FOUNDRY TRADE JOURNAL

Established 1902

WITH WHICH IS INCORPORATED THE IRON AND STEEL TRADES JOURNAL

Vol. 89 Thursday, August 10, 1950 No. 1771

49, Wellington Street, London, W.C.2.

Grams: "Zacatecas, Rand, London"

'Phone: Temple Bar 3951 (Private Branch Exchange)

PUBLISHED WEEKLY: 40s. per annum (Home) and 45s. per annum (Overseas)

Moulding Sands

Though the literature on foundry sands has reached vast proportions, there are distinct gaps in our knowledge. The first question which arises is whether the sands used in United Kingdom foundry practice are more heavily bonded than in most parts of the world, and why. Next, one should consider as to whether moulding machines should be made to match the sands currently used or whether the sand should be compounded to suit the machine. Then, consideration should be given to supplying an answer to the question whether batch or continuous melting produces a sand of more uniform properties. A final query is why the introduction of a mechanised sand system sometimes yields a better casting and sometimes the reverse.

From general observation, it does appear to us that, by and large, our domestic sands are more heavily bonded than in most other countries, and we leave it to the practitioners to decide whether this is or is not advantageous. It is obvious that a standard having been empirically established in the past when using naturally-bonded sands, those compounded synthetically will more or less conform to the same conditions. Again, are we mistaking bond for some property of flowability? That there is some difference is unquestionable, for published figures reveal in general that the American foundryman works with a distinctly lower moisture content than does his British counterpart. Obviously, we are unaware as to what is contained in the iron and non-ferrous productivity team reports, but some observations on the subject would be of distinct interest.

Sand control is of as much importance in the foundry industry as metal supervision. Moreover, in most foundries some measure of control is the standard practice, yet there is insufficient knowledge as to what one is controlling. One of the factors is moisture content. It may be kept at a certain percentage; but why? Then the bond is also controlled, but whilst the figures on the display board may remain constant, the fundamental nature of the bond may vary. The nature of the inter-granular clay can differ, whilst the effect of grain size and shape can change, though still yielding a sand conforming to the control schedule. Whilst satisfactory results are being obtained under present conditions, the working specification should be kept under constant review. Additional tests such as the shatter test, which shows distinct potentialities, should be co-ordinated with the existing control system. The metallurgist has a distinct advantage over the sand technologist, as the use of coke and pig-iron has removed him just one stage further from nature. With sand consignments one is usually at nature's mercy. Truly, sand control is a fascinating subject and one which demands a vision which will correlate raw material cost with the quality and worth of the final product, coupled with a fundamental knowledge of what sand really is and its practical foundry application.

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I.B.F. Golf Meeting

At Woodhall Spa (Lincs), September 23 and 24

Entry forms are now available on application to the hon. secretary, Mr. F. Arnold Wilson, c/o William Jacks & Company, Limited, Winchester House, Old Broad Street, London, E.C.2, for the annual I.B.F. Golf Meeting to be held at Woodhall Spa, Lincolnshire, on September 23 and 24. The meeting is organised by the I.B.F. Golfing Society, details of which were announced in our issue of June 1. The membership is already over thirty; the annual subscription for members is 5s.

Arrangements for this year's meeting are as follows:—

Accommodation.—All will stay at the Golf Hotel in one party. This hotel offers first-class accommodation and is recommended. *Terms.*—Friday night (including dinner) to Sunday (including luncheon) £2 8s. per head, plus 10 per cent. surcharge. Separate days (including all meals and afternoon tea) £1 5s. per head, plus 10 per cent. surcharge.

Transport.—Members are asked to state whether travelling by their own transport, and their proposed route to Woodhall Spa if they are able and willing to offer lifts to other competitors.

Non-playing members and their wives are particularly welcome at this event.

Details of Play

Standard Scratch Score 76.

Handicaps are limited to 24; a course allowance will be made—competitors are therefore asked to provide a score card of the course on which they are handicapped.

September 23 (*morning*).—Medal round of 18 holes. Couples will be arranged on a similar handicap basis. Lowest nett score returned will be deemed the winner of the I.B.F. Handicap Challenge Cup, which will be held for one year. Lowest gross score returned will be deemed the winner of the I.B.F. Scratch Challenge Cup to be held for one year. The two winners will also be presented with the usual I.B.F. tankard prizes kindly presented by the president of the Golfing Society, Mr. R. B. Templeton. No competitor can win more than one prize in the morning.

Ties, if any, will be decided on the last nine holes, or if necessary on the last 12 or 15 holes.

(*Afternoon*).—Greensome foursomes against bogey under $\frac{3}{8}$ of combined handicaps for a 5s. per head entrance fee. Partners will be drawn on the sheep-and-goats basis.

Sunday, September 24.—Four-ball foursomes against bogey ($\frac{3}{4}$ handicaps), partners by personal arrangement.

Green fees, 5s. per day to be paid to the I.B.F. golf secretary. Starting times—Mornings 8.30 a.m., Saturday afternoon 2 p.m. Time sheet for Saturday morning will be posted in the hotel on Friday night.

Caddies will be extremely scarce, so competitors should bring their own caddy cars or hire them at the course. Any caddies available will be allocated in seniority of age to those who apply for them.

ALFRED BULLOWS & SONS, LIMITED, of Long Street, Walsall, Staffs, have created a process-development advisory bureau under the control of Mr. A. Rice-Williams, who until recently was in charge of the paint experimental and development department of the Rover Company, Limited, of Solihull, Birmingham. This new section offers a free consulting service on industrial finishes in general, embracing queries on such subjects as:—pretreatment problems; choice of finish and materials; economics of application, and stoving.

Book Review

Pressed Metal—the Report of the Productivity Team. (Published by the Anglo-American Council on Productivity, 21, Tothill Street, London, S.W.1. Price 2s. 6d.

This report confirms the general conclusions of other teams which have visited the United States. The Americans are productivity minded. The American workman is not so highly taxed and possesses money to buy what he wants, but as he wants more he wishes to earn more—this he knows can only be done by making more goods more cheaply. Obviously there are many illustrations of gadgets to effect this end. There is a formal recommendation for the formation of an association of firms in the pressed-metal industry for the interchange of ideas and for research into problems of technique. It is a matter of some surprise that a team representing this industry did not know that such an organisation already existed. Below we publish a letter on the subject.

Correspondence

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

ANGLO-AMERICAN PRODUCTIVITY COUNCIL: BRITISH DEEP-DRAWN METALS PRESSING INDUSTRY REPORT

To the Editor of the FOUNDRY TRADE JOURNAL.

SIR,—The report and recommendations of the productivity team from the British deep-drawn metals pressing industry has now been published and is before the industry. I am sure that the importance and value of the report will be recognised by everyone and I trust that its recommendations will receive serious and immediate consideration.

There is one recommendation on which, with your permission, I would like to add a brief note. Among the findings was one which emphasised the urgent need for an association of firms in the British pressed-metal industry for the interchange of ideas and for research into problems affecting pressing techniques and production methods.

There is already in existence the Sheet and Strip Metal Users' Technical Association, an organisation which is capable of expansion in the directions that the team would desire, and a most important contribution would be made to fulfilling the whole purpose of the report if that association took the recommendation into favourable consideration.

Yours, etc.,
J. M. PHILLIPS
(Leader of the Pressed-metal Industry Team)

July 28, 1950

New Vickers Tractor

The Vickers tractor, a new and powerful Class I heavy track-type tractor designed for industrial, earth-moving, and heavy agricultural work, will be introduced to world markets by January, 1952. It will weigh between 14 and 15 tons and will be fitted with a Rolls-Royce Diesel engine of approximately 180 h.p.

During 1951, pre-production machines will be supplied to operating companies for trials under practical conditions. Full production will begin in January, 1952, and it is planned to work rapidly up to a production rate of 500 a year. The tractor will be manufactured at the Elswick and Scotswood works of Vickers-Armstrongs, Limited, at Newcastle-upon-Tyne.

Castings for Contractors' Plant

By A. Graham Thomson

THE MANUFACTURE of all types of contractors' plant is undertaken by Winget, Limited, of Rochester, whose products also include refrigeration plant, wire-drawing equipment, etc. Since 1934, when the factory was transferred from Warwick to its present site overlooking the Medway,* the progress of the business has been rapid. The works has been considerably expanded and the number of employees has risen from about 300 to approximately 1,000.

All castings for Winget products are produced in Meehanite iron, the process being scientifically controlled at every stage. Built on the site formerly occupied by the foundry of Aveling & Porter, the steam-roller manufacturers, the Winget foundry covers some 30,000 sq. ft. and has a weekly output of between 70 and 80 tons of metal, castings ranging normally from a few ounces up to 35 cwt. About 150 men are employed in the foundry, which is laid out essentially for jobbing and besides supplying the company's own requirements undertakes a certain amount of work for outside customers Most castings are produced in either GE or GA Meehanite, but all other grades are made as and when required.

Foundry Layout

The foundry is divided into four bays. "A" bay adjoins the melting plant and is occupied mainly by two casting pits, and "B" bay is devoted essentially to medium-heavy work such as drum bases for concrete mixers. "C" bay is for smaller hand-moulded work, while machine moulding is undertaken in "D" bay. "A" and "B" bays are each spanned by a 5-ton overhead crane and "C" bay by a 2½-ton crane. Transport through the shop is by a light railway and it is noteworthy that, except for the pits in "A" bay, the floor of the foundry is concreted throughout. The machine moulding bay is equipped with four jolt-squeeze moulding machines (Fig. 1), supplied by the British Moulding Machine Company, Limited. Pressed-steel moulding boxes are used with the machines, and this department also makes considerable use of cover cores to avoid the necessity for two boxes. In "C" bay a British Moulding Machine model AT5 is engaged almost exclusively in the production of road wheels for concrete mixers, etc. These are manufactured in Meehanite in sizes ranging from about 14 to 20 in. dia.

Exacting Tests

Since concrete machinery is normally subjected to extremely rough handling, the substitution of Meehanite for fabricated steel for making this equipment was an innovation which seemed to call for special tests. Three sample wheels were therefore cast, one in grade "GA" having a tensile exceeding 22½ tons per sq. in., the second in "GC" with 18 tons minimum tensile strength, and the third in "GE" of 13½ tons per sq. in. minimum.

For test purposes, a concrete track 10 ft. dia. was provided at three points with 6-in. steps, the bottom of each step being filled with nuts, bolts, pebbles and other objects capable of causing a severe impact. On the end of a 5-ft. radial arm was fastened a small wagon loaded with 1,400 lb. of

* New foundry of Winget, Limited, FOUNDRY TRADE JOURNAL, October 24, 1935.

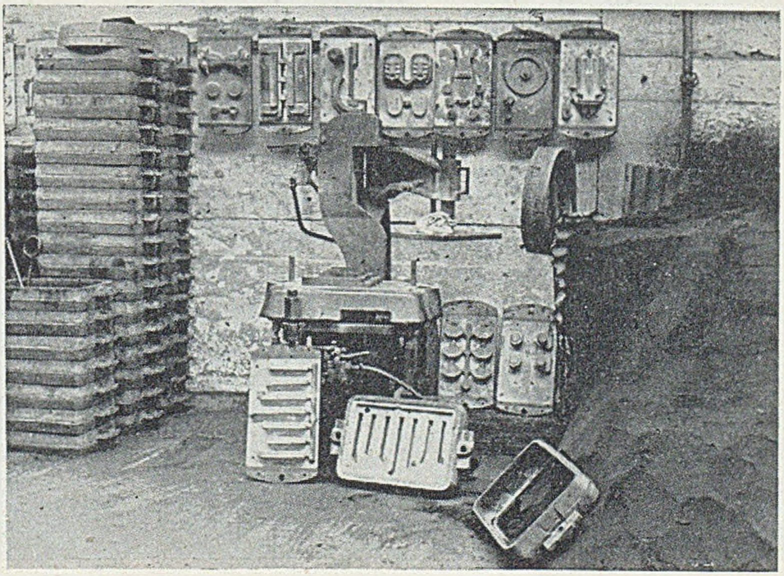


FIG. 1.—*A Unit in the Machine-moulding Bay. Note the Orderly Arrangement of Pattern Plates.*

Castings for Contractors' Plant

pig-iron and mounted on one of the sample wheels. Powered by a little engine the radial arm took the wagon round the track at the rate of two circuits per min. This test was carried out for a whole day, but the sample "GE" wheel, the lowest grade, remained unbroken. In the circumstances it was considered unnecessary to test the two tougher grades.

Types of Castings

A certain amount of pressure-resisting castings are also undertaken in "C" bay, a typical example being a cylinder for a refrigeration compressor made in grade "GA" Meehanite and tested to 600 lb. per sq. in. hydraulic and 300 lb. air pressure. The largest production line consists of drum-base castings for concrete mixers, to which a considerable portion of bay "B" is devoted. Varying in weight from about 3 to 10 cwt., these jobs cover quite a large surface area in the mould, and are actually cast in green sand. Among the largest products is a 2½-ton housing for the wire-drawing department, an intricate job with a large number of internal bosses, walls, etc. Each casting contains as many as 39 cores. A few typical castings are shown in Figs. 2, 3 and 4.

The foundry also produces a variety of arms of different shapes and sizes for knitting machinery, these being moulded for the most part from metal pattern equipment. A fairly extensive business is done in castings for refrigerators and bar stock is also produced.

An impressive indication of the potentialities of Meehanite was provided by a rush order for castings for a die-sinking machine, which according to the specification had to be stress-relieved and annealed. These being urgently required, the company was asked whether the first batch could safely be used without annealing. Since the design was fairly regular the company was confident that the castings could safely be left in the as-cast state. The advice was followed and no trouble was experienced by the customer. A number of lathe-bed castings for machines turning out very fine work have also been produced and these, too, have been entirely free from any sign of distortion.

Throughout the shop, adequate facilities for the storage of waste metal have been provided. A useful outlet has been found for the old stock which is liable to prove such a nuisance in a foundry. This material is cast into standard-size plates which are used to make bins for sand, thus providing a practical and convenient system of sand storage.

Melting Plant

The melting plant consists of two cupolas of 34-in. inside dia. (Fig. 5), which are equipped with a recently rebuilt charging stage having ample storage facilities for raw materials in immediate use. The melting capacity is 3 tons per hr. per cupola. The raw materials in bulk are stored in

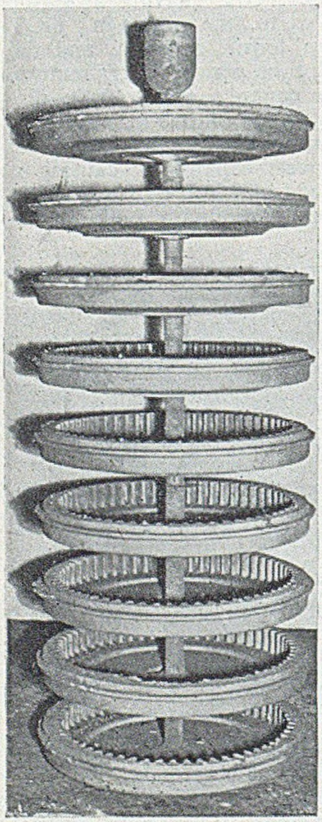
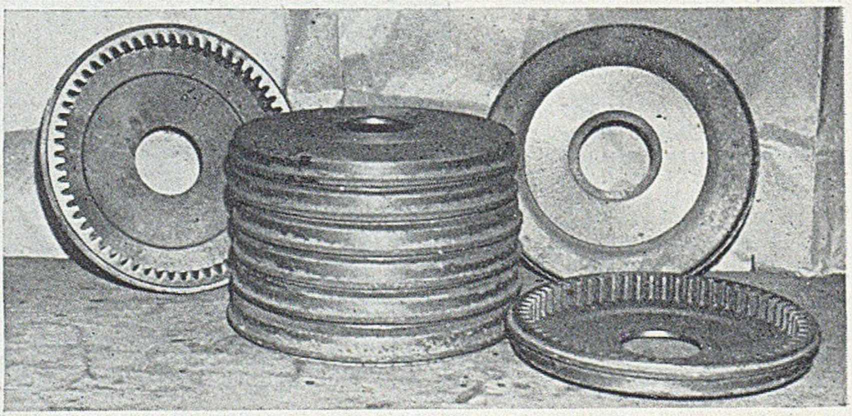


FIG. 2 (LEFT).—*Stack-moulded Castings for the Tilting Gear on Concrete Mixers. These jobs used to be made on the floor, but requirements increased so rapidly that a larger output was required. Due to shortage of floor space and labour, it therefore became necessary to evolve a method of building up a nest of cores. This consists of a main outer body core with an inner core giving the truth form, this arrangement being repeated nine times in such a manner that a runner cup can be put on the top and the whole set-up clamped together between plates.*

FIG. 3 (BELOW).—*Castings as in Fig. 2 after Machining.*



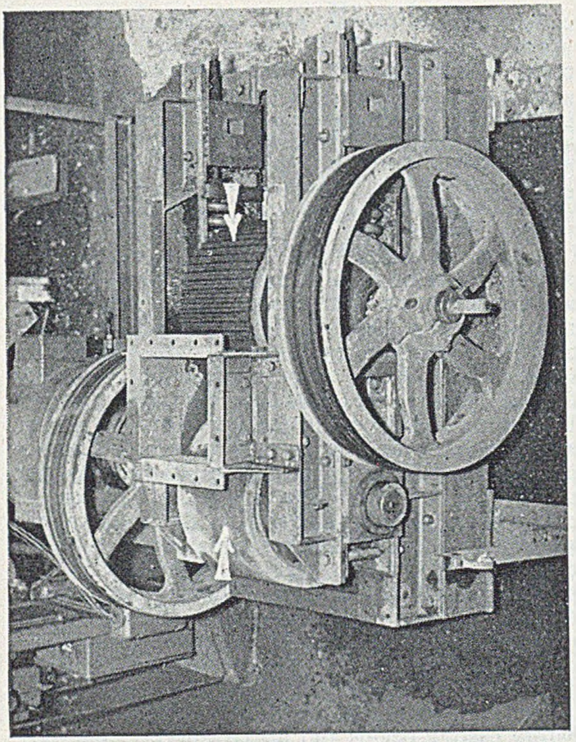


FIG. 4.—*Plain and Serrated Shells (shown by Arrows) for this Crushing Machine are both cast in "WA" Meehanite and are used successfully for crushing various Light Stones, Gasworks Clinker and Similar Material. They are sometimes used As-cast and sometimes Heat-treated to give from 450 to 500 Brinell.*

a yard immediately behind the cupolas, and are handled by a jib crane which also serves the castings despatch department. Frequent temperature measurements are taken by means of a Cambridge disappearing-filament pyrometer. The ladles are ganister lined.

Sand System

The mill used for sand treatment is one of the company's own standard products, which was designed primarily for mixing builders' mortar, but has proved very suitable for foundry sand. Comprising a miller, two ploughs and a spinner, it gives efficient mixing and excellent aeration of the sand without crushing.

For green-sand facing, the foundry uses ten parts of floor sand, three of Bramcote red sand, three of Borough Green silica sand, two of Upnor loam sand, two of coal dust and one of Fulbond No. 4. This mixture has a permeability of 30 to 40 and a compression strength ranging from 5 to 7 lb. per sq. in., while moisture content is usually between 5 and 7 per cent. The dry-sand facing used consists of eight parts of floor sand to 14 of Bramcote red sand and one of bentonite. This gives a green strength of 6 to 8 lb. per sq. in. and a green permeability between 40 and 50, moisture content again varying from 5 to 7 per cent. For the preparation of the standard backing sand used throughout the shop, the company makes use of three Pneulec Royer machines.

Core Shop

Due to shortage of floor space, the core shop is at present in two sections. Cores for use with the moulding machines are produced for the most part in a section adjoining the sand-preparation plant, which is equipped with a drawer-type stove of the company's own manufacture. The other section is located opposite the hand-moulding bays and is equipped with two core stoves and the usual extrusion machine for stock cores. The majority of the cores are made from oil-bonded sands.

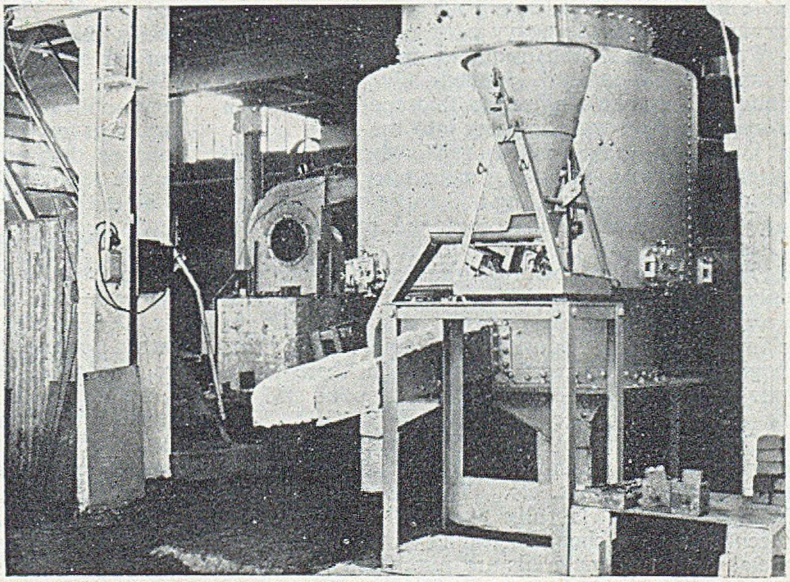


FIG. 5.—*A Close-up of the Tapping Spout of one of the Cupolas.*

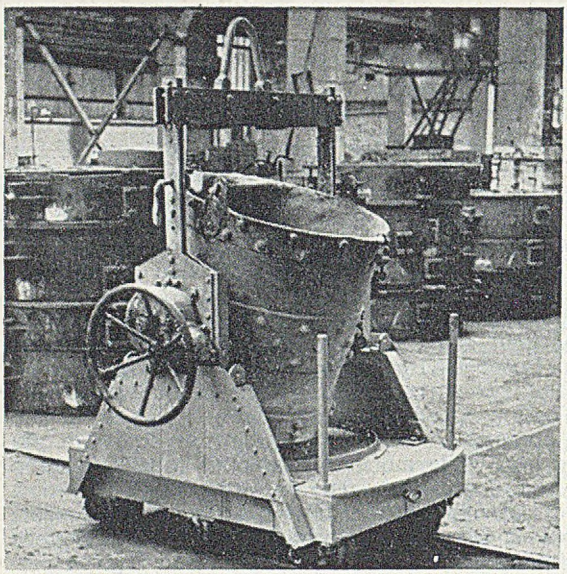


Fig. 6.—*Bogie Ladle which was constructed to transport Metal when Power was cut off during the Cold Spell of* 1947. *Note the Clamping Device.*

Patternshop

The patternshop is situated in a modern building which has been fully equipped with machinery since the war. Machines which have recently been installed include a Wadkin over-head recessing machine, a band-saw, thicknesser, drilling machine and tool grinder. A disc and bobbin sander and a canting-spindle dimension saw have yet to come. The building is both light and spacious and is warmed by a hot-water heating system although this is still in the experimental stage. The reorganisation programme will also include the construction of a gallery round the pattern store to accommodate light jobs, thus leaving adequate space on the ground floor for the heavy patterns.

Patterns for all jobs required are brought to the foundry and stored immediately outside the foundry foreman's office, so that the foreman can keep an eye on what is going into the shop.

During the cold spell in 1947, when the use of electricity was prohibited, the foundry was able to keep going though melting had to be curtailed, and only the smaller castings could be produced. A Diesel engine was used to drive the fan on the furnaces, while the problem of transporting metal was solved by the construction of a ladle mounted on a bogie, Fig. 6, and so designed that it could be clamped down for pouring into hand ladles. This bogie ladle proves very useful when there are a number of machine-made moulds to pour and the crane happens to be engaged elsewhere.

The fettling shop is supplied with the normal complement of pneumatic chisels and hammers, a shot-blasting cabinet, etc. The laboratory at the Winget foundry is fully equipped to carry out mechanical and chemical testing of both sand and metal. All raw materials are purchased to specification and as far as possible repeat orders are always placed with the same suppliers. This policy extends to such details as blacking and core gum, on the principle that the more thoroughly any possible inconsistencies can be reduced the more easily can defects be traced. The aim is not so much to find faults which have been made, however, as to detect and remedy them before they have a chance to develop.

Quality Control

The system of quality control in force involves taking six consecutive tests of metal, from which both the mean figures and also the range are obtained. The mean figures show how closely the specified figures are approached, while the range figures indicate the outside limits of variation. Limits of plus or minus 0.1 per cent. for carbon and 0.15 per cent. for silicon are regarded as efficient melting control, but the results achieved are usually well within these ranges. The tensiles obtained are actually higher than the specifications lay down. Meehanite being a high-duty cast iron, control is maintained over all other constituents besides carbon and silicon, and the company is, of course, particularly careful to produce a low-phosphorus metal. Samples are taken from about one out of every three ladles poured and frequently every ladle is sampled.

The day's jobs are discussed in the laboratory before casting begins and are arranged in the most suitable order metallurgically, a copy of the daily melting programme being despatched to the foundry superintendent and foundry foreman. A complete record of each day's casting is kept, so that, in the event of any complaint, full details of the cast in question are available.

Equally rigid is the system of sand control, all the normal tests being undertaken at regular and frequent intervals. Of particular interest is the use of the Deane & Starke method for measuring moisture in oil-bonded core sands. A weighed sample of sand is mixed with some dried toluene and heated. The toluene boils at 110 deg. C. and so distills the water, which is collected in a receiver and measured by volume. This method was actually designed for tar and pitch but has proved very applicable to oil-bonded sands. The laboratory was reconstructed after the war and is so designed that each individual assistant has his own section to himself, so that he can take a personal pride in the work he is carrying out.

Personnel and Working Conditions

The foundry superintendent, Mr. George Perch, has been with the firm since 1934. His assistant, Mr. D. F. Knight, is also the foundry metallurgist. Both a foundry foreman and a coremaker foreman are employed. Characteristic of the entire works is the attention devoted to the provision of optimum working conditions. The entire foundry has been re-glazed since the war. Already-efficient lighting has been improved by the use of aluminium and cement paints. A programme is at present under way for repairing and re-building all walls round the foundry and for the provision of more efficient

(*Continued on page* 147)

University of Birmingham

Graduate Course in Metallurgy

The purpose of the Graduate Course in Metallurgy organised in the Department of Industrial Metallurgy at Birmingham University is to provide training at a post-graduate level for men who already hold degrees in metallurgy, physics, chemistry or engineering, and who are occupying positions of responsibility in metallurgical industry. In general, it is expected that entrants will have spent some time, *e.g.*, two years or more, in the metallurgical industry, but in suitable instances a proportion of metallurgical graduates with less industrial experience may be admitted. In all cases it will be assumed that students possess a knowledge of metallurgy to at least ordinary degree standard.

The course comprises lectures and practical work and is planned to be completed in one academic year. The Diploma in Graduate Studies (Metallurgy) is awarded on satisfactory completion of the course. Most of the practical work is in the form of exercises and investigations in the University laboratories, but provision is also made for some time to be spent with industrial concerns.

Lecture courses occupying a total period of eight hours per week are given during normal term time. Men recently graduated at this University in the Departments of Industrial Metallurgy or Theoretical and Physical Metallurgy may only find it necessary to take a portion of the lectures, since some of these will be devoted to revision for the benefit of men separated from their undergraduate period by several years.

Lecture Courses

Structural Metallurgy

Physical metallurgy and its application to precipitation phenomena, stress-corrosion, preferred orientation, hardening of steels, etc.

Industrial Metallurgy

(*a*) Structure of metallurgical industry and its components; organisation of personnel; layout of factories; control of processes and costing; industrial administration and management.

(*b*) More advanced treatment of individual topics, *e.g.*, preparation and use of standard specifications; technical and commercial significance of secondary metals; wages systems, incentives, productivity and mechanisation; statistical treatment of data; organisation and control of industrial research; organisations of employers and employees.

Principles of Refining, Melting and Casting

Thermodynamics of refining, melting and solidification; gas, slag and metal reactions; heat and liquid flow. Applications to manufacturing processes.

Principles of the Working of Metals, Heat-treatment and Welding

Theory of deformation of metals by rolling, extrusion, forging, drawing and pressing; its relation to metallurgical structure and application to industrial metalworking processes. Principles of industrial annealing, heat-treatment and welding.

Modern Laboratory Techniques

X-ray crystallography; radiography and other non-destructive testing; strain gauges, instrumentation of plant.

Practical Course

The practical work is carried out principally with the full-scale manufacturing plant in the new Aitchison laboratories. The programme is organised to be carried out by the students operating in groups, the needs of individual men being taken into careful consideration in making up the groups; each group includes in its practical work a self-contained project capable of being carried to completion or to a reportable stage within the session. With the co-operation of industry, some problems in actual production and administration are studied in suitable works. While the practical work consists principally of industrial metallurgy, laboratory exercises also play an essential part in the theoretical and physical studies.

In the course as a whole, both as regards lectures and practical work, provision is made not only for a study of the principles and their application, but also for a revision of work normally covered in preparation for the Bachelor's degree. It should be emphasised that the third and fourth lecture courses mentioned earlier are concerned with the principles underlying the technology of the subject.

Castings for Contractors' Plant

(*Continued from page* 146)

ventilation. Excellent washing facilities are available to the foundrymen.

Mr. George Dickson, managing director of Winget, Limited, has always been one of the pioneers of efficient full employment. He is a firm believer in joint consultation between all grades of personnel and considers that all should continuously be kept fully informed as to the policy of the firm, which is run on very democratic lines. An attractively-produced house organ is published quarterly and helps to maintain the close liaison between all employees.

In the matter of apprentices, the company is exceptionally well placed. As licensees, Winget, Limited, are able to send all their apprentices to the Meehanite Foundry Training School at the foundry of the Butterley Company, Derby. During his period of apprenticeship each youth spends four separate months at Butterley under the control of a qualified instructor, and is taken right through a comprehensive course of general education on foundry practice. Whether as a result of these facilities, or due to the democratic policy of the management, the ratio of apprentices throughout the shops seems to be well above the usual figure.

Progress Report

By V. C. Faulkner

A FEW HOURS spent in the works of K. and L. Steelfounders and Engineers, Limited, of Letchworth, sufficed to show that the progress registered since the writer's last visit is indeed noteworthy.

Melting. The baby Bessemer plant was functioning owing to alterations to the electric furnaces, but it is shortly to be closed down and sold to South Africa. Here conditions are more favourable for its use than in this country owing to the plentiful supply of suitable pig iron. In the electric melting department, a large transformer was being put into commission, which will place the furnace it services amongst the most highly-powered in Europe if not in the world. The oxygen blow is now being practised as a matter of routine.

Moulding Plant. Whilst this is to be the subject of a full-scale illustrated article in the near future, it is now possible to state that the system installed shows excellent promise. The moulding machine hoppers are filled from a skip suspended from power-operated monorail bogies. The closure of the hoppers is by a short length of conveyor belting. There are two Pneulec jar-ram-turnover machines for mould making and the cycle is quite automatic. Two time-cycle control clocks, one of which relates to the time of sand supply and the second to the time of jarring are installed. These are set to predetermined times and inter-connection causes ramming to start almost before the stream of sand has finished being delivered. Handily placed is a pneumatic rammer for going over the surface of the mould before strickling-off. Aluminium for boards has replaced wood. In front of the machines, there is a vast network of roller conveyor which allows plenty of space for coring-up and storage of moulds prior to casting. A well-ventilated "Sterling" knock-out, furnished with sound mould-handling devices has made for easy and hygienic working conditions. Amongst points noted, was that there was a minimum spillage from the hopper to the moulding box, and that though at the moment each machine has one operator, the automatic contrivances will enable one man to work both machines. Periodic visits have been paid to this works since its erection during the 1914 war, but the writer has never seen the castings so well finished as they are to-day.

Fettling. The management, in co-operation with the Factory Department of the Ministry of Labour, has designed a new type of fettling bench the "floor" of which is a grid made of removable 2½-in. square battens with their corners removed. They are so placed as to form V grooves. When chipping sideways, chocks are dropped into the grooves to ensure steadiness. About a 40 mile per hour exhaust air-stream takes the dust downwards to a box, where it is filtered. Then 90 per cent. passes to atmosphere, whilst the residual 10 per cent. goes horizontally across the work so as to form a curtain between that and the operator. The prototype having successfully undergone its trials, a batch of eight is going through the shops, and we understand that, later on, the model will be made available to the foundry industry generally.

Amenities. There is at the present time being erected what promises to rank amongst the finest in the country among changing, washing and bathing establishments. Ventilated and warmed lockers are to be provided at both ends of the bathing section, one series for the working and the other for the "town" clothes. Individual wash-hand-basins are being installed. Considering this is a steel foundry—with no coal dust admixture and that it is located in a garden city where one would imagine every house has its own bathroom, this is a very generous gesture by the management and it is hoped that it will receive the appreciation and respect which it merits.

Exothermic header practice. Over the whole industry, the average weekly melt of steel for steel castings is running about 8,000 tons. This liquid steel makes about 4,700 tons of castings. That means that 3,300 tons is discard in one form or another. The research department at K. & L.'s has been tackling this problem by means of a mixture based on an alumino-thermic reaction. The mixture yields quite good material of about 27 tons per square inch tensile and its use on the wide range of castings has reduced the weight of headers by about 25 per cent. Reference to the figures quoted earlier shows that there is a yearly potential gain to the industry of 40,000 tons less to be melted and then remelted. Nobody is more cognisant than the writer of "what's one man's meat is another man's poison," yet the toxic properties of this new mixture deserve careful examination before putting on the list of dangerous drugs. From the above it will be realised that the directorate of K. & L.'s is taking full cognisance of the Steelfounders' Production Report and—be it noted—the Garrett Report, which applies to iron foundries only. For a most interesting afternoon we extend our thanks to Mr. Frank Rowe, B.SC., Mr. R. F. Ottgnon and Mr. Brearley.

SPEAKING at a dinner of the Sheffield branch of the Purchasing Officers' Association, Mr. W. R. S. Stevenson, the Master Cutler, said that bulk buying had very great dangers. Although centralised purchasing was theoretically correct, it was likely to lead to harmful rigidity unless proper care was taken to avoid this danger. The president of the Association, Mr. T. F. Turner, of the English Electric Company, Limited, said that buyers found that trade associations' restrictions could be just as rigid in effect as Governmental controls. He claimed that the terms given to nationalised industries should not be unduly favourable.

Cast Iron at Sub-atmospheric Temperatures*

By G. N. J. Gilbert

Very few published data on the low-temperature properties of cast iron are available. Cases in which cast iron may be required to withstand low temperatures are to be found in connection with the production of liquid air, in certain chemical processes requiring the use of liquid air, and in industries dealing with refrigeration. Low temperatures will be encountered by equipment used under arctic conditions. Other possible cases where low temperatures may be encountered are in connection with the operation of aircraft and projectiles at high altitude. Cast iron may also be subjected to low temperature for the purpose of shrink-fitting.

THIS PAPER CONTAINS a summary of the available literature on the low-temperature properties of cast iron and details of the tensile and impact properties of a number of cast irons down to temperatures of −100 deg. C. or lower. Dilatation tests have been carried out at high and low temperatures on each of the materials tested, so that results can be compared and more knowledge gained of any phase change that occurs at low temperature. It is intended that the results should give a general picture of the properties of the various types of cast iron at low temperature.

PART I—SUMMARY OF PREVIOUS WORK

Before considering published work on the low-temperature properties of cast iron it is worthwhile to note the more ample information on other ferrous and non-ferrous materials. Some of the earliest work was carried out by Hadfield,[1] who tested a wide range of materials in liquid air. Russell[2] summarised the available information on the properties of metals and alloys covering, principally, data obtained since Hadfield's paper. In 1939, Foley[3] summarised in general terms information that had become available since the Paper by Russell in 1931. This information is more fully reported in 1941 by Gillett.[4] A very comprehensive literature survey of the available low-temperature properties of metals and alloys was published by White and Siebert[5] in 1941. In 1944, Donaldson[6] reviewed the more important researches carried out during the previous five years. Early in 1949, Colbeck[7] presented a brief review of the present state of knowledge on the subject.

* Paper presented at the Buxton Conference of the Institute of British Foundrymen. The Author is on the staff of the British Cast Iron Research Association.

Grey Cast Iron

The most comprehensive series of results available in the literature on the low-temperature properties of cast iron are those of Pardun and Vierhaus,[8] who report in particular on materials suitable for cast-iron pipes. They found increases of tensile strength up to 16 per cent. at −100 deg. C. and reduction in impact up to 16 and 28 per cent. at temperatures of −80 and −180 deg. C. respectively. The hardness increased at low temperatures. The detailed results of their transverse, tensile, impact and hardness tests are given in Tables I to V, together with details of the cast irons tested.

Transverse bend tests.—Bars 30 mm. dia. were broken on 600-mm. centres (approximately 1.2 in. dia., 24-in. centres). The transverse strength and deflection are shown in Table II, together with the percentage variation from the values at 23 deg. C.

Tensile Tests.—The tensile strength is shown in Table III with the percentage variation from the value at 24 deg. C. for each material.

Impact Resistance.—The values quoted are in M.Kg. per sq. cm. and the percentage variation from the value at 23 deg. C. for each material is shown in Table IV. The impact tests were carried out on unnotched bars.

Hardness.—The Brinell hardness of the materials at various temperatures are shown in Table V, together with the percentage change from normal temperature.

TABLE I.—*Grey Cast Irons, Analyses of Materials Tested.*

No.	Material.	T.C. Per cent.	G.C. Per cent.	Si. Per cent.	Mn. Per cent.	S. Per cent.	P. Per cent.
1	Machine cast iron, medium strength ..	3.56	3.06	1.80	0.60	0.080	0.527
2	High-grade machine cast iron	3.42	2.35	1.24	0.56	0.103	0.326
3	Pipe cast iron	3.64	2.94	1.81	0.56	0.071	0.509
4	Hematite cast iron	3.78	3.26	2.03	0.86	0.071	0.095
5	Iron for thin-walled castings	3.42	2.82	2.17	0.49	0.088	1.084

TABLE II.—*Transverse Properties of Grey Cast Irons at Sub-normal Temperatures (f = transverse variation and d = deflection variation).*

No.	23 deg. C. (75 deg. F.)		0 deg. C. (32 deg. F.).				−20 deg. C (−4 deg. F.).				−35 deg. C. (−31 deg. F.).			
	Trans., tons per sq. in.	Deflection, in.	Trans., tons per sq. in.	Deflection, in.	f, per cent.	d, per cent.	Trans., tons per sq. in.	Deflection, in.	f, per cent.	d, per cent.	Trans., tons per sq. in.	Deflection, in.	f, per cent.	d, per cent.
1	19.18	0.421	20.00	0.433	+4.1	+2.8	19.94	0.437	+4.0	+3.7	19.30	0.421	+0.7	+0.0
2	23.62	0.429	23.11	0.402	−2.1	−6.4	24.57	0.425	+4.0	−1.0				
3	19.62	0.404					19.75	0.394	+0.65	−2.4				
4	17.27	0.469					18.03	0.476	+4.4	+1.7				
5	21.56	0.396					19.81	0.341	−8.1	−14				

TABLE III.—*Tensile Properties of Grey Cast Irons at Sub-normal Temperatures.*

No.	24 deg. C. (75 deg. F.).	−20 deg. C. (−4 deg. F.).		−80 deg. C. (−112 deg. F.).		−100 deg. C. (−150 deg. F.).*	
	Tensile, Tons per sq. in.	Tensile, Tons per sq. in.	Per cent. at + 24 deg. C.	Tensile, tons per sq. in.	Per cent. at +24 deg. C.	Tensile, tons per sq. in.	Per cent. at +24 deg. C.
1	9.18	9.75	+6.2				
2	13.87	13.56	−2.3				
3	9.72	10.00	+2.9	10.79	+11.1	11.02	+13.4
4	8.03	8.41	+4.5			9.33	+16.2
5	9.72	9.94	+2.3	10.76	+10.8	10.99	+13.1

* Bars were immersed in liquid oxygen at 183 deg. C. and broken at a temperature of −100 deg. C. to −120 deg. C.

TABLE IV.—*Impact Resistance at Sub-normal Temperatures for Grey Cast Irons, 30 mm. sq., 120 mm. span.*

No.	23 deg. C. (73 deg. F.)	0 deg. C. (32 deg. F.)		−20 deg. C. (−4 deg. F.)		−35 deg. C. (−31 deg. F.)		−80 deg. C. (−112 deg. F.)		−180 deg. C. (−290 deg. F.)	
	Impact.	Impact.	Per cent. at 23 deg. C.	Impact.	Per cent. at 23 deg. C.	Impact.	Per cent. at 23 deg. C.	Impact.	Per cent. at 23 deg. C.	Impact.	Per cent. at 23 deg. C.
1	0.512	0.504	−1.5	0.509	−0.6	0.527	+3.1				
2	0.624			0.585	−6.2			0.520	−16.7		
3a	0.550			0.515	−6.4			0.481	−14.4		
3b	0.460			0.421	−8.5			0.394	−14.3	0.328	−28.7
4	0.582			0.543	−6.7			0.504	−13.4		
5	0.491			0.479	−2.5	0.434	−11.6				

The British Oxygen Company[9] report on the tensile strength of cast iron at a very low temperature. Test-bars 14 in. long and 1 in. dia. of iron of the following composition:—Total carbon, 3.30; silicon, 2.25; manganese, 0.45; sulphur, 0.10; and phosphorus, 1.2 per cent., were tested at atmospheric temperatures and at −194 deg. C. There was no apparent difference in the appearance of the fractures of the two bars, nor in the mechanical properties. The results are given in Table VI:—

TABLE V.—*Brinell Hardness of Grey Cast Irons at Sub-normal Temperatures.*

Material No.	Temperature, deg. C.	B.H.N.
1	+22	134
	−20	140
	−30	140
	−40	147
2	+23	180
	−40	189
	−60	195
3	+23	151
	−180	199
4	+24	142
	−50	151
	−65	153
5	+24	164
	−20	171
	−180	221

TABLE VI.—*Properties of a Cast Iron at Normal and Sub-normal Temperatures Compared.*

	Tensile strength, tons per sq. in.	B.H.N.
Atmospheric temperature	13.32	235
Liquid air temperature, −194 deg. C. ..	13.04	235

The American Foundrymen's Association and Society for Testing Materials[10] report as follows on the properties of cast iron at sub-normal temperatures:—

"Exposure of grey irons to sub-normal temperatures apparently does not result in serious impairment in physical properties. Tensile strength and Brinell hardness are maintained, or slightly increased, according to tests made at various temperatures down to −317 deg. F. (−194 deg. C.). At temperatures of −112 deg. F. (−80 deg. C.) and below there is a slight decrease in impact value. There is no pronounced increase in brittleness or change in appearance of fracture at −317 deg. F. (−194 deg. C.)."

Rajakovics[11] reports on the influence of testing temperature on the specific impact strength of grey cast iron. The range of temperature used was −20 deg. C. to +580 deg. C. At +20 deg. C. an impact strength of 27.4 cm. kg. per sq. cm. was reported and this fell to 21.9 cm. kg. per sq. cm. at −20 deg. C.

Table VII gives data on the impact properties of unnotched 1.2-in. dia. specimens broken in an Izod machine as reported in Nickel Cast Iron News.[12]

TABLE VII.—*Impact Tests on Cast Irons Containing Nickel.*

Material.	Chemical composition, per cent.					Izod impact, ft.-lb.	
	T.C.	Si.	Ni.	Cr.	Cu.	Room temp.	−45 deg. F. (−43 deg. C.)
A	3.44	1.96				39	29
B	2.76	2.02	1.75			44	38
Ni-Resist	2.73	1.59	13.76	1.95	6.00	55	50
Invar cast iron	2.50	1.40	30.00	4.00		81	70

Boone and Wishart[13] determined the endurance limit of various metals, including cast iron, between +80 deg. F. (27 deg. C.) and −50 deg. F. (−46 deg. C.), using both notched and unnotched specimens. The compositions of the materials were as follow:—

	T.C.	Si.	Mn.	S.	P.
Grey cast iron* ..	3.25	1.1	0.60	0.096	0.46
Meehanite cast iron..	3.07	1.26	0.90	0.080	0.15

* Annealed 30 minutes at 1,040 deg. F. (560 deg. C.) and cooled in the furnace.

The " Meehanite cast iron " is also, presumably, a grey cast iron and the different mechanical properties of the materials can be explained on the basis of their differing phosphorus content. The endurance limits and stress-concentration factors at various temperatures are as detailed in Table VIII.

TABLE VIII.—*Endurance Limits and Stress Concentration Factors for Two Additional Grades of Iron.*

Specimen temp., deg. C.	Endurance limit, lb. per sq. in. Unnotched specimen.		Endurance limit, lb. per sq. in. Notched specimen.		Stress concentration factor:— Endurance. Limit, unnotched. / Endurance. Limit, notched.	
	Grey cast iron.	Meehanite cast iron.	Grey cast iron.	Meehanite cast iron.	Grey cast iron.	Meehanite cast iron.
+27	9,000	21,000	10,000	20,000	0.90	1.05
+10	9,000		10,000		0.90	
−20	9,500	23,000	9,500	22,000	1.00	1.05
−40	11,500		13,500		0.85	

Endurance limit based on 10 × 10^6 cycles.

Malleable Cast Iron

Simmons, Rosenthal and Lorig,[14] in an investigation on the mechanical properties of malleable cast iron, included results of impact tests from room temperature to −60 deg. C. The compositions of the irons tested are set out in Table IX.

TABLE IX.—*Composition of Malleable Irons Tested by Simmons, Rosenthal and Lorig.*

Mark.	Type.	Chemical Composition, per cent.				
		T.C.	Si.	Mn.	S.	P.
A	Standard ..	2.30	1.05	0.302	0.084	0.162
B	Standard ..	2.33	0.98	0.34	0.078	0.168
C	Short cycle ..	2.32	1.31	0.41	0.092	0.071
D	Short cycle ..	2.38	1.40	0.35	0.072	0.097
G	Cupola ..	3.25	0.65	0.57	0.156	0.10
P	Pearlite ..	2.33	0.98	0.34	0.078	0.168
E	Pearlite ..	2.27	1.22	0.48	0.17	0.11
F	Pearlite ..	2.23	0.96	0.81	0.09	0.15
H	Pearlite ..	2.23	0.14	0.64	0.08	0.11

The sub-zero tests were carried out using Charpy keyhole-notched specimens of single and double width, unnotched specimens, wedge-shaped specimens and tensile impact specimens. The notched-bar toughness of all the irons decreased gradually at sub-zero temperatures. Only on iron B was this increasing brittleness shown by a sudden decrease in the double-width Charpy test-bar values, similar values in all other irons being approximately twice the values obtained from the single-width bars. Unnotched specimen values also decreased with temperature, although the loss was slight.

Impact values given by the curves for A and B materials are quoted in Table X for the notched and unnotched specimens so that the magnitude of changes involved may be appreciated.

TABLE X.—*Charpy Impact Strength of Malleable Irons at Decreasing Temperatures.*

Temp., deg. C.	Single width notched bar.		Double width notched bar.		Unnotched bar.	
	A.	B.	A.	B.	A.	B.
24	8.3	6.9	15.6	11.8	90	81
0	7.3	6.3	11.8	10.8	90	71
−18	6.3	5.2	10.1	8.1	90	71
−45	3.9	3.3	8.6	3.7*	71	63

* Sudden decrease at approximately 38 deg. C.

Other data on malleable iron are given by Schwartz,[15] who reports on a commercial malleable iron which gave 8 ft.-lb. in a Charpy test at room temperature and fell uniformly to 3 ft.-lb. at −60 deg. C. The specimens were notched.

Gillett[16] reports on a cupola malleable iron (3.05 per cent. C, 0.85 per cent. Si, 0.55 per cent. Mn, 0.15 per cent. P, and 0.15 per cent. S) which had been annealed in 30 hours at 980 deg. C. The data were as follow:—

Temperature, deg. C.	Charpy impact, ft.-lb.
Room	4
−46	3
−59	3

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PART II—EXPERIMENTAL WORK

Materials Tested

For this investigation 21 different materials have been examined. A summary of the compositions of these materials is given above in Tables XI to XV.

TABLE XI.—*Grey Cast Irons.*

Melt No.	T.C.	Si.	Mn.	S.	P.	Ni.	Cr.	Ti.	V.	Mo.	Cu.
W339	3.20	1.90	0.69	0.030	0.039						
W488	3.08	1.80	0.47	0.032	0.030						
W559	3.19	2.09	0.53	0.034	0.027						
W565	3.11	2.42	0.96	0.037	0.024		0.19	0.15	0.27		
W561	3.07	2.00	0.90	0.077	0.58						
W669	3.12	1.92	0.90	0.057	0.63						
A	3.13	2.31	0.69	0.141	0.67						
B	2.91	1.57	0.87	0.096	0.17	0.16	0.10			0.57	0.11
W842	2.89	1.68	0.54	0.063	0.041	2.13					
W779	3.79	3.06	0.63	0.020	0.037						

TABLE XII.—*Nodular Cast Irons.*

Melt No.	T.C.	Si.	Mn.	S.	P.	Ce.
W677	3.62	3.11	0.49	0.010	0.037	0.054
W755	3.65	3.06	0.44	0.003	0.033	0.070

TABLE XIII.—*Acicular Cast Irons.*

Melt No.	T.C.	Si.	Mn.	S.	P.	Ni.	Cr.	Mo.
W568	3.13	2.19	0.46	0.034	0.028	1.88		0.57
W687	3.17	2.11	0.50	0.030	0.029	1.59		0.75
W747	3.03	1.60	0.55	0.032	0.028	2.32	0.21	0.95
W772	3.06	2.18	0.46	0.036	0.038	3.10		0.54

TABLE XIV.—*Martensitic Cast Iron.*

Melt No.	T.C.	Si.	Mn.	S.	P.	Ni.
W874 ..	2.81	1.81	0.52	0.050	0.046	4.87

TABLE XV.—*Austenitic Cast Irons.*

Melt No.	T.C.	Si.	Mn.	S.	P.	Ni.	Cu.	Cr.
W335	2.95	2.64	0.60	0.025	0.035	13.93	6.36	1.06
W491	2.91	2.44	0.57	0.022	0.031	15.55	6.17	1.17
W765	2.65	2.43	0.48	0.016	0.051	15.52	8.65	1.41
W571	3.56	2.22	5.20	0.025	0.026	10.40		

Further details about these materials are given in the appropriate later sections, where the results are reported in full.

Melting Procedure

The test-bars used in this investigation were prepared either by melting in a "Salamander" crucible using an oil-fired furnace, or in a "Salamander" crucible using a coke-fired pit furnace. The oil furnace was used for the preparation of the 1.2 in. dia. test-bars, and in each case the charge weighed 270 lb., and from each melt five 50-lb. taps were taken. For the pit furnace melts, the charge weighed 60 lb. The charges for all the melts consisted of mixtures of pig iron and steel scrap, together with the appropriate alloys. In certain cases the material was inoculated before casting, and details of this treatment are given with the detailed presentation of the results in a later section. The two pearlitic grey cast irons A and B were prepared in an industrial foundry and represent cupola-melted metal.

Casting Procedure

In the case of oil-furnace melts, five taps of 50 lb. were taken, from each of which five 16 in. long 1.2 in. bars were cast. The bars had large feeding heads and were cast shorter than the standard length to ensure soundness. Test-bars of materials A and B prepared in an industrial foundry, were standard 1.2 in. dia. bars each 21 in. long. From each pit-furnace melt, eighteen 0.875 in. bars each 15 in. long were cast. All the test-bars except those of materials A and B were top run in green-sand moulds; A and B were bottom-run.

(A) Tests at Room Temperature without Treatment at Low Temperature

Transverse.—From the oil-furnace melts, one bar of each tap was tested in transverse on 15-in. centres. Materials A and B were tested on the standard 18 in. centres. In the case of the pit-furnace melts, the first and last 0.875 in. dia. bars to be cast were tested in transverse on 12-in. centres.

Tensile.—The bottom half of each transverse test-bar was used to prepare a tensile test-bar having a gauge length dia. of 0.798 in. in the case of the 1.2 in. bars, and 0.564 in. in the case of the 0.875 in. bars.

Charpy Impact.—Charpy impact test-bars were machined from the top half of each of the transverse bars. These test-pieces were unnotched bars, 4 in. long, tested on a 3-in. span, and they were of circular section. Usually, the Charpy impact test-pieces were 5/8 in. dia., but in some cases the material could not be broken, and then a 3/8 in. dia. bar was used.

Brinell Hardness Tests.—Brinell hardness tests were carried out on the shoulders of the tensile test-bars.

In presenting the results of these tests carried out at room temperature, average values have been reported for each melt. In some cases the average value obtained for the Charpy tests have been based on more than the two or five specimens obtained from the broken transverse bars, as and when spare bars were left over from the low-temperature tests. This is also the case for the tensile results on the 1.2 in. dia. bars.

(B) Tests at Low Temperatures

Tensile.—A schematic representation of the apparatus is shown in Fig. 1. Oxygen gas is passed into the valve system at A and is used to force the liquid oxygen contained in the Dewar flask up the delivery tube to the two compartments of

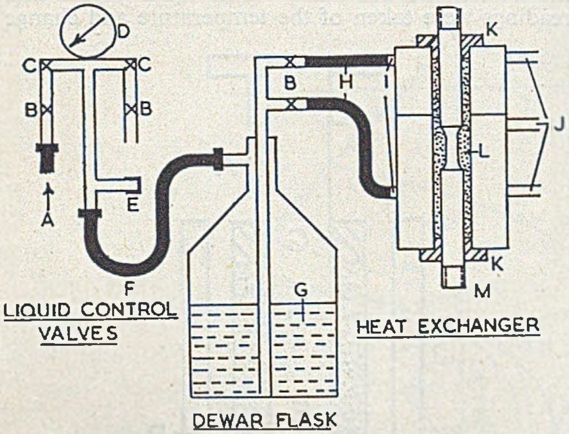

FIG. 1.—*Tensile-testing Equipment.*

A.—Oxygen Supply from Cylinder.
B—On/off Valves.
C—Fine-adjustment Valves.
D—Pressure Gauge.
E—Rubber Safety Valve.
F—Armoured Flexible Hose.
G—Liquid Oxygen.
H—Rubber Tubing.
I—Inlet Tubes.
J—Outlet Tubes.
K—Sindanyo Locating Pieces.
L—Mixture of Copper and Aluminium Filings.
M—Tensile Test-piece.

the heat exchanger. The liquid reaching the heat exchanger evaporates, thus cooling the specimen. The copper and aluminium filings surrounding the test specimen allow the quick transfer of heat from the specimen, thus temperature gradients along the specimen were quickly removed. The heat transference when there was only air between the specimen and heat exchanger was found to be very slow. The two compartments in the heat exchanger enabled temperature gradients along the length of the specimen to be quickly removed.

The control valve system was arranged so that the flow of liquid to the heat exchanger could be quickly stopped by opening the valve to the atmosphere. An excessive back pressure from the Dewar flask was shown on the pressure gauge and could be quickly released by opening the valve to the atmosphere. As a further precaution a safety valve, made of sheet rubber, was included to break at 15 lb. per sq. in. pressure. A pressure above that of the oxygen gas supply can build up because the liquid oxygen itself is continually evaporated from the surface.

Holes ⅛ in. dia. were drilled to the centre of each shank of the test-piece from opposite sides

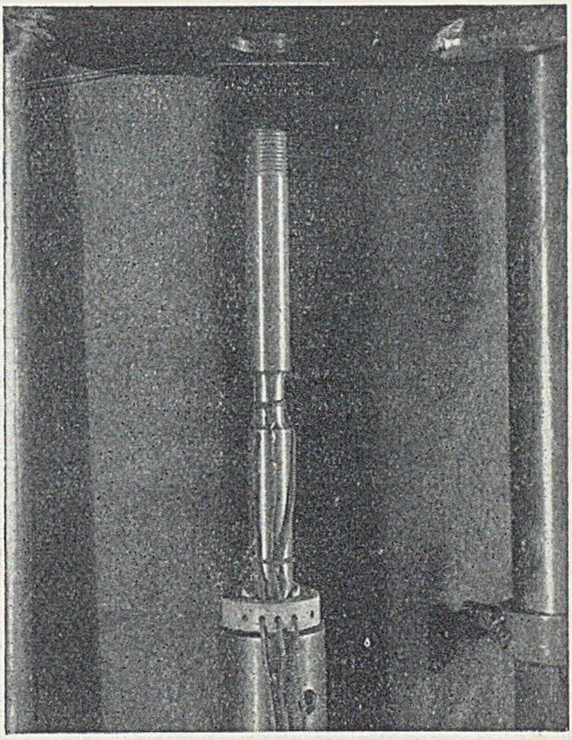

FIG. 2.—*Tensile Specimen with Thermocouples attached.*

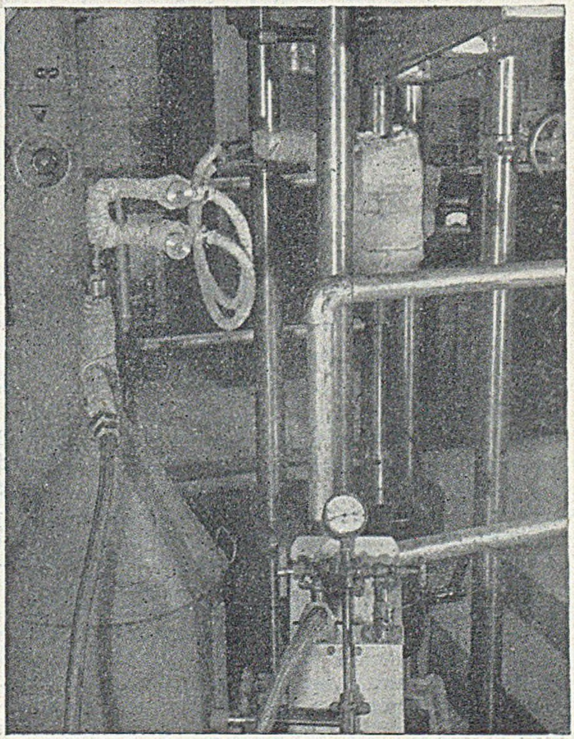

FIG. 3.—*Apparatus assembled for a Tensile Test.*

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of the specimen and were used to hold thermocouples. A third thermocouple was held at the centre of the gauge length. The arrangement of the thermocouples around the specimen is shown in Fig. 2. Fig. 3 shows a photograph of the assembled apparatus. All the tests were carried out on a 50-ton capacity Avery hydraulic testing machine. For measuring the temperature in these tests, as with all other low temperature tests reported here, copper/constantan thermocouples were used.

Tensile tests were only carried out at low temperatures on test-pieces machined from the 1.2-in. dia. bars. From each material from which 1.2-in. bars were available, ten low-temperature tensile specimens were machined having a gauge length of 1 in. and a dia. at the gauge length of 0.798 in. These bars were tested at temperatures between room temperature and approximately −100 deg. C.

Impact Tests.—The apparatus used for cooling the impact specimens is shown in Fig. 4. The cooling bath consisted of a double-walled vessel

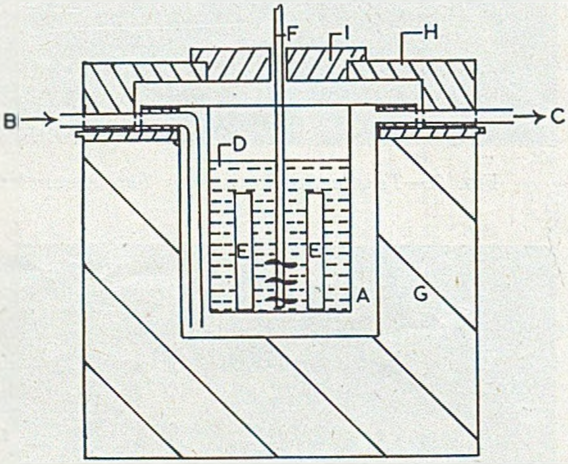


FIG. 4.—*Cooling Bath for Impact-testing Equipment.*

A—Heat Exchanger made of 16 s.w.g. Copper.
B—Inlet Pipe for Liquid Oxygen.
C—Outlet for Oxygen Gas.
D—Petroleum Ether.
E.—Charpy Impact Specimens.
F—Stirring Device driven by an Electric Motor.
G—Aluminium Vessel containing Asbestos Wool.
H—Sindanyo Top.
I—Sindanyo Split Lid to enable Specimens to be Removed.

containing petroleum ether. Liquid oxygen entered the space between the walls of this vessel and cooled the petroleum ether. The impact specimens were immersed in the petroleum ether which was continuously stirred. By varying the quantity of liquid oxygen entering the annular space, the temperature of the petroleum ether could be controlled.

When the required temperature had been reached, the split lid of the bath was removed and the specimens were quickly transferred to the Charpy machine by means of tongs. No appreciable change in temperature was detected in the specimen during the 5 sec. necessary to remove it from the bath and break it in the machine, and so the temperature of the bath was taken as the temperature at breaking. The Charpy machine used had a capacity of 50 ft.-lb. The impact-test specimens were of the same dimensions as those used for testing at room temperature.

Dilatometric Tests.—The dilatometric tests carried out at low temperatures entailed the use of a "Gale"-type dilatometer. The specimen in each case was 2 in. long and ½ in. dia. The specimen was contained in a silica tube and was connected to a dial gauge by means of another silica tube. Changes in length of the specimen were recorded on the dial gauge. All the irons were first tested by the following procedure: The outer silica tube of the dilatometer was immersed in liquid oxygen and readings were taken of the temperature and change

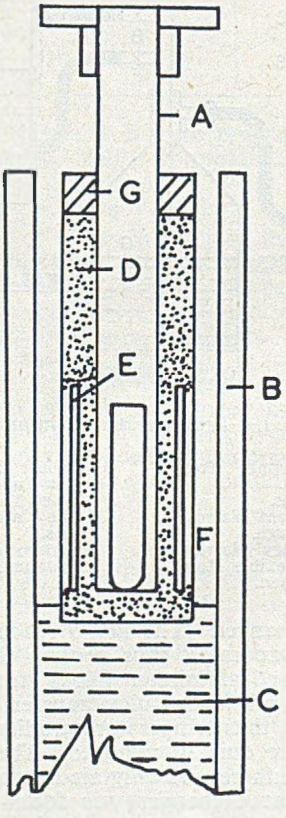


FIG. 5.—*Dilatometer.*

A—Dilatometer Tube with Specimen in Position.
B—Dewar Vessel.
C—Liquid Oxygen.
D—Asbestos Wool.
E—Copper Tube Concentric with Dilatometer Tube.
F—Silica Tube.
G—Rubber Tubing.

in length. When the temperature reached approximately −180 deg. C. the dilatometer tube was removed from the Dewar vessel containing the liquid air and it was then immersed in asbestos wool so that the temperature rose slowly. Again the readings of temperature and change in dimensions were taken.

For pearlitic grey cast irons and nodular cast irons which showed no phase transformation on cooling, this completed the dilatometric study at low temperatures. This testing procedure was carried out mainly for the purpose of determining whether any phase changes occurred. However, the actual coefficients of expansion obtained whilst the specimen was heated up are reported in detail for a few of the pearlitic grey cast irons and for all the other materials. (Whilst cooling down to −180 deg. C. took place very rapidly, the specimens heated up only very slowly so the results obtained on heating are more dependable.)

When a phase change was detected by an inflection in the dilatation curve with falling temperature, a further more reliable test was carried out in order to locate more exactly the temperature at means a fairly accurate curve was obtained for the change in dimensions on cooling and the temperatures at which phase changes occurred was accurately located. For the materials which showed the phase change the coefficient of thermal expansion on cooling is determined by this method and on warming to room temperature by the first method. These results, together with the temperature of the structural changes are given, together with the other dilatation results.

The low-temperature dilatation curves for each of the acicular and martensitic materials are shown in Fig. 6. Since it was not possible to reach temperatures below −100 deg. C. in a reasonable time

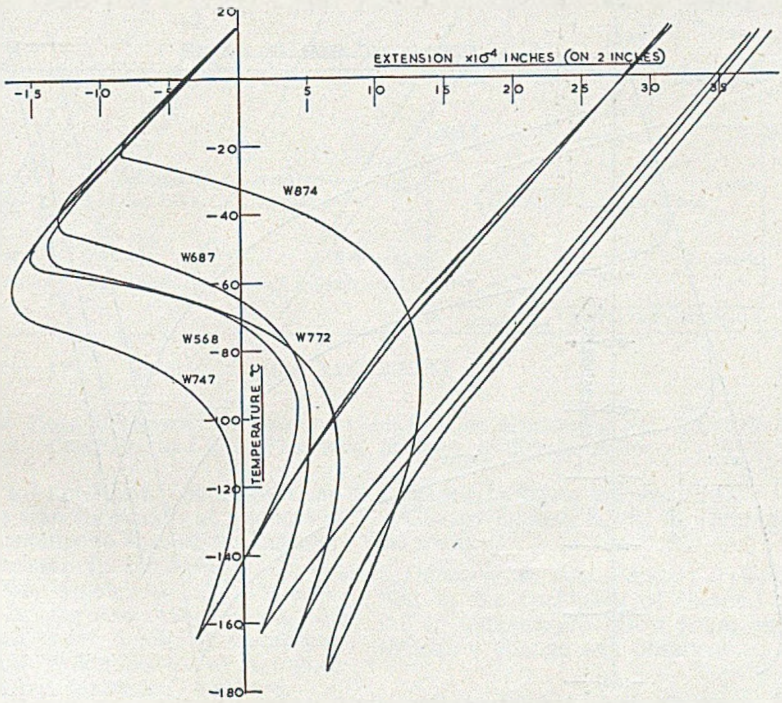


FIG. 6.—*Dilatometric Tests on Acicular and Martensitic Materials.*

W568, W687, W747, W772 } Acicular. W874—Martensitic

which the transformation took place and the magnitude of the change in dimensions resulting from it. The phase change occurred at low temperatures in all the austenitic, acicular and martensitic irons.

For these more accurate dilatometric tests at low temperatures the apparatus shown in Fig. 5 was used. The purpose of this arrangement was to reduce the temperature gradient on cooling by reducing the rate of cooling. This was accomplished by surrounding the dilatometer tube by another silica tube of approximately 2 in. dia. and filling the space with a material such as asbestos wool or alumina powder. In addition, the dilatometer tube was also surrounded for the length of the specimen with a copper tube, as is shown in Fig. 5. By this by the slow cooling method, and also because a continuous curve was required, the results in Fig. 6 have been obtained by using the rapid cooling method and the temperature gradients have been neglected. It will be seen that the quoted temperatures of the structural change (which are taken from the slow cooling method) differ slightly from those given in Fig. 6.

The temperatures of the structural changes varied between −48 deg. C. and −64 deg. C. for the acicular materials. For the martensitic material the change occurred at −26 deg. C.

The results of the dilatometric tests at low temperatures for the austenitic materials are shown in Fig. 7. The results were obtained using the rapid cooling method. The Nomag-type material W571 showed no change until about −170 deg. C., but it was not found possible to investigate this in any great detail because of the difficulty in reaching these low temperatures by the slow cooling method. The phase change in the Ni-Resist type of materials occurred at widely different temperatures.

The Ni-Resist type materials tested and described in this part of the Paper have higher silicon contents and lower chromium and manganese contents than are usual in commercially produced Ni-Resist. This is referred to in the Appendix. The present results indicate the danger in raising the silica and lowering the manganese and chromium contents if a Ni-Resist austenitic iron is required to be stable at low temperatures.

(C) Tests at Room Temperature after Treatment at Low Temperature

Tensile.—A few tensile tests were carried out at room temperature on materials which had been previously subjected to low-temperature heat-treatment. Details of these are given in the appropriate section of the reported results.

Impact.—Impact tests were carried out at room temperature, with the exception of the austenitic material W335, on specimens previously subjected to low temperature treatment. These results are presented for comparison with the actual test results obtained at low temperature.

Brinell Hardness Tests.—Brinell hardness tests were carried out on the broken halves of the impact specimens tested at low temperatures on all materials.

(D) Tests at High Temperatures

Dilatometric Tests.—Dilatometric tests were carried out on all materials at temperatures up to 200 deg. C. In the case of the pearlitic grey cast irons, these results are reported in a few instances.

The acicular, martensitic and austenitic materials were tested in the dilatometer, both in the as-cast condition and after treatment at low temperatures. A number of these materials were tested to temperatures above 200 deg C. The results of these high-temperature tests are shown in Fig. 8. The acicular and martensitic materials showed a transformation on heating at approximately 450 deg. C. The change in dimensions consequent upon this phase change was greater in the materials which had been treated at low temperature than in the as-cast materials, as is shown in the enlarged portions of the graphs given to the right of the diagram in Fig. 8. The coefficients of expansion of the material below this temperature are greater in the case of the as-cast materials than the treated materials. It is interesting to note that the austenitic material W335, which showed considerable

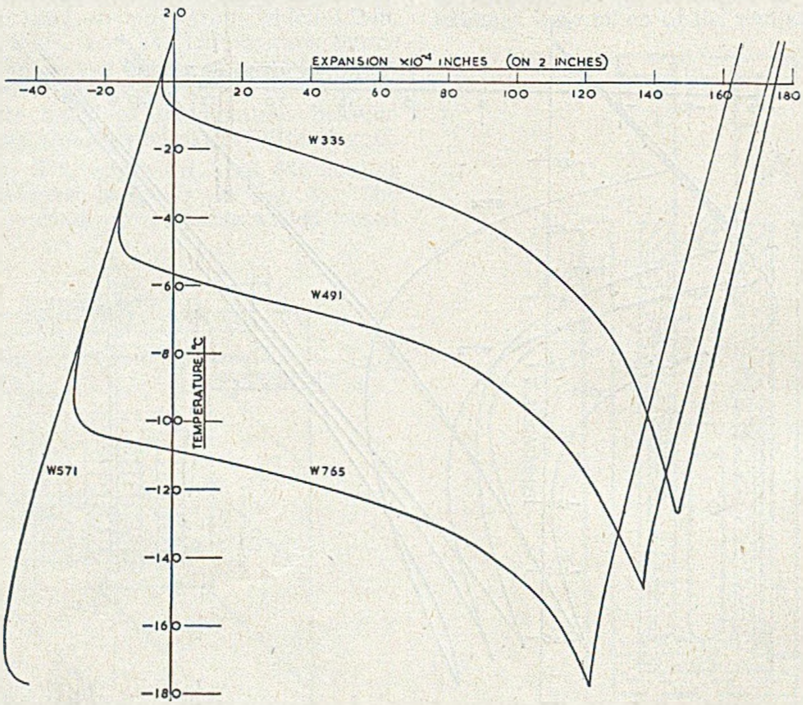


FIG. 7.—*Dilatometric Tests on Austenitic Materials.*

W335, W491, W765 } Nickel-copper-chromium. W571—Nickel-manganese.

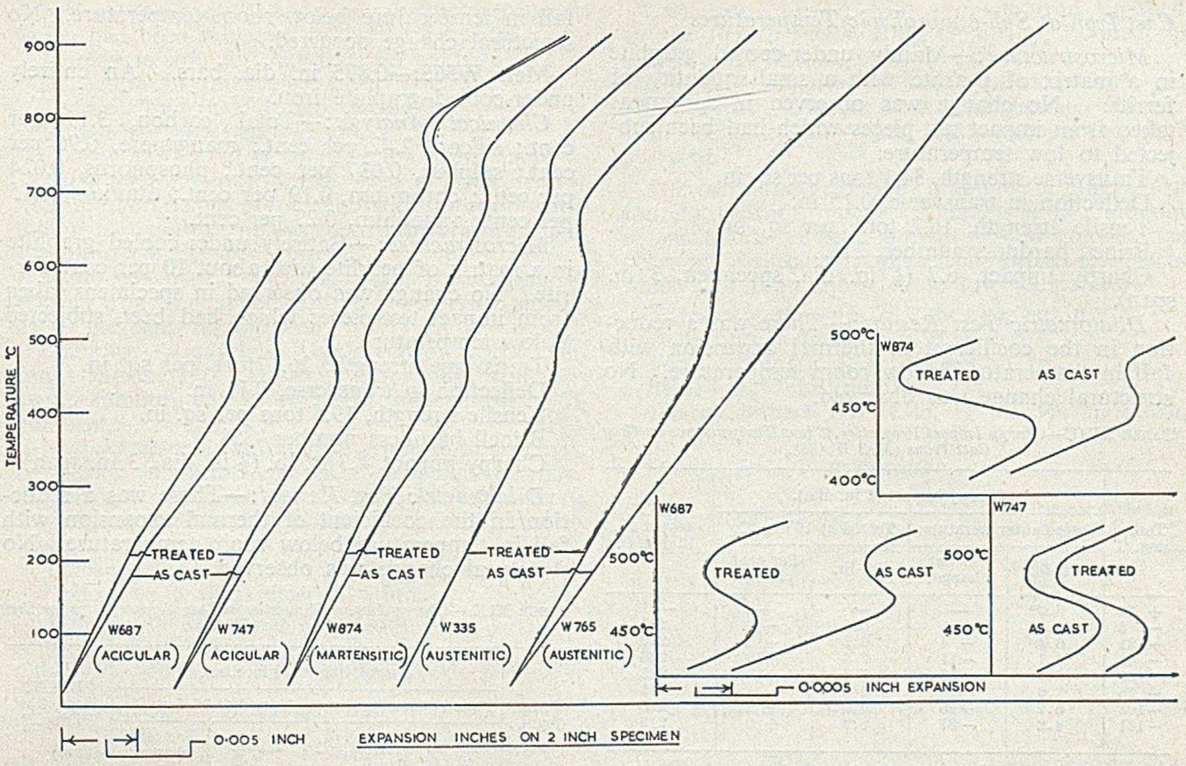


FIG. 8.—*Dilatometric Tests at Elevated Temperatures on Acicular, Martensitic and Austenitic Irons in As-cast Condition and after Treatment at Sub-zero Temperatures.*

transformation due to the low-temperature treatment, shows a phase transformation at about 450 deg. C. in a similar manner to that of the acicular and martensitic materials. In the case of the austenitic material W765, which was not so completely transformed by the low temperature, the phase change beginning at about 450 deg. C. merged into the phase change which occurs at a higher temperature in the other materials illustrated.

SUMMARIES OF MECHANICAL TEST RESULTS WITH DETAILS OF MATERIALS

(A)—Grey Cast Irons

Melt W339:—1.2 in. dia. bars, inoculated with 0.5 per cent. silicon as 80 per cent. ferro-silicon.

Chemical Analysis:—Total carbon, 3.20 per cent.; silicon, 1.90 per cent.; manganese, 0.69 per cent.; sulphur, 0.030 per cent.; phosphorus, 0.039 per cent.

Microstructure:—Medium flake graphite in a matrix of pearlite with a trace of ferrite. No change was observed in specimens taken from impact test-pieces which had been subjected to low temperature.

Transverse strength (on 18 in. centres), 29.5 tons per sq. in.

Deflection in transverse (on 18 in. centres), 0.23 in.

Tensile strength, 16.5 tons per sq. in.

Brinell hardness number, 207.

Charpy impact, 8.3 ft. lb. (⅝ in. dia. specimen, 3 in. span).

Dilatometric Test Results:—There was a reduction in the coefficient of thermal expansion with fall in temperature below room temperature. No structural change was observed.

TABLE XVI.—*Tensile and Impact Properties at Low Temperatures on Grey Cast Irons (Melt W.339).*

Temp., deg. C.	Tensile. Tested at temp. Tons per sq. in.	Tensile. Tested at temp. Per cent. change.	Temp., deg. C.	Impact (⅝ in. dia.). Tested at temp. Ft.-lb.	Impact (⅝ in. dia.). Tested at temp. Per cent. change.	B.H.N. tested at 16 deg. C.
+ 16	16.5†	—	+ 16	8.3*	—	—
− 5	15.5	− 6	− 1	8.1	− 2	200
− 19	17.0	+ 3	− 18	6.8	−18	197
− 23	17.8	+ 8	− 47	7.9	− 5	197
− 42	17.8	+ 8	− 54	7.2	−13	198
− 66	17.9	+ 8	− 72	6.2	−25	195
− 83	17.8	+ 8	−100	5.3	−36	197
− 93	18.2	+10	−114	5.7	−31	198
−111	18.4	+12				

* Average of five results. † Average of seven results.

Melt W488:—1.2 in. dia. bars, inoculated with 0.5 per cent. silicon as 80 per cent. ferro-silicon.

Chemical Analysis:—Total carbon, 3.08 per cent.; silicon, 1.80 per cent.; manganese, 0.47 per cent.; sulphur, 0.032 per cent.; phosphorus, 0.030 per cent.

Cast Iron at Sub-atmospheric Temperatures

Microstructure:—Mainly under-cooled graphite in a matrix of pearlite with a small quantity of ferrite. No change was observed in specimens taken from impact test-pieces which had been subjected to low temperature.

Transverse strength, 34.1 tons per sq. in.
Deflection in transverse, 0.15 in.
Tensile strength, 16.2 tons per sq. in.
Brinell hardness number, 213.
Charpy impact, 6.7 ($\frac{5}{8}$ in. dia. specimen, 3 in. span).

Dilatometric Test Results:—There was a reduction in the coefficient of thermal expansion with fall in temperature below room temperature. No structural change was observed.

TABLE XVII.—*Charpy Impact Properties at Low Temperatures on Grey Cast Irons (Melt W 488).*

Temp. deg. C.	Charpy impact ($\frac{5}{8}$ in. dia.). Tested at temperature. Ft.-lb.	Tested at temperature. Per cent. change.	Tested at 16 deg. C. Ft.-lb.	Tested at 16 deg. C. Per cent. change.	B.H.N. tested at 16 deg. C.
+ 16	6.7*	—	—	—	—
− 3	6.1	−11	6.6	− 1	211
− 21	6.4	− 4	6.2	− 7	202
− 43	6.1	−11	7.4	+10	226
− 59	5.7	−15	7.4	+10	222
− 75	5.6	−16	6.6	− 1	211
−104	5.7	−15	6.8	+ 1	215
−141	4.2	−37	6.7	+ 0	219

* Average of five results.

Melt W559:—0.875 in. dia. bars, inoculated with 0.5 per cent. silicon as 80 per cent. ferro-silicon.

Chemical Analysis:—Total carbon, 3.19 per cent.; silicon, 2.09 per cent.; manganese, 0.53 per cent.; sulphur, 0.034 per cent.; phosphorus, 0.027 per cent.

Microstructure:—Medium fine flake graphite and a little under-cooled graphite in a matrix of pearlite. There was a small amount of ferrite associated with the graphite. No change was observed in specimens taken from impact test-pieces which had been subjected to low temperatures.

Transverse strength, 29.0 tons per sq. in.
Deflection in transverse, 0.16 in.
Tensile strength, 16.4 tons per sq. in.
Brinell hardness number, 217.
Charpy Impact, 6.5 ft. lb. ($\frac{5}{8}$ in. dia., 3 in. span).

Dilatometric Test Results:—There was a reduction in the coefficient of thermal expansion with fall in temperature below room temperature. No structural change occurred.

TABLE XVIII.—*Charpy Impact Properties at Low Temperatures for Grey Cast Irons (Melt W.559).*

Temp. deg. C.	Charpy impact ($\frac{5}{8}$ in. dia.). Tested at temperature. Ft.-lb.	Tested at temperature. Per cent. change	Tested at 16 deg. C. Ft.-lb.	Tested at 16 deg. C. Per cent. change.	B.H.N. tested at 16 deg. C.
+ 16	6.5*	—	—	—	217
− 2	5.7	−12	6.1	− 6	213
− 25	5.9	− 9	7.2	+11	214
− 38	5.8	−11	6.9	+ 6	219
− 64	6.4	− 2	6.2	− 5	221
− 71	6.2	− 5	6.5	0	211
−106	5.1	−22	6.0	− 8	219
−109	4.7	−28	6.4	− 2	225

* Average of four results.

Melt W565:—0.875 in. dia. bars. An entirely under-cooled graphite iron.

Chemical Analysis:—Total carbon, 3.11 per cent.; silicon, 2.42 per cent.; manganese, 0.96 per cent.; sulphur, 0.037 per cent.; phosphorus, 0.024 per cent.; chromium, 0.19 per cent.; titanium, 0.15 per cent.; vanadium, 0.27 per cent.

Microstructure:—Entirely under-cooled graphite in a matrix of pearlite with about 10 per cent. ferrite. No change was observed in specimens taken from impact test-pieces which had been subjected to low temperature.

Transverse strength, 26.1 tons per sq. in.
Deflection in transverse, 0.11 in.
Tensile strength, 19.5 tons per sq. in.
Brinell hardness number, 258.
Charpy impact, 4.3 ft. lb. ($\frac{5}{8}$ in. dia., 3 in. span).

Dilatometric Test Results:—There was a reduction in the coefficient of thermal expansion with fall in temperature below room temperature. No structural change was observed.

TABLE XIX.—*Charpy Impact Properties at Low Temperatures for Grey Cast Irons (Melt W.565).*

Temp. deg. C.	Charpy impact ($\frac{5}{8}$ in. dia.). Tested at temperature. Ft.-lb.	Tested at temperature. Per cent. change.	Tested at 16 deg. C. Ft.-lb.	Tested at 16 deg. C. Per cent. change.	B.H.N. tested at 16 deg. C.
16	4.3*	—	—	—	—
− 1	4.4	+ 2	4.4	+ 2	257
− 23	4.5	+ 5	3.8	−12	256
− 40	4.2	− 2	4.9	+14	263
− 62	3.8	−12	4.9	+14	256
− 77	3.8	−12	4.2	− 2	255
− 90	3.8	−12	4.5	+ 5	262
−111	4.0	− 7	4.3	0	262

* Average of eight results.

Melt W561:—0.875 in. dia. bars, medium-phosphorous iron, inoculated with 0.5 per cent. of silicon as 80 per cent. ferro-silicon.

Chemical Analysis:—Total carbon, 3.07 per cent.; silicon, 2.00 per cent.; manganese, 0.90 per cent.; sulphur, 0.077 per cent.; phosphorus, 0.58 per cent.

Microstructure:—Medium fine flake graphite in a matrix of pearlite. There is a fair amount of phosphide eutectic present. No change was ob-

TABLE XX.—*Charpy Impact Properties at Low Temperatures of Grey Cast Irons (Melt W.561).*

Temp. deg. C.	Charpy impact ($\frac{5}{8}$ in. dia.). Tested at temperature. Ft.-lb.	Tested at temperature. Per cent. change.	Tested at 16 deg. C. Ft.-lb.	Tested at 16 deg. C. Per cent. change.	B.H.N. tested at 16 deg. C.
+ 16	4.1*	—	—	—	—
0	4.1	0	4.3	+ 5	246
− 20	3.7	−10	4.2	+ 2	245
− 40	3.4	−17	4.3	+ 5	244
− 57	3.2	−22	4.4	+ 7	246
− 76	3.2	−22	4.0	− 2	246
− 90	3.1	−24	3.7	−10	244
−105	3.0	−27	4.3	+ 5	252

* Average of eight results.

served in specimens taken from impact test-pieces which had been subjected to low temperature.

Transverse strength, 25.8 tons per sq. in.
Deflection in transverse, 0.13 in.
Tensile strength, 18.1 tons per sq. in.
Brinell hardness number, 259.
Charpy impact, 4.1 ft. lb. ($\frac{5}{8}$ in. dia., 3 in. span).

Dilatometric Test Results:—There was a reduction in the coefficient of thermal expansion with fall in temperature below room temperature. No structural change was observed.

Melt W669:—1.2 in. dia. bars, medium-phosphorus iron, inoculated with 0.5 per cent. silicon as 80 per cent. ferro-silicon.

Chemical Analysis:—Total carbon, 3.12 per cent.; silicon, 1.92 per cent.; manganese, 0.90 per cent.; sulphur, 0.057 per cent.; phosphorus, 0.63 per cent.

Microstructure:—Fine flake graphite in a matrix of pearlite with a fair amount of phosphide eutectic. No change was observed in specimens taken from the impact test-pieces which had been subjected to low temperature.

Transverse strength, 29.3 tons per sq. in.
Deflection in transverse, 0.14 in.
Tensile strength, 16.3 tons per sq. in.
Brinell hardness number, 255.
Charpy impact, 3.6 ft.-lb. ($\frac{5}{8}$ in. dia. specimen, 3 in. span).

Dilatometric Test Results:—

Temperature range, deg. C.	Coefficient of thermal expansion per deg. C. × 10^{-6}.
0 to 200	10.5
−25 to 0	10.1
−50 to −25	9.1
−75 to −50	8.5
−100 to −75	8.0

No structural change was observed on cooling.

Cast Iron (A):—A flake graphite iron supplied by the British Piston Ring Company, Limited, in standard 1.2 in. dia. bars.

Chemical Analysis:—Total carbon, 3.13 per cent.; silicon, 2.31 per cent.; manganese, 0.69 per cent.; sulphur, 0.141 per cent.; phosphorus, 0.67 per cent.

Microstructure:—Flake graphite in an almost entirely pearlitic matrix. There is a fair amount of phosphide eutectic present. No change was observed in specimens taken from impact test-pieces which had been subjected to low temperature.

Transverse strength, 28.2 tons per sq. in.
Deflection in transverse, 0.18 in.
Tensile strength, 17.4 tons per sq. in.
Brinell hardness number, 244.
Charpy impact, 4.6 ft.-lb. ($\frac{5}{8}$ in. dia. specimen, 3 in. span).

Dilatometric Test Results:—

Temperature range, deg. C.	Coefficient of thermal expansion per deg. C. × 10^{-6}.
140 to 200	13.0
0 to 140	10.2
−25 to 0	10.0
−50 to −25	9.5
−75 to −50	8.2
−100 to −75	7.5

No structural change was observed at low temperatures.

Cast Iron (B):—A good-quality engineering iron supplied by the British Piston Ring Company, Limited, in standard 1.2 in. dia. bars.

Chemical Analysis:—Total carbon, 2.91 per cent.; silicon, 1.57 per cent.; manganese, 0.87 per cent.; sulphur, 0.096 per cent.; phosphorus, 0.17

TABLE XXI.—*Tensile and Charpy Impact Properties at Low Temperature on Grey Cast Irons (Melt W.669).*

Temp. deg. C.	Tensile.		Temp. deg. C.	Charpy impact ($\frac{5}{8}$ in. dia.).				B.H.N. tested at 16 deg. C.
	Tested at temperature.			Tested at temperature.		Tested at 16 deg. C.		
	Tons per sq. in.	Per cent. change.		Ft.-lb.	Per cent. change.	Ft.-lb.	Per cent. change.	
+16	16.3*	—	+16	3.6*	—	—	—	239
−16	15.4	−6	−1	3.6	0	3.3	−8	—
−32	15.8	−3	−19	3.0	−17	3.7	+3	240
−54	16.4	+1	−43	3.1	−14	4.2	+17	242
−98	17.0	+4	−62	3.1	−14	3.8	+6	236
			−76	3.2	−11	4.1	+14	237
			−89	2.9	−19	4.0	+11	239
			−107	3.0	−17	3.9	+8	240

* Average of five results. † Average of eight results.

TABLE XXII.—*Tensile and Charpy Impact Properties at Low Temperature of Grey Cast Irons (A).*

Temp. deg. C.	Tensile.		Temp. deg. C.	Charpy impact ($\frac{5}{8}$ in. dia.).				B.H.N. tested at 16 deg. C.
	Tested at temperature.			Tested at temperature.		Tested at 16 deg. C.		
	Tons per sq. in.	Per cent. change.		Ft.-lb.	Per cent. change.	Ft.-lb.	Per cent. change.	
+ 16	17.4*	—	+ 16	4.0*	—	—	—	240
− 6	17.7	+ 2	− 1	4.3	− 7	4.4	− 4	240
− 21	18.4	+ 6	− 19	4.1	−11	4.8	+ 4	234
− 48	18.4	+ 6	− 45	3.4	−26	4.9	+ 7	232
− 63	18.8	+ 8	− 64	3.7	−20	4.9	+ 7	232
− 86	18.3	+ 5	− 76	3.3	−28	4.1	−11	232
−110	19.3	+11	−106	3.3	−28	4.0	−13	235
			−129	3.2	−30	4.2	− 9	235

* Average of three results. † Average of eight results.

Cast Iron at Sub-atmospheric Temperatures

per cent.; nickel, 0.16 per cent.; chromium, 0.10 per cent.; molybdenum, 0.57 per cent.; copper, 0.11 per cent.

Microstructure:—Medium flake graphite in a matrix of pearlite. There are small areas of phosphide eutectic. No change was observed in specimens taken from impact test pieces which had been subjected to low temperature.

Transverse strength, 33.6 tons per sq. in.
Deflection in transverse, 0.19 in.
Tensile strength, 23.0 tons per sq. in.
Brinell hardness number, 267.

Dilatometric Test Results:—

Temperature range, deg. C.	Coefficient of thermal expansion per deg. C. × 10^{-6}.
0 to 200	10.6
−25 to 0	10.7
−50 to −25	10.0
−75 to −50	9.1
−100 to −75	8.4

No structural change was observed.

in specimens taken from impact test-pieces which had been subjected to low temperature.

Transverse strength, 33.1 tons per sq. in.
Deflection in transverse, 0.20 in.
Tensile strength, 21.7 tons per sq. in.
Brinell hardness number, 252.
Charpy impact, 7.4 ft.-lb. ($\frac{5}{8}$ in. dia. specimen, 3 in. span).

Dilatometric Test Results:—

Temperature range, deg. C.	Coefficient of thermal expansion per deg. C. × 10^{-6}.
0 to 200	10.6
−25 to 0	10.1
−50 to −25	9.7
−75 to −50	8.7
−100 to −75	6.6

No structural change was observed.

A tensile bar held at −87 deg. C. for 15 min. and tested at 19 deg. C. had a breaking stress of 20.3 tons per sq. in.

Melt W779:—1.2 in. dia. bars, inoculated, with

TABLE XXIII.—*Tensile and Charpy Impact Properties at Low Temperature of Grey Cast Irons (B).*

Temp. deg. C.	Tensile. Tested at temperature. Tons per sq. in.	Tensile. Tested at temperature. Per cent. change.	Temp. deg. C.	Charpy impact ($\frac{5}{8}$ in. dia.). Tested at temperature. Ft.-lb.	Charpy impact. Tested at temperature. Per cent. change.	Charpy impact. Tested at 16 deg. C. Ft.-lb.	Charpy impact. Tested at 16 deg. C. Per cent. change.	B.H.N. tested at 16 deg. C.
16	23.0*	—	16	7.6†	—	—	—	259
− 5	23.2	+ 1	0	7.0	− 8	6.8	−11	263
− 20	23.4	+ 2	− 18	7.4	− 3	6.3	−17	266
− 45	23.6	+ 3	− 37	6.7	−12	6.4	−16	259
− 57	23.0	0	− 56	5.2	−32	6.4	−16	259
− 92	23.6	+ 3	− 76	6.4	−16	7.8	+ 3	266
−100	22.7	− 1	− 92	5.8	−24	8.5	+12	263
−118	26.4	+15	−135	4.7	−38	9.0	+18	—
−120	26.2	+14	−183	3.5	−54	7.8	+ 3	260

* Average of two results. † Average of seven results.

TABLE XXIV.—*Tensile and Charpy Impact Properties at Low Temperature of Grey Cast Irons (Melt W.842).*

Temp. deg. C.	Tensile. Tested at temperature. Tons per sq. in.	Tensile. Tested at temperature. Per cent. change.	Temp. deg. C.	Charpy impact ($\frac{5}{8}$ in. dia.). Tested at temperature. Ft.-lb.	Charpy impact. Tested at temperature. Per cent. change.	Charpy impact. Tested at 20 deg. C. Ft.-lb.	Charpy impact. Tested at 20 deg. C. Per cent. change.	B.H.N. tested at 20 deg. C.
19	21.7*	—	20	7.4†	—	—	—	235
0	22.4	+3	0	6.6	−11	6.6	−11	231
−23	21.3	−2	−24	7.2	− 3	7.0	− 5	235
−48	20.8	−4	−42	6.5	−12	6.7	− 9	239
−61	23.4	+3	−60	5.5	−26	6.1	−18	242
−73	21.7	0	−79	4.7	−37	7.2	− 3	240
−98	21.6	0	−98	4.3	−42	8.0	+ 8	236
			−125	3.5	−53	7.8	+ 5	240

* Average of seven results. † Average of nine results.

Charpy impact, 7.6 ft.-lb. ($\frac{5}{8}$ in. dia. specimen, 3 in. span).

Melt W842:—A flake-graphite iron with 2 per cent. of nickel, inoculated with 0.5 per cent. silicon as 80 per cent. ferro-silicon. 1.2 dia. bars.

Chemical Analysis:—Total carbon, 2.89 per cent.; silicon, 1.68 per cent.; manganese, 0.54 per cent.; sulphur, 0.063 per cent.; phosphorus, 0.041 per cent.; nickel, 2.13 per cent.

Microstructure:—Medium flake graphite in a matrix of fine pearlite. No change was observed

0.5 per cent. silicon as 80 per cent. ferro-silicon. The material was partly ferritic.

Chemical Analysis:—Total carbon, 3.79 per cent.; silicon, 3.06 per cent.; manganese, 0.63 per cent.; sulphur, 0.020 per cent.; phosphorus, 0.037 per cent.

Microstructure:—Medium flake graphite in a pearlitic matrix with about 30 per cent. ferrite. No change was observed in specimens taken from impact test-pieces which had been subjected to low temperature.

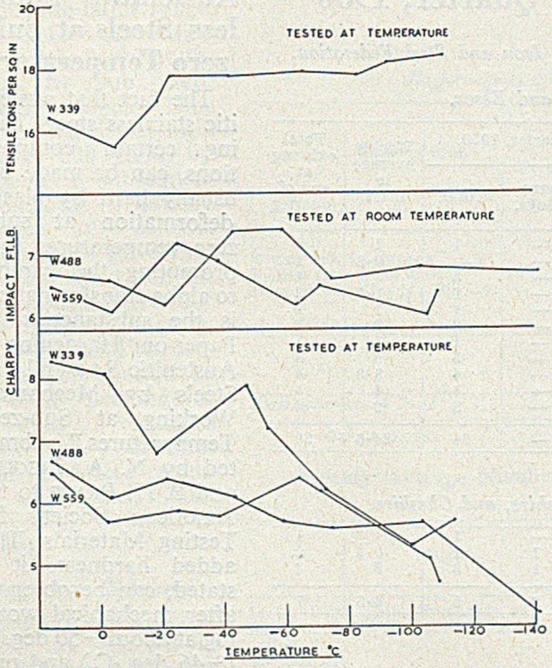


FIG. 9.—*Tensile and Impact Results on Pearlitic and Pearlitic/Ferritic Irons (Melts W*339, 488 *and* 559).

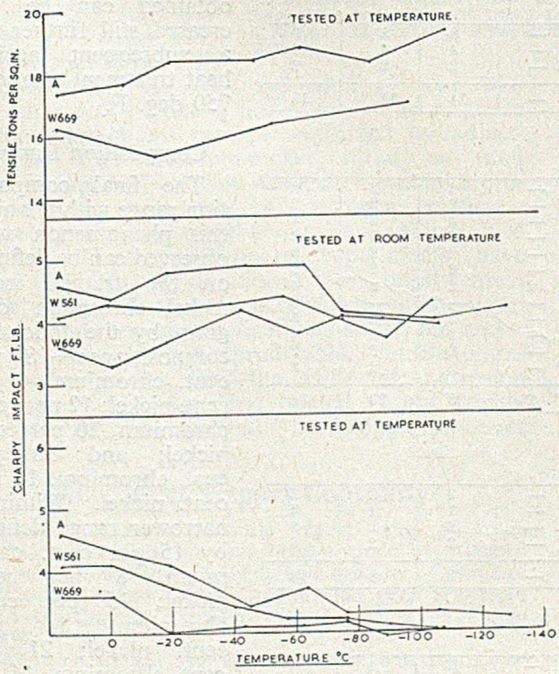


FIG. 10.—*Tensile and Impact Results (Melts W*561 *and* 669).

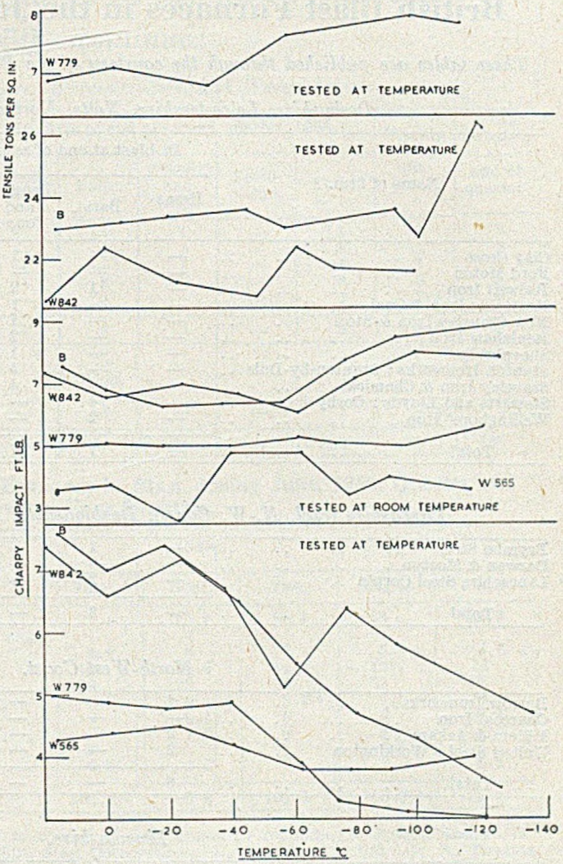


FIG. 11.—*Tensile and Impact Results (Melts W*565, 779 *and* 842).

Transverse strength, 14.7 tons per sq. in.
Deflection in transverse, 0.25 in.
Tensile strength, 6.9 tons per sq. in.
Brinell hardness number, 119.
Charpy impact, 5.0 ft.-lb. ($\frac{5}{8}$ in. dia. specimen, at 3 in. span).

Dilatometric Test Results:—

Temperature range, deg. C.	Coefficient of thermal expansion per deg. C. × 10^{-6}.
130 to 200	12.8
0 to 130	10.3
−25 to 0	10.6
−50 to −25	10.5
−75 to −50	9.2
−100 to −75	8.7

No structural change was observed.

Figs. 9, 10 and 11 show the results of the mechanical tests graphically. For this purpose the irons have been divided into three groups. Fig. 9 shows three grey irons of similar composition, Fig. 10 three medium-phosphorus grey irons, and Fig. 11 the remaining irons.

(*To be concluded.*)

British Blast Furnaces in the June Quarter, 1950

These tables are published through the courtesy of the British Iron and Steel Federation.

Name of firm.	In blast at end of second quarter, 1950.					Weekly average in blast.	Total existing at end of quarter
	Hematite.	Basic.	Foundry and forge.	Ferro-alloys.	Total.		
Derbyshire, Leicestershire, Notts, Northants, and Essex.							
Clay Cross	—	—	1	—	1	1	2
Ford Motor	—	—	—	—	—	0·8	1
Holwell Iron	—	1	2	—	3	3	4
Kettering Iron & Coal	—	—	1	—	1	1·5	2
New Cransley Iron & Steel	—	—	1	—	1	1	2
Renishaw Iron	—	—	2	—	2	2	2
Sheepbridge	—	—	1	—	1	1	1
Stanton Ironworks: Stanton-by-Dale	—	—	5	—	5	5	5
Staveley Iron & Chemical	—	—	4	—	4	3·3	4
Stewarts and Lloyds: Corby	—	4	—	—	4	4	4
Wellingboro' Iron	—	2	—	—	2	2	3
Total	—	7	17	—	24	24·6	30
Lancashire (excl. N.-W. Coast), Denbighshire, Flintshire, and Cheshire.							
Brymbo Steel	—	1	—	—	1	1	1
Darwen & Mostyn	—	—	—	1	1	0·5	2
Lancashire Steel Corp'n	—	2	—	1	3	3	4
Total	—	3	—	2	5	4·5	7
North-West Coast.							
Barrow Ironworks	2	—	—	—	2	2	2
Charcoal Iron	—	—	—	—	—	0·8	1
Millom & Askam	2	—	—	—	2	1·8	3
United Steel: Workington	2	—	—	—	2	2	3
Total	6	—	—	—	6	6·6	9
Lincolnshire.							
Appleby-Frodingham	—	8	—	—	8	8	9
Lysaght, J.: Scunthorpe	—	3	1	—	4	4	4
Thomas, R., & Baldwins: Redbourn	—	2	—	—	2	2	2
Total	—	13	1	—	14	14	15
North-East Coast.							
Cargo Fleet Iron	—	2	—	—	2	2	2
Consett Iron	1	1	—	—	2	2	2
Dorman, Long: Acklam	—	3	—	—	3	3	4
Redcar	—	2	—	—	2	2	2
Cleveland	—	2	—	—	2	2	5
Bessemer	—	2	—	—	2	2	3
South Bank	—	—	—	2	2	2	4
Grangetown	—	—	—	—	—	—	2
Gjers, Mills & Co.	2	—	—	—	2	2	5
Pease & Partners	2	—	—	—	2	2	3
Skinningrove Iron	—	2	—	—	2	2	2
South Durham Steel & Iron	—	2	—	—	2	2	2
Total	5	16	—	2	23	23	36
Scotland.							
Bairds & Scottish Steel: Gartsherrie	1	1	1	—	3	3	5
Carron	—	—	1	—	1	1	4
Colvilles	—	2	—	—	2	2	3
Dixon's	—	1	1	—	2	2	6
Total	1	4	3	—	8	8	18
South Wales and Monmouthshire.							
Briton Ferry Works	1	—	—	—	1	1	1
Guest Keen Baldwins: Cardiff	1	2	—	—	3	3	4
Thomas, R., & Baldwins: Ebbw Vale	—	2	—	—	2	2	3
Steel Co. of Wales: Margam	—	2	—	—	2	2	2
Total	2	6	—	—	8	8	10

Austenitic Stainless Steels at Sub-zero Temperature

The fact that austenitic stainless steels, having certain compositions, can be made unusually hard by plastic deformation at sub-zero temperatures thus promoting the gamma to alpha transformation, is the substance of a Paper on "Hardening of Austenitic Stainless Steels by Mechanical Working at Sub-zero Temperatures," submitted by N. A. ZIEGLER and P. H. BRACE to the American Society for Testing Materials. This added hardness, it is stated, can be observed after mechanical working at about −50 deg. F. (−46 deg. C.) and progressively increases as the working temperature is lowered to that of liquid nitrogen (about −300 deg. F.). Hardness values thus obtained can be increased still further by a subsequent ageing heat treatment at about 750 deg. F.

Composition Range

The final composition range within which this phenomenon was observed can be defined on the triaxial iron-nickel-chromium diagram by the following compositions:—18 per cent. chromium, 4 per cent. nickel; 12 per cent. chromium, 20 per cent. nickel; and 30 per cent. chromium, 14 per cent. nickel. Within a narrower range defined by 15 per cent. chromium, 8 per cent. nickel; 15 per cent. chromium, 14 per cent. nickel; 21 per cent. chromium, 14 per cent. nickel; and 21 per cent. chromium, 8 per cent. nickel the response is particularly strong. Within the latter range, hardnesses exceeding 500 V.P.N. can be obtained by sub-zero working alone. They can be further increased to over 600 V.P.N. by applying a subsequent ageing heat treatment. Samples of suitable compositions have thus been hardened all the way through by rolling, wire drawing or swaging. Superficial hardening can be effected by shot-blast peening or burnishing, although these two methods result in surface roughness which makes their application inconvenient.

Properties Obtained

Other physical properties are affected in the same proportion as hardness, so that in an 18-8 strip rolled at −300 deg. F. and aged at 750 deg. F. the following values can be obtained:—Tensile strength, 131 tons per sq. in.; yield stress, 129; proportional limit, 118; elongation, 2.0 per cent. reduction of area, 24.8 per cent.; and hardness, 607 V.P.N. The response to these treatments can be controlled by adjusting the iron-chromium-nickel ratios as well as by adding as "alloying elements" austenite promoters such as carbon and nitrogen or ferrite promoters such as molybdenum, columbium, and titanium. Some preliminary experiments have shown the possibility of a considerable improvement in the wear resistance of austenitic chromium-nickel steels. However, more refined techniques are necessary to make this effect reproducible. Some exploratory tests indicate that the salt-water corrosion resistance of samples thus treated is not greatly reduced by the special hardening processes described.

British Blast Furnaces in the June Quarter, 1950—*continued*

Staffordshire, Shropshire, Worcestershire, and Warwickshire.

Name of firm.	In blast at end of second quarter, 1950. Hematite.	Basic.	Foundry and forge.	Ferro-alloys.	Total.	Weekly average in blast.	Total existing at end of quarter.
Goldendale Iron	—	—	1	—	1	1	2
Lilleshall	—	—	1	—	1	1	2
Round Oak Steelworks	—	—	1	—	1	1	3
Shelton Iron, Steel & Coal	—	3	—	—	3	3	3
Stewarts and Lloyds: Bilston	—	3	—	—	3	2·4	3
Total	—	6	3	—	9	8·4	13
Sheffield.							
Park Gate Iron & Steel	—	1	—	—	1	1.5	2
GRAND TOTAL	14	56	24	4	98	98.1	140

Weekly Average Number of Furnaces in Blast during June, 1950, Quarter and Previous Four Quarters

District.	1949. June.	1949. Sept.	1949. Dec.	1950. March.	1950. June.
Derby, Leics, Notts, Northants, and Essex	24.4	25.3	25.4	26	24.6
Lancs (excl. N.-W. Coast), Denbigh, Flint, and Ches	4.9	5	5	5	4·5
Lincolnshire	15	14.6	14.8	13.7	14
North-East Coast	23	23	23	23	23
Scotland	8.8	9	8.7	7.5	8
Staffs, Shrops, Worcs, and Warwicks	9	8.4	9	9	8·4
S. Wales and Monmouth	8	7.9	8	8	8
Sheffield	1	1	1	1.5	1
North-West Coast	6.6	6.6	7	7	6·6
Total	100.7	100.8	101.9	100.7	98·1

The following companies have furnaces in course of construction or rebuilding:—Barrow Ironworsk Cargo Fleet Iron; Consett Iron; Lancashire Steel Corporation; J. Lysaght (Scunthorpe); R. Thomas & Baldwins (Redbourn); Sheepbridge; South Durham Steel & Iron; Skinningrove Iron & Steel Co. of Wales.

New Steel Export Company

A new company to handle export sales of mild-steel flat-rolled products has been formed by Richard Thomas & Baldwins, Limited, and the Steel Company of Wales, Limited. The company has been registered as R.T.S.C. Exports, Limited, with a nominal capital of £1,000.

The directors are Mr. H. F. Spencer, chairman, who is joint assistant managing director of Richard Thomas & Baldwins, Limited, and Mr. E. J. Pode, managing director of the Steel Company of Wales, Limited.

Carbon-black Plant Opened

Britain would save a million dollars a year on the completion of a new carbon-black plant built by Cabot Carbon, Limited, at Ellesmere Port (Cheshire), said Mr. W. John Kenney, Minister in Charge of E.C.A. Mission to the U.K., at the opening of the plant last Friday week. The company was the first, he said, to get a "currency convertibility guaranty," which meant that E.C.A. would assure the convertibility into dollars of sterling profits or other returns on the dollar investment, which in this case was $2,025,000—the largest guaranty so far granted.

Opening the plant, Mr. Harold Wilson, President of the Board of Trade, announced that the Government had considered new plans for the development areas. It had decided that within the total amount of investment resources available to the community, certain building projects could be allowed to go forward if they were to give permanent employment to predominantly male labour in these areas, even though they did not qualify for building facilities under the existing capital investment tests, that is, even though they did not satisfy the strict dollar-earning or dollar-saving criterion. The areas which would benefit from this special relaxation were certain localities in the development areas and certain places outside the development areas—Portsmouth, Hull, Barrow, West Cornwall, and parts of North Wales, though from time to time they might need to alter the list.

News in Brief

THE LEIPZIG FAIR is being held from August 27 to September 1.

WEST GERMAN INDUSTRIES are arranging to hold a German Industries Exhibition in Berlin from October 1 to 15 next.

THE DIRECTORS of the Great Bridge Foundry Company, Limited, Great Bridge (Staffs), have purchased the New Garter Foundry (1926), Limited, Tipton (Staffs), which firm will continue to operate under its old title.

THE REPUBLIC STEEL CORPORATION'S London office at 115, Park Street, W.1, has been closed. Future communications should be sent to the company's head export office—9th Floor, Chrysler Building, 230, Lexington Avenue, New York.

WEEKLY WAGE RATES of 2,277,000 workers were increased by £380,700 during the first six months of this year. In the corresponding period of 1949 there was a net increase of £622,800 for 3,993,500 people, according to the "Ministry of Labour Gazette."

INDUSTRIAL DISPUTES accounted for 755 stoppages of work between January and June, 1950, and involved a loss of 587,000 working days. In the comparative period last year there were 826 stoppages involving 924,000 working days, according to the "Ministry of Labour Gazette."

PROVISIONAL SUBJECTS of the Autumn conference of The British Cast Iron Research Association to be held at Ashorne Hill on October 12 and 13 are the purely technical aspects of the report of the General Ironfounders' Productivity Team which, it is expected, will be published in September.

NEW WEEKLY RECORD FIGURES were set up by the tube works of Stewarts and Lloyds, Limited, at Corby, Kettering (Northants), during the week ended May 13, when 8,038 tons and 8,327,000 ft. of tube were produced. During the five weeks ended June 3 the blast furnaces produced 64,521 tons of iron, a record for any similar period.

A NEW 10-ACRE FACTORY is to be built by Brook Motors, Limited, Huddersfield, in the Barnsley area, to meet the requirements of additional production. The company hopes that the recent tour of America and Canada by the joint managing directors, Mr. F. V. Brook and Mr. J. C. Brook, will result in considerable dollar trade coming to England.

UNABLE TO COMPETE with comparatively cheap French and German railway tyres, the Blaenavon Company, Limited, Blaenavon, near Pontypool (Monmouthshire), has found it is necessary to close down its 90-year-old tyre mill. The amount of work available will allow the mill to work for about three weeks after this month's holidays. Sixty workmen are employed there.

OWING TO an enormously increased consumption of water for industrial purposes, the Tees Valley Water Board has decided to embark upon the construction of a new ironfounding reservoir and other capital works which will involve an estimated expenditure of £6,163,159 during the next 10 years. New works at Low Worsall to be opened next month will provide 42 million gallons of "raw water" per week to the new I.C.I. works at Wilton.

INDUSTRIAL EYE INJURIES, their prevention and treatment, were the feature of a recent exhibition of industrial and social ophthalmology at the London School of Hygiene and Tropical Medicine. The exhibition was divided into 15 sections ranging from the use of optical devices in close work, eye safety devices, first aid and subsequent treatment of industrial eye injuries, to the early history of industrial ophthalmology, the manufacture and fitting of contact lenses, and the care of the blind.

Personal

MR. S. HAMILTON DUNLOP, assistant general manager of the Central Marine Engine Works (W. Gray & Company, Limited), West Hartlepool, has been appointed general manager.

MR. T. B. COLMAN, assistant works manager at the Grantham (Lincs) works of Ruston & Hornsby, Limited, engineers and foundrymen, has been appointed works manager in succession to MR. T. H. EDWARDS, who has retired after nearly 25 years' service.

MR. H. S. HOLBROOK, who has relinquished the managership of the transformer engineering department of the British Thomson-Houston Company, Limited, on being appointed consulting engineer on transformers, is succeeded by MR. K. W. MCBAIN, his chief assistant.

MR. G. E. D. HALAHAN, chief labour superintendent of the United Steel Companies, Limited, Sheffield, is to become acting general works manager of the Steel Peech & Tozer Branch of the company in October. MR. ANDREW JOLLIE, the present general works manager, is extending his activities, which will necessitate his absence from the works for a time.

LT.-COL. STEVEN J. L. HARDIE, chairman of the British Oxygen Company, Limited, and its associated companies, has been appointed by the Minister of Transport to membership of the British Transport Commission on a part-time basis. CAPT. SIR IAN BOLTON, a director of the Coltness Iron Company, Limited, and other companies, has been reappointed to part-time membership.

British Standards Institution

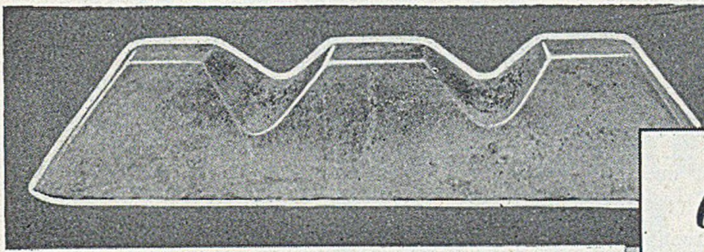
The monthly information sheet issued by the British Standards Institution for June lists, under "Revised Standards Issued," B.S. 18:1950, Tensile testing of metals (2s. 6d.). Section 1 contains definitions of the principal terms; the limit of proportionality, yield, proof and ultimate tensile stress, percentage elongation and percentage reduction of area and Young's modulus. Section 2 describes the forms of test-pieces for sheets, plates, strips, flat bars, and sections; machined test-pieces for general purposes; special tensile test-pieces for cast iron and malleable cast iron, for wire, for tubes and for steel cylinders. Standard methods of procedure are defined in Section 3.

Under "Amendment Slips Issued," there are P.D. 1046, Amendment No. 1 to B.S. 1575:1949, Cast-iron pipe flanges and flanged fittings, class 125, for the petroleum industry; and P.D. 1047, Amendment No. 1 to B.S. 1576:1949, Cast-iron pipe flanges and flanged fittings, class 250, for the petroleum industry.

Welding Research Laboratory

The British Welding Research Association is planning to build a fatigue testing laboratory at Abington, near Cambridge, so as to release a portion of the old laboratories for much-needed expansion of other work. At the Association's recent annual meeting it was stated that the new laboratory would cost in the neighbourhood of £20,000—a sum much beyond the amount which the Association could spare from its reserves, and an appeal for support would have to be made.

During the past year a pulsating pressure-testing plant, for fatigue testing pressure vessels, had been installed and a large tensile-testing machine had been placed on order.



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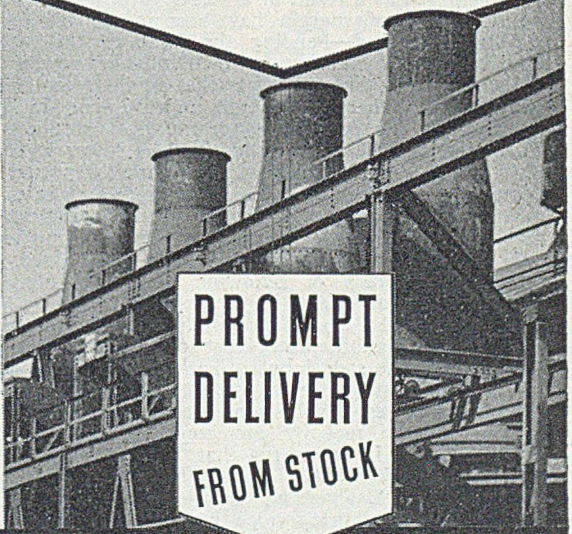
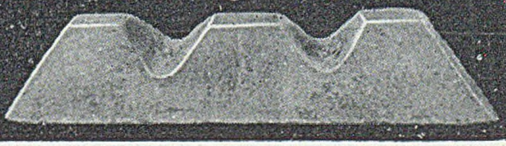


PROMPT DELIVERY FROM STOCK



THE STANTON IRONWORKS COMPANY LIMITED – NEAR NOTTINGHAM

Company News

The information under this heading has been extracted from statements circulated to shareholders, speeches made at annual meetings, and other announcements.

Henry Meadows, Limited—A new agreement concerning the guarantee by Associated British Engineering, Limited, of the dividend on Henry Meadows' preference capital was placed before an extraordinary general meeting of the latter company on July 28. The present guarantee expires with the payment due on September 1, 1950. Extension to September 1, 1952, is proposed.

A further proposal is that the liability to reimburse Associated British Engineering out of future profits, the amounts paid under its guarantee shall cease. The meeting was also asked to agree that the present right of Associated British Engineering to subscribe for 200,000 5s. ordinary shares in Henry Meadows at 10s. each be varied so that the right is exercisable up to September 1, 1953, at par.

The directors hope to be in a position early in 1951 to meet shareholders with proposals for reconstruction.

Meters, Limited—The board proposes to increase the existing limit on borrowing powers of £200,000 to the amount of the issued share capital, but under the proposed new articles this limit will apply not only to borrowing by the parent company but to the aggregate borrowing of the group. The fixed remuneration of the directors is £100 per annum each, and it is proposed that for directors not holding executive this figure be increased to £300 per annum each.

Mr. Joseph Morley, the chairman, says that the increase in the trading profit of the parent company has been achieved as a result of a record turnover, notwithstanding that profit margins have been appreciably lower.

Murex, Limited—Pending the issue of the report and chairman's statement, which will be posted on August 28, the directors state that in the year ended April 30 last there was some improvement in the demand for the company's metallurgical products in the home market. They add that the lower level of business in the European export market reported in March last has been compensated by increased sales in other oversea markets. The moderate improvement in the company's sales of welding rods and equipment, also reported in March last, has been maintained.

Richard Thomas & Baldwins, Limited—Referring to the general rise in transport charges Mr. E. H. Lever, the chairman, points out that this will increase the manufacturing cost of finished steel by 10s. a ton. The steel industry has decided not to pass on the additional cost to customers by way of an increase in prices. While some part of the additional burden will be met by increased productivity and efficiency, Mr. Lever warns that it must have some effect on current profits.

Sheepbridge Engineering, Limited—The first directors of two new Sheepbridge companies which have been formed, each with an initial capital of £100, are to be appointed by Sheepbridge Engineering, Limited. Sheepbridge Equipment, Limited, is to carry on the business of agents, manufacturers of and dealers in engines, machinery, engineering equipment, and accessories, etc. The other company is Sheepbridge Steel Castings, Limited.

Morgan Refractories, Limited—Robert Benson, Lonsdale & Company, Limited, has placed privately £1 million 4 per cent. guaranteed loan stock, 1955-60, on behalf of the firm, which is a wholly owned subsidiary of the Morgan Crucible Company, Limited. It is not intended to obtain a quotation for the stock, which is guaranteed as to principal and interest by the parent company.

House Organs

The Modern Foundry, No. 2, 1950. Issued by Gibson Engineering (Sales), Pty., Limited, 29-33, Wilson Street, Sydney.

Though the reviewer has known Mr. W. A. Gibson personally for the last eleven years, it was only during his recent visit to this country that he learnt that his firm have published a house organ for 14 years. Each issue runs to 16 pages, and carries in addition to the house advertisements a number of outside business announcements. It is the type of publication which is frowned upon by the technical Press in American circles and to a lesser extent in this country. Yet the conditions in Australia until recently were such that there was no national magazine specially catering for the foundry industry. This issue contains an article by Mr. Gibson on his recent visit to America, followed by a technical description of two core blowers—one of which has the special feature of being both a blowing and a stripping machine. Another article describes the welding operations used to complete a 8-ft. statue of the Hon. A. G. Ogilvie, K.C., at one time premier of Tasmania. At it was 82 years ago since a comparable work was carried out in Melbourne, the task must indeed have been difficult. Finally there is a short article on the implication of patents. It will be realised from the above statement that this house organ has really interesting contents. Readers wishing to be added to the mailing list should write to Sydney.

Nickel Bulletin, Vol. 23, No. 5. Issued by The Mond Nickel Company, Limited, Sunderland House, Curzon Street, London, W.1.

An interesting practical application of high-strength cast iron forms the subject of the leading article in this issue of the bulletin. This describes in some detail the complicated operation of a new automatic loom for the textile industry in which the severe service conditions have been met by the use of acicular cast iron. This type of cast iron has a combination of high strength and resistance to impact, with high hardness but machinable. These properties, together with relatively low cost and ease of production, make it an attractive material for a wide variety of engineering purposes. Its success for such applications as crankshafts and camshafts in petrol oil and gas engines is now well established, and other applications, including many in textile engineering are steadily being developed. The usual wide selection of abstracts includes several dealing with industrial finishing, covering electropolishing, enamelling and nickel plating. Copies may be obtained, free of charge, upon application to Sunderland House.

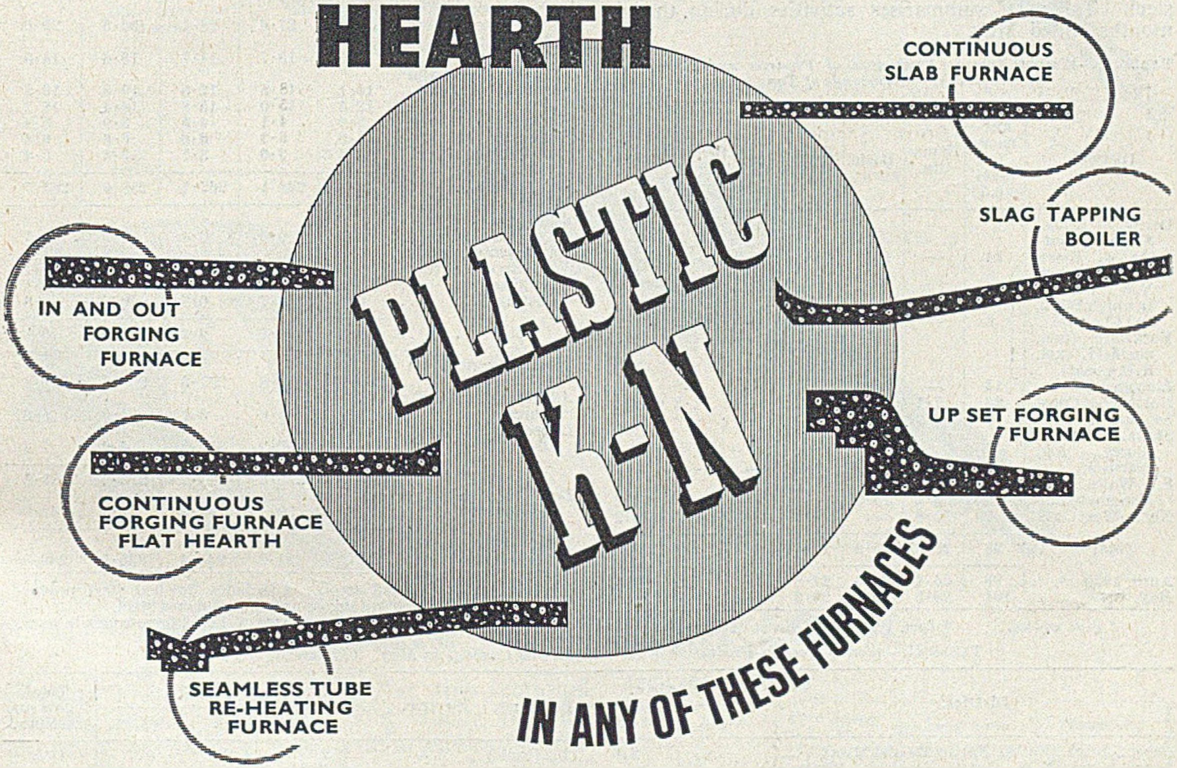
Sif Tips, Vol. 13, No. 70. Published quarterly by the Suffolk Iron Foundry (1920), Sifbronze Works, Stowmarket.

The reviewer congratulates the Suffolk Iron Foundry on attaining their 30th anniversary. This issue carries a good article on the repairing of a four-bladed cast-iron propeller as carried out in a large motor service station. After reading this issue nobody will be tempted to mend guns by welding—it is against the law, unless the article be re-proofed afterwards.

Rubber Developments, Vol. 3, No. 2. Issued by the British Rubber Development Board, Market Buildings, Mark Lane, London, E.C.3.

This issue contains an article on the protection of metal surfaces by either dipping or spraying with latex. This method is extensively used when packing metallic components for export to the tropics.

It pays TO INSTALL A MONOLITHIC HEARTH



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Pig-iron and Steel Production in Great Britain

Summary of May Statistics

The following particulars of pig-iron and steel production in Great Britain have been extracted from the Statistical Bulletin for June, issued by the British Iron and Steel Federation. Table I gives the production of pig-iron and ferro-alloys in May, with the number of furnaces in blast; Table II, production of steel ingots and castings in May, and Table III, deliveries of finished steel. Table IV summarises activities during the six months ended May.

TABLE I.—*Weekly Average Production of Pig-iron and Ferro-alloys during May. (Thousands of Tons.)*

District.	Furnaces in blast 3.6.50	Hematite.	Basic.	Foundry.	Forge.	Ferro-alloys.	Total.
Derby, Leics., Notts., Northants, Essex	24	—	18·3	23·3	1·3	—	43·0
Lancs. (excl. N.W. Coast) Denbigh, Flints and Cheshire .. Yorkshire (incl. Sheffield, excl. N.E. Coast) ..	6	—	7·1	—	—	1·1	8·2
Lincolnshire ..	14	—	24·3	—	—	—	24·3
North-East Coast	23	7·1	38·4	0·2	—	1·3	47·0
Scotland ..	8	0·9	10·1	2·3	—	—	13·3
Staffs., Shrops., Worcs., and Warwick ..	8	—	8·7	1·6	—	—	10·3
S. Wales and Monmouthshire	8	4·2	19·0	—	—	—	23·2
North-West Coast	7	15·8	—	0·2	—	0·2	16·2
Total ..	98	28·0	125·9	27·6	1·3	2·6	185.5*†
April, 1950 ..	98	26·4	124·6	27·8	1·1	2·5	182·5†
May, 1949 ..	101	28·5	124·4	29·3	1·4	2·9	186·5

* Five weeks. † Incl. 100 tons of direct castings.

TABLE III.—*Weekly Average Deliveries of Non-alloy and Alloy Finished Steel. (Thousands of Tons.)*

Product.	1948.	1949.	1949 May	1950. April.	1950. May*
Non-alloy Steel :—					
Heavy rails and sleepers	8·9	9·8	9·5	11·3	11·6
Heavy and medium plates	36·1	39·2	42·3	41·2	41·5
Other heavy prod.	34·7	36·1	39·2	38·7	39·2
Light rolled prod.§	59·7 (Light rolled prod. and Hot-rolled strip)	46·4	49·5	45·8	47·2
Hot-rolled strip ..		17·1	17·6	19·3	20·9
Cold-rolled strip ..	4·8	4·9	5·2	4·7	5·5
Bright steel bars ..	6·1	5·8	5·9	5·6	5·9
Sheets, coated and uncoated ..	26·3	27·6	28·1	30·5	29·6
Tin-, terne- and blackplate ..	13·5	13·7	14·7	13·6	14·3
Tubes, pipes and fittings	15·1	18·5	19·5	19·3	19·5
Wire	12·8	15·0	15·8	14·4	15·2
Tyres, wheels, axles	3·9	4·1	4·5	3·9	3·4
Forgings	6·0	6·3	6·6	6·6	6·5
Castings	3·5	3·6	3·7	3·4	3·4
Total	231·4	248·1	262·1	258·3	263·7
Alloy Steel† :—					
Tubes and pipes ..	0·4	0·6	0·4	0·9	1·1
Bars, plates, sheets, strip and wire ..	4·7	4·7	5·2	4·9	5·1
Forgings	2·5	2·7	2·9	2·9	3·1
Castings	0·7	0·7	0·7	0·8	0·8
Total	8·3	8·7	9·2	9·5	10·1
Total deliveries from U.K. prod.‡ ..	239·7	256·8	271·3	267·8	273·8
Add from other U.K. sources	5·7	5·8	5·1	4·9	5·6
Imported finished steel	3·4	7·7	12·3	4·0	2·4
	248·8	270·3	288·7	276·7	281·8
Less intra-industry conversion ..	35·0	39·1	43·3	41·2	42·0
Total deliveries of finished steel ..	213·8	231·2	245·4	235·5	239·8

† Excludes high-speed steel. ‡ Includes finished steel produce in the U.K. from imported ingots and semi-finished steel.
§ Excl. wire rods and alloy-steel bars, but incl. ferro-concrete bars.

TABLE II.—*Weekly Average Production of Steel Ingots and Castings in May. (Thousands of Tons.)*

District.	Open-hearth. Acid.	Open-hearth. Basic.	Bessemer.	Electric.	All other.	Total. Ingots.	Total. Castings.	Total ingots and castings.
Derby., Leics., Notts., Northants and Essex ..	—	2.6	11.2 (basic)	1.4	0.2	14.7	0.7	15.4
Lancs. (excl. N.W. Coast), Denbigh, Flints., and Cheshire .. Yorkshire (excl. N.E. Coast and Sheffield) ..	0.6	22.4	—	1.1	0.4	23.6	0.9	24.5
Lincolnshire ..	—	30.7	—	—	0.1	30.7	0.1	30.8
North-East Coast ..	1.8	62.6	—	0.9	0.4	64.1	1.6	65.7
Scotland ..	4.6	43.0	—	1.7	0.8	48.2	1.9	50.1
Staffs., Shrops., Worcs. and Warwick ..	—	15.1	—	0.7	0.7	15.2	1.3	16.5
S. Wales and Monmouthshire ..	9.9	48.3	5.4 (basic)	0.8	0.1	64.2	0.3	64.5
Sheffield (incl. small quantity in Manchester) ..	8.5	26.8	—	7.5	0.6	41.8	1.6	43.4
North-West Coast ..	0.1	3.5	4.7 (acid)	—	—	8.2	0.1	8.3
Total ..	25.5	255.0	21.3	14.1	3.3	310.7	8.5	319.2*
April, 1950 ..	24.2	262.0	20.8	13.3	3.2	315.5	8.0	323.5
May, 1949 ..	28.7	245.5	22.1	15.8	3.5	306.8	8.8	315.6

TABLE IV.—*General Summary of Pig-iron and Steel Production. (Weekly Average in Thousands of Tons.)*

Period.	Iron-ore output.	Imported ore consumed.	Coke receipts by blast-furnace owners.	Output of pig-iron and-ferro-alloys.	Scrap used in steel-making.	Steel (incl. alloy). Imports.†	Steel (incl. alloy). Output of ingots and castings.	Steel (incl. alloy). Deliveries of finished steel.	Steel (incl. alloy). Stocks.‡
1938 ..	228	89	—	130	118	16	200	—	—
1948 ..	252	172	200	178	174	8	286	214	1,028
1949 ..	258	169	199	183	188	17	299	231	1,275
1949—December ..	249	170	197	186	181	12	291	231	1,275
1950—January ..	260	175	198	187	189	11	305	234	1,263
February ..	250	170	194	184	206	8	325	244	1,257
March* ..	255	174	197	186	212	12	330	252	1,279
April ..	242	171	196	183	207	11	324	236	1,320
May* ..	248	172	199	186	204	10	319	240	1,326

* Five weeks. † Weekly average of calendar month. ‡ Stocks at end of years and months shown.

Raw Material Markets

Iron and Steel

Taking advantage of favourable opportunities, the blast furnaces have recently increased their intake of foreign ores and are now fairly comfortably situated in regard to other raw materials. It is hoped, therefore, that it will be possible, as soon as the holidays are over, to restore the aggregate output of pig-iron, which has recently fallen short of consumers' requirements. A brief recession has not caused serious inconvenience, as some foundry demands are rather quiet; but it is disappointing to have to refuse export orders, and the ban on pig-iron shipments cannot be removed until more liberal supplies are available.

Trade in ferro-alloys has been rather quiet of late, but an acceleration of the rearmament programme would be quickly reflected in sales.

Re-rollers are still finding it difficult to keep their mills in full operation, and interest in semi-finished steel is consequently subdued. British makers are maintaining regular deliveries, and the chief effect of the reduced demand is to be seen in the sharp drop in the tonnage of imported material. Belgian exporters are seriously concerned about the shrinkage of their trade with this country, but, on the other hand, there has been a definite rise in the shipments of French steel to British ports. Maximum outputs of black and galvanised sheets are called for and consumption of bars and slabs is correspondingly high, but, apart from the smaller sizes, trade in billets is rather quiet.

This has been a quiet week in the finished-steel trade, but there is no easement of pressure on the sheet-makers, who are offered business far in excess of their capacity. Plate mills, too, are heavily booked and the recent spate of shipbuilding orders for tanker tonnage carries with it the assurance of continued support. Steel plates figure conspicuously in the export list, and there has also been a spectacular expansion in the demand for railway material. Mills engaged on steel bars, angles, sections, and joists enjoy steady employment.

Non-ferrous Metals

On Tuesday morning the all-time record price of £755 a ton was paid for nearby tin metal. The official price yesterday (Wednesday) jumped to £761 10s. to £762 10s. for cash. The Exchange was closed after midday on Friday until Tuesday morning.

Metal Exchange official tin quotations were as follow:

Cash—Thursday, £735 to £736; Friday, £746 to £746 10s.; Tuesday, £750 10s. to £751; Wednesday, £761 10s. to £762 10s.

Three Months—Thursday, £729 to £730; Friday, £740 to £740 10s.; Tuesday, £743 to £744; Wednesday, £752 to £753.

Stocks of tin in Government hands are falling and, according to the Bureau of Non-ferrous Metal statistics, stood at 11,600 tons at the end of the half-year. Consumers held 1,629 tons. The premium ruling for the cash position, of course, indicates a scarcity of metal for near dates.

Other details supplied by the Bureau in its exhaustive monthly survey of the statistical situation reveal that June consumption of lead at 27,377 tons showed a fall of about 1,000 tons on May, but carried the total for the first six months up to 161,424 tons. Some 6,000 tons of secondary lead were included in the June figure. Usage of zinc in June was 27,881 tons, an increase of 640 tons, and the six months' total was 163,374 tons. Stocks of zinc advanced by about 3,000 tons to 52,722 tons. The relative figures in lead were a gain of 8,796 tons to 74,119 tons. Little change took place in stock of copper, the May figure of 124,291 tons giving place to 125,196 tons at the end of June. Consumption in June was 44,499 tons, 1,090 tons up on May, and the total for the first six months was 252,855 tons. The division of the June consumption figure showed 26,827 tons virgin and 17,672 tons secondary.

In view of the holiday, business has, on the whole, been quiet, sales of scrap being particularly light. Many factories are closed throughout this week and August is likely to show a marked decline in consumption figures. Prices are very firm in New York and zinc on the Commodity Exchange has been quoted up to 16.80 cents, although the producers continued to offer at 15 cents. A sharp increase in American requirements of zinc in the United States as a result of an extension in the defence programme has been forecast and a similar trend is bound to occur in copper. One figure mentioned for copper is an additional 10,000 tons per month. At the time of writing, no further news has come through about the 2 cents duty on foreign copper, which has been effective since July 1 and is making things very difficult for fabricators. It is certainly very surprising in the light of present developments that Congress has not found it possible to deal with this matter of suspension of the duty for a further term.

Company Results

(Figures for previous year in brackets.)

SHANKS & COMPANY—Interim dividend of 5% (same).

SMITH & WELLSTOOD—Final dividend of 12½%, making 17½% (same).

BANISTER, WALTON & COMPANY—Consolidated trading profit for the year to March 31, £177,946 (£142,998); net profit, £61,969 (£49,235); dividend of 15% on doubled capital (dividend of 25% and bonus of 5%), £20,235 net (same); reserve, nil (£25,000); provision for directors' fees, £1,750 (same); future repairs and replacement of equipment, £20,000 (nil); forward, £71,910 (£51,926).

DAVEY, PAXMAN & COMPANY—Trading profit to March 31, £462,845 (£716,074); net profit, £216,433 (£305,780); to plant replacement reserve, £25,000 (£70,000); stock and general contingencies reserve, £50,000 (£120,000); pensions reserve, £25,000 (£50,000); general reserve, £60,000 (£40,000); preference dividend, £8,662 (£4,331); ordinary dividend of 10% (same rate on smaller capital), £28,875 (£19,250); forward, £43,082 (£24,186).

WOLVERHAMPTON METAL COMPANY—Group profits to March 31 after all charges, £117,543 (£123,021); excess provision for taxation now not required, £30,000 (nil); final dividend of 20%, making 40% (same); to metal price reserve, £20,000 (nil); employees' service fund, £2,000 (same); contingencies, £35,000 (nil); off goodwill on branch business, £1,100 (nil); general reserve, £50,000 (same); forward, £107,865 (£102,444).

EDGAR ALLEN & COMPANY—Balance of trading profits from April 3, 1949, to April 1, 1950, £454,352 (£468,478); balance, £437,083 (£429,042); to profits tax, £56,500 (£50,000); income tax, £177,500 (£178,000); provision for deferred taxation, being relief in respect of capital expenditure, £6,000 (nil); reserve for development and replacement of fixed assets, £125,000 (£50,000); reserve for contingencies, nil (£25,000); provision for pensions, nil (£50,000); general reserve, £28,648 (£31,534); dividend of 12½% (12½% and bonus of 5%, on smaller capital), £29,628 (£27,652); forward, £100,454 (£94,897).

AMALGAMATED METAL CORPORATION—Consolidated trading profit for 1949, including net profit on realisation investment of subsidiary finance companies, £578,198 (£321,804); net profit, £295,419 (£212,896); less £7,461 (£7,247) outside holders' interest in profits, less losses of subsidiaries, leaving profit attributable to group, £287,958 (£205,649); dividend of 6% (5½%); to income tax, £144,067 (£134,086); net balance, £111,877 (£41,766); from contingencies, £9,164 (nil); general reserve, £4,682 (nil); written off goodwill, £126,959 (£4,975); further income tax, £70,927 (nil); forward, £521,429 (£593,592).

GEORGE KENT—Group trading profit for the year ended March 31, £438,486 (£393,960); balance, £186,537 (£126,615); to sinking fund for redemption of debenture stock, £3,556 (£3,410); stock reserve, £25,000 (nil); employees' pension scheme, £50,000 (nil); written off goodwill, £46,381 (nil); preference dividends, £9,902 (£3,215); final ordinary dividend of 7%, making 10% (same); subsidiary dividend applicable to minority shareholders, £2,480 (£1,734); to employees' assurance scheme trustees, £9,000 (£7,750); forward: George Kent proportion £183,721 (£164,553), minority shareholders £5,935 (£1,206).

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

(Delivered, unless otherwise stated)

August 9, 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, £109 per ton.

Ferro-tungsten.—80/85 per cent., 10s. 3d. per lb. of W.

Tungsten Metal Powder.—98/99 per cent., 11s. 9d. 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., 13s. 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. 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, £186; high-grade fire-refined, £185 10s.; fire-refined of not less than 99.7 per cent., £185; ditto, 99.2 per cent., £184 10s.; black hot-rolled wire rods, £195 12s. 6d.

Tin.—Cash, £761 10s. to £762 10s.; three months, £752 to £753; settlement, £762.

Zinc.—G.O.B. (foreign) (duty paid), £127 10s.; ditto (domestic), £127 10s.; "Prime Western," £127 10s.; electrolytic, £132; not less than 99.99 per cent., £138.

Lead.—Good soft pig-lead (foreign) (duty paid), £96; ditto (Empire and domestic), £96; "English," £97 10s.

Zinc Sheets, etc.—Sheets, 10g. and thicker, all English destinations, £146 5s.; rolled zinc (boiler plates), all English destinations, £144 5s.; zinc oxide (Red Seal), d/d buyers' premises, £119.

Other Metals.—Aluminium, ingots, £112; antimony, English, 99 per cent., £150; quicksilver, ex warehouse, £18 19s. to £19; nickel, £386.

Brass.—Solid-drawn tubes, 19¾d. per lb.; rods, drawn, 25½d.; sheets to 10 w.g., 24d.; wire, 24½d.; rolled metal, 22¾d.

Copper Tubes, etc.—Solid-drawn tubes, 21½d. per lb.; wire, 209s. per cwt. basis; 20 s.w.g., 217s. 9d. per cwt.

Gunmetal.—Ingots to BS. 1400—LG2—1 (85/5/5/5), £131 to £138; BS. 1400—LG3—1 (86/7/5/2), £141 to £145; BS. 1400—G1—1 (88/10/2), £185 to £244; Admiralty GM (88/10/2), virgin quality, £192 to £239, per ton, delivered.

Phosphor-bronze Ingots.—P.Bl, £235-£245; L.P.Bl, £143-£156 per ton.

Phosphor Bronze.—Strip, 32d. per lb.; sheets to 10 w.g., 33¾d.; wire, 33¾d.; rods, 31½d.; tubes, 36¾d.; chill cast bars: solids, 32d., cored, 33d. (C. Clifford & Son, Limited.)

Nickel Silver, etc.—Ingots for raising, 2s. 2d. per lb. (7%) to 3s. 1¼d. (30%); rolled metal, 3 in. to 9 in. wide × .056, 2s. 8d. (7%) to 3s. 7¼d. (30%); to 12 in. wide, × .056, 2s. 8¼d. to 3s. 7½d.; to 25 in. wide × .056, 2s. 10¼d. to 3s. 9½d. Spoon and fork metal, unsheared, 2s. 5d. to 3s. 4¼d. Wire, 10g., in coils, 3s. 1½d. (10%) to 4s. 0¾d.; (30%). Special quality turning rod, 10%, 3s. 0½d.; 15%, 3s. 5¼d.; 18%, 3s. 9¾d.