which is to attempt to discover the answers to specific scientific and technical questions when normal sources of information have apparently failed. A series of 19 questions is published—twenty would have been more topical! No. 14 is the replica of one which has been through our hands several times during the last twenty years. It relates to use of a type of machine encountered on railway stations for embossing one's name on a strip of aluminium, but adapted for use with foundry patterns so as to give a larger and sharper letter and using brass strip. Experience has shown that brass is too stiff to emboss, but machines are available providing that use can be made of aluminium. All the other questions enter fields which are unfamiliar to us. Beyond publicising the fact that the D.S.I.R. do answer abstruse questions, we see very little use in such a bulletin, as its range is too wide.

Davy United Secure Norwegian Order

Despite German competition, Davy United Engineering Company, Limited, of Sheffield, have been successful in securing a £1,000,000 export contract for the supply of rolling-mill equipment for a new integrated iron and steel works to be operated by A.S. Norsk Jernverk, at Mo i Rana, in Northern Norway, 25 miles south of the Arctic Circle. The plant will be complete with a 900-ton electric bloom shear, 350-ton billet shear, and will comprise, in all, nearly 7,000 tons of finished machinery. The plant, when in operation, will extend over 1,100 ft. in length and will handle bloom ingots up to 3½ tons and 5-ton slab ingots. The initial output of the plant will be up to 220,000 ingot-tons a year.

Forty Years Ago. The September, 1910, issue of the JOURNAL contained a full account of the Manchester Conference of the British Foundrymen's Association. Mr. (later Dr.) Percy Longmuir was elected as president and Mr. C. Jones, of Cardiff, as vice-president. The Papers were commendably short in those days—probably they were hand written instead of dictated to a typist. At any rate, one issue was sufficient to print eight Papers plus the Presidential Address and discussions.

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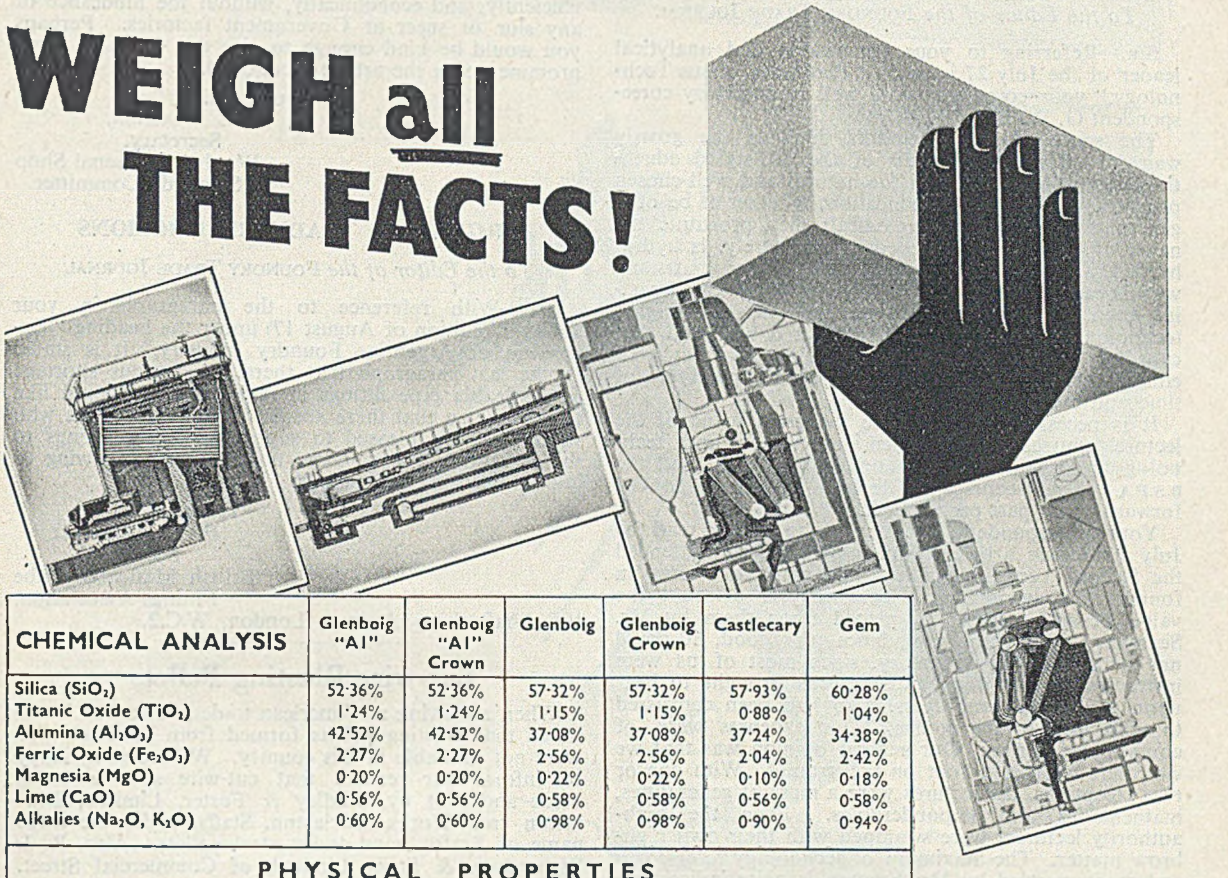

CHEMICAL ANALYSIS	Glenboig "A1"	Glenboig "A1" Crown	Glenboig	Glenboig Crown	Castlecary	Gem
Silica (SiO_2)	52·36%	52·36%	57·32%	57·32%	57·93%	60·28%
Titanic Oxide (TiO_2)	1·24%	1·24%	1·15%	1·15%	0·88%	1·04%
Alumina (Al_2O_3)	42·52%	42·52%	37·08%	37·08%	37·24%	34·38%
Ferric Oxide (Fe_2O_3)	2·27%	2·27%	2·56%	2·56%	2·04%	2·42%
Magnesia (MgO)	0·20%	0·20%	0·22%	0·22%	0·10%	0·18%
Lime (CaO)	0·56%	0·56%	0·58%	0·58%	0·56%	0·58%
Alkalies (Na_2O, K_2O)	0·60%	0·60%	0·98%	0·98%	0·90%	0·94%
PHYSICAL PROPERTIES						
Refractoriness	Seger Cone 34 (1750°C)	Seger Cone 34 (1750°C)	Seger Cone 32/33 (1720°C)	Seger Cone 32/33 (1720°C)	Seger Cone 32/33 (1720°C)	Seger Cone 31/32 (1700°C)
Refractoriness U/L of 2 kilos/sq. cm.	1630°C	1610°C	1610°C	1580°C	1600°C	1580°C
Refractoriness U/L of 50 lb./sq. in.	1580°C	1530°C	1530°C	1510°C	1520°C	1510°C
Thermal (Reversible) Expansion—mean co-efficient X 10^{-5}	0.568	0.522	0.584	0.540	0.562	0.623
Porosity—Total Percentage by Volume	18/20	24/26	18/20	24/25	16/20	16/20

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Correspondence

[We accept no responsibility for the statements made or the opinions expressed by our correspondents.]

PLATITUDES VERSUS TECHNOLOGY

To the Editor of the FOUNDRY TRADE JOURNAL

SIR,—Referring to your remarkable and analytical leader of the July 27 issue on "Platitudes versus Technology," your comments were well seconded by correspondent G. W. B.

The sense of your remarks deplores the grossly wasteful efforts and results of the self-styled educationalists who intervene in the natural and well-chosen progressive true lines of education, whether it be of a general character or technological; they prostitute the name of education. True education, surely, is hydra-headed, and may include that highly-skilled craftsman who is capable of making a large or complicated casting even if he has not had the time to study higher technological management. Again, it is well said that capacity without education is deplorable, but that education without capacity is a useless expenditure of time and money.

It is necessary to emphasise the great value of the lecture courses for foremen, executives and technologists organised by the I.B.F., the B.C.I.R.A. and the B.S.F.A. Such courses of lectures are being looked forward to by past participants.

Your correspondent, Mr. M. Seaman, should read the July 27 leader article again. As one who attended the Salford Technical College post-graduate course on foundry management and technology, I discount the value of such courses as placed upon them by Mr. Seaman. Whilst the attendance was good, it could not be said to be voluntary, since most of us were instructed to attend or pressure was brought to bear upon us by our employers, who had been canvassed to send men to the course. Our expenses were, of course. paid for us. Our general opinion was that we were left without a foot on the ground. With one or two exceptions, the lectures were a mass of generalities, mathematics and imponderables. Even the high-authority lecturers were swamped with their own high-brow matter. The maximum of technology referred to and recommended by Mr. Seaman is quite indigestible and useless in the form put forward.

From all the welter of paper management "The Lord Save Us."

Yours, etc.,
META-TECH-PRACTITION.

REARMAMENT PROBLEMS

To the Editor of the FOUNDRY TRADE JOURNAL

SIR,—Your leading article headed "Rearmament Problems" in the FOUNDRY TRADE JOURNAL of August 17 has been noted by the foundry workers and other allied tradesmen in these factories.

Your suggestion that "The Ministries would be well advised to realise that the tempo of manufacturing processes is at its highest under conditions of private enterprise" is not related to actual fact, and is refuted. The foundries are operated by management and workers who in the large majority of cases worked for a considerable number of years under "private enterprise," and are now working with equipment and plant as is used commonly in the industry.

Without any desire to quarrel with private industry, we could point out that in many cases the word enterprise is a misnomer, since that is one of the things they sadly lack, and state-owned foundries are often called upon to do what others are either unable to do or prefer not to do because the profit margin is not high enough.

If His Majesty's Government decide in their wisdom that some expansion of the armament programme is necessary. then let us get on with the job, quickly, efficiently, and economically, without the hindrance of any slur or sneer at Government factories. Perhaps you would be kind enough to give this letter as much prominence as the article mentioned.

Yours, etc.,
F. E. GLASSON,
Secretary,
Woolwich Arsenal Shop
Stewards' Committee.

ARGENTINE TRADE RESTRICTIONS

To the Editor of the FOUNDRY TRADE JOURNAL

SIR,—With reference to the paragraph in your JOURNAL (edition of August 17) under the heading "Expansion of Argentine Foundry Industry," it is stated in the last paragraph that there is a serious shortage of malleable pipe fittings in Argentina. I should like to advise you that there are British manufacturers who would be very pleased to supply malleable fittings to the Argentine, but who are unable to do so owing to import licensing restrictions.

Yours, etc.,
F. B. RIDGWELL
Secretary,
British Malleable Tube
Fittings Association.
196, Shaftesbury Avenue, London, W.C.2.

Cut-wire Blasting Pellets

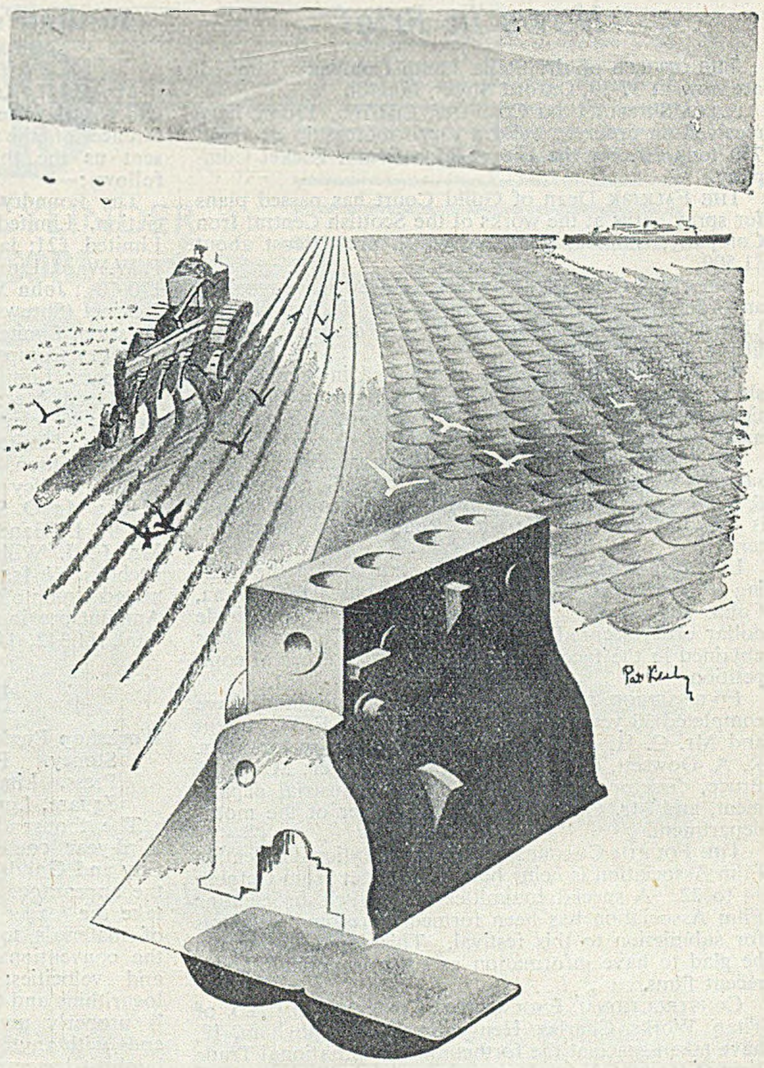
When reviewing an American trade publication it was stated that blasting pellets formed from cut-steel wire were not available in this country. We are now happy to inform our readers that cut-wire shot is being made and sold by Bradley & Foster, Limited, Darlaston Iron Works, Darlaston, Staffs, under the trade name of Brafos hand-drawn steel pellets. Also, R. J. Richardson & Sons, Limited, of Commercial Street, Birmingham, 1, have written to say that they are able to supply cut-wire shot.

Cupola Innovation

In *Die Neue Giesserei*, dated September 7, Professor Piwowarsky describes and illustrates a new form of combination cupola/electric induction plant which he has developed. In the latest model, the induction furnace section of the plant is mounted on wheels, and when operating forms the well for metal melted in the cupola. Because of the introduction of high-frequency heating very hot metal can be cast. The object of combining the two furnaces into one plant is not too obvious except as a method of saving factory space.

Sir John Cass College

Amongst the numerous special courses organised by the Sir John Cass College, Jewry Street, Aldgate, London, E.C.3, are "Statistical Methods in Scientific Industrial Research," "Spectrochemical Analysis and Absorption Spectroscopy," and "Domestic and Industrial Fuel." The last one is to be opened by a public lecture by Sir Ernest Smith on October 11 at 6.30 p.m. His subject is "Your Future in Fuel."



News in Brief

THE OFFICES of the Stella Lamp Company, Limited, are now at 37-39, Oxford Street, London, W.1.

AILSA SHIPBUILDING COMPANY, LIMITED, Troon, have received an order to build a cargo motorship of about 750 tons dw. for the Isle of Man Steam Packet Company.

THE FALKIRK Dean of Guild Court has passed plans for spray baths at the works of the Scottish Central Iron Company, Limited, Camelon, which are to cost about £1,500.

LOBNITZ & COMPANY, LIMITED, Renfrew, have received an order from the Mersey Docks and Harbour Board, Liverpool, for a self-propelled floating crane capable of lifting 25 tons.

A NEW FACTORY is to be established in Irvine, Ayrshire, by the Glasgow firm of Wilson Bros., Pipe Fittings, Limited, ironfounders, which will give employment to about 200 skilled men.

WE REGRET that in referring to the availability of free samples we printed the old address for Major, Robinson & Company, Limited. The present address of this firm is "Scols" Works, Warwick Road South, Manchester, 16.

LEYLAND MOTORS, LIMITED, in announcing the signing of a contract for the sale of 620 buses to Havana, Cuba, suggest that this is possibly the largest single dollar order secured by a British firm. The order was obtained in the face of American and Continental competition.

FIVE SENIOR EXECUTIVES of Sternol, Limited, have completed 30 years' service; they are Mrs. E. W. Argent and Mr. C. H. Hudson, joint managing directors; Mr. R. A. Dowsett, director and export manager; Mr. J. D. Bruce, director and manager of the industrial department, and Mr. G. H. Reynolds, manager of the motor department.

THE FOURTH CONGRESS of the International Scientific Film Association is being held in Florence from October 14 to 22. A special committee of the British Scientific Film Association has been formed to recommend films for submission to this festival. This committee would be glad to have information as soon as possible about recent films.

CONSTRUCTIONAL ENGINEERING COMPANY, LIMITED, of Titan Works, Charles Henry Street, Birmingham, 12, have taken space at the forthcoming International Trade Fair at Zagreb, Yugoslavia, where they will show a 75-lb. capacity core-blowing machine; model M-12-12 horizontal centrifugal casting machine and an Adaptable moulding machine with a turn-over attachment. We congratulate the firm on its enterprise and hope that the effort made will achieve the success it merits.

THE NEXT EXAMINATIONS for admission to the Institute of Marine Engineers will be held as follow:—Students (common preliminary examination), April 3 to 6 and October 2 to 5, 1951; Graduates (Section A of Associate Membership examination), April 30, May 2 and 4, 1951, and Associate Members, April 30 to May 7, 1951. Syllabuses of these examinations, copies of previous Papers, and particulars of exempting qualifications will be supplied on application to the secretary, at 85, Minories, London, E.C.3.

SAILING FOR AMERICA in the Queen Elizabeth on September 14 were Mr. S. H. Moss and Mr. W. R. Staton, winners of the two scholarships offered jointly by the Dean and Faculty of the Harvard School of Business Administration and the chairman and council of the British Institute of Management. The scholarships, which are tenable for two years, are designed to maintain the student for the full two years of the course, and allow for travel during vacations.

Institute's Buxton Conference Fund

Third List

Mr. C. H. Kain, the honorary treasurer of the fund which was raised in connection with the Buxton conference of the Institute of British Foundrymen, has sent us the third and final list of subscribers, as follows:—

The Foundry Trades' Equipment & Supplies Association, Limited, £76 8s.; English Electric Company, Limited, £21; James Durrans & Sons, Limited, £10 10s.; T. W.Ward, Limited, £10 10s.; Brown & Polson, Limited, £10 10s.; John Maddock & Company, Limited, £10 10s.; Sentinel (Shrewsbury), Limited, £10; English Steel Corporation, Limited, £10; Mr. John Gardom, £10; Dudley Foundry Company, Limited, £5 5s.; Waverley Foundry Company, Limited, £5; Wm. Elwell & Sons, Limited, £5; Mr. G. M. Menzies, £3 18s. 6d.; Colin Stewart, Limited, £3 3s.; Oakley Brothers, Limited, £3 3s.; G. & R. Thomas, Limited, £3 3s.; Mr. C. A. Payne, £2 2s.; William Olsen, Limited, £2 2s.; Mr. Gilbert Griffiths, £2 2s.; Dudley Coal, Coke & Iron Company, Limited, £2 2s.; Mr. O. Smalley, £1 17s.; Dr. J. E. Hurst, £1 9s.; Mr. R. L. Handley, £1 1s.; Mr. G. L. Harbach, £1 1s.; Mr. F. J. Williams, £1 1s.; Mr. James Willoughby Etchells, £1 1s.; Mr. F. D. Webb, £1 0s. 6d.; Amalgamated Union of Foundry Workers, £1, anonymous, 10s.; Amount previously acknowledged, £1,126 2s. 6d. Grand total, £1,342, 11s. 6d.

Book Reviews

Workshop Engineering Calculations, Vol. II. By J. T. Stoney. Published by the English Universities Press, Limited, Saint Paul's House, Warwick Square, London, E.C.4. Price 12s. 6d. net.

The thousands of students taking the second- and third-year courses in workshop engineering for the City and Guilds and similar examinations will welcome the appearance of this second volume. Its 26 chapters take the reader along the tortuous road from strength of materials to quadratic equations. In between all the conventional subjects are included such as forces and velocities; energy; velocity and acceleration: logarithms and trigonometry. To ensure that the matter is properly understood by the student, each chapter ends with anything up to twenty questions. As a textbook, it has everything to commend it—good English, clear illustrations, and a well-graduated approach.

The Machining and Manipulation of Stainless Steels. By W. F. Walker. Published by Emmott & Company, Limited, 31, King Street West, Manchester, 3. Price 3s. 6d. net.

This book first details the various grades of stainless steel normally available and then describes their general machine properties. Forming operations, heat-treatment and surface finishing are amongst the phases dealt with.

Steel Castings Research

It has been announced that a basis of collaboration has been established between the Technical and Research Division of the Steel Founders' Society of America and the Research and Development Division of the British Steel Founders' Association. It is understood that these two research organisations—which have been formed and are strongly supported by the steel-foundry industries in the U.S.A. and the United Kingdom respectively—will exchange information relating to their research programmes and upon certain specified fields of research, both fundamental and applied.

Raw Material Markets

Iron and Steel

The need for bigger outputs of pig-iron is increasingly apparent. The melting shops are receiving adequate supplies of hot metal, but foundrymen are on meagre rations and, moreover, have comparatively slender stocks. Thus there is an eager demand for all grades of merchant iron, which leaves no margin for the acceptance of export orders. The stringency is most marked in the case of low- and medium-phosphorus iron, but hematite is also eagerly sought, and there is an expanding market for all grades of special iron. Blast-furnace men have good stocks of ore in hand, but the position in regard to coke is less satisfactory.

Reduced tonnages of Continental steel semis are still being distributed, but re-rollers obtain the bulk of their supplies from home sources and, having recently booked substantial orders for bars and light sections, they have developed a keen appetite for billets, blooms, etc. Mills which, before the holidays, were working very irregularly, are now engaged to the limit of their capacity, and there are more big inquiries in circulation for re-rolled products.

Conditions in the sheet trade are unlikely to change, unless it be that the demand is more urgent than ever. Shortage of sheet steel is the principal bottleneck in the motor industry, and military requirements may further restrict the supplies available for other purposes. There is also a heavy run on steel plates, to which further impetus has been provided by the recent spate of orders for tanker tonnage. Rollers of heavy sections are well booked to the end of the year, and steel rails, chairs, etc., are in world-wide demand.

Under an Order signed by the Minister of Supply, the Control of Iron and Steel (Scrap) Orders, 1943-50 are consolidated. The new Order releases scrap alloy steel, including stainless steel scrap, from price control, but not from control of acquisition and disposal. The schedule to the new Order also lists a limited number of price amendments. The new Order—the Iron and Steel Scrap Order, 1950 (SI 1950, No. 1523)—came into force on Monday.

Non-ferrous Metals

Apart from an increase of some £8 in the price of tin, following fluctuations in fairly active trading, last week brought no alterations to ruling values. From New York came reports of copper being on offer at 22½ cents for October, but so far as export was concerned the quotation remained at 24½ cents f.a.s. The 2 cents duty on imported copper is still effective and the prospects of its removal now seems somewhat remote. It is now nearly three months since this tax was reimposed, and for some time past consumers have been taking delivery of foreign copper, paying the 2 cents extra, making 26½ cents in all. On the "grey" market a much higher figure has been mentioned and, indeed, copper is so short in supply that consumers seem to be willing to pay almost any price for accommodation. Persistent as the call for copper is, it would not put the situation into a "straight jacket" were it not for stockpiling, which continues at a high rate. Foreign copper is entering the United States at about 30,000 tons monthly, for so far the return of the duty does not seem to have made any difference. Chief supplying countries are Chile, Canada, and Mexico, much of the copper coming in the form of blister, which is refined at the U.S. plants. A certain amount of copper also comes in the form of concentrates and matte. All this helps to balance the U.S. copper budget, which otherwise would certainly be sadly out of trim.

Stocks of refined copper in producers' hands at the end of August amounted to 50,952 short tons, a gain of some 2,700 tons over the July figure. These details have been published by the Copper Institute in New York, and it is also revealed that a year ago the reserves stood at 217,000 tons. Production of crude copper during August totalled 81,904 tons, compared with 76,563 tons in July. Deliveries have shown of late a tendency to decline, not because demand is down, but through the inability of the producers to find the necessary tonnage.

In the U.K. stocks of copper are probably in the neighbourhood of 100,000 tons, which is a satisfactory figure against the background of our present rate of consumption. Moreover, supplies seem to be reasonably well assured, for we are getting practically all the Rhodesian output and some 60,000 tons annually from Canada.

Tin last week was, on the whole, a firm market, the close showing a gain of nearly £10 from the previous Friday.

Official tin quotations on the London Metal Exchange during the past week were as follow:—

Cash—Thursday, £784 to £785; Friday, £770 to £771; Monday, £755 to £757; Tuesday, £764 to £765; Wednesday, £786 to £787.

Three Months—Thursday, £782 to £784; Friday, £770 to £771; Monday, £752 to £753; Tuesday, £758 to £760; Wednesday, £780 to £781.

House Organs

Nickel Bulletin, July. Published by The Mond Nickel Company, Limited, Sunderland House, Curzon Street, London, W.1.

A year ago an article introduced to readers the new cast iron obtained by treatment at the molten iron with magnesium. This spheroidal-graphite cast iron has such unusual properties that its rapid development is certain. The current issue of the Nickel Bulletin has a further article dealing with this important material, and includes a wide variety of illustrations of castings made in five different countries on the Continent. Several of the castings referred to are now being turned out on a mass-production basis, with entire reliability. The article includes an outstanding example of the properties which can be obtained from the new iron in the figures quoted for test pieces cut from the central boss of a 5-ton flywheel. A wide selection of abstracts is included, which will be of interest to readers. Copies may be obtained, free of charge, upon application to Sunderland House.

Pera Bulletin, August. Published by the Production Engineering Research Association, Staveley Lodge, Melton Mowbray, Leicestershire.

This bulletin tells, in its opening article, of a series of refresher courses which have been held at the laboratory. These start with an illustrated talk on "Know More About the Machines You Use." Then there is an informal discussion, followed by a visit to the workshops, where there are about twenty demonstrations at strategic points. For the rest, there are the usual particularly well-chosen abstracts from fields in which production engineers should be interested.

MR. W. H. THURSFIELD, a well-known industrialist of West Bromwich, has been appointed a Justice of the Peace for West Bromwich. Mr. Thursfield is managing director of Izons & Company, Limited, West Bromwich, and of Albion Foundry, Limited, Tipton. He is also a director of Allied Ironfounders (Ireland), Limited, Waterford. He has been a director of West Bromwich Albion F.C. since 1937.

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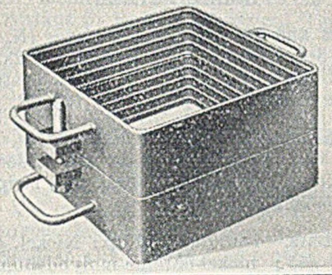

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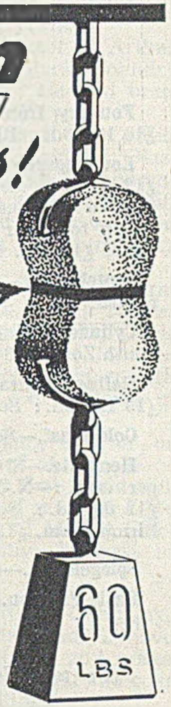

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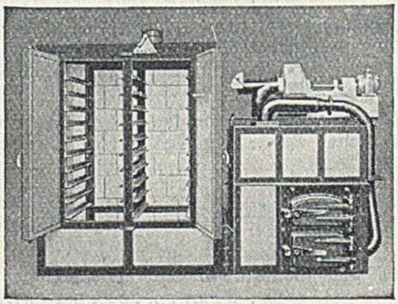

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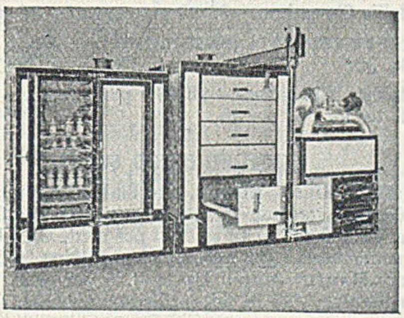

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Current Prices of Iron, Steel, and Non-ferrous Metals

(Delivered, unless otherwise stated)

September 20, 1950

PIG-IRON

Foundry Iron.—No. 3 Iron, Class 2:—Middlesbrough, £10 10s. 3d.; Birmingham, £10 5s. 6d.

Low-phosphorus Iron.—Over 0.10 to 0.75 per cent P, £12 1s. 6d., delivered Birmingham. Staffordshire blast-furnace low-phosphorus foundry iron (0.10 to 0.50 per cent. P, up to 3 per cent. Si)—North Zone, £12 10s.; South Zone, £12 12s. 6d.

Scotch Iron.—No. 3 foundry, £12 0s. 3d., d/d Grangemouth.

Cylinder and Refined Irons.—North Zone, £13 2s. 6d.; South Zone, £13 5s.

Refined Malleable.—P, 0.10 per cent. max.—North Zone, £13 12s. 6d.; South Zone, £13 15s.

Cold Blast.—South Staffs, £16 3s. 3d.

Hematite.—Si up to 2½ per cent., S. & P. over 0.03 to 0.05 per cent.:—N.-E. Coast and N.-W. Coast of England, £12 0s. 6d.; Scotland, £12 7s.; Sheffield, £12 15s. 6d.; Birmingham, £13 2s.; Wales (Welsh iron), £12 0s. 6d.

Spiegeleisen.—20 per cent. Mn, £17 16s.

Basic Pig-iron.—£10 11s. 6d., all districts.

FERRO-ALLOYS

(Per ton unless otherwise stated, basis 2-ton lots, d/d Sheffield works.)

Ferro-silicon (6-ton lots).—45 per cent., £33 15s.; 75 per cent., £49.

Ferro-vanadium.—35/60 per cent., 15s. per lb. of V.

Ferro-molybdenum.—70/75 per cent., carbon-free, 8s. 6d. per lb. of Mo.

Ferro-titanium.—20/25 per cent., carbon-free, £100 per ton.

Ferro-tungsten.—80/85 per cent., 13s. 9d. per lb. of W.

Tungsten Metal Powder.—98/99 per cent., 15s. 3d. per lb. of W.

Ferro-chrome.—4/8 per cent. C, £60; max. 2 per cent. C, 1s. 5½d. lb.; max. 1 per cent. C, 1s. 6d. lb.; max. 0.15 per cent. C, 1s. 6¾d. lb.; max. 0.10 per cent. C, 1s. 7d. lb.

Cobalt.—98/99 per cent., 15s. 6d. per lb.

Metallic Chromium.—98/99 per cent., 5s. 3d. per lb.

Ferro-manganese (blast-furnace). — 78 per cent. £28 3s. 3d.

Metallic Manganese.—96/98 per cent., carbon-free, 1s. 7d. to 1s. 8d. per lb.

SEMI-FINISHED STEEL

Re-rolling Billets, Blooms, and Slabs.—Basic: Soft, u.t., £16 16s. 6d.; tested, up to 0.25 per cent. C (100-ton lots), £17 1s. 6d.; hard (0.42 to 0.60 per cent. C), £18 16s. 6d.; silico-manganese, £23 19s.; free-cutting, £20 1s. 6d. Siemens Martin Acid: Up to 0.25 per cent. C, £22 4s.; case-hardening, £23 1s. 6d.; silico-manganese, £26 6s. 6d.

Billets, Blooms, and Slabs for Forging and Stamping.—Basic, soft, up to 0.25 per cent. C, £19 16s. 6d.; basic, hard, over 0.41 up to 0.60 per cent. C, £21 1s. 6d.; acid, up to 0.25 per cent. C, £23 1s. 6d.

Sheet and Tinplate Bars.—£16 16s. 6d.

FINISHED STEEL

Heavy Plates and Sections.—Ship plates (N.-E. Coast), £20 14s. 6d.; boiler plates (N.-E. Coast), £22 2s.; chequer plates (N.-E. Coast), £22 19s. 6d.; heavy joists, sections, and bars (angle basis), N.-E. Coast, £19 13s. 6d.

Small Bars, Sheets, etc.—Rounds and squares, under 3 in., untested, £22 6s.; flats, 5 in. wide and under, £22 6s.; rails, heavy, f.o.t., £19 2s. 6d.; hoop and strip, £23 1s.; black sheets, 17/20 g., £28 16s.

Alloy Steel Bars.—1-in. dia. and up: Nickel, £37 7s. 3d.; nickel-chrome, £55; nickel-chrome-molybdenum, £61 13s.

Tinplates.—I.C. cokes, 20 × 14, per box, 41s. 9d., f.o.t. makers' works.

NON-FERROUS METALS

Copper.—Electrolytic, £202; high-grade fire-refined £201 10s.; fire-refined of not less than 99.7 per cent. £201; ditto, 99.2 per cent., £200 10s.; black hot-rolled wire rods, £211 12s. 6d.

Tin.—Cash, £786 to £787; three months, £780 to £781; settlement, £786.

Zinc.—G.O.B. (foreign) (duty paid), £147 10s.; ditto (domestic), £147 10s.; "Prime Western," £147 10s.; electrolytic, £152; not less than 99.99 per cent., £158.

Lead.—Good soft pig-lead (foreign) (duty paid), £128; ditto (Empire and domestic), £128; "English," £129 10s.

Zinc Sheets, etc.—Sheets, 10g. and thicker, all English destinations, £167 2s. 6d.; rolled zinc (boiler plates), all English destinations, £165 2s. 6d.; zinc oxide (Red Seal), d/d buyers' premises, £136 10s.

Other Metals.—Aluminium, ingots, £112; antimony, English, 99 per cent., £205; quicksilver, ex warehouse, £22; nickel, £386.

Brass.—Solid-drawn tubes, 21d. per lb.; rods, drawn, 26¾d.; sheets to 10 w.g., 24⅛d.; wire, 25¾d.; rolled metal, 23¾d.

Copper Tubes, etc.—Solid-drawn tubes, 23¼d. per lb. wire, 226s. 6d. per cwt. basis; 20 s.w.g., 254s. per cwt.

Gunmetal.—Ingots to BS. 1400—LG2—1 (85/5/5/5), £150 to £163; BS. 1400—LG3—1 (86/7/5/2), £160 to £169; BS. 1400—G1—1 (88/10/2), £185 to £260; Admiralty GM (88/10/2), virgin quality, £225 to £274, per ton, delivered.

Phosphor-bronze Ingots.—P.Bl, £230 to £275; L.P.Bl £164 to £179 per ton.

Phosphor Bronze.—Strip, 34d. per lb.; sheets to 10 w.g., 35¾d.; wire, 36d.; rods, 33½d.; tubes, 38¾d.; chill cast bars: solids, 34½d., cored, 35½d. (C. Clifford & Son, Limited.)

Nickel Silver, etc.—Ingots for raising, 2s. 3¾d. per lb. (7% to 3s. 2¾d. (30%); rolled metal, 3 in. to 9 in. wide × .056, 2s. 9¾d. (7%) to 3s. 8¾d. (30%); to 12 in. wide × .056, 2s. 10d. to 3s. 9d.; to 25 in. wide × .056, 3s. to 3s. 10½d. Spoon and fork metal, unsheared, 2s. 6¾d. to 3s. 5¾d. Wire, 10g., in coils, 3s. 3¼d. (10%) to 4s. 2¼d.; (30%). Special quality turning rod, 10%, 3s. 2¼d. 15%, 3s. 6¾d.; 18%, 3s. 11¼d.

Personal

MR. H. A. R. BINNEY, C.B., an under-secretary of the Board of Trade, has been appointed deputy director of the British Standards Institution.

MR. DONALD J. PEARCE, B.SC., A.M.I.E.E., a 42-year-old Bolton man, has been appointed Principal of Clydesdale College, Mossend, Lanark County Council's new centre for technical instruction. He was previously senior assistant in Bolton Municipal Technical College.

MR. ALEXANDER MARSHALL has been appointed a partner in the firm of Albert Smith & Company, of 40, St. Enoch Square, Glasgow, the proprietor of which has for many years been Mr. John Bell, the honorary secretary of the Scottish branch of the Institute of British Foundrymen.

MR. W. LINDSAY BURNS, managing director of Henry Balfour & Company, Limited, Durie Foundry, Leven, and donor of bronze and silver medals to the school for mechanical engineering, presented the awards for the past session at the annual prize-giving at Buckhaven on September 8.

MR. A. TALBOT, M.I.B.F., of Western Foundries, Southall, Middlesex, whose demonstrations of foundry practice in youth clubs and schools in the London area are well known, has been appointed lecturer and demonstrator in general foundry practice to the Middlesex County Council Education Committee, for their courses of instruction for teachers.

MR. WILLIAM PATTERSON has retired after a long period of service with M. Cockburn & Company Limited, ironfounders, Falkirk. For the past 30 years he has been foreman of the dressing and inspection shop, joining the firm as a young man after having Carron Company.

Obituary

MR. WALTER TAYLOR, managing director of Ball Brothers (Engineers), Limited, of Stratford-on-Avon, has died at the age of 50. Mr. Taylor, a native of Derby, had served the firm for fifteen years.

MR. A. J. WITHERIDGE, managing director of Arthur Shaw & Company, Limited, and the Shaw Foundry Company, Willenhall, died last month He had been associated with the two companies for 37 years.

MR. F. C. WILLIAMS, who was manager of Cardiff branch office of G. & J. Weir, Limited, engineers, Glasgow, has died at the age of 64. He began his apprenticeship with the firm in 1902. Before going to Cardiff he had experience of marine fitting and repair work on the Clyde, and of land installations in the Manchester area.

MR. DAVID WILSON SHAW, chief partner of the firm of David W. Shaw, engineers, Falkirk, and a former Dean of Guild of the town council, died recently at his home, 1, James Street, Falkirk, at the age of 74. He served his apprenticeship as a mechanical engineer with the Carron Company and started his own business in 1918.

MR. MATTHEW BROWN, late managing director of Shotts Iron Company, Limited, has died at the age of 80. He joined the company during the first world war and 25 years later was appointed general manager. He was a past-president of the Association of Mining Electrical Engineers, and retired from active business in 1941.

Works Furniture. The Welconstruct Company, Grenville Buildings, Cherry Street, Birmingham, 2, have sent us a leaflet which describes, illustrates and prices a number of such articles as cycle racks, hat-and-coat lockers, shelving, bins and office partitions.