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Rearmament Problems

Now that the Government has decided upon a policy of rearmament, it will not be long before the impact is felt by the foundry industry. The steelfounders and makers of heavy- and light-alloy castings will soon have pressure brought upon them to produce armaments in ever increasing quantity. The impact on ironfounding will be patchy. There should be no need for some time to come—and we sincerely hope never—for a system of priorities to be put into operation. There will obviously be a great demand for pig-iron and steel, but as this industry is already working to full capacity only a change in the nature of the output can be envisaged. Both this industry and foundry practice in general have made very great strides since 1945. They are both in a better position quickly to turn over to munitions of war than ever before. If mass-produced iron castings be needed, then with but little modification to existing plant almost any demand can be met.

A major difference between 1938 and 1950 is that the foundry industry is infinitely better organised, and co-operation between the various Ministries and the manufacturers of castings—already functioning—can be fostered initially. At no time has it been more imperative that the strongest support should be given to manufacturer's organisations than to-day. With memories of the needless concentration of iron foundries carried out during the last war still fresh in the minds of our readers, a realisation of the benefits to be derived from co-operative action will be obvious. Moreover, these organisations are specially well placed to advise Government departments on the potentialities possessed by each section of the industry.

The Ministries would be well advised to realise that the *tempo* of manufacturing processes is at its highest under conditions of private enterprise. In saying this we cast no aspersions on the arsenals, dockyards and railway services, but personal observation has convinced us as to the truth of our statement. Whether it is unnecessarily strict inspection, technological semi-isolation, or a psychological attitude peculiar to nationalised industries, we are unable to judge.

Planning—inevitable under rearmament conditions—is essential. Planning obviously can be much more realistic if it is carried out with the full co-operation of industry. The Services each make their own insistent demands and often each relies upon the same overtaxed factory. For load spreading there is no better or more reliable source of information than the employers' organisations. There must be no action taken based on production per man-hour so far as foundries are concerned, because ingot moulds and turbo castings are such different species of castings as to have but little in common. Everybody wishes to do his best to avoid a third world war, and the first step—if it has not already been taken—is to join the appropriate manufacturers' organisation in order that the fullest and most intelligent support can be accorded to the Government through co-operation.

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Correspondence

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

PLATITUDES *versus* TECHNOLOGY

To the Editor of the FOUNDRY TRADE JOURNAL

SIR,—Your comments on the above in the issue of July 27, 1950, were most refreshing.

According to the writer's conversations, similar thoughts are not only held by many others, but are expressed in like terms. "Example is better than precept," and what is wanted is work and examples, and less of listening to the "know hows," also, less non-operators to operators. In the writer's early days, managers and foremen filled the position of labour managers, timekeepers, ratefixers, jig and tool designers, material control, progress and many others, which was not only unreasonable, but ridiculous, and in many cases what was saved on the swings was lost on the roundabouts.

Now we are getting to be a community of criticisers and advisors with non-operators out of reasonable proportion to operators, and the expressive pleasures through craftsmanship are being lost. Mechanical methods, mechanisation, and management technique is vitally essential to progress, but as it is commonsense policy it can be left to evolution and accelerated by competition.

As you remark, "psychological benefits will arise from the mutual discussion of technology," and the spoken criticism from discussions can be more effective than generalisations in a lecture.

The chairman of the Dunlop Rubber Company, Limited, at their annual meeting gave several illusions we as a people should be prepared to shed, two of them being:—

"That paper schemes create wealth."

"That words are a substitute for work."

Yours etc.,

August 1, 1950 G. W. B.

CARBLOX

To the Editor of the FOUNDRY TRADE JOURNAL

SIR,—We thank you for your editorial mention of the book "The Evolution of the All-carbon Blast Furnace" in your issue of July 27. There are, however, two points to which we should like to draw your attention. The first is that the initials of Mr. Elliott should be "G. D." and not "C. D." as stated.

The second point concerns your statement "The solution of the difficulties encountered was the designing of an interlocking carbon brick—now known as Carblox." This is not strictly accurate; "Carblox" is the registered name of the material manufactured by Carblox, Limited, of Storrs Bridge, Loxley, Nr. Sheffield (the company being formed by the association of Thomas Marshall & Sons (Loxley), Limited. and the Morgan Crucible Company, Limited, of London). This company produces "Carblox" carbon refractories for lining blast furnaces, carbon bricks and tiles for lining pickling tanks and other chemical plant, also "Carblox" chemical-resisting cements and mortars. Strictly speaking, the production by this associate company of "Carblox" carbon refractory blocks materially assisted in solving Mr. Elliott's difficulties. The design of "Carblox" corrugated hearth blocks overcame the many difficulties encountered in constructing hearth blocks from carbon.

Yours, etc.,
E. P. COLLINS,
Morgan Crucible Company, Limited.

August 9, 1950.

Factories Acts

Siliceous Parting Powders in Foundries

The Minister of Labour and National Service has given notice that he proposes to make special regulations entitled the Foundries (Parting Materials) Special Regulations, 1950, in accordance with a draft headed "Revised Draft, August, 1950."*

The effect of these regulations would be to prohibit, in general, the use as a parting material in foundries of any material containing more than 3 per cent. of compounds of silicon calculated as silica. The prohibition would not, however, apply to natural sand or to certain specified substances (*e.g.*, sillimanite) which contain—or might contain—substantial percentages of compounds of silicon other than "free silica."

The draft regulations are almost identical with a previous draft published by the Minister in February, 1950. The only difference is that, in response to representations made to him, the Minister proposes to add the substance known as "olivine" to the schedule of exempted substances. He is advised that the use of this substance as a parting powder is not liable to cause silicosis and ought to be permissible under the regulations.

In accordance with the statutory procedure, any objections to the draft regulations by or on behalf of persons effected must be sent to the Minister on or before September 30, 1950. Any objections must be in writing and must state:—

(*a*) The specific grounds of objection; and
(*b*) the omissions, additions, or modifications asked for.

Objections may be addressed to the Secretary, Ministry of Labour and National Service, 8, St. James's Square, London, S.W.1.

* Copies may be obtained from H.M. Stationery Office or through any bookseller, price 1d. net; post free, 2d.

Catton's 75th Anniversary

Catton & Company, Limited, steelfounders, of Chadwick Street, Leeds, celebrate this month the seventy-fifth anniversary of the firm's foundation in Dewsbury Road, Leeds, in 1875 by Mr. Alfred Catton. In those early days, three years after the founding, some 15 men were employed, the wage bill per week amounting to £18 17s. 6d., and the total sales over a three-month period were about 7½ tons, their value being £273 9s. 4½d. After thirteen years, new premises were built in Black Bull Street, the original premises being vacated. It was during the last year in the original premises that the father of the present joint managing directors joined the firm—at 6s. per week. The company, three years ago, was the first in this country to introduce on a production scale the method of steel making where oxygen is used to enrich the blast of the converters. The managing directors are Mr. Alfred H. Catton and his brother, Mr. Douglas E. Catton, the former being a member of the committee which was appointed to select the British Steel Founders' productivity team. Both men are experienced pilots and appreciate the advantages of air travel and transport to make rapid contact with customers.

THE CATERPILLAR TRACTOR COMPANY, Peoria, U.S.A., announces the formation of a wholly-owned subsidiary in England—the Caterpillar Tractor Company, Limited, which will establish and maintain supplies of British-made Caterpillar spare parts.

Air-setting Core Paste

By " Argus "

FACED WITH A sudden increase in the required production of large cores of relatively simple design, it was found that if stoving space were to be allowed for the drying of the pasted sections, a serious decrease in the production of standard work would result. It was therefore decided to investigate the possibility of producing a paste which would not require to be stoved, or at least, which would require less time to dry. If such a material could not be found, it would be necessary to consider building additional core stoves.

In carrying out the initial comparisons of core pastes, the shear test was adopted as a standard. The core-box shown in Fig. 1 (*a*) and (*b*) was used to make half cores, which, when pasted gave a 2 in. by 2 in. dia. core (A.F.S. standard specimen). This core, when the paste had hardened, was placed in the shear-test adaptor (shown in Fig. 1 (*a*) and broken in the dry-compression-test machine. A number of materials, including glue and synthetic resins, were examined, but all had at least one disadvantage—that they developed insufficient strength.

A sample of a proprietary tile cement, however, was found to give good results, but as this was not economical to use in the prepared condition, a sample was given to the laboratory for analysis. It was found to contain sodium silicate and fused alumina, and experiments were immediately started in which powdered clay was substituted for the alumina.

Bentonite, a well-known proprietary clay, and fireclay were used in comparisons with a proprietary air-setting resin core-paste.

Trial Mixtures

(1) 47 per cent. bentonite, 53 per cent. commercial sodium silicate.*

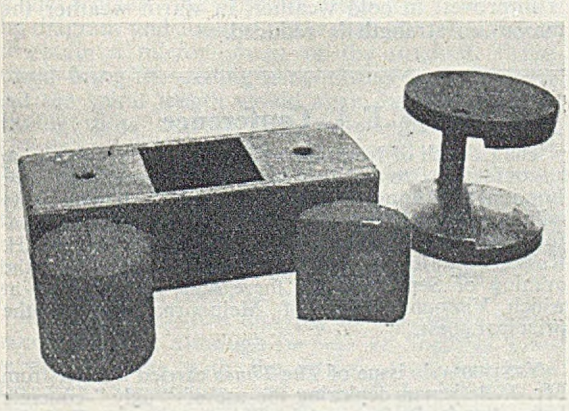


FIG. 1 (*a*).—*Core-box, Half-core, Pasted Core and Shear-test Adaptor.*

(2) 57 per cent. proprietary brand of clay, 43 per cent. commercial sodium silicate.*

(3) Available fireclay was tried, but was found to be too coarse for use in a core-paste.

(4) Proprietary core-jointing paste.

Shear-test cores were pasted and left on the laboratory bench for a number of hours before being tested. Three of each were broken after five, and after 24 hrs., and the average strength was reported.

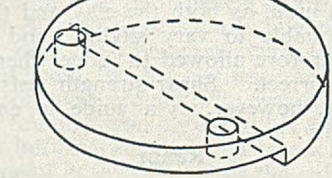
TABLE I.—*Strength of Cores after Short and Long Drying Times.*

Air-drying time.	Shear strength (lb. per sq. in.).			Remarks.
	No. 1.	No. 2.	No. 4.	
5 hours ..	19.6	19.6	35.6	Fracture at paste.
24 hours ..	51.5	63.2	49.0	Fracture in sand behind paste.

Shop Tests

In view of the good results obtained with mixture No. 2, after lying for 24 hrs., the following shop test was carried out:—Three 6-in. dia. pipe-bend cores

* Sufficient sodium silicate to give a smooth workable paste was added.



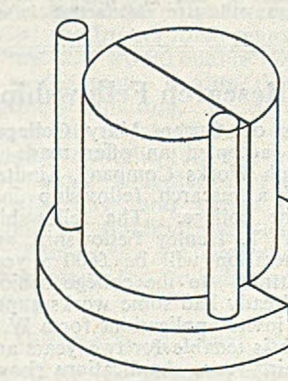


FIG. 1 (*b*).—*Shear-test Adaptor with Pasted Core in Position.*

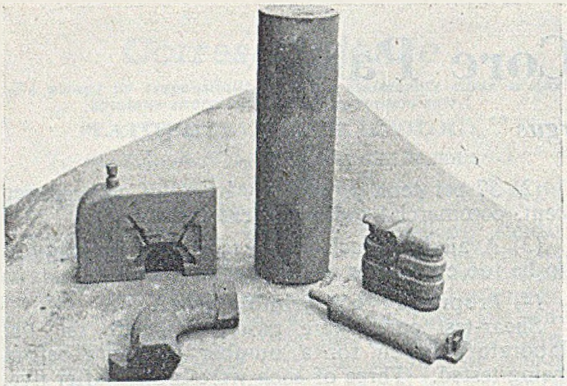


FIG. 2.—*Examples of Cores Jointed with the New Air-setting Paste.*

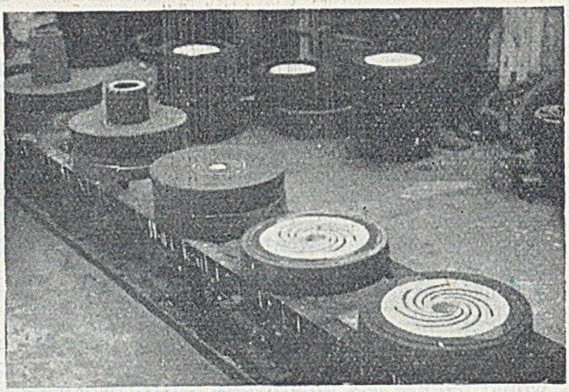


FIG. 3.—*Impellor Moulds Assembled with Core Paste.*

were pasted and used as follows:

(1) Pasted, seamed, and left overnight on core-shop bench.

(2) Pasted, seamed, and stoved in a gas oven for 1 hr.

(3) Pasted and seamed in the morning, then left on a bench to dry until used in the afternoon.

All three pipes were cast at the same time, and all these castings showed no signs of blowholes, or disturbances near any of the joints.

This paste was then tried out on a 10-in. dia. straight core and was found to have insufficient strength when used green, but to be quite satisfactory after lying overnight.

After a few other comparisons, this paste* was put into production on June 2, 1949, and has been in regular use since that date for half-cores weighing up to 1½ cwt. No control is exercised over the proportions used, as both the clay and the sodium silicate are liable to vary slightly, and the core-paster is therefore allowed to judge when the consistency is correct. Shear strength tests are made occasionally, however, as a guide to ensure continued quality.

Range

The variety of cores joined with the new air-setting paste has gradually increased, and Fig. 2 shows a selection ranging in weight from 10 lb. to 3 cwt. Some mould assemblies built-up of cores have also been pasted with this material, and Fig. 3 illustrates an impellor mould made at an associated foundry, where the internal and external cores and the pouring bushes were all secured by this paste.

The costs of both materials used in the new paste are less than either " D " grade flour or molasses, which are the normal ingredients of foundry paste, and this in itself is a good incentive to the continued development of this material.

One disadvantage does, however, occur, and that is that in cold or damp weather the rate of drying of the paste is greatly reduced. This has not yet caused any trouble, however, probably due to the fact that the last winter has been rather mild, but in any case it can be counteracted. The storage of the jointed cores at a temperature above 60 deg. F. will eliminate any danger of the paste not setting, but if this is not possible, the paste may be sprayed very lightly with a " hardener," after being spread over one of the halves. One such hardener which has proved satisfactory consists of a dilute solution of phosphoric acid (23 per cent. by volume), but this should only be used when absolutely necessary. The reason being that although the strength is improved in cold weather, in warm weather the maximum strength is reduced.

* Further investigation has shown that most available finely-powdered clays will give satisfaction in service.

New Research Fellowship

The governors of Queen Mary College, London University, have accepted an offer made by W. T. Henley's Telegraph Works Company, Limited, for the establishment of a research fellowship in electrical engineering at the college. The fellowship will be known as the W. T. Henley Fellowship, and, as the maximum remuneration will be £600 a year, it may be possible to attract to the college senior research men who have already had some works experience.

The governors invite applications for a W. T. Henley Fellowship, which is tenable for two years and may be extended for a third year. Applications should be sent before September 15 to the Registrar, Queen Mary College (University of London), Mile End Road, London, E.1.

C.F.A. Conference

The Council of Ironfoundry Associations is organising a conference, to be held at the Connaught Rooms, London, W.C.2, on September 20 and 21. The first day will be devoted to a discussion on the General Ironfounders' Productivity Team Report. Mr. S. H. Russell, the leader, will be in attendance. On the evening of September 21 there will be a dinner, at which Viscount Bruce of Melbourne will be the principal guest.

YESTERDAY'S issue of *The Times* carried a letter from Mr. J. Betjeman deploring the use of " ugly " concrete lamp standards for pretty village streets. Foundry owners should pin reprints of this letter when tendering for rural contracts.

Casting Fluidity of Metals

Joint discussion of two Papers—"The Fluidity of Steel," by J. E. Worthington, B.SC., and "Effect of Liquid-metal Properties on the Casting Fluidity of Alloys,"† by V. Kondic, B.SC., PH.D.—presented at the Buxton Conference of the Institute of British Foundrymen, Dr. Dadswell presiding. Mr. Worthington is on the staff of the British Iron & Steel Research Association and Dr. Kondic is a lecturer in metallurgy at Birmingham University.*

IN PRESENTING his Paper Mr. Worthington mentioned that at normal temperatures the fluidity temperature curves were almost linear, but at the two extremes, the curves departed from the straight line. At temperatures approaching that of the liquidus, the slope became very much steeper, than that of the main curve, and at elevated temperatures, further increases in temperature did not produce equivalent increases in fluidity-test spiral length, the fluidity tending to reach a fixed value at a high temperature.

Following Mr. Worthington's Paper, the Paper by Dr. Kondic was introduced by the Author, and both Papers were then discussed together.

Opening the discussion DR. RILEY, having thanked the Authors for their Papers, remarked that he could not help feeling that the practical foundryman was well able to and often did carry out fluidity tests such as those described by Mr. Worthington. He thought that one was entitled to expect from the universities a more fundamental approach to the problem of fluidity. The two Papers brought one but little nearer to knowledge of the influence of the various physical factors upon the actual fluidity of the metal. Before any real advance could be made in the understanding of fluidity, some more fundamental approach was necessary, backed up where possible by precise measurement of the physical constants in a way which only could be accomplished by those qualified academically.

His next point was one of detail and he asked the members present to examine Fig. 6 in Mr. Worthington's Paper, and having in mind the fact that the temperature and spiral length were given as the ordinate and abscissæ respectively, to invert the diagram and look at it through the paper so as to obtain a mirror image of the original. That would bring the casting temperature to the bottom and the spiral length would again be the ordinate. Having done that if they would glance at Dr. Kondic's drawing on the blackboard they would see there the curves in the same relative positions. Both sets of curves displayed the same cusp and the same form at the higher temperatures, but the two sets of curves did not fit in very closely near the origin. He wondered if there was some explanation which could be given.

MR. WORTHINGTON replying to the points raised mentioned that although he was at Sheffield University, he was with the British Iron and Steel Research Association, and one of the objects of his research was to obtain a method whereby fluidity could be determined in the melting shop in order to provide more information about the metal than the temperature determination alone gave. He was since then trying to do more work on the fundamental aspect, but that had not been covered in the present Paper.

The difference in the curves, which he had noticed when Dr. Kondic was drawing his on the blackboard, made him wonder if Dr. Kondic had got his ordinates misplaced or whether there was some other explanation.

Practical and Fundamental Aspects of Research

DR. KONDIC in reply to the question of the need for fundamental work said that he did not know what exactly Dr. Riley had in mind. If he meant the problem of relating fluidity and spiral length to viscosity and surface tension, heat content and other properties, he could assure him that all that work was being done, but results were only slowly being accumulated. If Dr. Riley had attempted to measure the viscosity at high temperatures he would appreciate why the work had been progressing so slowly. He agreed with him in the argument that one would feel happier when one could interpret the spiral length in terms of the physical constants, but he disagreed with him entirely that the practical foundryman would be particularly interested in that side of the work. To his mind, what the foundryman wanted from the fluidity test—and he would be glad if someone present who was using fluidity testing in a foundry would express his views on that point—was information that told him a little more about the metal in the furnace or the ladle than the simple information obtained by temperature measurements. He did not think that the foundryman would be any happier to know the physical reasons why the fluidity of a metal was lower or higher. What the foundryman wanted to have was a sensitive test that would enable him to detect any difference in the metal quality that arises in the normal foundry melting, in as far as those differences could be shown by the fluidity test without unduly complicating the test as such. A foundryman more enlightened would go further and know the ways and means of correcting a metal of inferior fluidity and deal with similar questions. Those were the viewpoints that seemed to him to explain the foundryman's interest in fluidity testing.

Differences in Curve Shape

With regard to the question of the slope in the fluidity/temperature graph, anyone who had watched, say, a gunmetal or certain phosphor-bronzes cooling from a high temperature must have observed that to a certain temperature the

† Papers printed in the JOURNAL, July 27 and June 29.†

Casting Fluidity of Metals

surface of the metal was clear and then suddenly, at a given temperature, the metal clouded over. Some testing of the fluidity of copper-base alloys had revealed that the appearance of clouding on the surface was followed by a change in the slope of the fluidity/temperature graph very much like that which Mr. Worthington had found. The reason for this effect was the reaching of the solidification point of oxides in certain copper-base alloys. He would, however, not be dogmatic on that point, but thought that was not the only phenomenon to be taken into account as metal cooled towards the freezing point.

Work on fluidity of very pure metals and alloys had been carried out, using the best experimental technique available and the fluidity/temperature graph had been obtained. It was found that the change in slope was usually at a temperature less than ten degrees above the melting point. Could Mr. Worthington give exactly the melting point of the steel he used? He wondered what the temperature of the melting point was and what was the corresponding temperature where he found the change in the slope?

Dealing with these points, MR. WORTHINGTON said in the case of the steels mentioned, except the aluminium steel, the change took place very near the liquidus temperature; but in the aluminium steel at a temperature of 60 deg. or more above the liquidus.

Link with Viscosity

DR. KONDIC, continuing, said that most of the work reported had been done on non-ferrous alloys and one had to be very careful not to generalise to cover the whole field, but they did find that the particular type of change shown in the graph was an image of the viscosity/temperature graph. It was found that near the melting point of certain metals and certain alloys—a few degrees above the melting point and up to 10 deg. in certain cases—there was a sudden increase in the viscosity. That, he thought, might explain the change in the fluidity behaviour of certain metals and alloys.

MR. COOPER said that when runninfg a long spiral, the length was not entirely dependent on the metal. The mould was also a factor; the sand and its preparation, the moisture content, the rate of pouring, the gas from the metal itself and that from the sand when the metal ran along and the ease with which the gas could escape at the end of the spiral. He thought a mistake had been made in not taking into account the evolution of gas and the permeability of the mould in all the tests.

MR. WORTHINGTON replied that as far as the escape of gas went, if Mr. Cooper would look at the diagrams of the moulds for spiral test-pieces, he would see that they had a vent 0.4 in. dia. leading from the end of the spiral which gave the gases a very free exit.

Fluidity Test Limitations

MR. C. H. KAIN thought that the trouble with all these tests was that they were past measurements and as far as the foundryman went, particularly in batch melting, such tests were not a lot of good because the information came too late. Mr. Worthington had said that an average of six or seven specimens was sufficient to obtain a trustworthy figure. One could not take six or seven tests and take the average in practice. To be any good, a test was required which was positive, the result of which could be used on the metal before pouring a casting.

One of the things to which no-one seemed to have given any thought was the fact that the testing of fluidity in moulds and under conditions at room temperatures of a material which was considerably above that temperature—in the case of steel over 1,500 deg. C.—might offer some explanation of the unreliability of the tests.

He did not think Mr. Worthington was justified in saying that " it was generally agreed that fluidity is best determined by the length of flow in a spiral." It was not generally agreed. Mr. Kain thought greater attention should be given to devising a different method. The fundamental of the test was pouring a very small amount of metal through tiny channels in a relatively large mould. In foundry practice one studied the " mass effect " on the properties of castings, etc., and insufficient attention had been given to the effect of the relativity of a large mould and a tiny casting. It was time some thought was given to devising a different method.

He had made some trials himself and still thought that the possibility of pouring the metal through a restricted orifice should be further explored. He was glad Mr. Worthington made his tests in green sand, but he had not given any particulars of the properties of the mould and no assurance that the moulds were uniform and constant. It was much easier to obtain a uniform mould in dried sand than green sand.

Gating is Critical

The pouring device was very ingenious in controlling the pouring speed, but it controlled the speed of the metal delivery into the runner basin only, and surely the pouring into the spiral was controlled by the gate system and not by the ladle condition? In that case, it seemed that the ingenious and elaborate ladle gear was rather wasted, if the metal was poured through a gate system incorporating a choke. He did not wish to be too condemnatory, but it had been asked what the foundryman wanted, and so he had given his view of the requirements. He congratulated Mr. Worthington on having collected some further data on that problem, but he did feel very strongly that in pursuing the spiral tests they were flogging a dead horse.

MR. WORTHINGTON said as far as the use of the spiral was concerned he wanted to cast a spiral straight from the furnace, but so far no method had been obtained of getting accurate and reproducible results when the metal had been taken from the furnace. As for the sand used, the moisture was determined—he had not got the figures by him—but every effort was made to keep the properties of the sand constant. The Americans made a point that it was rather easier to keep two per cent. of moisture in a sand over a period, than to keep it absolutely free from moisture. Dry sand tended to pick up moisture.

Referring to the use of the ladle, there was quite a difference in length obtained if the pouring speed was altered. In their original paper, Taylor, Briggs and Rominski gave actual figures of variations in spiral length when the pouring speed was altered from one up to three or even more seconds. It made quite a difference to the length of spiral obtained.

Dr. Kondic said it was not correct to say that the test was *post mortem* because the test could be used to decide the metal quality while the metal was still in the furnace or ladle and then the required adjustments could be made. He understood that the test had been successfully used in that manner. Similarly, normal fracture and chill tests were used in the grey-iron foundry and were popular. A very good value could be obtained by fluidity testing providing one had made up one's mind as to what the test was wanted to show.

He did not agree that an orifice test would give good fluidity information. The orifice method had been tried, but this test gave the same data as the viscosity test, but the latter was much more accurate. Fluidity was not a function of viscosity alone, but of other properties also.

The Chairman (Dr. Dadswell), thought someone might like to raise a point arising from page 7 of the preprint of Mr. Worthington's Paper. He could not reconcile conclusion number 5, where an addition of chromium of 0.76 per cent. increased the fluidity and further additions, even up to as much as 11 per cent., had no further effect. He would have thought from experience on casting stainless steel that the reverse was the case and that the further increase of chromium reduced the fluidity.

Mr. E. R. Evans discussed the Paper from the point of view of the influence of mould conditions on fluidity. He spoke not from the point of view of steel, but cast iron. At the British Cast Iron Research Association were carried out a number of tests and within very small limits it had been found that mould conditions did not have very much effect on fluidity.

For example, regarding the coal-dust content of the sand; coal dust from virtually nil to nine per cent. in the sand had been used and there was no noticeable effect on the length of the spiral obtained for the same type of iron at the same temperature. Variations of other mould conditions, such as the use of pitch-bonded sand, dry-sand moulds, or the use of a vent at the end of the spiral channel, also had but little effect on the fluidity of the iron as measured by the spiral test.

In Fig. 9 of Mr. Worthington's Paper, the Author had shown some curves to illustrate the effect of nickel on fluidity, and from them it appeared that up to three per cent. there was virtually no effect, but when the nickel was increased to five per cent. there was a rather more sudden increase. If, however, reference was made to Fig. 6 on the previous page it was there shown that increasing the carbon content progressively increased the fluidity of steel. In Fig. 9 the carbon content varied from 0.14 to 0.29 per cent., a difference of 0.15 per cent. Increased carbon tended to displace the curve to the right whereas the lower content displaced it to the left, so that if the results shown in Fig. 9 were corrected for carbon content and brought into line with the 0.2 per cent. carbon steel, it would rather seem that there would be a gradual increase of fluidity with increasing nickel content and not a sudden jump in over 3 per cent. of nickel.

Mr. Worthington was inclined to agree with the speaker as far as the importance of mould conditions was concerned. He had not used coal dust, but he thought sand condition within wide limits had not much effect; neither had the moisture. Personally, he always felt inclined to put a wide vent at the end of the spiral because he thought that might have some effect. As far as the nickel curves referred to by the speaker were concerned, correcting for carbon, there would be a very slight increase, probably, of fluidity, but at the 6.72 per cent. nickel, surely that corrected for the 0.2 per cent. carbon would tend to displace the curve to the left. In other words, as the nickel content was increased to nearly 7 per cent. over 5 per cent., the fluidity would tend to be rather lower. Considering the curves separately, all the points obtained were close to the line, but, as he had said in the introduction, the melting conditions for each melt were necessarily variable, so there might be a slight displacement of one curve in relation to the other; it was not known what these displacements might be. In that connection, he had experimented with two heats of similar carbon steel, one of which was left in the furnace for a considerable period of time in excess of normal, and that particular steel had a remarkably increased fluidity at all temperatures over the other, so melting conditions did play a part and might mask any fine differences that existed.

Factors Influencing Results

Dr. Kondic suggested that, in discussing the fluidity and mould conditions, one had to start with the fact that the fluidity was affected by about a dozen factors, and perhaps more, and in trying to single out one of them, unless the remaining factors were constant, one would get into trouble. For example, on the question of mould conditions, whether it affected fluidity or not, a previous speaker had stated that it did not, but the trouble was that it was wrong to generalise on the results obtained with one alloy. They derived much interest from studying the effect of mould conditions on the fluidity of zinc- or aluminium-base alloys. There, the mould conditions affected the fluidity spiral considerably. It was a question of surface-oxide films, he thought, which was an important factor with those alloys. The question whether during the flow through the channel the aluminium-oxide film remained undisturbed, or whether it was turbulently mixed with the metal had an effect on the spiral length, and this depended on the mould conditions. In other words, the mould factors had very considerable effect on altering the apparent fluidity of alloys he had mentioned. One could not generalise

Casting Fluidity of Metals

and say the mould conditions did not matter: one had to qualify the statement by reference to the alloy.

On the question as to whether mould conditions affected the fluidity of steel and grey iron, there was some experimental evidence. No tests had been carried out on steel, but a few had been carried out on iron. The ramming density had been varied from 50 to 100 (A.F.S. test), which was from a fairly soft to fairly-hard degree of ramming, and the change in the spiral length was somewhere between two and three inches. One or two other factors in mould condition similarly affected the spiral length, but his opinion was that, if one was investigating the metal-fluidity/mould-condition relationship, one had to use a very reproducible test to get satisfactory sensitivity.

MR. EVANS said he also had done some ramming density tests between approximately the same ranges and he also had found that on the face of it a soft ramming density did give a slightly increased length of spiral. However, he had noticed that in the soft rammed moulds the spiral channel had slightly larger dimensions than in the hard rammed moulds, and he thought that the increased length of spiral was due to this factor.

MR. WRIGHTSON thought Dr. Kondic had very rightly stressed the difference between three types of fluidity—the purely physical property of the metal, the inverse of the viscosity; the figure that they derived as a result of the spiral fluidity tests and that property which foundrymen wanted and which might shortly be called the mould-filling capacity which gave them sharp, clean castings.

It might be advisable to try and introduce some other term than fluidity for defining the third property. The influence of the other factors on it at present were not clearly known. They were the subject of experiment. At times, Dr. Kondic's Paper was not too clear as to which property he was referring to when he used the word "fluidity," and he thought the foundryman sometimes tended not to realise that the fluidity as measured by the spiral had not necessarily any relation to the properties that he sought. If they could have some other term to cover that it might save trouble.

MR. WORTHINGTON pointed out that the matter had long been a point of contention and many and various names had been proposed, but none had been adopted. Fluidity, it seemed, was there, and they were likely to be stuck with it, although he thought there was much to be said for the French term *coulabilité*.*

DR. KONDIC fully agreed with the last speaker. They had there a fundamental point, and if they could sort it out progress would be made, because the fluidity spiral as used at present was just a reflection of the metal quality. But if one tried to apply the fluidity results to the problem of mould filling ability there was only a very restricted field where this could be done.

The question was, what kind of test could be used to meet the mould-filling ability requirements? It would seem to him that this was a matter for further experiment. He would not like to rush ahead with promises, but at Birmingham they were making a certain number of tests with exactly that object. They had found that there was a good correlation in certain cases, but the trouble was that the test became often so difficult to correlate to anything numerical that he was afraid it would take some time before they had sorted it out, although he thought this would have to be done eventually. As far as he could see the fluidity spiral was going to settle down as a useful test for research or in the foundry, and it would be a test of metal quality, just as a standard test-bar had resolved to-day as a metal-quality test. They would have to look for some other test which would fulfil the need for what the foundryman wanted in the way of mould-filling ability.

THE CHAIRMAN closing the discussion said there were one or two points arising out of earlier questions on which he would like to touch.

There was the point raised by Dr. Riley regarding the comparisons of the curves. It had struck him that those curves could be wrong. It was always very dangerous drawing curves when there were not very many points through which to draw them. It seemed to him that the Author was copying a pattern all through established by the 0.2 per cent. carbon when putting that definite kink in them all and there was nothing really to prove that the kink should be there for every case. For example in Fig. 10 one could draw straight lines for both.

The other point concerned the value of a fluidity test. It was a bit late having a control for fluidity when the steel was ready for tapping. If it was not going to be fluid they could not do much about it—it had been spoiled or not properly made. The correct way to make fluid steel was to institute process control. On the other hand, as Dr. Kondic had said, fluidity tests had value in that they would allow one to learn the factors which did affect fluidity, and that was important. He thanked the Authors, on the members' behalf, for giving up time to the preparation of the Papers and for spending time with them to discuss their work and results.

* The English equivalent is "life."—EDITOR.

Courses in Laboratory Arts Discontinued

The Institute of Physics announces that its certificate in laboratory arts will not be awarded after 1951, in view of the establishment of the Intermediate Certificate for Laboratory Technicians by the City and Guilds of London Institute, which it welcomes.

The City and Guilds of London Institute has agreed that holders of the Institute of Physics' certificate shall be eligible to enter, should they so wish, the course for the Advanced Laboratory Technicians Certificate, which is to be established shortly, on the same terms as those who have passed examinations for the new Intermediate Certificate and this is regarded as a fitting recognition of the standard which the Institute of Physics' certificate holders had reached. Students who have already begun courses for the Institute of Physics' certificate will be able to complete these by 1951.

Cast Iron at Sub-atmospheric Temperatures*

By G. N. J. Gilbert

(*Concluded from page 161.*)

(B)—Nodular Cast Irons

Melt W677:—1.2 in. dia. bars produced by the cerium process, inoculated with sufficient S.M.Z. alloy to raise the silicon content by 0.5 per cent.

Chemical Analysis:—Total carbon, 3.62 per cent.; silicon, 3.11 per cent.; manganese, 0.49 per cent.; sulphur, 0.010 per cent.; phosphorus, 0.037 per cent.; cerium, 0.054 per cent.

Microstructure:—Nodules in a matrix of pearlite with about 30 per cent. of ferrite. No change was observed in specimens taken from impact test-pieces which had been subjected to low temperatures.

Transverse strength, 64.5 tons per sq. in.
Deflection in transverse, 0.63 in.
Tensile strength, 34.3 tons per sq. in.
Brinell hardness number, 217.
Charpy impact, 16.8 ft.-lb. (⅜ 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	11.4
−25 to 0	11.4
−50 to −25	11.4
−75 to −50	10.0
−100 to −75	8.0

No structural change was observed.

Melt W755:—1.2 in. dia. bars produced by cerium process, inoculated with sufficient S.M.Z. alloy to raise the silicon content by 0.5 per cent.

Chemical Analysis:—Total carbon, 3.65 per cent.; silicon, 3.06 per cent.; manganese, 0.44 per cent.; sulphur, 0.003 per cent.; phosphorus, 0.033 per cent.; cerium, 0.070 per cent.

Microstructure:—Nodules in a matrix of ferrite with about 25 per cent. or less pearlite. No change was observed in specimens taken from impact test-pieces which had been subjected to low temperatures.

Transverse Strength, 59.6 tons per sq. in.
Deflection in transverse, 0.67 in.

* 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.

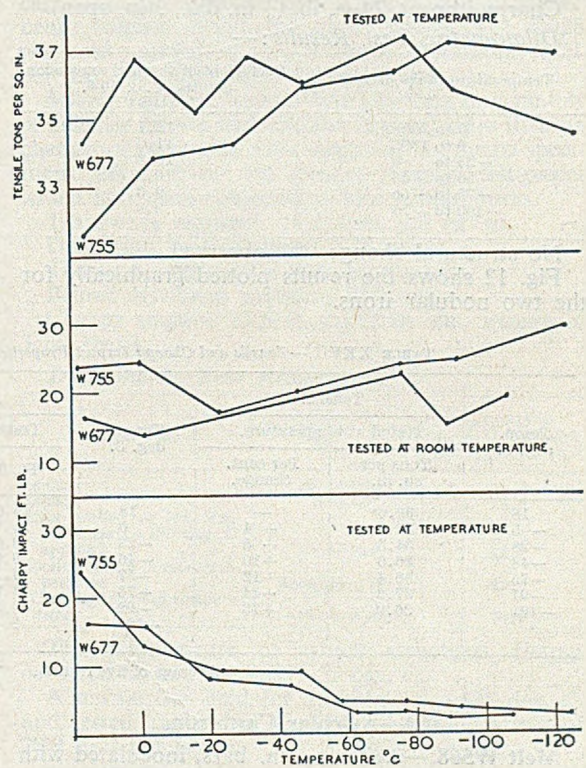


FIG. 12.—*Tensile and Impact Tests on Nodular Iron (Melts W677 and 755).*

TABLE XXV.—*Tensile and Charpy Impact Properties at Low Temperature of Grey Cast Irons (Melt W.779).*

Temp. deg. C.	Tensile. Tested at temperature. Tons per sq. in.	Tensile. Tested at temperature. Per cent. change.	Temp. deg. C.	Charpy impact (⅜ in. dia.). Tested at temperature. Ft.-lb.	Charpy impact. Tested at temperature. Per cent. change.	Charpy impact. Tested at 18 deg. C. Ft.-lb.	Charpy impact. Tested at 18 deg. C. Per cent. change.	B.H.N. tested at 18 deg. C.
18	6.9*	—	18	5.0†	—	—	—	103
− 3	7.1	+ 3	0	4.9	− 2	5.1	+ 2	109
−33	6.8	− 1	−18	4.8	− 4	5.0	0	100
−59	7.6	+10	−39	4.9	− 2	5.0	0	99
−97	7.9	+14	−61	3.9	−22	5.3	+ 6	101
−113	7.8	+13	−73	3.3	−34	5.1	+ 2	106
			−95	3.1	−38	5.0	0	104
			−120	3.0	−40	5.3	+ 6	103

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

TABLE XXVI.—*Tensile and Charpy Impact Properties at Low Temperatures of Nodular Cast Irons (Melt W.077).*

Temp. deg. C.	Tensile. Tested at temperature. Tons per sq. in.	Per cent. change.	Temp. deg. C.	Charpy impact (⅝ in. dia.). Tested at temperature. Ft.-lb.	Per cent. change.	Tested at 16 deg. C. Ft.-lb.	Per cent. change.	B.H.N. tested at 16 deg. C
+16	34.3*	—	+16	16.8†	—	—	—	198
+ 1	36.8	+7	− 1	16.0	− 5	14	−17	187
−17	35.2	+3	−19	8.2	−51	—	—	207
−32	36.8	+7	−43	7.2	−57	—	—	204
−48	36.0	+5	−62	2.9	−83	—	—	207
−78	37.4	+9	−76	3.1	−82	22.7	+35	198
−92	35.9	+5	−89	2.2	−87	15.4	+ 8	202
−127	34.5	+1	−107	2.5	−85	19.2	+14	211

* Average of six results. † Average of eight results.

Tensile strength, 32.6 tons per sq. in.
Brinell hardness number, 214.
Charpy impact, 24 ft. lb. (⅝ in. dia., 3 in. span).

Dilatometric Test Results:—

Temperature range, deg. C.	Coefficient of thermal expansion per deg. C. × 10^{-6}.
130 to 200	12.1
0 to 130	11.0
−25 to 0	10.3
−50 to −25	10.3
−75 to −50	9.3
−100 to −75	8.6

No structural change was observed.

Fig. 12 shows the results plotted graphically for the two nodular irons.

TABLE XXVIII.—*Charpy Impact Properties at Low Temperatures of Acicular Irons (Melt W.568).*

Temp. deg. C.	Charpy impact (⅝ in. dia.). Tested at temperature. Ft.-lb.	Per cent. change.	Tested at 16 deg. C. Ft.-lb.	Per cent. change.	B.H.N. tested at 16 deg. C.
16	13.3*	—	—	—	—
− 2	12.1	− 9	14.6	+10	266
− 23	13.9	+ 5	13.4	+ 1	285
− 38	13.8	+ 4	13.1	− 2	268
− 60	12.7	− 5	10.9	−18	295
− 83	11.4	−14	10.3	−23	309
− 97	9.7	−24	11.9	−11	315
−119	8.3	−38	10.6	−20	311

* Average of seven results.

TABLE XXVII.—*Tensile and Charpy Impact Properties at Low Temperatures of Nodular Irons (Melt W.755).*

Temp. deg. C.	Tensile. Tested at temperature. Tons per sq. in.	Per cent. change.	Temp. deg. C.	Charpy impact (⅝ in. dia.). Tested at temperature. Ft.-lb.	Per cent. change.	Tested at 18 deg. C. Ft.-lb.	Per cent. change.	B.H.N. tested at 18 deg. C.
18	32.6*	—	18	24.0†	—	—	—	173
− 5	33.9	+ 4	0	13.3	−45	24.7	+ 3	169
−28	34.3	+ 5	−23	9.0	−63	16.9	−30	158
−48	36.0	+10	−46	9.0	−63	20.1	−16	171
−75	36.4	+12	−57	4.3	−82	—	—	177
−91	37.2	+14	−76	4.3	−82	23.7	− 1	178
−121	36.9	+13	−92	3.8	−84	24.6	+ 3	165
			−124	2.4	−90	29.9	+25	165

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

(C)—Acicular Cast Irons

Melt W568:—0.875 in. dia. bars, inoculated with 0.5 per cent. silicon as 80 per cent. ferro-silicon.

Chemical Analysis:—Total Carbon, 3.13 per cent.; silicon, 2.19 per cent.; manganese, 0.46 per cent.; sulphur, 0.034 per cent.; phosphorus, 0.028 per cent.; nickel, 1.88 per cent.; molybdenum, 0.57 per cent.

Microstructure:—Fine flake graphite in a matrix of acicular ferrite and acicular structure. No definite change of structure was apparent from a study of microspecimens taken from the broken impact test-pieces which had been subjected to low temperatures.

Transverse strength, 44.6 tons per sq. in.
Deflection in transverse, 0.29 in.
Tensile strength, 23.9 tons per sq. in.
Brinell hardness number, 287.
Charpy impact, 13.3 ft. lb. (⅝ in. dia., 3 in. span).

Dilatometric Test Results:—

Condition.	Temperature range, deg. C.	Coefficient of thermal expansion per deg. C. × 10^{-6}.
As-cast	0 to 200	14.6
Immersed in liquid oxygen for 10 min.	0 to 200	12.0
Cooling below room temperature	Room to −64	12.2
Warming to room temperature	−100 to room	10.7

Temperature at which structural change occurred on cooling was −64 deg. C.

Melt W687:—1.2 in. dia. bars, inoculated with 0.5 per cent. silicon as 80 per cent. ferro-silicon.

Chemical Analysis:—Total carbon, 3.17 per cent.; silicon, 2.11 per cent.; manganese, 0.50 per

TABLE XXIX.—*Tensile and Charpy Impact Properties at Low Temperatures of Acicular Irons (Melt W.687).*

Temp. deg. C.	Tensile. Tested at temperature. Tons per sq. in.	Tensile. Tested at temperature. Per cent. change.	Temp. deg. C.	Charpy impact (⅝ 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	21.4*	—	16	16.8*	—	—	—	229
−16	22.6	+ 6	0	17.7	+ 5	17.3	+ 3	234
−29	22.7	+ 6	−19	15.5	− 8	16.2	− 4	235
−44	23.5	+10	−38	16.7	− 1	16.2	− 4	229
−59	24.7	+15	−58	14.3	−15	15.5	− 8	266
−74	24.6	+15	−84	10.6	−37	13.2	−21	272
−105	25.2	+18	−96	10.4	−38	13.2	−21	271
			−107	8.5	−49	11.2	−33	280

* Average of six results.

cent.; sulphur, 0.030 per cent.; phosphorus, 0.029 per cent.; nickel, 1.59 per cent.; molybdenum, 0.75 per cent.

Microstructure:—Fine flake graphite in a matrix of acicular ferrite and acicular structure. No definite change of structure was apparent from a study of microspecimens taken from the broken impact test-pieces which had been subjected to low temperatures.

Transverse strength, 49.1 tons per sq. in.
Deflection in transverse, 0.42 in.
Tensile strength, 21.4 tons per sq. in.
Brinell hardness number, 239.
Charpy impact, 16.8 ft. lb (⅝ in. dia. specimen, 3 in. span).

Dilatometric Test Results:—

Condition.	Temperature range, deg. C.	Coefficient of thermal expansion per deg. C. × 10-6.
As-cast	0 to 200	14.1
After testing at low temperature (to −180 deg. C. approx.)	0 to 200	11.2
Cooling below room temperature	Room to −54	12.0
Warming to room temperature	−100 to room	10.6

The temperature at which structural change occurred on cooling was −54 deg. C.

A tensile bar subjected to a temperature of −106 deg. C. had a breaking stress of 23.4 tons per sq. in. when tested at room temperature.

Melt W747:—1.2 in. dia. bars, inoculated with 0.5 per cent. silicon as 80 per cent. ferro-silicon.

Chemical Analysis:—Total carbon 3.03 per cent.; silicon, 1.60 per cent.; manganese, 0.55 per cent.; sulphur, 0.032 per cent.; phosphorus, 0.028 per cent.; nickel, 2.32 per cent.; chromium, 0.21 per cent.; molybdenum, 0.95 per cent.

Microstructure:—Fine flake graphite in a matrix of acicular ferrite and acicular structure. No definite change of structure was apparent in micro-specimens taken from the broken impact test-pieces which had been subjected to low temperatures.

Transverse strength, 51.2 tons per sq. in.
Deflection in transverse, 0.35 in.
Tensile strength, 27.4 tons per sq. in.
Brinell hardness number, 320.
Charpy impact, 19.0 ft. lb. (⅝ in. dia. specimen, 3 in. span).

Dilatometric Test Results:—

Condition.	Temperature range, deg. C.	Coefficient of thermal expansion per deg. C. × 10-6.
As-cast	130 to 200	15.7
As-cast	0 to 130	13.8
After testing at low temperatures (−180 deg. C. approx.)	0 to 200	12.1
Cooling below room temperature	Room to −53	12.5
Warming to room temperature	−100 to room	10.9

The temperature at which structural change occurred on cooling was −53 deg. C.

A tensile bar held for 15 min. at −125 deg. C. and tested at 18 deg. C. had a breaking stress of 29.9 tons per sq. in.

Melt W772:—1.2 in. dia. bars, inoculated with 0.5 per cent. silicon as 80 per cent. ferro-silicon.

TABLE XXX.—*Tensile and Charpy Impact Properties at Low Temperatures of Acicular Irons (Melt W.747).*

Temp. deg. C.	Tensile. Tested at temperature. Tons per sq. in.	Tensile. Tested at temperature. Per cent. change.	Temp. deg. C.	Charpy impact (⅝ in. dia.). Tested at temperature. Ft.-lb.	Charpy impact. Tested at temperature. Per cent. change.	Charpy impact. Tested at 18 deg. C. Ft.-lb.	Charpy impact. Tested at 18 deg. C. Per cent. change.	B.H.N. tested at 18 deg. C.
18	27.4*	—	18	19.0†	—	—	—	306
− 8	27.9	+ 2	0	20.0	+ 5	18.5	− 3	309
−20	25.0	− 9	−23	14.6	−23	18.5	− 3	326
−31	31.4	+15	−30	16.1	−15	17.6	− 7	339
−49	25.1	− 8	−57	15.6	−18	17.4	− 8	321
−68	27.8	+ 1	−79	11.7	−38	12.2	−36	326
−103	28.8	+ 5	−92	10.9	−43	14.0	−26	354
−122	31.4	+15	−124	8.7	−54	14.0	−32	273

* Average of six results. † Average of eleven results.

TABLE XXXI.—*Tensile and Charpy Impact Properties at Low Temperatures of Acicular Irons (Melt W.772).*

Temp. deg. C.	Tensile. Tested at temperature. Tons per sq. in.	Tensile. Tested at temperature. Per cent. change.	Temp. deg. C.	Charpy impact (⅜ in. dia.). Tested at temperature. Ft.-lb.	Charpy impact. Tested at temperature. Per cent. change.	Charpy impact. Tested at 18 deg. C. Ft.-lb.	Charpy impact. Tested at 18 deg. C. Per cent. change.	B.H.N. tested at at 18 deg. C.
18	23.6*	—	18	17.2†	—	—	—	271
− 1	24.7	+ 5	− 4	17.0	− 1	15.6	− 9	266
−14	24.8	+ 5	−23	17.9	+ 4	16.4	− 5	266
−36	22.6	− 4	−39	15.3	−11	18.4	+ 7	266
−55	26.1	+11	−60	13.3	−23	12.4	−28	293
−62	24.4	+ 3	−74	11.7	−32	12.9	−25	298
−70	26.5	+12	−93	8.7	−49	11.2	−35	317
−96	25.3	+ 7	−124	7.9	−54	10.2	−41	326
−105	25.2	+ 7	−130	7.0	−59	9.7	−44	326

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

Chemical Analysis:—Total carbon, 3.06 per cent.; silicon, 2.18 per cent.; manganese, 0.46 per cent.; sulphur, 0.036 per cent.; phosphorus, 0.038 per cent.; nickel, 3.10 per cent.; molybdenum, 0.54 per cent.

Microstructure:—Fine flake graphite in a matrix of acicular ferrite and acicular structure. No definite change of structure was apparent in micro-specimens taken from the broken impact test-pieces which had been subjected to low temperatures.

Transverse strength, 43.9 tons per sq. in.
Deflection in transverse, 0.37 in.
Tensile strength, 23.6 tons per sq. in.
Brinell hardness number, 278.
Charpy impact, 17.2 ft. lb. (⅜ in. dia. specimen, 3 in. span).

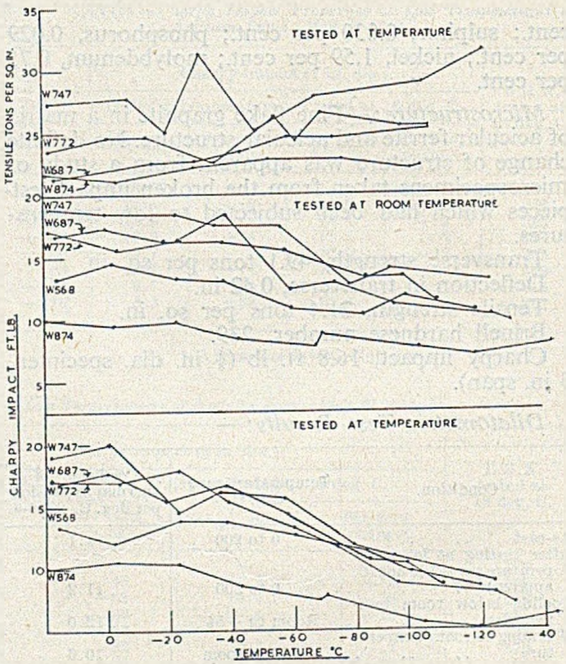
Dilatometric Test Results:—

Condition.	Temperature range, deg. C.	Coefficient of thermal expansion per deg. C. × 10^{-6}.
As-cast	0 to 200	15.0
After testing at low temperature (− 180 deg. C. approx.)	0 to 200	11·3
Cooling below room temperature	Room to −48	11.5
Warming to room temperature	−100 to room	10.4

Temperature at which structural change occurred on cooling was −48 deg. C.

A tensile bar held for 15 min. at −104 deg. C. and tested at 18 deg. C. had a breaking stress of 23.3 tons per sq. in.

Fig. 13 shows the results of the mechanical tests at low temperatures on these acicular irons.



Material.	Temperature of Phase Change.
W568 (Acicular).	− 53 deg. C.
W687 "	− 48 "
W747 "	− 54 "
W772 "	− 64 "
W874 (Martensitic).	− 26 "

FIG. 13.—*Tensile and Impact Tests on Acicular and Martensitic Irons.*

TABLE XXXII.—*Tensile and Charpy Impact Properties at Low Temperatures of Martensitic Cast Iron (Melt W.874).*

Temp. deg. C.	Tensile. Tested at temperature. Tons per sq. in.	Tensile. Tested at temperature. Per cent. change.	Temp. deg. C.	Charpy impact (⅜ 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	21.9*	—	20	10.0†	—	—	—	309
− 4	21.3	− 3	− 3	10.6	+ 6	9.5	− 5	309
−29	22.3	+ 2	−23	10.4	+ 4	9.9	− 1	325
−53	22.9	+ 5	−43	8.6	−14	8.5	−15	329
−77	22.8	+ 4	−68	7.5	−25	7.9	−21	359
−99	22.0	+ 0	−70	7.8	−22	8.8	−12	380
−102	22.2	+ 1	−101	5.5	−45	7.6	−24	395
			−119	5.0	−50	7.0	−30	404
			−144	6.4	−36	7.9	−21	383

* Average of six results. † Average of five results.

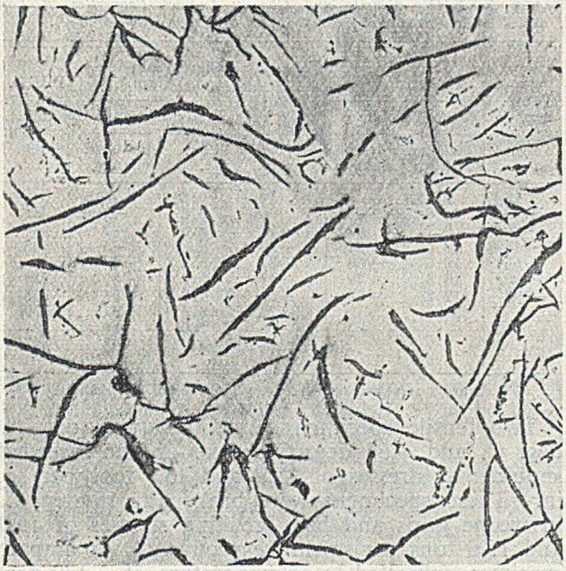


FIG. 14.—*Structure of Nickel-Copper-Chromium Austenitic Iron W335 in the As-cast state. Graphite Flakes in a Matrix of Austenite with a little Carbide. Etched in 4 per cent. Picral* × 100.

(D)—Martensitic Cast Irons

Melt W874:—1.2 in. dia. bars, inoculated with 0.5 per cent. silicon as 80 per cent. ferro-silicon.

Chemical Analysis:—Total carbon, 2.81 per cent.; silicon, 1.81 per cent.; manganese, 0.52 per cent.; sulphur, 0.050 per cent.; phosphorus, 0.046 per cent.; nickel, 4.87 per cent.

Microstructure:—Medium flake graphite with some under-cooled graphite in martensitic structure

FIG. 15.—*Same Material as shown in Fig. 14, after Treatment at −20 deg. C. Etched in 4 per cent. Picral* × 100.

FIG. 16.—*Same Material after Treatment at −55 deg. C. Etched* × 100.

with about 10 per cent of troostite. No definite change in microstructure was apparent in micro-specimens taken from the broken impact test-pieces which had been subjected to low temperatures.

Transverse strength, 33.7 tons per sq. in.
Deflection in transverse, 0.27 in.
Tensile strength, 21.9 tons per sq. in.
Brinell hardness number, 340.
Charpy impact, 10 ft. lb. (⅝ in. dia. specimen, 3 in. span).

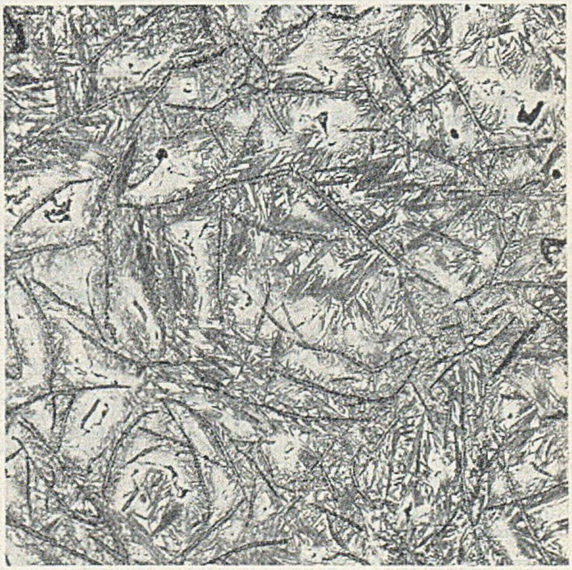


FIG. 17.—*Same Material after Treatment at −114 deg. C. Etched* × 100.

Cast Iron at Sub-atmospheric Temperatures

Dilatometric Test Results:—

Condition.	Temperature range, deg. C.	Coefficient of thermal expansion per deg. C. × 10-6.
As-cast	0 to 200	13·3
After testing at low temperature (−180 deg. C. approx.)	0 to 200	10.7
Cooling below room temperature	Room to −26	12.4
Warming to room temperature	−100 to room	10.4

The temperature at which structural change occurred on cooling was −26 deg. C.

Tensile bars held for 15 min. at temperatures of −47 deg. C. and −92 deg. C. and tested at 19 deg. C. had breaking stresses of 22.2 tons per sq. in. and 22.4 tons per sq. in. respectively. The mechanical results at low temperatures for this material are shown graphically in Fig. 13, together with those for the acicular materials.

(E)—Austenitic Cast Irons

Melt W335:—Ni-Resist type, 1.2 in. dia. bars.

Chemical Analysis:—Total carbon, 2.95 per cent.; silicon, 2.64 per cent.; manganese, 0.60 per cent.; sulphur, 0.025 per cent.; phosphorus, 0.035 per cent.; nickel, 13.93 per cent.; chromium, 1.06 per cent.; copper, 6.36 per cent.

Microstructure:—Medium flake graphite in a matrix of austenite with small quantity of carbide. Micro-specimens taken from the impact test-pieces which had been tested at various temperatures had the following structures:—

Temp., deg. C.	Structure.	Remarks.
0	Unchanged	Non-magnetic
−20	Increasing amounts of martensite	Slightly magnetic
−47		Magnetic
−55		Magnetic
−72		Magnetic
−98		Magnetic
−114		Magnetic

Micrographs of the specimens in the as-cast condition and those subjected to temperatures of −20 deg. C., −55 deg. C., and −114 deg. C., are shown respectively as Figs. 14, 15, 16 and 17.

Transverse strength, 15.7 tons per sq. in.
Deflection in transverse, 0.56 in.
Tensile strength, 9.1 tons per sq. in.
Brinell hardness number, 96 (3,000 kg./10 mm).
Charpy impact, 9.3 ft./lb. ($\frac{3}{8}$ in. dia. specimen, 3 in. span).

Dilatometric Test Results:—

Condition.	Temperature range, deg. C.	Coeff. of thermal expansion per deg. C. × 10−6.
As-cast	0 to 200	18.2
Immersed in liquid oxygen for 10 minutes	0 to 200	12.4
Cooling below room temp...	Room to −10	15.5
Warming to room temp. ..	−100 to Room	11.4

The temperature at which the structural change occurred on cooling was −10 deg. C. approximately.

TABLE XXXIII.—*Tensile and Charpy Impact Properties at Low Temperatures of Ni-Resist type Cast Irons (Melt W.335).*

Temp. deg. C.	Tensile. Tested at temp. Tons per sq. in.	Tensile. Tested at temp. Per cent. change.	Temp., deg. C.	Charpy impact ($\frac{3}{8}$ in. diam.). Tested at temp. Ft.-lb.	Charpy impact. Tested at temp. Per cent. change.	B.H.N. (250 kg. 5 mm.), tested at 10 deg. C.
16	9.1*	—	16	9.3†	—	—
−4	8.3	−9	0	9.2	−1	89
−20	9.7	+7	−17	8.5	−9	—
−45	12.5	+37	−20	8.8	−5	93
−55	12.6	+38	−37	5.2	−44	—
−83	16.3	+79	−47	5.7	−39	118
−100	17.2	+89	−55	4.3	−54	128
			−72	3.6	−61	179
			−98	2.9	−69	191
			−114	3.0	−68	197

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

Two tensile specimens at temperatures of −59 deg. C. and −63 deg. C. broke on the threaded shoulder at stresses of 13.9 and 13.6 tons per sq. in. These specimens were broken at 16 deg. C. in wedge grips and had breaking stresses of 15.0 and 15.6 tons per sq. in. respectively. An impact specimen subjected to a temperature of −120 deg. C. and tested at room temperature had an impact value of 2.0 ft./lb.

Melt W491:—Ni-Resist type 1.2 in. dia. bars.

Chemical Analysis:—Total carbon, 2.91 per cent.; silicon, 2.44 per cent.; manganese, 0.57 per cent.; sulphur, 0.022 per cent.; phosphorus, 0.031 per cent.; nickel, 15.55 per cent.; chromium, 1.17 per cent.; copper, 6.17 per cent.

Microstructure:—Medium flake graphite in a matrix of austenite. There was a small amount of carbide present in the structure. Microspecimens taken from the impact test-pieces which had been tested at various temperatures had the following structures.

Temperature, deg. C.	Structure.	Remarks.
−3	No change in structure	Non-magnetic
−21		
−43		
−59	Increasing amounts of martensite	Slightly magnetic
−75		Magnetic
−114		Magnetic
−141		Magnetic

Transverse strength, 19.7 tons per sq. in.
Deflection in transverse, 0.51 in.
Tensile strength, 8.3 tons per sq. in.
Brinell hardness number, 86 (1,000 kg./10 mm.).
Charpy impact, 5.7 ft./lb. ($\frac{3}{8}$ in. dia. specimen, 3 in. span).

Dilatometric Test Results:—

Condition.	Temperature range, deg. C.	Coeff. of thermal expansion per deg. C. × 10−6.
As-cast	0 to 200	18.0
Immersed in liquid oxygen for 10 minutes	0 to 200	13.3
Cooling below room temp...	Room to −50	15.5
Warming to room temp. ..	−100 to Room	13.2

The temperature at which the structural change occurred on cooling was −50 deg. C. approximately.

TABLE XXXIV.—*Charpy Impact Properties at Low Temperatures of Ni-Resist type Irons (Melt W491).*

Temp., deg. C.	Charpy impact (⅝ in. diam.). Tested at temp. Ft.-lb.	Per cent. change.	Tested at 16 deg. C. Ft.-lb.	Per cent. change.	B.H.N. tested at 16 deg. C.
16	5.7*	—	—	—	—
−3	7.2	+26	—	—	<90
−21	8.9	+56	6.1	+7	<90
−43	8.4	+47	4.8	−16	95
−59	7.4	+30	6.0	+5	122
−75	6.0	+5	4.0	−30	157
−114	4.5	−21	3.2	−44	195
−141	3.1	−46	2.8	−51	219

* Average of six results.

Melt W765:—Ni-Resist type 1.2 in. dia. bars. This material has a composition close to that recommended in Specification D.T.D. 649.

Chemical Analysis:—Total carbon, 2.65 per cent.; silicon, 2.43 per cent.; manganese, 0.48 per cent.; sulphur, 0.016 per cent.; phosphorus, 0.051 per cent.; nickel, 15.52 per cent.; chromium, 1.41 per cent.; copper, 8.65 per cent.

Microstructure:—Medium flake graphite in a matrix of austenite. Microspecimens taken from the impact test-pieces which had been tested at various temperatures had the following changes in structure:—

Temperature, deg. C.	Structure.	Remarks.
Down to −60	No change	Non-magnetic
−92	Increasing amounts of martensite	Slightly magnetic
−106	Increasing amounts of martensite	Magnetic
−124	Increasing amounts of martensite	Magnetic

Transverse strength, 25.1 tons per sq. in.
Deflection in transverse, 0.44 in.
Tensile strength, 9.8 tons per sq. in.
Brinell hardness number, 123.
Charpy impact, 16 ft./lb. (⅝ in. dia. specimen, 3 in. span).

Dilatometric Test Results:—

Condition.	Temperature range, deg. C.	Coeff. of thermal expansion per deg. C. × 10⁻⁶.
As-cast	0 to 200	17.7
After testing at low temp. (−180 deg. C. approx.) ..	0 to 200	14.5
Cooling below room temp...	0 to −25	16.6
	−25 to −50	15.9
	−50 to −75	15.1
Warming to room temp. ..	−100 to 0	12.6

The temperature at which the structural change occurred on cooling was −88 deg. C. approximately.

Two tensile specimens subjected to temperatures of −60 deg. C. and −126 deg. C. and tested at 18 deg. C. had breaking stresses of 9.4 and 14.9 tons per sq. in. respectively.

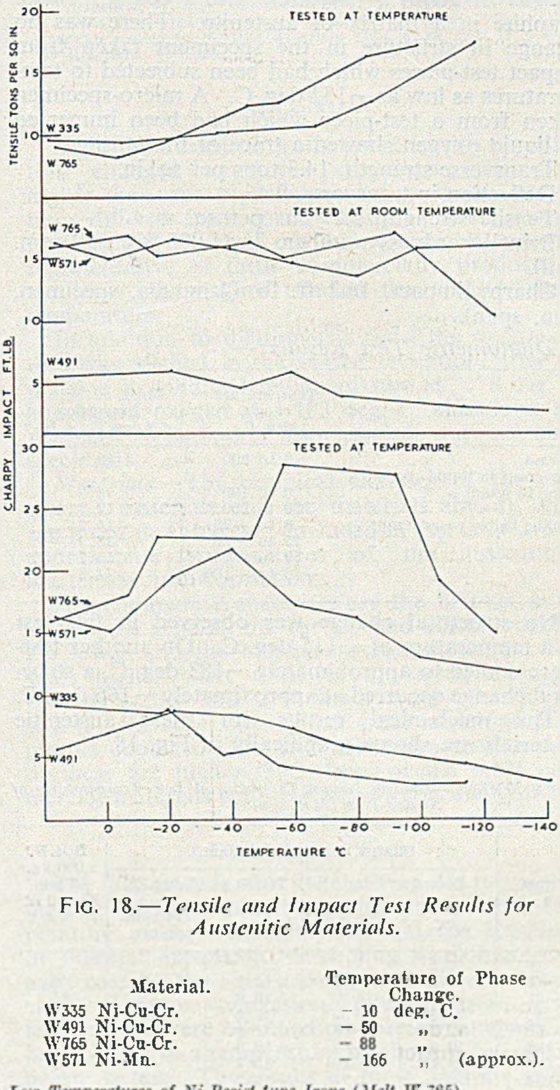


FIG. 18.—*Tensile and Impact Test Results for Austenitic Materials.*

Material.	Temperature of Phase Change.
W335 Ni-Cu-Cr.	−10 deg. C.
W491 Ni-Cu-Cr.	−50 „
W765 Ni-Cu-Cr.	−88 „
W571 Ni-Mn.	−166 „ (approx.).

TABLE XXXV.—*Tensile and Charpy Impact Properties at Low Temperatures of Ni-Resist type Irons (Melt W.765).*

Temp., deg. C.	Tensile. Tested at temp. Tons per sq. in.	Per cent. change.	Temp., deg. C.	Charpy impact (⅝ in. diam.). Tested at temp. Ft.-lb.	Per cent. change.	Tested at 18 deg. C. Ft.-lb.	Per cent. change.	B.H.N. 1,000 kg./10 mm. tested at 18 deg. C.
18	9.8*	—	18	16.0†	—	—	—	97
−5	9.4	−4	−7	18.1	+13	16.5	+3	104
−30	10.2	+4	−16	22.9	+43	15.4	−4	103
−39	10.2	+4	−46	22.6	+41	16.4	+3	102
−67	10.8	+10	−56	28.5	+78	15.1	−6	108
−85	12.7	+30	−76	28.2	+76	—	—	105
−100	14.8	+51	−92	27.8	+74	17.2‡	−8	118
−118	17.5	+79	−106	19.2	+20	—	—	143
			−124	15.0	−6	10.5‡	−34	184

* Average of six results. † Average of seven results. ‡ Single results only.

Cast Iron at Sub-atmospheric Temperatures

Melt W571:—Nomag, 0.875 in. dia. bars.

Chemical Analysis:—Total carbon, 3.56 per cent.; silicon, 2.22 per cent., manganese, 5.20 per cent.; sulphur, 0.025 per cent.; phosphorus, 0.026 per cent., nickel, 10.40 per cent.

Microstructure:—Medium to coarse flake graphite in a matrix of austenite. There was no change in structure in the specimens taken from impact test-pieces which had been subjected to temperatures as low as −132 deg. C. A micro-specimen taken from a test-piece which had been immersed in liquid oxygen showed a trace of martensite.

Transverse strength, 14.3 tons per sq. in.

Deflection in transverse, 0.46 in.

Tensile strength, 5.8 tons per sq. in.

Brinell hardness number, 76 (1,000 Kg., 10 mm. ball).

Charpy impact, 16.2 ft. lb. ($\frac{5}{8}$-in. dia. specimen, 3-in. span).

Dilatometric Test Results:—

Condition.	Temperature range, deg. C.	Coeff. of thermal expansion per deg. C. × 10^{-6}.
As-cast	0 to 200	18.8
Immersed in liquid oxygen for 10 minutes	0 to 130	18.3
	130 to 200	19.3
Cooling below room temp...	0 to −25	16.9
	−25 to −50	16.9
	−50 to −75	15.7
	−75 to −100	14.6

No structural change was observed in this test to a temperature of −115 deg. C. On another test-piece cooled to approximately −183 deg. C. a structural change occurred at approximately −166 deg. C.

The mechanical results for these austenitic materials are shown graphically in Fig. 18.

TABLE XXXVI.—*Charpy Impact Properties at Low Temperatures of Nomag Iron (Melt W571).*

Temp., deg. C.	Charpy impact ($\frac{5}{8}$ in. diam.). Tested at temp.		Tested at 16 deg. C.		B.H.N. 1,000 kg./10 mm. tested at 16 deg. C.
	Ft.-lb.	Per cent. change.	Ft.-lb.	Per cent. change.	
16	16.2	—	—	—	—
−1	15.1	−7	15.1	−7	86
−21	19.5	+20	16.6	+2	85
−40	21.8	+35	16.0	+1	83
−60	17.2	+6	14.9	−8	78
−80	16.3	+1	13.8	−15	77
−99	13.1	−19	15.7	−3	83
−132	11.9	−27	16.2	0	80

Conclusions

Grey Cast Irons.—In general, grey irons show a rise in tensile strength of up to 12 per cent. and a fall in impact strength of approximately 30 per cent. at temperatures of −100 deg. C. Subjecting the material to low temperatures has no adverse effect on the subsequent room-temperature properties.

A pearlitic iron, W842, containing 2 per cent. of nickel, showed a fall in impact strength of 53 per cent. at −125 deg. C. and little change of tensile strength. In the under-cooled iron, W565, the impact strength fell only 12 per cent. at low temperatures. The partly ferritic material W779 had a large percentage fall in impact strength between −39 deg. C. and −61 deg. C. This material was similar in composition to a hyper-eutectic nodular iron but did not receive the nodulising treatment. The coefficient of thermal expansion is reduced at low temperatures and there is no structural change in these materials.

Nodular Irons.—The impact strength of the cerium-treated nodular irons which contain considerable ferrite in the structure decreases rapidly as the temperature falls below normal. Reductions of 90 per cent. at temperatures of −100 deg. C. occurred. A rise of tensile strength of 14 per cent. was obtained at −100 deg. C. It is to be noted that the rapid fall in impact strength begins at temperatures about normal. The coefficient of thermal expansion is reduced at low temperatures and no structural change occurs.

Acicular and Martensitic Irons.—At low temperatures there is a fall in impact value of up to 50 per cent. at −100 deg. C. The tensile strength shows an increase at low temperatures and amounted to 18 per cent. at a temperature of −105 deg. C. in W687 material. The impact specimens soaked at low temperatures and tested at room temperature showed a reduction in impact value due to a change of structure which occurred, but the values were above the corresponding bars tested at low temperatures, *i.e.*, the strength fell at low temperatures quite independently of the changed structure.

The temperature at which the phase change occurred in the acicular materials was between −48 and −64 deg. C., a fairly narrow range of temperature. The martensitic material changed structure at −26 deg. C. The change in structure was not apparent from a study of the microstructure, but it seems reasonable to suppose that retained austenite in the structure was transformed to martensite. The phase change was accompanied by an expansion of about 20 per cent. of that obtained in the austenitic materials. The coefficient of thermal expansion was less after the change, but the reduction was not so marked as in the austenitic materials.

The contraction accompanying the phase change at approximately 420 deg. C. in these materials was always greater in the specimens which had been subjected to low temperatures (structure transformed) than in the as-cast materials.

Austenitic Materials.—The nickel-copper-chromium austenitic irons W491 and W765 show a considerable rise in impact with decrease in temperature, as the phase change is approached. This rise amounted to 78 per cent. of the room temperature strength in the case of W765 material. On returning to room temperature the strength is unaffected. It was not possible to decide if this effect occurred in W335 material, since the phase change took place so near to room temperature. At temperatures below that of the phase change the impact strength falls off rapidly in the bars tested at low temperature, but remains above the corresponding values for the material returned to room temperature and tested, *i.e.*, unlike the acicular materials, the impact strength rises at low temperature when considered independently of the structure.

The Nomag material showed a maximum in the impact curve, but it occurred at a temperature appreciably above that of the phase change. The tensile strength of the Ni-Resist type materials increased rapidly at temperatures below those of the phase change. In the case of W335 material the strength increased by 89 per cent. at −100 deg. C. Though the micrograph shows W335 material to be substantially martensitic due to treatment at −114 deg. C., the hardness was found to be only 197 B.H.N. Presumably these materials have a considerable amount of untransformed austenite.

The phase change in these materials is acompanied by a large expansion which proceeds with a series of audible clicks. A considerable reduction in the rate of cooling occurred and it was assumed that the reaction was exothermic. The microstructure showed that the austenite was changing to martensite as the structural change proceeded. The coefficient of thermal expansion was considerably reduced after the change. The dilatometric curve on materials W765 and W335 which had been subjected to low temperatures, showed a change at approximately 430 deg. C., which in the case of W765 was complete at about 700 deg. C. The change occurred in two distinct stages in the case of W335 material.

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REFERENCES

[1] Hadfield, R. A., "Experiments relating to the effect on mechanical and other properties of iron and its alloys produced by liquid air temperatures," Journal of the Iron and Steel Institute, 1905, v. 61, No. 1, pp. 147-219.

[2] Russell, H. W., "Effect of low temperatures on metals and alloys," American Society for Testing Materials and the American Society of Mechanical Engineers, Symposium on Effects of Temperature on the Properties of Metals, 1931, pp. 486-508.

[3] Foley, F. B., "Résumé of round-table discussion on effect of sub-atmospheric temperatures on the properties of metals," Proceedings, American Society for Testing Materials, 1939, v. 39, pp. 637-641.

[4] Gillett, H. W., "Impact resistance and tensile properties of metals at sub-atmospheric temperatures," American Society for Testing Materials, Project 13, August, 1941.

[5] White, A. E., and Siebert, C. A., "Report on literature survey on the low temperature properties of metals to October, 1941." O.S.R.D. Report No. 281, December, 1941, 591 pp.

[6] Donaldson, J. W., "Properties of metals and alloys at sub-zero temperatures," Metals Treatment, 1944, v. 11, Autumn, pp. 161-171.

[7] Colbeck, E. W., "Materials of construction for use at low temperatures," Paper presented to Physical Society and Institution of Chemical Engineers, 1949, Feb. 24.

[8] Pardun, C., and Vierhaus, E., "The properties of cast iron at low temperatures with special reference to cast iron pipes," Die Giesserei, 1928, v. 15, February 3, pp. 99-102 (in German). Summarised in Reference 2, p. 502, and in B.C.I.R.A. Bulletin, 1928, v. 1, April, p. 22.

[9] British Oxygen Company, "Strength of cast iron at very low temperatures," Industrial Gases, 1927, v. 8, June, p. 73. Summarised in B.C.I.R.A. Bulletin, 1928, v. 1, January, p. 18.

[10] American Foundrymen's Association and Society for Testing Materials, "Symposium on cast iron," Proceedings of the American Society for Testing Materials, 1933, v. 33, p. 202.

[11] Rajakovics, E. V., "The influence of testing temperature on the specific impact strength of cast iron," Die Giesserei, 1935, v. 22, March 1, pp. 95-96 (in German).

[12] Nickel Cast Iron News, November, 1940, p. 11. See Reference 4, p. 24.

[13] Boone, W. D., and Wishart, H. B., "High speed fatigue tests of several ferrous and non-ferrous metals at low temperatures." American Society for Testing Materials, 1935, v. 35, Part 2, pp. 147-152.

[14] Simmons, O. W., Rosenthal, P. C., and Lorig, C. H., "Study of malleable castings for military applications." Foundry, 1943, v. 71, October, pp. 102-104; November, pp. 122-125, 190-192, and December, pp. 106-108, 202-204. Summarised in Reference 6, p. 169.

[15] Schwartz, H. A., "Discussion by H. A. Schwartz of symposium on effects of temperature on the properties of metals," Proceedings, American Society for Testing Materials, 1924, v. 24, Part II, p. 164.

[16] Reference 4, p. 25.

APPENDIX

Since the austenitic irons tested in this investigation changed structures at temperatures much higher than was expected, and since their compositions differed from commercially available irons, it was decided to carry out a few tests on materials representative of those commercially produced to see how composition effected the transformation temperature.

In addition to dilatometric tests, the microstructure was studied in the as-cast condition, after immersion in solid CO_2/ether mixture at −78 deg. C., and liquid oxygen at −183 deg. C. Hardness and magnetic tests were also carried out on these specimens.

Materials.—The chemical analyses of the commercial materials and the materials already tested are given in Table A.* Included in this table are the approximate temperatures of the austenite-to-martensite transformation.

The commercial materials are the first six in the Table. In general, the carbon and silicon contents are lower and the manganese and chromium contents higher than those in the other materials. Materials 2/8 and 2/9 which were centrifugally cast (all the others being sand cast) have high phosphorus contents. The transformation temperatures of these are higher than those of the other commercial materials with low phosphorus contents.

Dilatometric Tests

The dilatometric tests were carried out in a similar manner to those previously described. The temperature of the transformation and the coefficient of thermal expansion on cooling was obtained in each case by the slow-cooling method. The coefficients of thermal expansion while warming to room temperature were obtained on specimens which had been cooled to a temperature of about −175 deg. C. before testing. The results of these tests are shown in Table B.

Immersion Tests

Microstructure.—The microstructure of each material was examined in the as-cast condition, after immersion in CO_2/ether mixture at −78 deg. C., and liquid oxygen at −183 deg. C. The speci-

* The first five of these materials were kindly supplied by Mr. M. M. Hallett, of the Sheepbridge Stokes Centrifugal Castings Company, Limited, Chesterfield, and the sixth material was supplied by Mr. P. A. Russell, of S. Russell & Sons, Limited, Leicester. The remaining materials were prepared in the laboratories of the British Cast Iron Research Association.

TABLE A.—*Composition of Austenitic Irons Tested.*

Material.	T.C. per cent.	Si, per cent.	Mn, per cent.	S, per cent.	P, per cent.	Ni, per cent.	Cu, per cent.	Cr, per cent.	Approx. temperature of transformation, deg. C.
146	2.51	2.17	1.10	0.088	0.09	15.92	7.97	1.88	Below −175
171	2.42	1.85	0.98	0.086	0.062	15.50	7.06	1.72	Below −175
180	2.52	1.73	1.11	0.092	0.073	13.20	6.87	1.67	−155
2/8	2.58	2.36	0.98	0.122	0.88	15.55	8.02	1.61	−120
2/9	2.67	2.29	1.25	0.085	0.90	13.30	6.51	1.64	−85
LA	2.62	2.44	0.95	0.044	0.60	15.88	6.43	2.47	−140
W. 335	2.95	2.64	0.60	0.025	0.035	13.93	6.36	1.06	−10
W. 491	2.91	2.44	0.57	0.022	0.031	15.55	6.17	1.17	−50
W. 765	2.65	2.43	0.48	0.016	0.051	15.52	8.65	1.41	−88

mens were immersed for 15 min. and returned to room temperature before polishing the micro-specimens. The structure of each material before and after treatment is reported in Table C.

Hardness and Magnetic Properties.—After examining the microstructure, Brinell hardness tests were carried out on each specimen. The specimens were also tested with a magnet. The results of these tests are shown in Table D.

It is to be noted that the centrifugally-cast materials with high phosphorus contents are very slightly magnetic in the as-cast state.

TABLE B.—*Dilatometric Tests on Austenitic Irons.*

Material.	Condition.	Temperature range, deg. C.	Coefficient of thermal expansion per deg. C. × 10-6.	Temperature of structural change, deg. C.
146	Warming to room temperature	−100 to room	16.1	Unchanged
171	Warming to room temperature	−100 to room	16.3	Unchanged
180	Cooling below room temperature	Room to −100	17.0	−155
	Warming to room temperature	−100 to room	16.4	
2/8	Cooling below room temperature	Room to −100	15.8	−120
	Warming to room temperature	−100 to room	13.6	
2/9	Cooling below room temperature	Room to −85	17.1	−85
	Warming to room temperature	−100 to room	13.6	
L.A.	Cooling below room temperature	Room to −55	16.2	−140
		−55 to −100	9.0*	
	Warming to room temperature	−100 to room	14.7	
W. 335	Cooling below room temperature	Room to −10	15.5	−10
	Warming to room temperature	−100 to room	11.4	
W. 491	Cooling below room temperature	Room to −50	15.5	−50
	Warming to room temperature	−100 to room	13.2	
W. 765	Cooling below room temperature	0 to −25	16.6	−88
		−25 to −50	15.9	
		−50 to −75	15.1	
	Warming to room temperature	−100 to room	12.6	

* Note change of slope at about −55 deg. C.

TABLE C.—*Microstructure of Austenitic Irons Before and After Cooling Treatment.*

Material.	Microstructure in as-cast condition.	Change of microstructure after treatment.	
		(*a*) −78 deg. C.	(*b*) −183 deg. C.
146 and 171	Medium flake graphite in a matrix of austenite. Some free carbide	None	A few isolated areas of martensite at the edge.*
180	Medium flake graphite in a matrix of austenite. Some free carbide	None	A trace of martensite with more at the edge than centre.*
2/8 and 2/9	Medium to fine flake graphite in a matrix of austenite with a fair amount of phosphide eutectic	None	Well-developed martensite in 2/8, with slightly more in 2/9
L.A.	Medium to coarse flake graphite in a matrix of austenite with a fair amount of free carbide present	None	Well-developed martensite
W. 335 and W. 491	Medium flake graphite in a matrix of austenite with a small quantity of carbide	W. 335 martensitic W. 491 less martensite than W. 335	Martensitic Martensitic
W. 765	Medium flake graphite in a matrix of austenite	None	Martensitic

* The isolated areas of martensite at the edge of specimens 146 and 171 were associated with rosette-type graphite. Rosette-type graphite was also found at the edge of specimen 180, where the quantity of martensite increased.

TABLE D.—*Hardness and Magnetic Properties of Austenitic Irons.*

Material.	B.H.N. 750 kg./5 mm.			Magnetic properties.		
	As-cast.	After treatment.		As-cast.	After treatment.	
		−78 deg. C.	−183 deg. C.		−78 deg. C.	−183 deg. C.
146	138	141	146	n.m.	n.m.	s.m.*
171	144	146	150	n.m.	n.m.	s.m.*
180	146	150	150	n.m.	n.m.	s.m.
2/8	160	164	241	v.s.m.	v.s.m.	S.M.
2/9	128	134	266	v.s.m.	v.s.m.	S.M.
L.A.	138	134	197	n.m.	n.m.	M.
W. 335	102	211	266	n.m.	S.M.	S.M.
W. 491	93	143	229	n.m.	M.	S.M.
W. 705	109	109	239	n.m.	n.m.	S.M.

ABBREVIATIONS: n.m. = non-magnetic; v.s.m. = very slightly magnetic; s.m. = slightly magnetic; M. = magnetic; S.M. = strongly magnetic.

* These specimens were slightly more magnetic at the edge.

The results obtained on the commercial materials of the Ni-Resist type indicate the austenite to be most stable and to transform at the lowest temperature the lower the silicon and phosphorus contents and the higher the manganese, chromium, nickel and copper contents. Although the individual effects of these elements have not been determined it is possible that, provided the nickel content is above 13 per cent. and the copper content above 6.5 per cent., the silicon content should be below 1.8 per cent., the chromium content above 1.7 per cent. and the manganese content above 1 per cent. if the iron is not required to transform above −150 deg. C. This applies to low-phosphorus iron only.

DISCUSSION

Opening the discussion on the Paper, MR. HALLETT congratulated the Author on a very valuable piece of work. There was no doubt that the Paper would for a long time be a standard source of reference. He proposed to confine his remarks to the austenitic irons. For a long time he had suspected that silicon played an important part in determining the stability of austenitic irons at low temperatures and at slightly elevated temperatures. That feeling was based on the relative behaviour of Nicrosilal with its high-silicon content, and of Ni-resist, of much lower silicon content. In spite of the lower nickel content of the latter, it was much the more stable iron of the two.

He thought the Paper useful in that it showed clearly how important silicon was in determining the stability of austenitic irons. Provided the silicon content was in the region of 1.8 per cent., the nickel could fall to levels well below those specified in specification D.T.D. 649. In other words, silicon appeared to act as a potent-negative-nickel, if it could be put that way. It was perhaps more economical to achieve low-temperature stability by seeing that the silicon contents were kept low, rather than by raising the nickel, copper or chromium contents.

Mr. Gilbert's results might be used to explain some puzzling reported instances of inversion of austenitic irons during storage under conditions of extreme cold. It now appeared that these irons were probably high in silicon, although the other alloy elements might have been normal. That was an important addition to their knowledge of the austenitic irons.

MR. GILBERT, in reply, said he was inclined to agree with Mr. Hallett that silicon had a great effect on the stability of austenite at low temperatures, but this assumption was not factual from the results in the Paper. If Table A of the appendix were examined, it would be apparent that the commercial Ni-resist type materials had a higher manganese and chromium content as well as a lower silicon content than the other materials, so that it was not possible to judge conclusively from these results the effect of silicon, since the effect of the other two elements was not known. Mr. Hallett, of course, was basing his conclusions on work of his own concerning the behaviour of Nicrosilal and Ni-resist at low temperatures.

Expansion of Argentine Foundry Industry

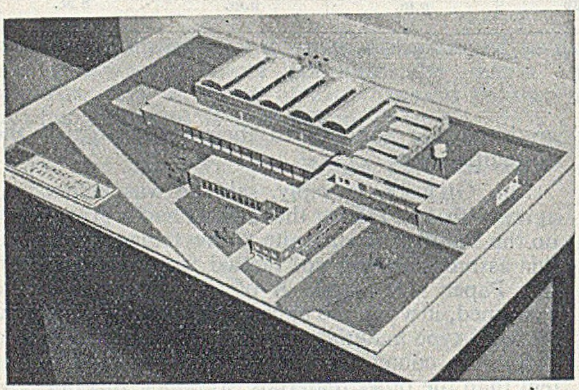
According to an article in the *Iron Age* written by the late Mr. A. W. Gregg, the *Industria Agentina de Aceros*, of Rosario, Argentina has in recent years built up a prosperous steelmaking concern. To service this an ingot mould foundry will shortly be installed in a building, now under construction, adjacent to the open-hearth building. This foundry is now being engineered by the Whiting Corporation of Harvey, Ill. Capacity is planned for 16,000 metric tons per year. Of this, 1,600 metric tons will be ingot moulds. The heaviest ingot mould will weigh 2 metric tons. Miscellaneous grey castings will also be made in this foundry.

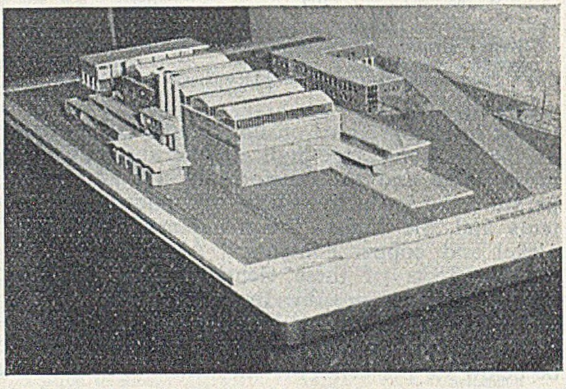
A new steel foundry for maintenance operations at Rosario and the new plant at Villa Constitucion will be installed in the near future. The melting department will have 6-ton side-blown converters, operated with a basic lining of local magnesite. Cupolas will supply the molten charge for the converters. Capacity in excess of that required for castings will be used to pour ingots to supplement the open-hearth furnace production. Plans for the steel foundry are also being prepared by the Whiting Corporation.

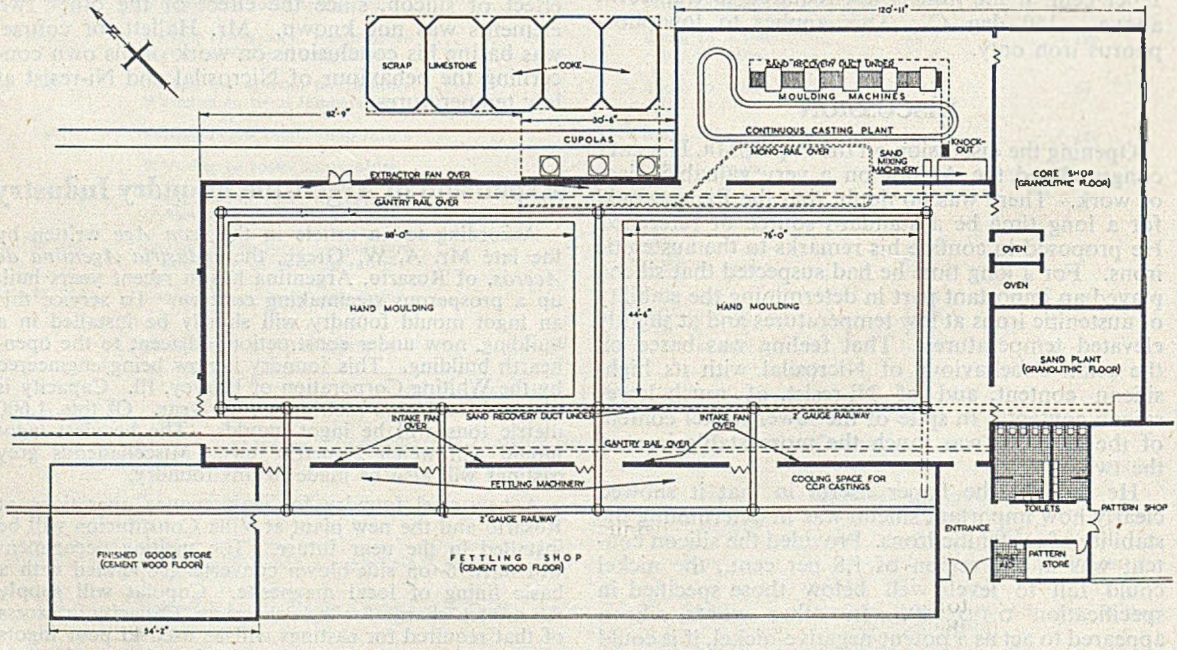
Another major project to be undertaken in 1951 will be a malleable-fittings foundry. There is a serious shortage of malleable-iron pipe-fittings in Argentina. When the new rod mill at the Villa Constitucion plant is completed, the mill at Rosario will be scrapped, and the building which it now occupies will be used for the new malleable foundry. Present plans call for a capacity of 200,000 metric tons per year.

Students Design a Foundry

We recently commented eulogistically on the work carried out by the students at the Architectural Association School of Architecture, Bedford Square, London. During last term, some of the 4th-year students were given the task of designing a mechanised foundry. The layout which the authorities considered best was designed by a group consisting of the following five students:—R. Brandt, J. H. Fried, J. A. Holderness, R. G. Harris and G. T. Myers. Their joint effort is shown by a plan view and two photographs of models of the building. In fairness to the students it should be stated that a change in pencil indicated that the positions of the core shop and sand-preparing shop should be transposed. A feature of the layout is that the castings from the mechanised foundry are sent underground to the fettling shop. Though the pattern store is rather too small, the whole conception is creditworthy. The site chosen actually exists at the side of the railway foundry at Eastleigh.







ALBION MOTORS, LIMITED, Glasgow, as a result of a year's negotiations and in face of stiff American, Canadian and German competition, have secured an order valued at £160,000 for eighty buses for South Africa's nationalised haulage system. The Glasgow firm have been seeking the contract since their managing director, Mr. Hugh Fulton, went to Johannesburg to begin negotiations with the South African Railway & Harbour Board.

AN INNOVATION of the national conference of the Purchasing Officers' Association, at the Hotel Metropole, Brighton, from September 28 to October 1, is the staging of the P.O.A. "Minibition" in the hotel rooms and corridors adjacent to the conference meeting rooms. This miniature exhibition is intended as an educational feature of the conference, and the hundred available stands were quickly taken up by leading manufacturers.

Inspection and Storage of Foundry Lifting Equipment

By W. M. Halliday

The basic features of a practical scheme of inspection and storage service, designed to ensure proper control of chains and lifting equipment, are briefly outlined for the guidance of foundry maintenance engineers. Regular and systematic inspection, together with detailed recording of movements, treatment, storage and repair activities, is considered essential.

THE FUNDAMENTAL preliminary of a control scheme is that of being able to identify each piece of lifting equipment employed in the foundry. To accomplish this simply and effectively, lifting equipment should be segregated according to the various departments in which it is to be used. If lifting chains, etc., are used indiscriminately, it may well happen that unsuitable equipment will be employed. Even though an accident may not occur, damage may often be inflicted on the chains themselves. In any case, failure to segregate chains in this manner will place such a responsibility upon the user when selecting a piece of equipment. Correct use will then depend upon personal judgment, a factor which will often prove unreliable.

Stamping of Chains

As a first step, each chain should be stamped plainly with an appropriate departmental symbol. In the case of the usual link-type chain, this symbol should be borne on the ring or loop. With other types of chain, the stamping may best be situated upon an end link. In endless chains it is usual to fashion one link slightly larger, this being selected for carrying the identification symbol. Symbol markings should consist of numerals and letters. The number would identify the chain on the register and other records. The letters would designate the particular department in which the chain is to be normally or exclusively used.

Colours can also be advantageously employed to improve identification facilities. One colour should be allotted to each department. All chains, wire, ropes, slings, hooks, etc., used in that department would have one link, or an attached label, painted in that colour. This colour scheme would also coincide with a similar bin-colouring arrangement employed in the stores. This simple provision will greatly facilitate the selection of the proper chain, etc., both in the chain stores and on the foundry floor.

Additional to the chain number and departmental reference, the following important items should be stamped on the link or label:—(*a*) The safe working load (S.W.L.); (*b*) the maker's certificate number; (*c*) the weight and length of the chain; (*d*) date of purchase, or when first issued for use in the foundry; and (*e*) the diameter of the link or wire. As an example, a chain with a $\frac{1}{8}$-in. dia. link required for use in the casting shop would have a link coloured blue, and would be stamped: C.D.5. $\frac{1}{8}$ in. S.W.L. 1 ton. Cert. No. 4873. Weight 95 lb. Date.... This system would be employed throughout all records in the stores, for any repair, annealing, or other treatment orders and instructions.

Equipment Register

A book register should also be compiled weekly, covering every chain and other piece of lifting equipment in use. This should contain the following vital information:—Date of purchase; date first issued to works; full identification symbol; maker's certificate reference or other relevant details; spaces for denoting dates of each inspection, results found, and decisions reached; the nature of any repairs, alteration, etc., conducted, and by whom; dates of despatch and receipt to and from the annealers; together with code number used by them; the storage bin number, etc., and any other germane information.

Supplementing this register record, a complete history of the chain should be kept in the form of a simple card index. On this every inspection would be recorded, giving the results. All movements of the chain to stores, works, repair shop, annealers, etc., would also be recorded. The chain register would be kept up to date by a weekly transfer of information from the stores card index.

By referring to this index and the register it would be possible to determine whether a chain is being used for the most suitable application, whether certain defects constantly recur, the amount of repair service and its cost entailed on every unit, and similar helpful information. With wire and cotton ropes stamping cannot be performed in the above way. Steel labels should be securely affixed by wire clips, each label being coloured and stamped with the appropriate department symbol.

Examination of Chains and Wires

A strict rule should be enforced ensuring that all chains are returned to the chain stores immediately after use. No chain should be left lying around the floor of the works. Immediately upon receipt in the stores, the equipment should be given at least a cursory examination. From the card index the storekeeper would ascertain whether the part was due for its regular normal inspection. All details emanating from such an examination should be entered on the card index at once.

Storage of Foundry Lifting Equipment

In the actual examination, all chains should be subjected to a link-by-link inspection and test. This will reveal whether surface cracking, distortion, wear, stretching, nicking, or corrosion has occurred during use. Links showing excessive wear should be carefully noted, and if the chain is withdrawn from service, it must be isolated and distinguished from correct parts, either by attaching a suitably coloured (red) label bearing details of the defect, or by painting the affected link in that colour. Proper gauges should be supplied the inspector, these being preferably of the simple "go–not-go" type, one for every size of chain and rope. The "go" dimension will be the original diameter of the link, the "not-go" corresponding to the maximum reduction in diameter permissible with safety. By applying these gauges the engineer will quickly ascertain whether a link has passed the safe limit.

Any chain having its initial link diameter reduced by more than 10 per cent. should be withdrawn from use or, alternatively, delegated for use in another department where lighter loading will be entailed. In this latter case the identification symbol must be immediately modified on all records, and on the part itself. Its behaviour should thereafter be closely watched. Obviously, chains and ropes used in the casting shop will have a marked tendency towards wear and surface corrosion, and especially close attention will be required on such items.

Chain Stores

The importance of an orderly storing of all lifting equipment cannot be over-emphasised. A central store-room should be provided. This should possess sufficient spaciousness to deal with all the lifting equipment in an orderly fashion. The stores should be equipped, too, with an overhead crane, or be located close to such a means of transport. Wall cranes should also be provided to assist loading and unloading. Facilities should be installed for the cleaning and de-rusting of all chains by means of simple dipping tanks.

The walls of the stores should also be furnished with strong, well-designed shelves or bins, into which individual chains may be deposited when not in use. Each shelf or bin would be distinguished according to the colour-scheme employed, and would also bear a label having all the identification details plainly marked. No chains should be piled indiscriminately on the floor of the stores. A special section should be allocated for storing defective chains and parts whilst awaiting correction or repair. A similar separate section should be devoted to the storage of chains and wires awaiting despatch to the annealers.

Very heavy chains and wires should be stored on floor racks, robustly constructed from channel or angle iron. These should be of a type enabling each chain to be kept separate from its neighbour on the rack. Lightweight and short-length ropes and slings may be suspended from wall hooks. There should also be a strong bench provided in the stores, which must be long enough to allow a chain to be stretched on it for examination purposes.

In addition to the usual lifting chains, ropes, and wires, there will generally be a miscellaneous collection of smaller accessories such as chain-blocks, block stands, hooks, shackles, screw-jacks, wedges and thimbles. Proper provisions should also be ensured for the safe storage of these important items, which are frequently found lying about the works floor in odd corners. As with the chains in regular use, these accessories must be frequently inspected, and repaired as required. Proper records must also be maintained of all such inspection and repair treatment.

In the conduct of the stores, it would be treated as standard practice that no user would accept a chain bearing a red label, this denoting that at some earlier date a fault had been discovered. After chains have been repaired, cleaned, or corrected in some way, the store-keeper would attach a green label to indicate their availability for further works use. One person should be appointed solely in charge of the chain stores, and for keeping records up to date. If a number of people perform these duties, oversights, mistakes, and arguments are bound to arise.

Conclusion

The chain inspector's duties should also include regular testing of all wires belonging to overhead cranes, or jib-cranes mounted on walls. Spare wire-ropes should be kept in stock. For cranes engaged on heavy lifting duty the ropes should be inspected not less than once per week. Such ropes should be thoroughly cleaned at least once every month, to ensure freedom from corrosion, proper lubrication, and greater ease for inspecting their condition. Crane hooks, shackles, and swivels should receive special attention by weekly inspections. These should be cleaned before every examination.

It will be advisable to employ a test-load block, in the form of a ladle filled with ingots or a casting of sufficient weight. This test should be applied to the crane hook and wires at least once each month, and observations made and recorded of the mechanical reactions of the crane mechanism and gantry. This test weight should approximate to the maximum lift of molten metal charge likely to be lifted. A similar regular examination will be required in the case of metal ladles, and their trunnions, and tilting mechanism.

Swivelling trunnions particularly should be inspected monthly, after being cleaned and properly lubricated. Wear on the trunnion spindles will usually be concentrated over about 150 deg. included angle of the bearing surfaces, generally being located on the lower side. Spindle diameter must be checked frequently and, where this is reduced more than about 7½ per cent. below the original diameter, the trunnions should be discarded and replaced by new ones.

Iron and Steel. Dorman Long & Company, Limited, of Zetland Road, Middlesbrough, have recently issued a catalogue in which is given a general description of their lines of manufacture. It is somewhat amazing, but that requires 72 pages. Jacketed in stiff cardboard the catalogue presents a dignified aspect, as the two colours incorporated are particularly pleasing.

Why the Laboratory?*

By P. R. Paxton

DURING THE READING through of recent technical information, the Author has come across references to detailed examinations of castings made during the early days of the industrial revolution. One of the examples referred to was the beam of a pumping engine cast over one hundred and twenty years ago. An example of much earlier origin was the cannon ball found on the field of battle at Lichfield. The mechanical properties and microstructure make the engine-beam casting of ample suitability for the needs of the modern engineering era, with all its increased speeds. The cannon ball, which was cast over 300 years ago, was an example of the way in which the early ironfounder had made attempts to obviate porosity and other internal unsoundness. These still remain veritable headaches for the modern ironfounder despite recent progress.

When one reads and discusses the large amount of technical literature, published in the Proceedings, dealing with similar matters from the present-day point of view of urgency and severity, one is very tempted to ask "Is this progress?" With all modern technical knowledge and equipment, is the industry progressing in the right direction, and is the laboratory really necessary? In this Paper, the Author, although possibly biased due to his laboratory training will endeavour to give an answer to these questions.

Control Organisation

In general, the purpose of a well-organised laboratory is to carry out observations and measurements of day-to-day production activities, in order to keep rigid control of the materials produced, and to carry out investigation and research work to improve the ultimate finished product. The language of the laboratory to-day approaches an international nomenclature, it does not vary from one locality to another as do the terms used by the craftsmen. The measurement of test results are now standardised, not as in the day when the engine beam was cast, depending on the initiative and enthusiasm of each individual ironfounder. This standardisation enables a more rapid exchange of knowledge and development, besides making the customer's requirements clearer.

The laboratory control may extend from one acting in an advisory capacity, supplying analyses and test results to the foundry management; to one having complete control of all technical processes, except actual manual production. No matter what the need for co-operation between the laboratory and foundry staff cannot be over emphasised. For example, on a cupola during an afternoon blow where the scheduled time for the bottom to be dropped is five-thirty, a mechanical defect may arise, causing half-an-hour's delay. The foundry management, requiring their men to be finished at the official stopping time, order the blast to be increased. Then the result would be that some of the carbon would be oxidised, possibly causing the metal mixture not to conform to specification, leading to scrap castings due to hardness. Such examples as this are tests of co-operation between laboratory and foundry management which occur very frequently in day-to-day practice.

Apart from giving guidance in crises and times of emergency, the laboratory on the routine control of raw materials and finished products is rarely in the limelight. Often non-destructive tests are carried out on the finished product to maintain quality. In this respect, the laboratory is able to detect irregularities, and by minimising variations before these have a chance to influence adversely the results aimed for, claim justification for its existence. The laboratory also investigates the cause of failures in castings which are returned from the customer or failed in service due to possible metallurgical defects. These investigations are carried out on an impersonal basis, not to lay the blame on anyone, but to find the true cause of the failure and to eliminate it in future production.

In the research and experimental field one cannot judge the value of this work by its current activities. The last twenty-five years has brought into relief results of some of this work. From the purely metallurgical side there have been the development and use of highly-alloyed irons for heat-resisting, wear-resisting, corrosion-resisting or mechanical properties. Extremely high strength acicular and nodular cast irons have been developed, and new knowledge and techniques of heat treatment have been gained. In the fields of sands and refractory-material experiments, two developments come to mind, one being the development of synthetic sands, the other being resin-bonded core sand. There has also been improvement in furnace operation and design due to research work carried out by the laboratory. It is significant that more and more "pilot" research work is being carried out on the foundry floor during normal operation, and developments in laboratory technique are towards greater speed and reliability in providing required results. The Author's opinion that the laboratory has justified its existence in the foundry is widely shared, and its development, techniques and services are continuously being improved to make it an indispensable tool to the foundryman of the future.

In conclusion it should be pointed out that the association between the laboratory and its activity in times of trouble and inquest is often misleading. After all, the scrap engine beams and cannon balls produced must have found their way back into the furnace as shop returns, only the good ones surviving. Similarly the true perspective of laboratory services will be that in the centuries ahead, when the casting reject notes have faded into dust, the castings made to-day will still be serviceable.

* An entry for a Short Paper Competition organised by the East Midlands branch of the Institute of British Foundrymen.

Tyne Ore-discharging Plant

The Tyne Improvement Commission announces a £1 million project for a modern iron-ore discharging plant at Tyne Dock. The scheme will require Treasury sanction. The commission's statement said that the Consett Iron Company's increasing consignments of foreign ores would continue to be imported at Tyne Dock for a considerable number of years.

The commission would extend Sutherland Quay to berth vessels of up to 20,000 tons capacity and install the most modern ore-discharging and handling equipment in the country.

News in Brief

EXTENSIONS costing £24,000 are being made to the Copperas Bank Forge, Pallion, Sunderland, of T. S. Forster & Sons, Limited.

ARBUTHNOTT & SON, boatbuilders, of Montrose, intend to lay down plant for the construction of ship's aluminium-alloy lifeboats.

THE MINISTER OF SUPPLY announces that the certified increase in the price of manganese ore for the manufacture of blast-furnace ferro-manganese is 1d. per unit.

ANOTHER FURNACE is to be blown in by the Consett Iron Company, Limited, Consett (Co. Durham), to bring the company's output of pig-iron from three units up to 2,100 tons daily.

ALUMINIUM WIRE AND CABLE COMPANY, LIMITED, Port Tennant, Swansea, have changed their London office address to 37, Thurloe Street, South Kensington, London, S.W.7.

"NEWFOUNDLAND—AN INTRODUCTION TO CANADA'S NEW PROVINCE," is the title of a 142-page illustrated handbook published recently by the Canadian Ministry of Trade and Commerce.

UNDER A PROFIT-SHARING SCHEME initiated two years ago the employees of Hick, Hargreaves & Company, Limited, engineers and ironfounders, of Bolton (Lancs), are to receive a total of £12,500.

THE TREASURY has made the Import Duties (Exemptions) (No. 5) Order, 1950, which exempts from duty unwrought copper imported in the form of billets. The Order came into operation last Tuesday.

ENGLISH STEEL CORPORATION, LIMITED, Sheffield, will exhibit at next month's Yugoslavia trade fair at Zagreb. It will be the first time for 20 years that the firm has exhibited at a trade fair in Yugoslavia.

SPANISH CONTRACTS worth some £500,000 have been secured by Markham & Company, Limited, Chesterfield, for the construction and installation of large water turbines at two hydro-electric power stations.

THE AIR POLLUTION AND SMOKE ABATEMENT PREVENTION ASSOCIATION OF AMERICA, reconstituted from the Smoke Prevention Association of America, has as its temporary secretary Mr. Frank Chambers, Chief Smoke Inspector, Chicago, Ill.

BRITISH INSULATED CALLENDER'S CABLES, LIMITED, have installed about 65 miles of cables in connection with their contract with the Steel Company of Wales, where there is to be installed 175,000 horse power, including about 6,000 motors.

WORK IS TO START shortly at the Kapfenberg (Austria) steel works of the nationalised *Gebr. Böhler & Company, A.G.*, for the erection of a blooming mill for semi-finished special steel and rod steel. The major part of the mechanical installations has been ordered from Germany.

DOLLAR CONTRACTS to the value of over £2,000,000 have recently been negotiated between Stewarts and Lloyds, Limited, and American oil and natural gas companies for the supply of many thousand tons of steel pipelines for shipment to the U.S.A. One of the largest orders was arranged through the Anglo-American Oil Company on behalf of the Standard Oil Company, of New Jersey.

A BRITISH-AMERICAN COMBINED CONTRACT worth £130,000 ($360,000) for the supply of tractors has recently been negotiated with the Greek Government. Henry Meadows, Limited, Wolverhampton, will supply the Diesel-engine and ancillary units and the Minneapolis-Moline Company, Minnesota, will supply transmissions, wheels, gearboxes, and all other parts. Assembly of the tractors is to be carried out in Greece.

THE NORTH BRITISH LOCOMOTIVE COMPANY, LIMITED, Glasgow, shipped two locomotives, each weighing with tender and spares more than 125 tons, as part of a consignment of 100 heavy goods locomotives of the 2-8-2 W.G. class for the Indian Government Railways. The locomotives were lifted on to the fore deck of the City of Agra by the 175-ton crane at Finnieston Quay. Two tenders were loaded on the after-deck.

MAJOR, ROBINSON & COMPANY, LIMITED, of Eastnor Street, Manchester, 15, makers of "Scols" Super iron cement, for foundry use, inform us that they are making a free offer of samples of this material to any foundry who have not yet had an opportunity of testing this cement in their own works. This offer is limited to foundries in the British Isles. It applies only to those users not already on the company's books, and fullest help and information will be gladly extended to interested users.

LACK OF CO-OPERATION from employers was one of the causes for the shortage of recruits to the foundry industry, according to Alderman A. E. Wheatley, speaking to the West Bromwich Education Committee recently. He suggested that if employers were looking ahead, it should be their duty to give proper training. He added that the foundry recruitment question had been constantly under review for some considerable time and, while employers were making effort, they were not meeting with much success.

THE ASSOCIATION between Jack Olding & Company, Limited, Hatfield, and the Caterpillar Tractor Company is being terminated, but the company will continue to carry out the supply of spare parts and the servicing of tractors until alternative arrangements have been made by the Caterpillar Tractor Company. Olding's have been appointed the sole world distributors for the track-type tractors and ancillary equipment, the production of which is being undertaken by Vickers-Armstrongs, Limited. The tractors will be fitted with Rolls-Royce Diesel engines.

F.T.J. Prize Crossword Puzzle

Below is given the solution to the puzzle we published on page 124 of our issue of August 3. The name of the winner will be announced next week.

1 B	E	2 E	H	3 I	V	4 E		5 T	U	6 N	G			7 I
U		L		N		N		U		E		8 M		N
9 M	O	U	L	D	I	N	G	B	O	X	P	I	N	S
P		T		E		O		U		T		X		I
10 E	A	R	N		11 O	B	E	S	E		12 R	I	N	G
R		I		13 Q		L		E		14 C		N		H
15 S	T	A	T	U	T	E		16 R	E	L	I	G	H	T
		T		I						O		M		
17 W	R	I	T	E	T	18 O		19 S	A	U	S	A	G	20 E
A		O		T		X		T		S		C		A
21 S	I	N	K		22 B	I	S	R	A		23 C	H	A	R
T		J		24 S		D		I		25 S		I		T
26 E	L	E	C	T	R	I	C	A	L	W	I	N	C	H
R		T		A		S		T		A		E		E
S			27 F	R	E	E		28 E	X	P	O	S	E	D

July's Steel Output

Despite the intervention of annual holidays, United Kingdom steel production in July was maintained at a high level. The British Iron and Steel Federation announced last Thursday that last month's output was at an annual rate of 14,366,000 tons, the best ever recorded in July. The previous best July output was in 1940, the annual rate then being 13,140,000 tons.

Steel output in the first seven months of this year was running at an annual rate of over 16½ million tons, which compares with an actual total of 13¼ million tons for 1939, when capacity was about 2¾ million tons below the end-1949 level. It is felt that the industry is well placed to meet the nation's re-armament programme.

Pig-iron output in July was at an annual rate of 9,990,000 tons, compared with 9,224,000 tons a year ago.

The latest steel and pig-iron production figures (in tons) compare as follow with earlier returns:—

	Pig-iron.		Steel ingots and castings.	
	Weekly average.	Annual rate.	Weekly average.	Annual rate.
1950—1st half-year ..	184,000	9,611,000	319,600	16,619,000
June	182,200	9,474,000	312,500	16,249,000
July	175,000	9,990,000	276,300	14,366,000
1949—1st half-year ..	181,600	9,442,000	305,700	15,897,000
June	185,800	9,664,000	300,900	15,645,000
July	177,400	9,224,000	244,200	12,697,000

International Harvesters' Australian Plant

Announcing that the International Harvester Company of Great Britain, Limited, was beginning the manufacture in Australia of motor trucks, Mr. R. G. Casey, Australian Minister for National Development, said that this included the making of truck engines in Australia for the first time. Although significant in itself, he said, the project had wider implications for a rapidly expanding nation since Australia would have a flying start if called on to be a supply base in the event of war.

The company's managing director said the company was investing more than £1,000,000 in a motor-truck factory at Dandenong, Victoria. When these works were completed all equipment at the Melbourne plant would be transferred and the output of trucks would be double the present planned rate of 10 daily.

Research Work at Cambridge

A grant of £1,500 a year for the next two years has been offered by the British Steel Founders' Association in support of work in the Department of Metallurgy at Cambridge University. Vauxhall Motors, Limited, Luton, has offered a grant of £1,000 a year for a period of two years in furtherance of Dr. Bowden's research in the physical properties of metal surfaces.

Research Fellowships endowed by Imperial Chemical Industries, Limited, at the University are to be continued, but the company proposes to increase the endowment from £600 to £800 per annum for seven years.

Board Changes

Tube Investments, Limited—Mr. W. L. Fraser has resigned.

Richard Thomas & Baldwins, Limited—Sir John James has resigned.

Round Oak Steel Works, Limited—Mr. W. H. B. Hatton has resigned.

John Brown & Company, Limited—Mr. C. M. McLaren has been appointed vice-chairman.

Guest, Keen & Nettlefolds, Limited—Mr. K. S. Peacock has been appointed deputy chairman.

Mason & Burns, Limited—Mrs. J. M. Mason and Mrs. N. Hope have been appointed directors.

Worthington-Simpson, Limited—Mr. W. J. M. Adams has been appointed a director and assistant managing director.

Ward & Goldstone, Limited—Mr. M. E. Rustin, Mr. E. R. Norbury, and Mr. A. G. Jackson have been appointed additional directors.

Ransomes, Sims & Jefferies, Limited—Mr. W. D. Akester has been elected to the board and assumes the executive position of home sales director.

Revo Electric Company, Limited—Mr. W. L. Barrows has been appointed to the board and elected chairman. Mr. G. H. Gunson has been appointed deputy chairman.

Associated Equipment Company, Limited—Mr. A. J. Romer, a director and general manager of the motor constructional works of the Bristol Tramways & Carriage Company, Limited, is to join the board and will assume office as managing director on October 1. The appointment carries with it also a directorship of the parent company of the A.C.V. group—Associated Commercial Vehicles, Limited.

Obituary

Dr. Richard Warden, of the National Physical Laboratory, Teddington, died on August 3.

Mr. J. E. H. Landers, formerly of the Hallamshire Steel & File Company, Limited, Neepsend, Sheffield, died a week last Saturday.

Mr. Cyril Pease, who was associated with Pease & Partners, Limited, Darlington, has died in London following a short illness. He was 59. Mr. Pease had also been connected with a London firm of consulting engineers for 20 years.

The American Press reports the death of Mr. Richard G. McElwee, who was known internationally for his researches into cupola practice. His outstanding work was recognised by the award of a gold medal by the American Foundrymen's Society. He was for many years manager of the ironfounding division of the Vanadium Corporation of America. At the time of his death he was 60 years old.

Wills

Smith, W. T., late of Thomas Smith & Sons (Rodley), Limited, electrical engineers and ironfounders, of Rodley, Leeds £123,006

Christmas, E. B., managing director of Christmas & Walters, Limited, engineers and contractors, etc., of London, S.W.16 ... ... £7,818

Wilson, David, retired engineer, general sales manager to Babcock & Wilcox, Limited, and later with International Combustion, Limited ... £7,424

Rees, W. J., late head of the department of refractory materials at Sheffield University, a past-president of the Refractories Association of Great Britain and at his death secretary, and a past-president of the British Ceramic Society £32,558

Crichton, Sir Robert, joint vice-chairman of the Lancashire Steel Corporation, Limited, chairman of the West Cumberland Development Company, a director of Rylands Bros., Limited, Workington, and the Wigan Coal Corporation, Limited ... £24,618

Company News

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

George Kent, Limited—The company's capacity to produce industrial instruments has been expanded and that process is still continuing, says the chairman, Mr. P. W. Kent. "The makers of motor-cars and vehicles to which our steering gears are supplied have, throughout the year, increased their output and their demands upon us. For more than 20 years it has been an axiom for our steering gear department that it must never hold up a motor-car production line; and, although the struggle has sometimes been fierce, we have kept pace," Mr. Kent continues.

"During the year there has been a recession in the volume of orders for our third main group, mechanised meters for water measurement. There is still a large unsatisfied requirement, but partly this is frustrated by currency maladjustment and import restrictions, and competition for what succeeds in getting through has increased greatly as meter makers in Germany, Italy, and Japan have entered the market. However, we have continued to make great efforts and towards the end of this year under review an upward trend was apparent."

Coltness Iron Company, Limited—The directors have now approved and are in course of adjusting a scheme of arrangement of which full particulars will shortly be submitted to shareholders. Briefly, the scheme is to repay the preference share capital in full with dividend to date of repayment and a capital bonus by way of 4½ per cent. redeemable loan stock to the extent of 3s. 6d. in respect of each 5 per cent. preference share and 4s. in respect of each 5½ per cent. second preference share in lieu of the premium to which these shares would, respectively, be entitled on the voluntary liquidation of the company; and also to repay the ordinary share capital to the extent of 10s. a share. The company's articles, as they stand at present, do not contain the necessary power to issue redeemable loan stock. It is, therefore, necessary to alter the articles and an extraordinary meeting has been called for August 28 for the purpose.

The scheme and reduction of capital will require confirmation by the court and approval by each class of shareholder.

General Electric Company, Limited—Sir Harry Railing, the chairman, says that the profits for the year ended March 31 last are greater than those for the previous year in spite of the fluctuations in demand and the return to competitive conditions. These improved results are due partly, he says, to the completion of remunerative contracts taken in previous years, and partly to a higher volume of turnover at a slightly lower rate of profit. There has been a definite falling-off in orders for some of the company's products, notably those connected with the building industry, which has created production problems in the factories concerned.

Exports have again created a record and were considerably in excess of the target figures fixed by the Government. The extensions at the company's heavy electrical and mechanical engineering works are in the course of completion, and the programme of plant re-equipment has been continued. The number of employees at March 31 was approximately 54,400.

Boulton & Paul, Limited, engineers, etc., of Norwich—Underwriting has been completed for an issue of £300,000 4½ per cent. unsecured loan stock, 1955-60, at par. The stock will be offered to preference and ordinary shareholders registered as at Tuesday's date. Net proceeds, estimated at £294,250, will be applied towards repayment of the bank overdraft which at June 30 stood at £436,796.

Laurence Scott & Electromotors, Limited—A placing is being made through the market of 50,000 of the unissued 4½ per cent. £1 cumulative preference shares. One-half has already been placed, and the remainder is on offer at 20s. 1½d., free of stamp and fee into first names. The shares are *cum* the half-year's dividend due next month.

Davey, Paxman & Company, Limited—The report states that despatches for the year ended March 31 last were lower than the record total of the previous year. This was the anticipated result of the termination of a large special programme, and of hardening market conditions.

A.P.V. Company, Limited—The new capital issue will consist of 750,000 10s. ordinary shares of 15s. each. Resolutions altering the capital were passed at last week's meeting, which also approved the four-for-one capital bonus and the consolidation of the 2s. shares in shares of 10s. each.

Whessoe, Limited—The directors state that further progress has been made with the works reconstruction scheme; the new unloading gantry has been completed and the new west bay is under construction. Production during the year ended March 31 again reached a new high level both in tonnage and value.

Foundry Worker wins £785 claim

In a successful claim against his employers, Dartmouth Auto Castings, Limited, of Smethwick, Thomas Arthur Edkins, a millwright, was awarded £785 damages at the recent Birmingham Assizes. The claim arose out of an accident, referred to by Mr. Justice Lynskey as "no doubt terrifying," in which his foot was trapped in an elevator.

For Edkins, Mr. A. J. Flint said that on February 16, 1948, he was told to make an adjustment to one of the sand mills. The section of the foundry where the mill was situated was in semi-darkness, in spite of the artificial lighting provided, and it was not a place where Edkins usually worked. The mill was stationary, but unknown to Edkins its elevator cover was not. He was also unaware that an inspection cover in the elevator casing had been removed. To reach the point where the adjustment was to be made, it was necessary for him to climb down in a narrow space between the mill casing and the elevator. He slipped, his foot went into the elevator through the hole, and it was trapped by the moving buckets. He had undergone hospital treatment, but there was still some limitation of ankle movement.

Mr. E. G. H. Beresford submitted on behalf of the defendant firm that there had been contributory negligence. Edkins ought to have seen the hole, and he ought to have made sure that the elevator was not working.

Giving judgment, Mr. Justice Lynskey said the uncovered hole in the elevator was an obvious danger, and he was satisfied that it constituted a breach of the defendant's statutory duty to maintain fencing on dangerous machinery. It had been contended that the plaintiff was guilty of contributory negligence in not taking certain precautions. "In theory, I suppose, the perfect man, indulging in the extreme care that one seldom meets in this world, would have done these things," added the judge, "but I am satisfied here that he had no reason to take extra special care, and that there was no negligence on his part."

Raw Material Markets

Iron and Steel

Obviously one of the first steps necessary to speed up rearmament must be the engagement of more blast furnaces. At no time during the past two years have there been so few furnaces at work as there are to-day, and as soon as the holidays are over active measures must be taken to increase pig-iron production. Meanwhile, in varying degrees, all grades of iron are scarce. To some extent shortages have been concealed by holiday stoppages and the temporary suspension of deliveries. But there is not enough low- and medium-phosphorus iron to meet all requirements and the big output of hematite is fully absorbed.

The outlook for the re-rolling industry is rapidly changing. After a period of drastic reductions, Continental quotations have taken a sharp upward trend, orders for British re-rolled products, particularly the lighter sizes, are flowing more freely, and there are hopes of a restoration of full employment in the near future. Consumers hold good stocks of the larger sizes of steel semis, which may come in useful if Continental sources dry up, and, in the meantime, there is a brisk demand for small square and flat billets, while sheetmakers are taking up offers of defective bars as well as their usual tonnages of primes.

Steel producers are preparing to respond to such changes as may be entailed by the rearmament programme. Already there are indications of a quickening demand. Once more the weekly returns from the United States indicate that production is exceeding maximum rated capacity, big orders from Canada are in hand, and Australia is making increased calls on the capacity of the British rolling mills. Demand for sheets and light plates is far in excess of supply and delivery dates for joists, channels, etc., are extending. Requisitions for railway material assure steady employment for the rail mills, and the strong position of the wire drawers has been further fortified by the receipt of additional export business.

Non-ferrous Metals

Business has not quickened up yet after the August holiday break, and during this time trading in scrap has been on a quiet and diminishing scale. In virgin metals the hiatus in trading has been less marked and consumers are believed to have been buying fairly freely. In the United States, prices are very firm, but at the time of writing no change has been made in the producers' quotations, which for copper and zinc remain at 22½ cents and 15 cents, respectively. On the Commodity Exchange copper has been bid at 22.20 cents, and for zinc futures 17½ cents was bid. For lead, 12½ cents was bid. Thus, all three metals have been showing great strength, but this has not been translated into terms of values on the domestic market in the United States. For export, zinc has been done at 16¾ cents, f.a.s., Gulf ports. In spite of all these manifestations of strength, it is very doubtful if there will be any advance in the current U.S. quotations, for there is a general feeling that any action of this kind would precipitate ceiling prices. Such a course has been more than hinted at and drastic action in regard to commodities generally in the United States is not by any means impossible. The market is now awaiting definite news about how things are going to develop both across the Atlantic and here, and presumably there will be announcements in some detail about the rearmament programmes.

The tin market ran into a difficult situation, for on Thursday of last week the Government broker announced that dealers could not in future count on the Ministry of Supply making available all the tin required. In the afternoon business came virtually to a standstill and prices were nominal. Trading in New York was also seriously affected. However, the following day brought a renewal of business, and although only five warrants changed hands at midday, the turnover in the afternoon was 125 tons. Prices were rather nominal, it is true, but the backwardation, which had widened to £12, disappeared. The outlook is uncertain, for the market must be short of prompt metal. There is little reason, however, to fear that a way out of the present difficulty will not be found. Nor is there any reason to fear that consumers in the U.K. will not be able to secure all the tin they need.

Tin prices this week have soared to new record high levels, the close yesterday (Wednesday) being £847 to £848 for both cash and three months' metal.

Metal Exchange official tin quotations were:—

Cash—Thursday, £779 10s. to £780; Friday, £799 to £801; Monday, £818 to £819; Tuesday, £838 to £839; Wednesday, £847 to £848.

Three Months—Thursday, £767 to £768; Friday, £799 to £801; Monday, £817 to £818; Tuesday, £838 to £840; Wednesday, £847 to £848.

Company Results

(Figures for previous year in brackets.)

DAWNAYS—Final dividend of 12½%, making 22½% (same).

W. H. DORMAN & COMPANY—Dividend of 37½% (same).

MORGAN CRUCIBLE COMPANY—Final dividend of 8¾%, making 12½% (same).

UNITED GAS INDUSTRIES—Final ordinary dividend of 12%, making 17% (same). Deferred dividend of 1s. 9d. per share, equal to 175% (same).

ELECTRIC FURNACE COMPANY—Final dividend on the preferred ordinary and ordinary shares of 4½%, making 8% (same).

ALUMINIUM CASTINGS COMPANY—Trading profit to March 31, £25,717 (loss £4,922); balance, £35,289 (£29,438); forward, £30,269. No dividend on ordinary or preferred ordinary shares (both same).

NEWMAN & WATSON—Group profit for the year ended March 31, £86,233 (£89,059); net profit, £32,046 (£34,274); proportion of income attributable to outside interests, £201 (£299); to general reserve, £13,000 (same); contingencies, £5,000 (£7,000); dividend of 10% (7½%); forward, £22,246 (£20,551).

DAVY & UNITED ENGINEERING COMPANY—Profit on trading of group, including sundry income, to March 31, £713,333 (£221,441); group net profit, £327,911 (£88,708); to dividend of 10% (7½%), £51,769 (£38,826); replacement reserve, £80,000 (£30,000); income tax initial allowances equalisation reserve, £70,000 (nil); reserve for pensions, £25,000 (nil); general reserve, £100,000 (nil); forward, £98,120 (£96,978). A note states that group income tax initial allowances equalisation reserve of £70,000 is estimated income tax relief of group on initial alllowances on capital expenditure up to March 31, 1950.

WELLMAN SMITH OWEN ENGINEERING CORPORATION—Net manufacturing and trading profits of the group to March 31, after all expenses of working and management, including taxation, £199,865 (£164,224); surplus taxation provisions from earlier years now in excess of requirements, £5,000 (£13,000); amount attributable to members of holding company, £204,865 (£177,224); final dividend of 7½%, making 12½%, and special cash bonus of 5%, free of tax (same); to general reserve, £100,000; supplementary staff pensions fund, £25,000; employees' benefit fund, £25,000; previous year's allocations:—To reserve for replacement of fixed assets, £75,000; supplementary staff pensions fund, £50,000.

GENERAL ELECTRIC COMPANY—Consolidated accounts to March 31 show trading profit, £6,021,980 (£4,996,454); aggregate profit before tax, £4,471,692 (£3,795,599); to taxation, £2,762,288 (£2,300,922); consolidated net profit for year, attributable to holding company, £1,709,404 (£1,494,677); balance brought in, £2,031,606 (£1,744,210); items relating to previous years—provisions not required £37,375 (£41,783), other income £229,664 (£147,554), less UK tax £58,299 (£134,065), making £3,949,750 (£3,294,159). (Note states that £1,498,680 of above consolidated net profit for the year and £110,220 of items relating to previous years have been dealt with in accounts of holding company, compared with £1,225,351 and £19,545 in 1949.); to discount and issue expenses of unsecured Loan stock, £110,000 (nil); general reserve, £596,194 (£53,210); reserve against future stock depreciation, £175,302 (£613,389); reserve for increased cost of plant replacement, £140,000 (£6,511); dividend of 10% and bonus of 7½% (same); forward, £2,338,811.

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

(Delivered, unless otherwise stated)

August 16, 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. 5¼d. 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, £847 to £848 ; three months, £847 to £848 ; settlement, £848.

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., £160 ; quicksilver, ex warehouse, £19 17s. 6d. to £20 ; nickel, £386.

Brass.—Solid-drawn tubes, 19¾d. per lb. ; rods, drawn, 25½d. ; sheets to 10 w.g., 24d. ; wire, 24¼d. ; 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), £135 to £140 ; BS. 1400—LG3—1 (86/7/5/2), £143 to £148 ; BS. 1400—G1—1 (88/10/2), £195 to £244 ; Admiralty GM (88/10/2), virgin quality, £200 to £244, per ton, delivered.

Phosphor-bronze Ingots.—P.Bl, £240-£250 ; L.P.Bl, £148-£158 per ton.

Phosphor Bronze.—Strip, 32¼d. per lb. ; sheets to 10 w.g., 34d. ; wire, 34d. ; rods, 31¾d. ; tubes, 36¾d. ; chill cast bars : solids, 32½d., cored, 33½d. (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. 9¼d. 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.

Personal

MR. JOHN DAVIS, director of Gaskell & Davis, Limited, brassfounders, Dukinfield, Cheshire, has retired after 58 years of foundry work. Mr. Davis was presented with a smoker's outfit by the employees of the firm.

MR. G. E. SPEARS has been appointed assistant manager of the coke-ovens department of the Workington Iron & Steel Company.

MR. PETER TURNBULL, a foreman boilermaker, of Colvilles, Limited, Clydebridge Works, Cambuslang, Glasgow, has retired after 50 years' service.

MR. A. P. COOTE, a director of the Butterley Company, Limited, Derby, is retiring from active business. He will remain a director of the company.

MR. C. W. SAUNDERS, formerly chief draughtsman and later technical engineer with Sheepbridge Engineering, Limited, Chesterfield, has been appointed technical manager (engineering) at the Distington Engineering Company, Limited, Workington (Cumberland).

MR. D. ROBERTSON, late of Douglas (Kingswood), Limited, has been appointed general manager of Ferrous Castings, Limited, Warrington, in place of MR. J. STOTT, B.SC., A.M.I.MECH.E., who is joining Personnel Administration, Limited, London, W.1, as a consultant.

MR. THOMAS MCCONNELL, a foreman blacksmith, has retired after 51 years' service with Barr, Thomson & Company, Limited, Netherton Ironworks, Kilmarnock (Ayrshire). He joined the firm in 1899, just two years after the company was formed, and was appointed foreman blacksmith four years later.

MR. D. S. PLAYER, sales director of the Newall Engineering Company, Limited, Peterborough, who recently returned from a visit to the Canadian International Fair at Toronto, at which the company exhibited specimens of their machine tools and optical measuring instruments, has accepted an appointment on the Dollar Exports Board.

MR. ARTHUR DODD, who began his career as a works chemist with the Workington Iron & Steel Company 32 years ago, has been appointed manager of the tar-distillation plant at Lowca (Cumberland), of the United Coke & Chemicals Company, Limited. He succeeds MR. R. D. MCGOWAN, who has retired. MR. CHARLES H. KAY, works manager with the Workington Iron & Steel Company, has been appointed manager of the firm's coke ovens.

MR. ROBERT LIVINGSTONE retired from the service of Glenfield & Kennedy, Limited, at the age of 69, after completing 52 years with the company. Nearly 40 years ago he was undertaking the supervision and erection of large and important contracts throughout the country, and in 1927 he was appointed foreman of the hydraulic section of the heavy general engineering department, a position he has filled with distinction. He was presented with a wallet of notes from the management, foremen and staff.

MR. M. F. DOWDING, M.A., A.M.I.MECH.E., has been appointed engineering sales manager of Davy & United Engineering Company, Limited. Mr. Dowding received his engineering training at Cambridge University and has been with Davy & United since 1946, when he returned from service in the army. Until recently he was the rolling-mill research engineer and has just returned from an extended tour of the U.S. steel industry. He is a member of the Rolling Committee of the British Iron and Steel Research Association. Sales of iron castings made by the firm will come into Mr. Dowding's sphere of activity.

CLASSIFIED ADVERTISEMENTS

PREPAID RATES: Twenty words for 5s. (minimum charge) and 2d. per word thereafter. Box Numbers. 2s. extra (including postage of replies).

Advertisements (accompanied by a remittance) and replies to Box Numbers should be addressed to the Advertisement Manager, Foundry Trade Journal, 49, Wellington Street, London, W.C.2. If received by first post Tuesday advertisements can normally be accommodated in the following Thursday's issue.

SITUATIONS WANTED

FOUNDRY FOREMAN (40), A.M.I.B.F., moulder, technician, experience of full mechanisation, wishes progressive change to similar or Assistant Manager, preferably Scotland.—Box 858, FOUNDRY TRADE JOURNAL.

FOUNDRY MANAGER, having to vacate house due to termination of contract, is prepared to work, any capacity, for assistance with house.—Box 870, FOUNDRY TRADE JOURNAL.

FOUNDRY MANAGER (36) desires progressive post with foundry requiring knowledge of modern methods production; 15 years' experience all branches; A.M.I.B.F.—Box 868, FOUNDRY TRADE JOURNAL.

METALLURGIST (25), Hons. Graduate, Diploma National Foundry College, 3 years' industrial experience in cast steel, iron, bronzes and malleable, seeks responsible technical or semi-technical post with foundry.—Box 862, FOUNDRY TRADE JOURNAL.

METALLURGIST, wide experience of metallurgical control, and problems encountered in iron founding, desires position as Foundry or Works Metallurgist or Assistant to Manager. Some experience of labour control.—Box 874, FOUNDRY TRADE JOURNAL.

QUALIFIED METALLURGIST, Chemist (34), seeks change. Ferrous, non-ferrous, analysis; metallography, etc. Lab. and foundry control. Electroplating. —Box 872, FOUNDRY TRADE JOURNAL.

SITUATIONS VACANT

A VACANCY exists in the laboratories of Ferranti, Ltd., Edinburgh, for a man with metallurgical training and experience in microphotography to be directly responsible to the Chief Chemist, Edinburgh. Opportunity to acquire experience of modern metallurgical, physico-chemical and spectro-chemical instruments. Initial salary according to experience and qualifications.—Apply, stating full details of training, qualifications and experience in chronological order, to the PERSONNEL OFFICER, Ferranti, Ltd., Ferry Road, Edinburgh.

A VACANCY occurs for a SENIOR FOUNDRY FOREMAN in a Company in East Anglia. High grade iron and non-ferrous castings for the firm's own product with a labour force of about 50. Applicants should have a good knowledge of both ferrous and non-ferrous moulding practice, possess the quality of leadership, together with experience in administration.—Replies, giving full particulars of career to date and salary required, to Box 866, FOUNDRY TRADE JOURNAL.

COUNTRY DISTRICT. — Experienced young MOULDER for Greensand Iron Foundry, with possibility of taking charge later.—Box 846, FOUNDRY TRADE JOURNAL.

SITUATIONS VACANT—*Contd.*

A SHOP MANAGER is required for an expanding Non-Ferrous and Ferrous Foundry in West London area. Previous experience essential. Good scope for improvement for the right man.—Write, giving full details and salary required, to Box 854, FOUNDRY TRADE JOURNAL.

ACCOUNTANT, with foundry as well as modern book-keeping experience, for foundries in Scotland. Good conditions and prospects. £400-£550 to start, according to experience.—Box 852, FOUNDRY TRADE JOURNAL.

DEVELOPMENT MANAGER required by the James Bridge Copper Works, Ltd., Darlaston Road, Walsall, Staffs. Preferably A.R.I.C., with practical experience of non-ferrous metals. Capable of supervising research and experimental work at all stages. This is an opportunity for a young man to join a progressive organisation, where there are excellent prospects for an enthusiast.—Please write, marking the envelope "Confidential," to the GENERAL MANAGER, stating full details of qualifications, experience, and salary required.

ENAMEL DEPARTMENT CONTROLLER.—Experienced Vitreous Enameller required by an important Midland Manufacturer of cooking appliances. Applicants should be strict disciplinarians, technically sound and capable of taking full charge of Mill Room, Laboratory, Cast Iron and Sheet Steel Enamel Shops, and able to organise full production. Continuous furnace experience would be an advantage. A good salary will be paid to an energetic production organiser.—Apply (quoting Ref. WMP.3), giving full details of age, education, experience, and salary required, to Box 864, FOUNDRY TRADE JOURNAL.

FOUNDRY MANAGER.—Salary £1,000-£2,000 offered by Messrs. Robert Cort & Son, Ltd., Reading, to a thoroughly experienced practical Foundry Manager, to take charge of their new semi-mechanised and jobbing foundry (no accounts or office work involved). Capacity 40/50 tons per week of valve castings and general jobbing work up to 5 tons. Experience of valve production preferred, but not essential. Motive type sand-slinger moulding machines. Modern sand handling plant, etc. Must hold similar position earning not less than £800 p.a. Age 35-50 years.—All replies must state age and present salary, and be addressed to the MANAGING DIRECTOR, Robert Cort & Son, Ltd., Reading Bridge, Reading.

FOUNDRY MANAGER with technical and practical experience in mechanised machine and floor products of grey iron and malleable castings, Birmingham. Good opportunity for first-class man with initiative.—Only applicants in receipt of a salary of £900 or over need apply, giving full details of experience, age and salary required, to Box 832, FOUNDRY TRADE JOURNAL.

SITUATIONS VACANT—*Contd.*

PRODUCTION CONTROL SUPERVISOR.—Heavy engineering company in the North West requires first class Production Control Executive. Full knowledge of modern methods is required and a record of successful application. Good salary with prospects and superannuation scheme in a first class company is available.—Please reply, stating qualifications, experience, salaries earned, and salary required, to Box 806, FOUNDRY TRADE JOURNAL.

REPRESENTATIVE required by London Non-ferrous Foundry. Applicant must have some technical knowledge of non-ferrous founding.—Apply in first instance to Box 860, FOUNDRY TRADE JOURNAL.

SALES ENGINEER required with comprehensive knowledge of modern furnace, boiler and incinerator construction and application, to handle the sale of refractories, mainly in Central and East Africa, and the Middle East. The successful applicant must possess sound technical qualifications, including at least Associate Membership of appropriate technical Associations. The job entails considerable travelling, from the headquarters in East Africa. A four-figure salary will apply, together with the usual privileges of overseas employment. Interviews in London. Applications will be treated in confidence and should be as complete as possible.—Write Box L.L.A., c/o 95, Bishopsgate, E.C.2.

THE International Meehanite Metal Co., Ltd., 66, Victoria Street, London, S.W.1, have vacancies for two METALLURGISTS with iron foundry experience to become Foundry Engineers. Ability to speak a foreign language desirable but not essential and to be willing to travel in Europe.—Applications must state clearly all educational and workshop experience, with dates, salary, married or single, and be as complete as possible in the first writing.

FOREMAN required for machine moulding section of a grey iron foundry situated in the North Midlands. Applicants must have previous experience of a fully mechanised plant and knowledge of automobile castings production will be an advantage.—Reply in confidence, stating age and experience, to Personnel Manager, Box 822, FOUNDRY TRADE JOURNAL.

FOUNDRY FOREMAN.—A really first-class, reliable, experienced and energetic man not under 38 years of age, required for modern foundry producing 40 tons per week, engineering and high class machine tool castings in green, dry sand and loam. It is essential that applicants produce evidence of successfully filling a similar position. Good house, adequate salary and pension scheme.—Applications, which will be treated as strictly confidential, should state full particulars of training, positions held, to Box 800, FOUNDRY TRADE JOURNAL.