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PRINCIPAL CONTENTS

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Cooling of Sand

One of the problems to be associated with the quantity production of castings is the cooling of the moulding sand. In this connection we read with interest a Paper by Mr. Wolf Mulhrad given before the *Association Technique de Fonderie.* In it the Author states "This difficulty of cooling is partially overcome by storing large masses of sands in voluminous silos. Yet the results looked for are not invariably attained because of the poor conductivity of the sand; it is also a question of evacuating not only the heat units contained in the sand, generally known as the 'sensible heat,' but also the calories of the water-vapour set-up at the time of casting and which remains enclosed in the mass of the sand.

"Foundrymen have often stated that the difficulties of the cooling of used sand are often greater in winter than in summer, despite the wider difference in temperature in the winter—which would appear paradoxical. This is, however, a quite normal physical phenomenon—the sensible heat of the water-vapour contained in the sand is sometimes higher than that of regenerated sand. Now, in summer, the atmospheric temperatures being relatively high, the air in the foundry easily absorbs the water-vapour given off from the sand all along its evacuation circuit. On the other hand, in winter this absorption is insignificant and the vapour has a tendency to condense on the outside layer of sand, because of the wide difference in temperature. The wetting of this outside layer makes the sand impermeable and the water-vapour enclosed in the centre of the mass of sand cannot escape. Moreover, it has been noticed that with each drop or turnover of the sand, a sort of vapour-explosion is produced due to the escaping moisture.

"The used sand arrives at the storage silos without being altogether freed from the vapour which it carried at the knock-out and it is often noticed that in winter, despite a prolonged period in the silo, the sand leaving it is not only damper, but as hot as when it entered. The introduction of vapour, which is set up therein, is, in effect, an exothermic reaction and this addition of calories largely nullifies the losses in the silo by radiation and convection."

This translated quotation is the basis of an argument for the use of a system of rapid cooling rather than an extensive circuit designed for this purpose. One method of doing this is to utilise a steel-band conveyor serving the sand from the knock-out, and causing this to run over a series of shallow tanks containing water running at such a speed that it impinges on the underside of the conveyor.

It is not every foundry that encounters this problem of hot system sand. It depends either on the ratio of sand to metal or the heavy use of cores or the like. Where very light castings are being made and substantial additions of new sand is the practice, then no trouble should arise, but where say, bath-tubs are being manufactured and a mass of the sand used is for a time enclosed by liquid metal, then real efforts are required to cool the sand. We have insisted in the past that hot sand, *per se*, will not harm the resulting casting as the Perlit process well demonstrates, but our translated excerpt gives the best clue to the danger—that of a retained water-vapour content.

E.

NOTICE

Replies to Box Numbers to be addressed to "Foundry Trade Journal," 49, Wellington Street, London, W.C.2.

SITUATIONS WANTED

FOUNDRY Plant Development Engineer, young and energetic seeks post as WORKS ENGINEER or similar executive position. Investment considered.—Box 1409, FOUNDRY TRADE JOURNAL.

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FOUNDRY FOREMAN for Non-ferrous Foundry (London area), must be fully experienced and highly skilled in the production of Bronze and Aluminium Castings to specification, and the mixing of all Non-ferrous alloys. Applicants please state experience in detail, age and salary expected.—Apply Box 1392, FOUNDRY TRADE JOURNAL.

TIME STUDY AND RATEFIXING ENGINEER required for modern engineering factory near Leeds. Foundry experience an advantage. An excellent opportunity for a capable man.—Apply, giving full particulars of age, experience, qualifications, and salary required, to Box 1384, FOUNDRY TRADE JOURNAL.

ASSISTANT FOREMAN, to act as Chief Inspector of castings in a mechanised foundry in Midlands. Staff position. Preference given to applicants with patternmaking or machine shop experience.—Reply, giving full particulars of experience and salary required, Box 1380, FOUNDRY TRADE JOURNAL.

MANAGER (British by birth) required for Metal Powder Plant in East London. Candidates should preferably, but not necessarily, be engineering or metallurgy graduates, with Foundry Management experience. Salary according to qualifications. Good prospects. Superannuation Scheme.—Write full details to Ref. S.M.P., Box 5431, c/o CHARLES BARKER & SONS, LTD., 31, Budge Row, London, E.C.4.

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MESSRS. PETER BROTHERHOOD, LTD., Engineers, Peterborough, require the services of a First Class FOUNDRYMAN with a general technical background to take charge of their Iron Foundry under the Works Director. The foundry is employed on high class pressure castings of a general engineering character. The selected applicant would be invited to become a permanent member of Works Staff where a pension scheme is in operation. A Chemist and Metallurgist is employed.—Apply in writing to: DEPUTY WORKS DIRECTOR, giving age, experience and salary expected.

SITUATIONS VACANT—*Contd.*

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THE BRITISH CAST IRON RESEARCH ASSOCIATION is extending its Operational Research Team and invites applications for two vacancies from those experienced in foundry operations affecting production. Salaries in accordance with training and experience. A memorandum on the appointments is available from, and applications (which will be treated in confidence) should be made to the SECRETARY, Bordesley Hall, Alvechurch, Birmingham.

VITREOUS ENAMELLER. — Experienced Enameller required for small Factory in Johannesburg, South Africa. Only experienced men need apply. Good salary and excellent prospects for the right man.—Apply in the first instance, giving full particulars of experience, age, and copies of references, to Box 1408, FOUNDRY TRADE JOURNAL.

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STEEL FOUNDRY ASSISTANT MANAGER (Yorkshire Area), 30-40 years of age, required to superintend production of approximately 3,000 tons per annum of jobbing and machine moulded castings. Applicant must be thoroughly practical; he will be in charge of all stages of production and responsible to the Director in control of the foundry. House will be provided if necessary, and position will be superannuated. Applications will be treated with complete confidence. State age, training, previous experience, positions held, and salary required.—Box 1391, FOUNDRY TRADE JOURNAL.

BUSINESSES FOR SALE

FOR SALE.—Small Brass Foundry, East Lancs, district, good connections, continuous runs, plenty of scope.—Box 1410, FOUNDRY TRADE JOURNAL.

FOR SALE AS A GOING CONCERN.—Old-established Foundry, 11 miles from Central London. Producing high grade Bronze and Aluminium Castings for all branches of engineering industry.—Replies to Box 1395, FOUNDRY TRADE JOURNAL.

Rebuilding of Nevill's Foundry

In the past, the maintenance and design requirements of Richard Thomas & Baldwins, Limited, and their associates have been largely undertaken by their works at Nevill's foundry, Llanelly, and to a lesser extent at their Landore foundries. A re-organisation has taken place, in which the old shops of Nevill's foundry have been moved to a completely new site which has been conceived on a larger scale.

The four buildings consist of foundry, machine-shop, construction shop and fettling shop, with a store and sub-station located in the last-named building. Working to the firm's own design, the structural steelwork was fabricated and erected by T. C. Jones & Company, Limited, who also supplied and fixed all glazing, asbestos sheets, rainwater goods, and hand- and electrically-operated roller shutters. All the buildings are 350 ft. long with the main stanchions at 50-ft. centres. The fettling shop is a single-bay building 55 ft. wide. A crane gantry covers 250 ft. of its length, and the remainder is taken up by the store and sub-station. The foundry building, for the production of both ferrous and non-ferrous castings, is of the two-bay type, one bay being 77 ft. 6 in. wide and the other 78 ft. 6 in. wide. One bay is provided with a gantry of 70 ft. span and the other of 46 ft. span, leaving 25 ft. not covered by cranes for the installation of cupolas, drying furnaces, and other plant. The height of the fettling shop is 31 ft. to eaves, the foundry having one bay 35 ft. high and one bay 43 ft. high.

Constructional Materials

The gantry girders are designed to carry cranes of capacities varying from 5 to 30 tons. All roofs are of the north-light type with a lattice-girder spanning between the main stanchions, and lean-to trusses between the lattice-girders. The north slopes, which are formed by rakers between the top boom to the lattice-girder and the rafters of the lean-to trusses, are all covered with ¼-in. wired glass in aluminium-alloy glazing bars, and the south slopes are covered with Trafford tiles. The foundry and fettling shops have curved sheets at the apex, to give adequate ventilation. All gutters and rainwater pipes are of asbestos, with the exception of the bottom 6 ft. of the latter, which are in cast iron to withstand rough usage.

Distinctive features of the scheme are the permanent platforms which are provided beneath the roof of all buildings for cleaning the underside of the glass. These platforms are constructed with open-grid flooring, and vertical ladders are fixed to give easy access.

Forty Years Ago

In our issue of December, 1911, the Editor in his leader which extended over five columns, reviewed current opinion on physical properties of cast iron. Of interest is a paragraph announcing that the *Verein Deutscher Geissereifachleute* (German Foundrymen's Technical Association) were awarding three quite substantial prizes for the best answer to the following question. "Has there been made any decided progress in the last twenty years in the construction and running of cupola furnaces?" Not too bad a subject for to-day! Amongst the articles printed is one of German origin which describes and illustrates an overhead electric travelling crane of 30 tons lifting capacity, which has suspended from it a cab and an auxiliary rotatable jib crane of 15 tons capacity. This enables loads to be placed outside the area spanned by the main crane. Amongst new companies registered was the Universal System of Machine Moulding and Machinery Company Limited.

Gillett & Johnston to Re-cast Aberdeen Bells

The carillon of bells in the tower of East and West Churches of St. Nicholas, Aberdeen, is to be renewed at a cost of £8,060. The local Council finance committee have agreed that the work be undertaken by Gillett and Johnston of Croydon. Church authorities have given the restoration their blessing. It will be undertaken without cost to the ratepayers, for there is a special fund out of which the outlay will be met. The existing bells, which were peeled first on the occasion of Queen Victoria's Jubilee in 1887 and which have been the subject of controversy ever since, will be removed, melted down and re-cast. Special mechanism will enable the heavy bourdon bell to be tolled automatically at any pre-set hour. It is also proposed to install mechanism that will ring tunes on a three-octave carillon by automatic means. On special occasions the Council may engage the services of a carilloneur to give recitals.

The original 37 bells were cast in Belgium and on several occasions previously the question of replacing them has arisen, always being shelved. All are now to be brought to the Croydon bell-foundry for remelting and a further 37 will be re-cast, properly tuned and re-installed. The largest of the 36 carillon (the D-Sharp bell) will weigh 27 cwt. 2 qr. 21 lb. and the bourdon bell about 90 cwt. Although installed in the church tower, the bells are the property of the civic authority, a not unusual arrangement.

Instituto del Hierro y del Acero

This Spanish organisation,—their Iron and Steel Institute—which embraces foundry practice within its activities, is holding its second annual general meeting from December 10 to 15 in Madrid. It has every appearance of being a very interesting occasion, the papers are perhaps in general a little on the theoretical side but here and there, judging from the titles, are practical interventions. The list is an extremely long one and we deplore that, whilst between them France and Germany have no fewer than sixteen papers, this country has only one—by Mr. John Miles of John Miles and Partners (London), Limited.

This metallurgical conference is probably unique in as much as it opens with a religious ceremony in the chapel of the Institute for Scientific Research. Included in the programme are a visit to the Prado Museum, a concert and a gala night. Apparently there are no works visits. Readers wishing to participate should write to the Director, Instituto del Hierro y del Acero, Villanueva, 15, Madrid.

More Long-service Awards

Recently 40 employees of Glenfield & Kennedy, Limited, Kilmarnock, received awards and certificates in recognition of their long service with the firm, under the presentation scheme inaugurated last October. Mr. Hugh Cowan-Douglas, chairman of the Company, presided over a gathering of 200, and gave a résumé of the service scheme. In 1919 the directors decided to grant allowances (on a non-contributory basis) to employees on retiral who had given at least 25 years' continuous service. Since then 468 workers had received pensions and there were 140 at present on the pension list. Amount paid out was almost £9,600 per annum.

Cast-iron Crankshafts, with Special Reference to Acicular and Spheroidal-graphite Cast Irons*

By A. B. Everest, Ph.D., F.I.M.

The Paper discusses cast versus *forged crankshafts and the advantages and disadvantages of cast iron for crankshafts. Also dealt with are the development of cast irons with the required mechanical properties; alloy cast irons, including acicular cast iron for crankshafts of Diesel engines; test data and service performance of alloy and special cast-iron crankshafts; spheroidal-graphite cast iron and its possibilities for crankshafts.*

Introduction

Cast crankshafts have been of interest to engineers for many years past on account of the production economies they offer over the conventional forged types. Cast-steel crankshafts are in fact used for this reason, but their consideration falls outside the scope of this Paper. It should be said, however, that due to the poor foundry characteristics of cast steel and consequent need for closer inspection of the crankshaft castings, they are not generally favoured by the foundryman and engineer. Cast iron, on the other hand, has good casting qualities and will readily give sound crankshaft castings. Until recent years, however, cast iron was regarded as a weak and brittle material and was rightly considered as deficient in the mechanical properties required in crankshafts, so its use was restricted to only the lightest duties, as, for example, for some types of compressors.

In recent years, great progress has been made in improving the quality and properties of cast iron. Simultaneously, foundry technique has developed, with the result that by 1937 it was reported by Walls[1] that true cast-iron crankshafts had been successfully developed in the U.S.A. and had withstood a searching testing period of over three years, and were then being adopted in a wide range of internal combustion engines. Since that date, further rapid strides have been made in cast-iron metallurgy, with the result that new types are now available which combine the good casting quality of cast iron with mechanical properties approaching nearer to those of steel. Several types of high-duty cast iron have now been applied to cast crankshafts since the early development work in the mid-1930's, and true cast-iron crankshafts are now standard in many of the petrol and Diesel engines in production in various parts of the world[2]. Impetus was given to the application of high-duty cast iron to crankshafts by the conditions in many industrial countries during the second world war. Supplies of crankshaft forgings were in many cases restricted and attention was given to their replacement by cast-iron shafts. It is interesting to record that, whereas it was felt that in many cases this use of cast iron was only a wartime expedient, the success experienced in the use of cast iron stimulated the interest of engineers to such an extent that further progress in the use of cast iron for crankshafts has continued since the war, even when supplies of steel became normal, and high-duty cast iron is to-day accepted as a good crankshaft material.

It should be explained that the term cast iron used in this Paper means a material containing carbon in the normal range for cast iron, that is generally between 2.7 and 3.5 per cent. (as compared with steel which contains generally less than 1.2 per cent. of carbon). This distinction excludes the well-known special alloy so successfully developed by Ford Motors for their cast crankshafts, and which is, in fact, a mixture of molten iron and steel, giving a carbon content lying between the two ranges mentioned[3]. From the metallurgical point of view the Ford alloy is a special steel rather than a cast iron and must be considered in a class by itself. An excellent review of the literature available on the subject of cast crankshafts up to the end of 1947 has been prepared by Love[4], and those interested are specially recommended to study this review which gives full details of the properties and behaviour of the various cast-crankshaft materials available at that time.

In this Paper special reference is made to two of the most recently-developed types of high-duty cast iron. In the first place, information is given on the acicular type of alloy cast iron which has been widely used for crankshafts since its development about 1940, and, secondly, reference is made to the new spheroidal-graphite cast iron which was introduced about two years ago, and which is now revolutionising existing views on cast-iron metallurgy. The latter material is too new for extensive service data to be yet available, but details of the new iron are given in this Paper, and already these have proved of interest to engineers for crankshafts. One of the main advantages of cast crankshafts is the production economy they offer. They have, however, also proved in service to have properties which favour their continued use, even when steel shafts are available. The development of high-duty

* Paper read before the *Congres International des Moteurs* in Paris.

Cast-iron Crankshafts

irons with ever better properties is focusing attention on the cast shaft and leading to its wider adoption in many types of engines.

Production Economies

Among the features which make cast-iron crankshafts attractive are the following:—

(1) Suitable grades of cast iron can be cast into the most complex forms allowing designs to be used which are not suitable for forging and stamping. Such special features as undercuts, and shaped balance-weights which would normally have to be attached as separate pieces to a forged shaft, allow greater scope to designers when cast shafts are adopted.

(2) Cast-iron castings can be produced to close tolerance to size, with the result that machining allowances are very much less than for forged shafts. Webs and other parts with non-bearing services can be cast sufficiently accurately to be put into service in their original as-cast state and with no machining.

(3) The weight of the finished shaft can be further reduced by coring out unnecessary metal as, for example, in the journals and bearings. This permits better designing, leading to shafts with better balance and stress distribution, and reduced power losses, and further assists the the foundryman in producing uniform castings by equalising the section thickness of the metal throughout the casting.

All these factors lead to a considerable economy in material and machining time. As an example, Love[4] quotes the case of a crankshaft of finished weight 12,000 lb., having to be machined from a block forging weighing 36,000 lb., as against a corresponding casting for the same shaft which weighed only 14,000 lb. Again, an automobile crankshaft weighed, as a steel stamping, 82 lb. for a finished crankshaft weight of 66 lb. With minor modifications to design, however, the same shaft was produced as a casting with a rough weight of 65 lb. to give a finished crankshaft weight of 56 lb. Templeton[2] quotes similar figures for a range of crankshafts; for example, a six-throw Diesel shaft required a rough steel-forging weighing 2,520 lb. for a finished crankshaft of 657 lb., whereas the corresponding cast-iron casting weighed 700 lb. for a finished weight of 637 lb. in high-duty cast iron. At the same time, the machining time was reduced from 160 to 80 hours. The average over nine types of shafts for Diesel engines and compressors, ranging from two- to six-throw shafts, was 255 lb. for the casting, as against 986 lb. for the forging, with machining times reduced from an average of 83 hours to 41 hours. The cast-iron shafts are put into service without heat-treatment, whereas such treatment is a necessity for steel shafts, and adds to their cost and production time.

Other factors favouring the cast crankshaft must also be kept in mind. The time and expense involved in the production of forging dies are much greater than the time and cost of the preparation of suitable foundry patterns. In this connection, due consideration must be given to the number of shafts required to a given design. Clearly, the smaller the number, the more the advantage lies with the cast shaft, whilst the advantages are less obvious in the case of mass production, where the cost of suitable dies can be spread over a large number of finished forgings or stampings. Modification of design can also be more readily made to pattern equipment than to forging dies, this again being a feature in favour of the cast shaft. Other significant production factors in favour of cast-iron crankshafts are that the machinability of the cast irons is generally better than for steel, allowing reduced machining time for any particular operation. Again most grades of cast iron, as used for crankshafts, do not require any heat-treatment, whereas heat-treatment is normally required for forged steel, with further consequent expense and production delay. Again, heat-treatment is sometimes accompanied by distortion of the steel shaft, whereas distortion is generally unknown in cast-iron crankshafts in production.

Production of Cast-iron Crankshafts

The foundry practice for the production of cast-iron crankshafts has been developed to a high degree. Detailed descriptions of the foundry methods now employed are out of place in a Paper of this type, and those interested are referred to the several excellent Papers on this subject. Templeton[2], for example, describes in some detail the methods adopted in his foundry, and the methods described by Cone[3] are of general applicability. A more recent paper by Finlayson[5] describes the methods developed for medium to large shafts in the U.S.A. A special feature of this method, which was evolved by Campbell Wyant & Cannon, pioneers of cast crankshafts in the U.S.A., is that the shafts are poured in a near-horizontal position and immediately after casting, the moulds are swung into a vertical position, feeding of the metal being ensured by a large feeder head at the end of the shaft. Naturally, the aims of all the special methods developed for casting crankshafts is to provide sound uniform castings, since the success or failure of the cast crankshaft depends on the ability of the foundryman to supply reliable castings, free from defects. The success which has been attained in this direction can be judged from the wide adoption of cast-iron crankshafts in the leading industrial countries to-day.

With new designs, every care must be taken to check soundness, and rigid rules are laid down by the inspecting authorities. Inspection involves the cutting up of prototype castings, and checking the quality of the metal in various parts of the casting. Radiographic inspection of selected castings is carried out and hardness surveys and other tests are applied. Routine checks on the cast-iron crankshaft castings are generally made on test coupons cast at points along the length of the shaft, or perhaps better on test-pieces cut from an extension cast at one end of the shaft. It is of interest to note that some designs of cast crankshafts have now been adopted under the rigid systems of inspection applied by world wide inspecting authorities, and now are accepted for vital services.

Field of Application of Cast-iron Crankshafts

In Great Britain, cast-iron crankshafts are used extensively for petrol engines, including such engines for road transport, marine engines and engines for general purposes as in agriculture. In the Diesel-engine field, cast-iron crankshafts have been used in sizes up to 10-in. dia. journals and are on trial in sizes up to 12 and 14 in. dia. Diesel engines are in regular production with cast-iron crankshafts in sizes up to 2,400 h.p. and more.

In cases where the crankshafts are adequately designed, high-duty cast iron can frequently replace steel without major modification to the engine design. In cases where the duty is more severe, however, it may prove necessary to modify the design substantially, in order to adopt cast-iron crankshafts. This is perhaps the major reason why, at least in Great Britain, cast iron has not, so far, proved successful for crankshafts in Diesel engines for road transport vehicles. On the other hand, it has been widely adopted for Diesels in stationary plant, marine service and in some agricultural applications, including tractors. Cast-iron crankshafts are also widely used for gas engines and in associated plant, including compressors. Some standard types of Diesel engine, in which steel is used for the crankshaft, employ a cast-iron end-shaft for the operation of blower cylinders, providing scavenging air.

In the U.S.A. wide use is made of cast-iron crankshafts, and these in the Diesel-engine field are, as in Great Britain, generally of the nickel-molybdenum alloy type, with the alloys in such proportions as to develop an acicular matrix in the cast iron. Such shafts are produced by one of the leading foundries for Diesel engines, ranging from 450 to 2,400 h.p., designed for locomotives of both the passenger and shunting types, marine engines and also for a wide variety of stationary applications. The shafts are cast in a range of sizes from 500 to 5,000 lb. rough weight, and an overall cast length of 6 to 18 ft., and up to and including twelve-throws. The advantages of properly-designed alloy cast-iron crankshafts are stated to be high vibration-damping capacity, lowered notched sensitivity, the economies inherent in the use of patterns, instead of dies, and easier and simplified machining, as compared with forged-steel shafts.

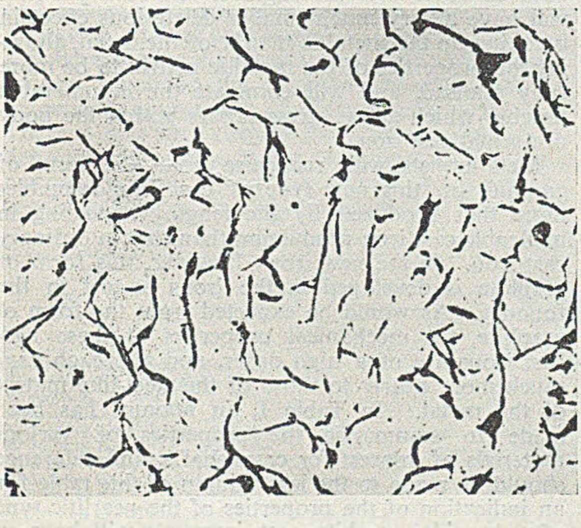


FIG. 1.—*Microstructure of Grey Cast Iron, unetched, showing Graphite Flakes.* × 100 *diameters.*

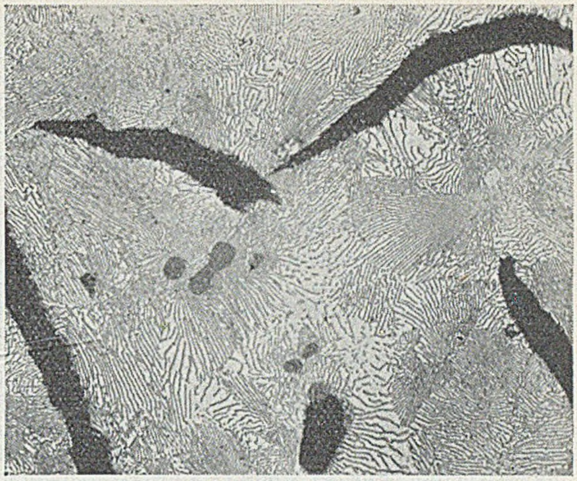


FIG. 2.—*Engineering Grey Cast Iron, etched, showing Graphite Flakes and Pearlitic Matrix.* × 500 *diameters.*

High-duty Cast Iron for Crankshafts

Many papers have been written reviewing the progress made in recent years in the metallurgy of cast iron (see, for example, Reference No. 6). It is well known that by the use of improved foundry technique and in particular careful control over metal composition and the use of improved melting furnaces, great strides have been made in the production of cast iron of improved and regular quality. Special metallurgical processes, such as inoculation of the molten metal in the ladle and the use of various alloys, have now provided grades of iron, which are in everyday production, with tensile strengths up to or exceeding 28 tons per sq. in. The achievement of these properties depends on the reduction of impurities and harmful elements in the iron and control over the other elements, so as to give a predetermined structure in the metal. The first aim of much of this foundry development has been to control the quantity and form of the graphite flakes which are characteristic of cast iron and which break up the continuity of the metal matrix (see Fig. 1) and thus determine the properties of the final casting. Cast iron consists essentially of a steel-like matrix, interrupted by the graphite and other inclusions: thus the control of the graphite is the first stage in producing a high-duty cast iron. In the second place, the properties of cast iron have been further improved by alloying the iron to refine the microstructure of the metallic matrix. Fig. 2 shows the etched structure of a typical high-quality engineering cast iron, the matrix in this case being of the normal pearlitic form. Several of the grades of cast iron which have proved successful for cast crankshafts for petrol

Cast-iron Crankshafts

engines and for general applications in smaller Diesel engines are of this type. Many thousands of crankshafts have been made in irons which are only slightly alloyed, but which are made under controlled conditions, including inoculation to give a favourable form to the graphite.

Acicular Cast Iron

Early in the development of cast iron for crankshafts in the U.S.A., alloy composition containing nickel and molybdenum were adopted, as it was found that this alloy combination gave the most favourable mechanical properties. Experiments with varying proportions of nickel and molybdenum showed that certain combinations of these elements gave castings with exceptionally high strength, and these castings showed an unusual microstructure. Further study established that these high mechanical properties could be obtained at will by using molybdenum in conjunction with nickel, the latter being varied in relation to the cooling rate or section thickness of the casting. The characteristic structure developed in these nickel-molybdenum cast irons is shown in Fig. 3 and has been termed the "acicular structure." It is closely related to the structure known to steel metallurgists as "bainite," and this type of cast iron is now known as acicular cast iron.[7]

The tensile strength of acicular cast iron can vary from 25 to 35 tons per sq. in., and can be further improved by heat-treatment. Its other mechanical properties are correspondingly high, and it is particularly noteworthy that its impact or shock resistance is at least twice that of the best pearlitic high-quality cast iron. As shown in Fig. 3, the graphite in the normal acicular cast iron is in the flake form and consequently this iron shares the good damping properties common to the flake graphite irons, and in common with all the other cast irons, it shows a low notch sensitivity in fatigue tests. The wear resistance of acicular cast iron is excellent. Its hardness is relatively high, but it is noteworthy that in spite of this high hardness, castings in acicular cast iron can be readily machined.

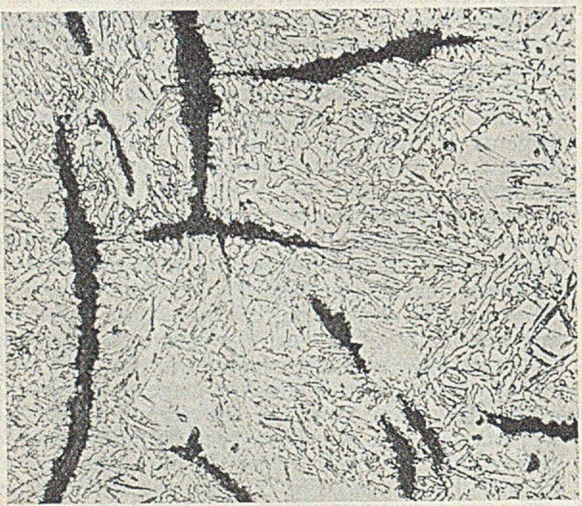


FIG. 3.—*Acicular Grey Cast Iron, etched, showing Graphite Flakes in Acicular Matrix.* × 500 *diameters.*

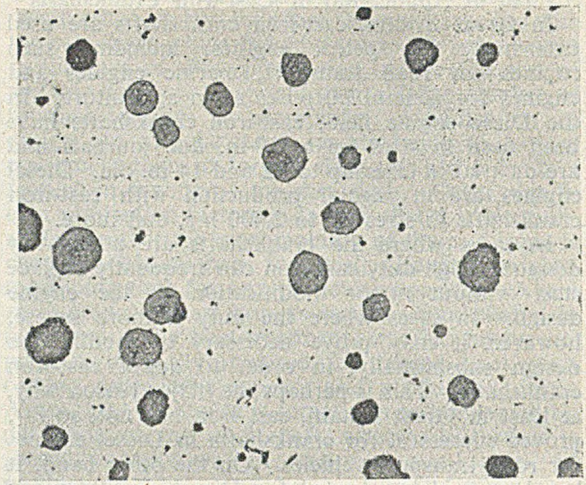


FIG. 4.—*Spheroidal-graphite Cast Iron, unetched.* × 100 *diameters.*

Spheroidal-graphite Cast Iron

During the last two years, the attention of engineers and metallurgists has been drawn to the latest development in cast-iron metallurgy, which has resulted in a product known variously as spheroidal-graphite cast iron, nodular cast iron or ductile cast iron. Typical microstructures in this new product are shown in Figs. 4 and 5. From these it will be seen at once that the essential characteristic of these new cast irons is that the graphite, instead of being in the conventional flake form, has now assumed the form of compact spherical particles. It will at once be obvious to the engineer that such particles will have a very much smaller deleterious effect in breaking up the metallic matrix of the metal, allowing the properties of the metallic matrix to be more fully realised, and will eliminate the innumerable notches which act as stress raisers within the body of normal cast iron.

Metallurgists will recognise that the form of graphite of this new type of cast iron resembles more that produced by the lengthy annealing in malleable cast iron production than that in ordinary cast iron. In the new irons, however, this form of graphite is developed in the irons as-cast in the foundry. As would be expected from the form of graphite, the mechanical properties of these new cast irons are of a high order, and approach very much more nearly to those of the steel-like matrix of the metal. In Table I, an attempt has been made to summarise the properties of various materials of interest for crankshafts, and reference should be made to the last column of this table for an indication of the properties of the pearlitic type of spheroidal-graphite cast iron. It will be seen that the strength under various forms of test is

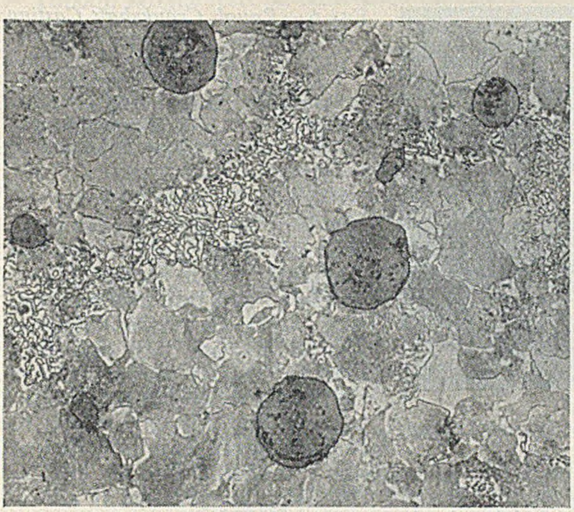


FIG. 5.—*Spheroidal-graphite Cast Iron, etched, showing Pearlitic Matrix in Iron as Cast.* × 250 *diameters.*

about double that of conventional cast iron. The elastic modulus is high, but of particular interest is the fact that like other cast irons, the notch sensitivity of the material is low compared to steel, as shown by the relatively low reduction in the endurance-limit figure, as a result of including a notch in the test-piece. The net result of this is that the endurance limit under notched conditions is, for the new material, frequently as high or even greater than that of steel as used for crankshafts.

As would be expected from the form of graphite, the vibration-damping capacity of the new cast irons lies midway between that of steel and the normal flake-graphite types; consequently, from this point of view, the new iron is perhaps not so favourable for crankshafts. On the other hand, the tests which have been carried out to date show that the wear resistance of the new iron is very good and compares favourably with the best of other types of high-duty cast iron.

Spheroidal-graphite cast iron is made by a special process involving the addition of small amounts of cerium, magnesium or other metals to the iron. There is now an extensive literature on the properties and applications of this new material. The magnesium process, which has proved the most successful and economic, was first described in a Paper by Gagnebin, Millis and Pilling[8] and more recently the present Author has reviewed its properties and applications.[9] Naturally, in view of its high strength, this new iron has been considered of interest for cast crankshafts, and a considerable amount of experimental work is in hand in assessing its suitability for this application. In this connection, however, it must be emphasised that much of the work on spheroidal-graphite cast iron has been carried out on the material in the annealed condition, in which a short high temperature anneal is given to break down the pearlitic matrix to the ferritic state and to develop high ductility. The elongation of the annealed material is of the order of 10 to 25 per cent., whereas the elongation of the material as-cast is generally not in excess of 3 per cent. unless special compositions are selected. It is anticipated that for applications such as cast crankshafts where wear resistance is vital, attention will be focused on the pearlitic low-ductility type, as the general experience is that cast irons with microstructures including ferrite are inferior in their wear resistance. Another feature of interest for the crankshaft application is that the new spheroidal-graphite cast irons show appreciably greater shock resistance as compared to the conventional types of cast iron.

Table I attempts to summarise some of the outstanding properties of these new cast irons in comparison with steel. This table is put forward with some diffidence. The data on which it is based are taken from widely-dispersed sources, and it is difficult to establish figures derived from truly comparable methods of test. Again, there are, in some cases, little data available to give representative figures, especially for the newer irons. In the case of the steels, two are quoted, but these, of course, are only two out of a large number used for crankshafts and even for them, the properties developed will depend on the heat-treatment employed. Attention is drawn in the table to two sets of figures which are not strictly comparable with the other figures quoted. It is felt, however, that the table will at least give some indication of the manner in which the new types of cast iron are approaching more and more to steel in those properties desired in crankshafts.

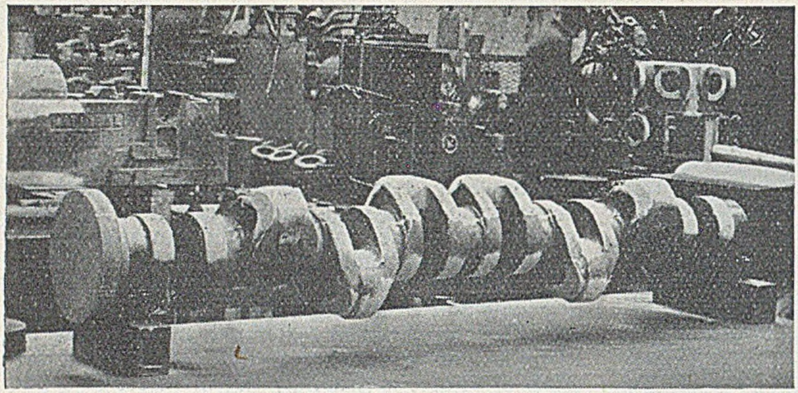
Service Properties of Cast-iron Crankshafts

The mechanical properties of some cast irons available for crankshaft production have been given in detail by Love.[1] Reference is made in Table I

TABLE I.—*Some Typical Properties of Crankshaft Materials.*

	Forged carbon steel quenched and tempered.	Ni-Cr-Mo alloy steel forged heat-treated.	High-duty cast iron to 20 ton tensile minimum.	Acicular cast iron.	Spheroidal-graphite cast iron (Pearlitic).
Tensile strength, tons per sq. in.	36	58	22	26	40
Yield strength, tons per sq. in.	20	50	—	—	30
Elongation per cent.	25	23	< 1	< 1	2
Brinell hardness	60	269	220	280	260
Modulus of elasticity, lb. per sq. in. × 10^6	29	29.5	18—20	22	25
Modulus of rigidity, lb. per sq. in. × 10^6	11	11.65	8.6	8.6	—
Izod notched-bar impact value, ft.-lb.	30	60	< 1	1.5	3—5
Endurance limit unnotched, tons per sq. in.	15.8	29	7.2	12	(10.8)†
Endurance limit 0.05 in. radius groove, tons per sq. in.	8	17.5*	6.0	9	(8.3)†
Reduction of endurance limit due to groove, per cent.	49	40*	16.7	25	(23)†
Vibration-damping capacity	Low	Low	High	High	Medium

* 60 deg. sharp notch. † On ferritic S.G.C.I.



[*By Courtesy of the National Gas & Oil Engine Company, Limited*

FIG. 6.—*Rough Crankshaft Casting in Acicular Cast Iron for 8-cylinder Diesel Engine. Overall Length, 76 in., diameter of Journals (finished), 4.75 in. Note Coring-out of Journals and Bearings and Close Tolerance to Finished Form.*

and below to the properties of the special grades of cast iron under consideration in this Paper. Experience over the past fifteen years with cast-iron crankshafts has showed that the bearing properties of cast iron are excellent and are generally superior to those of the steels, especially when the shafts are run in copper-lead bearings. The combination of cast iron with such bearings will stand up to the highest bearing pressures normally encountered in internal-combustion engine design. Another outstanding advantage of cast iron is its excellent resistance to wear, and the behaviour of cast-iron crankshafts, from this point of view, has proved up to the fullest expectation. The higher vibration-damping capacity of cast iron and its combination of other special properties is reported to lead to smoother running and quieter crankshafts.

Carter,[19] speaking of cast-iron crankshafts generally, emphasises that the lower modulus of elasticity of the cast irons is an advantage, in that the stress developed for a given deflection, such as that due to the misalignment of a main bearing or to distortion of the engine frame in service is, therefore, less than would be the case in a steel shaft under similar circumstances. This has been confirmed by tests on engines in which a main bearing has been deliberately displaced, and such tests have shown remarkable endurance for the cast-iron shafts under these adverse conditions.

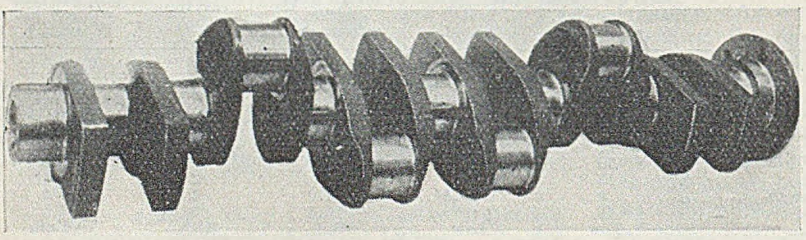
On the other hand, Carter points out that the low modulus of rigidity of cast iron as compared with steel lowers the natural frequency of vibration in crankshafts, and in some cases may bring critical vibration frequencies within the normal running speeds of the engine. This, however, is, in part, off-set by the inherently better damping properties of cast iron and the total stress built up on resonance is appreciably less for cast iron than for the corresponding steel shaft. Carter sums up by pointing out that for engines up to four cylinders, cast iron lessens the torsional oscillation problem, but in engines with six or more cylinders, the problem is accentuated by the lower natural frequency of the cast-iron shaft. This calls for careful designing where cast iron is used for the larger shafts.

Acicular Cast-iron Crankshafts in Service

As already indicated, considerable experience is now available on the use of the nickel-molybdenum acicular cast-iron crankshafts in internal combustion engines. Typical illustrations of such crankshafts accompany this Paper. The production economy in using cast-iron crankshafts which was mentioned earlier is underlined by the figures shown in Table II which were provided by a leading British Diesel-engine maker. This table shows the very substantial economy in using acicular cast-iron crankshafts as compared with the conventional type of steel forging or stamping. The crankshaft in question is illustrated in Fig. 7, whilst Fig. 6 is of a similar type but with eight instead of six throws and shows well the coring-out of the journals and crank pins.

On engine test, torsional vibration diagrams on the type of shaft illustrated in Fig. 7 have shown that the steel crankshaft developed a torsional shear stress of 9,100 lb. per sq. in., due to the sixth order critical speed, and this was reduced to 4,250 lb. per sq. in. in the cast-iron crankshaft.

Satisfactory fatigue strength is demonstrated by acicular cast-iron crankshafts: for example, one maker, who has recently been studying this material for a six-throw marine Diesel crankshaft, states that test-bars cut from an extension of the crankshaft casting give a fatigue strength on the plain bar of 15 kg. per sq. mm. The use of a notch in the test-bar only slightly reduces this figure and a strength of 14.5 kg. per sq. mm. is reported. Under similar conditions of test, the values for steel are normally of the order of 12 kg. per sq. mm.



[*By Courtesy of the National Gas & Oil Engine Company, Limited*

FIG. 7.—*Finished Acicular Cast-iron Crankshaft for 6-cylinder Diesel Engine, developing 240 b.h.p. at 1,500 r.p.m.*

Torsion fatigue tests on unnotched bars gave 8.5 kg. per sq. mm., and similar tests conducted on bars containing a drilled hole, so positioned as to give maximum concentration of stress, gave 6 kg. per sq. mm. This last test emphasises that the notch sensitivity of cast iron is much less than for steel, with the result that in practice there is appreciably less danger of fatigue failure due to stress concentration by such discontinuities as oil holes. Other earlier results on acicular cast iron are reported in the review by Love.[4] In the meantime, extensive work on the influence of complex stresses on acicular cast-iron crankshafts has been undertaken by various research associations in Britain and elsewhere. In particular, such research is in hand at the British Internal Combustion Engine Research Association and the Motor Industry Research Association.

TABLE II.—*Cost of Production of 6-Throw 4¾-in. Dia. Journal Diesel Engine Crankshaft.*

Material.	Form.	Rough weight, lb.	Cost in £ sterling. Rough form.	Machining and finishing.	Heat treatment.	Total.
Steel* ..	Forging	649	165		10	175
Steel* ..	Stamping	—	30	35	10	75
Acicular cast iron	Casting	532	13	35	—	48

* 1 per cent. Ni, 0·4 per cent. C.

TABLE III.—*A Comparison of the Properties of Steel and Acicular Cast Iron as Used in Crankshafts Provided by the Same Maker.*

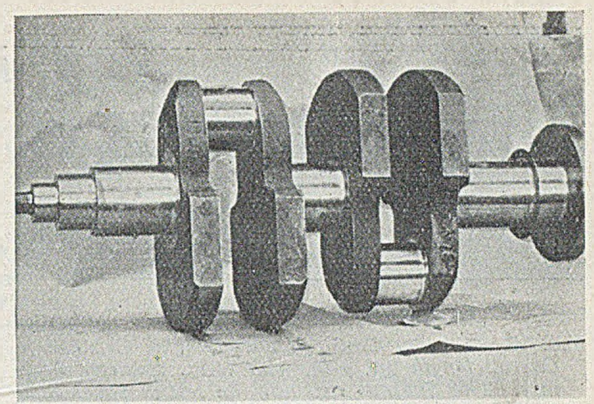
Property.	Steel shaft.	Acicular cast iron shaft.
Yield point, tons per sq. in.	20.0	—
Maximum stress, tons per sq. in.	34.5	34.5
Elongation, per cent. on 2 in.	30.0	—
Reduction of area, per cent. on 4√ area	62.0	—
Brinell hardness number	156	270
Modulus of elasticity, lb. per sq. in. $\times 10^6$	29	21
Modulus of rigidity, lb. per sq. in. $\times 10^6$	11.4	8.6
Damping capacity, per cent:		
Surface shear stress, 1 ton per sq. in. ..	0.7	3.0
Surface shear stress, 2 tons per sq. in...	1.3	3.5
Repeated impact test (Stanton) (blows to fracture)		
Blow energy 0.20 ft.-lb.	15,645	11,445
Blow energy 0.15 ft.-lb.	59,741	59,015
Blow energy 0.10 ft.-lb.	1,378,216	3,000,000*

* Bar unbroken and re-tested with blow energy of 0.15 ft.-lb., 121,570 blows.

The figures in this table were obtained from 2¾-in. dia. sections and relate to a shaft which has been standard for some time past.

Spheroidal-graphite Cast-iron Crankshafts

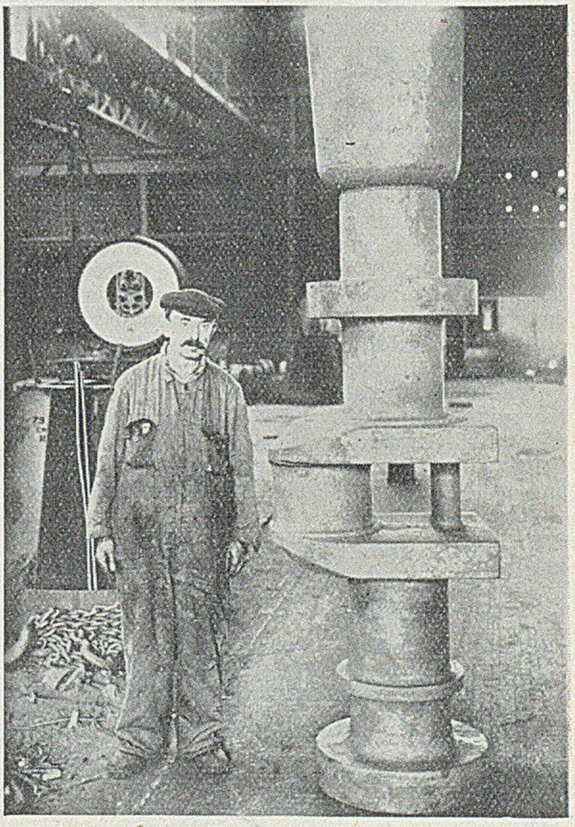
The properties of pearlitic spheroidal-graphite cast iron are included in Table I. No figures are immediately available for the endurance limit of this grade, but some figures have been published for the annealed ferritic grade and they have been included, as they give an indication of the influence of the spheroidal form of graphite, and emphasise that, as for other cast irons, the new type has a low notch sensitivity. The actual endurance limits of the pearlitic grade would be expected to be, if anything, rather higher. In the meantime, preliminary reports on tests carried out on crankshafts are distinctly encouraging. It is true that the new iron has not the



[By Courtesy of W. H. Dorman & Company, Limited

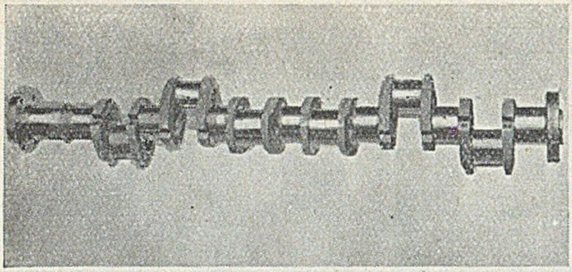
FIG. 8.—*Two-throw Acicular Cast-iron Crankshaft for 26-h.p., 1,000-r.p.m. Diesel Engine.*

high degree of damping capacity shown by the flake graphite types—in fact, the damping capacity is nearer that of steel than of cast iron. The higher mechanical properties of the new iron offer the possibility of producing crankshafts with properties



[By Courtesy of Ruston & Hornsby, Limited

FIG. 9.—*Experimental Acicular Cast-iron Single-throw Crankshaft. Weight as cast 2 tons. Overall length 8 ft.*

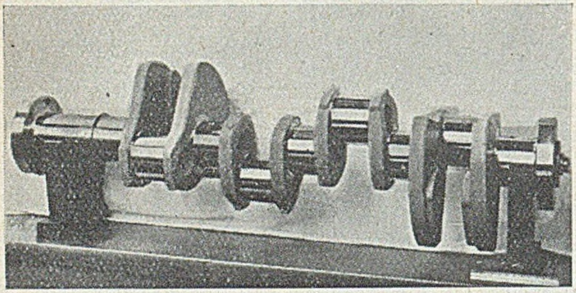


[By Courtesy of the Cooper Bessemer Corporation

FIG. 10.—*Acicular Cast-iron Diesel-engine Crankshaft. Overall length 9ft. 9 in. with 7¼-in. diameter Bearings. This Shaft is also now on test in Spheroidal-graphite Cast Iron.*

much nearer to those of steel, whilst having the full production economies possible with a readily cast metal.

Preliminary wear tests have been reported,[5] and show that the resistance to wear of the spheroidal-graphite iron under laboratory conditions is good. Vennerholm[11] reports that the wear resistance of such cast iron under lubricated conditions is excellent, in particular when free ferrite is absent. Preliminary service tests have confirmed this, and reports are now coming to hand that test spheroidal-graphite cast-iron crankshafts have run for long periods of time with no measurable wear. The Cooper Bessemer Corporation reports that they are carrying out tests on spheroidal-graphite cast iron for crankshafts (see Fig.10). The mechanical properties are as indicated in Table I, and they report that the impact strength is from three to five times that of the acicular cast iron. They express confidence in success for the new cast iron as a crankshaft material.[12] There seems no doubt that the spheroidal-graphite iron will be of great interest to engine designers, not only for crankshafts, but for other items, including rocker arms, pistons, cylinder heads, liners, timing gears, etc. These are, however, outside the scope of the present Paper. It is worth recording that tests have been carried out on spheroidal-graphite cast iron with an acicular matrix, developed by suitable additions of nickel and molybdenum. Preliminary indications show that tensile strength in this type of material can easily reach 50 to 60 tons per sq. in., with the other mechanical properties proportionately increased.



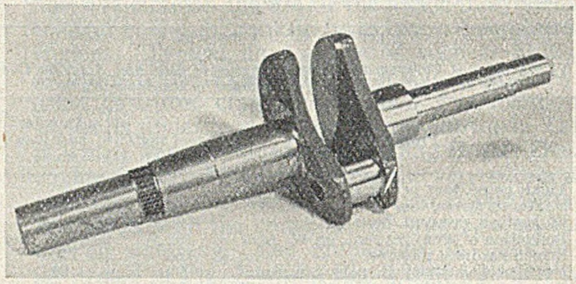
[By Courtesy of the Cooper Bessemer Corporation

FIG. 11.—*Acicular Cast Iron 4-throw Crankshaft for V. Diesel Engine. Length 7 ft. 1 in. Journals 7¼ in. diameter.*

Conclusion

The ground covered by this Paper is extensive, but the indications are clear that cast iron is a good crankshaft material, and that the deficiencies of the cast irons previously known are being overcome by the development of new grades with ever better properties. It has been emphasised that cast crankshafts, and particularly cast-iron crankshafts, offer production advantages which have proved of interest throughout the engineering world. Cast-iron crankshafts have now been in service for 15 years, and there is no doubt that now that new grades of cast iron have been developed to the stage where they can take their place with other high-duty engineering materials, their application will increase.

The Author wishes to acknowledge help in preparing this Paper from:—The National Gas & Oil Engine Company; The Cooper Bessemer Corporation; Crossley Brothers; W. H. Dorman & Company, Limited; The Midland Motor Cylinder Company, Limited; and Fiat Gradi Motori, and those firms as acknowledged in the various illustrations.



[By Courtesy of Sheepbridge Engineering, Limited

FIG. 12.—*Experimental Single-throw Crankshaft, Cast in Spheroidal-graphite Cast Iron.*

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Colouring Oxides in Vitreous Enamels*

By W. Ball

The manufacturer of a colouring oxide starts with a comparatively simple specification to be met. It is required to give the correct colour when used in a particular frit, the colour to be stable under the various conditions met with in the enamelling plant, and the cost is to be reasonable. In addition, it should not affect adversely the workability, gloss, acid resistance, or suspension of the enamel, and of course must be uniform from batch to batch. Unfortunately it is not as easy to meet this specification as might be supposed.

Colouring oxides used in the vitreous enamelling industry are of course inorganic, and are prepared by calcining metallic oxides such as cobalt oxide, chrome oxide, etc., with other materials which will develop the required colour, and form stable compounds likely to be affected as little as possible by the enamel during firing. The term "colouring oxide" is perhaps misleading, as the prepared colour is usually a compound such as a silicate or aluminate rather than an oxide in the chemical sense; chromium oxide, used as a green is the only example which comes readily to mind of a pure oxide being used as a colour for addition to frit at the mill.

To obtain a stable colour the usual aim is to produce a compound which will remain completely inert in suspension in the fused enamel. Most metals give one definite colour when combined with the materials usually considered suitable to produce a stable compound, only the tint varying according to the compound formed. For example, cobalt oxide, or a cobalt salt, calcined with silica to produce a cobalt silicate gives a "royal" blue; with alumina to produce a cobalt aluminate, a cleaner, brighter blue of the "Imperial" or "Turkish" blue shade, described by the British Standards Institution as "French" blue. Additions of small proportions of other materials are made to vary the tint. For example, additions of an alkali increase the purple tint of a cobalt silicate, while alumina decreases it, and gives a greener tint. Chromium is unusual in that whilst the predominant colour of its compounds is green, it can also be used to produce totally different colours. Chromium oxide calcined alone produces a strong green, with silica or alumina a lighter green, but when calcined in small proportions with tin oxide a pink can be produced, or with titanium oxide a strong yellow.

The general principle followed in the manufacture is first of all to obtain as intimate a mixture of the materials as possible, and then to calcine at as high a temperature as is compatible with the tint and strength required, which vary with the temperature and firing cycle used. This intimate mixture is usually obtained by wet-grinding the materials together, then drying, and sifting. In some cases they can be precipitated together from solutions. If it is found of advantage to introduce materials which are soluble they are usually dry-mixed and then wet-ground after the first calcination, dried, and re-fired.

Method of Firing

The temperature of calcination varies according to the materials used, and the tint required, but is usually within the range of 1,150 to 1,300 deg. C. The fired colour similarly varies from a material which is still powdery, to a completely-fluxed mass. Colours used in vitreous enamels have been developed from those used in the pottery industry, and similarly the methods of firing have altered. In the early days most colours used in enamel were those originally made for use on pottery, but with the development of enamelling, particularly the use of pastel shades, the manufacture of colours for use in enamel has become a specialised industry. In the first place the colours were fired in the same kilns, or ovens, as the pottery, and the required temperature was obtained by firing in an "earthenware biscuit oven" (1,160 to 1,200 deg. C.) or a "china biscuit oven" (1,280 to 1,350 deg. C.). Variations of these temperatures could be obtained by placing the colour in various parts of the oven, as the temperature was by no means uniform, and certain parts were known to be "hard" or "easy" fired. With the development of the industry, special kilns for firing the colours are now used, pyrometers are fitted, and time/temperature cycles standardised. The actual constituents have not varied much, but chemically-pure materials are the starting point, instead of the crude ores originally used. The compositions and methods of preparation have been adjusted to suit enamellers' needs, and are constantly under review, but the titanium/chrome yellow is probably the only completely new colour widely used. Most colours are fired once, ground, and re-fired. The fired colour is crushed, if necessary, and wet-ground on either a pan-mill, or cylinder, washed to remove any soluble salts, dried and sifted.

To obtain the maximum stability, strength, and brightness of colour, different bases need to be fired with different materials which act as colour developers and stabilisers, at the most suitable temperature for the particular combination. For this reason, as well as because of the large number of shades of colour required, the colour as supplied to the enameller is often a mixture of colours which have been fired separately. For instance, a green may be a mixture of a blue/green, composed of

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Colouring Oxides in Vitreous Enamels

cobalt, chrome, and alumina, calcined at 1,300 deg. C. and a titanium/chrome yellow calcined at 1,160 deg. C. Although these two colours have been developed, and one might suppose firmly combined, if in an attempt to obtain a more stable colour they were calcined together, again, at say 1,150 deg. C., further reaction would take place, particularly between the titanium and the cobalt, giving a much dirtier colour. In some cases, however, it is helpful first to produce two separate colours, and to recalcine them together. As a general rule, the lower the amount of metallic base in the fired colour the brighter is the tint, and the more stable the oxide. For this reason it may be necessary to compromise between maximum strength and maximum stability, and an oxide which needs to be used as say 4 per cent. will usually be more stable than a stronger oxide used at 2 per cent., perhaps with 2 per cent. opacifier. Different opacifiers used as mill additions along with the oxide can vary the stability of the colour noticeably, both so far as strength and tint are concerned. Wherever possible it is better for this opacifier to be calcined with the oxide, as a constituent of the formula, but of course this increases the total cost of the mill additions, particularly in the case of a jobbing enameller, because of the comparatively small quantity of a particular colour required. The enameller may do his own colour-matching by mixing stock colours available, but, as it is unlikely that he knows the composition and properties of each oxide, whilst an apparently satisfactory matching is obtained, the results may not be satisfactory if bulk production follows. Wherever possible it is advisable to pass the matching to the colour maker—it is his job, and he should do it promptly and accurately.

Colour Making

The colour maker, as has been said, tries to find the best combination of materials, and the best method of processing. Even then, however, colour variation in firing may persist, particularly in titanium-opacified enamels, and even more so when lithium is also present. If it is not possible to produce a single, stable oxide, the problem may be solved by mixing two or more oxides, which produce the same colour at the normal firing temperature of the enamel, but show a different variation when the enamel is over-fired. The least difficult example of this is probably a cream. Probably the standard oxide, previously regarded as stable, tends to strengthen, and go yellower with extra firing, when used in a new frit. When the apparent limit of stability produced by variation of the formula, or processing of the oxide is reached, the next step is to produce an oxide which will tend to weaken, and go browner in an over-fired enamel. A mixture of the correct proportions of these two oxides will then give a much more stable result than either alone. In the case of the usual cream, the variables are comparatively simple, being only brightness of tint, yellowness, brownness and strength, but a grey for instance is a very much more complicated mixture of tints, a neutral grey base often being tinted with green, brown, and blue, all with different reactions if any combination takes place with any of the frit constituents, particularly titanium.

The basic formulæ of the range of colours are well known, the difference in the quality of the products of different colour makers is mainly a difference between skill in adapting these formulæ to suit a particular frit, and of course the degree of care exercised in producing these colours to a regular and consistent standard, as well as a true appreciation of the difference between laboratory conditions and commercial production, even between one plant and another using the same frit.

The colour problem uppermost in the enameller's mind at the present time is how to produce, in large quantities, enamelled articles of a consistent colour, either sheet or cast. Often the sheet is required to match the cast, and various weights and sizes of cast iron to match each other when assembled together. The present standard of colour matching expected is much higher than previously, and whereas it was common practice to match-up sets of parts to be assembled together this is now practically ruled out by the quantities involved, and by the use of continuous assembly lines. However, firing conditions and control generally have been considerably improved, as well as the stability of oxides, and with co-operation between the enameller and the oxide manufacturer it is possible to meet the required standard of colour inspection. After a description of the method of preparation of the oxide, and knowing the care taken to obtain the most stable combination of materials, one might suppose that the same percentage of an oxide in two different frits, of the same opacity, would give the same colour, and that this colour would be constant throughout the firing range of the enamels, particularly when remembering that the oxide has already been fired at a far higher temperature than that reached in the enamelling muffle. Unfortunately this is rarely the case. If in fact the oxide did remain as a separate entity, in suspension in the fused enamel, but not in any way chemically combined with it, the above would be so.

Frit Compositions

Frit compositions show great variations, particularly between different types, such as acid-resistant and non-acid resistant, and the frit maker has so many desirable properties to consider that the question of stability so far as its action on colouring oxides is concerned usually comes low on his list, and is often completely ignored, the colour maker being left to solve the problem. However, even when it is carefully considered, practical considerations may make it necessary to use a frit composition which does not help colour stability. In the earlier days of enamelling, the range of frits and frit compositions was small, and comparatively simple. When wet-process enamelling with leadless enamels started on cast iron, the main difference in composition between the cast-iron frit and the sheet was that the cast-iron frit had a lower $Na_2O : B_2O_3$ ratio. The introduction of acid-resistant enamels on a production scale complicated the colour problem, not only because of the introduction of titanium into the frit, but also the considerably increased $Na_2O:B_2O_3$ ratio, and reduced Al_2O_3, resulted in a far less stable combination. Early wet-process frits depended largely on fluorides for opacity, and this, together with the ease with which high-borax frits melt, tended to increase the production of frits in which the combination of materials was not complete and stable. Whilst it was necessary to well-frit the early acid-resistant enamels, the use of higher percentages of titanium oxide, and better knowledge of the subject, made possible the introduction of more opaque enamels, using antimony opacification, and this discouraged fritting to completion because of the risk of loss, or variation, of opacity. In addition to being expected to remain inert in suspension in a molten frit, the oxide is also expected to resist the attack of the various loosely-combined elements of the frit. The introduction of super-opaque titanium frits has emphasised the problem. The enamel itself is usually well fritted, but on firing the titania crystallises from the enamel and, in suspension in the molten flux, is in an ideal condition to attack the constituents of the oxide. The tendency to colour variation is increased by the fact that, with the exception of the titanium/chrome yellow, titanium as a rule produces very dirty colours in combination with most metallic oxides. This may sound like an apology for colour variation, but it seems only reasonable that, whilst the colour maker should continue to make every effort to produce oxides which are stable under all reasonable conditions, the enameller should appreciate the difficulties. Regarding shop practice, in the first place sufficient care should be taken to obtain the most suitable oxide for the frit to be used. Even under the best firing conditions, before a colour is standardised the oxide should be tested to make sure that any deviation from the standard, due to variation in firing time or temperature, or "heat input," likely to be met with in practice is not greater than that to be permitted. It is obvious that it is essential to have a fired standard by which work processed should be compared regularly. It is also helpful to have a second standard showing the limit of variation which is to be permitted. All such standards should be in duplicate, at least, dated, and signed by a responsible person. The variation permitted is a matter of opinion, but should be rigidly adhered to. Variation from the true standard should be allowed in only one direction, that caused by slight overfiring, which may be justified as being caused by an attempt to remove such defects as slight blistering, or waviness, to keep down re-processing costs. The fired piece showing the permitted variation from the true standard should accordingly be harder fired than the true standard. If only one standard is kept, ostensibly because no variation is to be allowed, slight variations on either side of the standard may be passed, either accidentally, or otherwise, and the total variation in assembly may be doubled. Methods of testing the stability of the oxide in the frit to be used vary from plant to plant, and it is advisable to devise a method which will show the variation likely to be met with under a particular set of conditions. For instance, using a continuous furnace, a comparative trial of enamel once fired and a similar piece re-fired without recoating may be used, or two castings of different weight fired together. The test adopted should only be as severe as is likely to be met with in production, as one oxide may be stable under reasonable variations of conditions, but collapse under extreme conditions; whereas another may give trouble due to variation under slightly different conditions, but be little worse under extreme conditions.

Colour Control

Good shop control is of course the most important factor in maintaining colour standards. Variation in the grinding of the enamel can noticeably affect the colour, particularly the strength; usually the finer the grinding the lighter the colour produced. The size of mill used affects the strength of the colour, even though the enamel is ground to the same fineness by the screen test. Until recently it was usual for colour produced to be progressively stronger as the size of mill increased, but with some enamels and oxides, this tendency may be reversed. Similarly, the water content should be standardised. The opacity produced by the clay addition may seem a minor factor, but production tests have shown that a change of clay, used at 5 per cent., may be sufficient to make a noticeable difference in colour. Any variation in the opacity of the frit from batch to batch will not only cause a variation in strength, but may also cause a variation in tint, as the difference in opacity is usually associated with a difference in the degree of completion of combination of the materials during fritting. Each mill charge should be tested and approved for colour before emptying. If any correction is needed it is best to grind the addition with a small quantity of the enamel in a small mill and then add this to the large mill. This not only avoids overgrinding the whole charge but also enables the addition to be thoroughly milled in. Variations in fusing time and temperatures may be due to faulty furnace control, but in some cases variation in "heat input" is unavoidable. For instance, in the case of large sink units fired in a box muffle, the edges nearest the wall are bound to receive more heat when the time of firing heavy-gauge metal is limited by production requirements. Variation of colour due to differing thickness of coating is not common using opaque sheet-iron enamels, but may be an important factor with less-opaque cast-iron enamels. Where a mottle is used, the size, type, and quantity of the mottle has a very important bearing on the finished colour effect.

Matching Components

The problem of producing cast- and sheet-iron parts to match exactly emphasises the importance of stability of the oxide, particularly if both acid-resistant and non-acid-resistant enamels are to be used. It is essential that the enamels used are of similar opacity, and for this reason in plants where a super-opaque sheet-iron enamel is used, and a cast-iron enamel of similar opacity is not available, the designer is usually well advised if he

Colouring Oxides in Vitreous Enamels

specifies a contrast between sheet and cast parts. Where enamels of similar opacity can be used, if sufficient care is taken in the first place to obtain an exact matching between the enamels used, and the most suitable oxide for each frit, little trouble should be experienced in production, given good shop control.

The type of light in which colours are inspected is of importance. Whereas two batches of enamel using the same frit and oxide may show a certain variation in daylight, and a similar, but probably reduced variation in normal artificial light, the tint of two enamels showing a variation in tint in daylight may show the opposite variation in artificial light if oxides of different compositions are used. For example, an enamel using grey oxide A may appear browner than enamel using grey oxide B in daylight, but bluer in artificial light. In the case of two enamels this fault can usually be overcome by the colour maker, but in the case of baths, for instance, where an enamel is required to match a pottery glaze, in which the composition of the colour is often totally different, it may be necessary to compromise between an exact matching in daylight and in artificial light.

Conclusion

Summing up, the colour maker must do his best to provide an oxide which will give uniform results under the varying conditions existing in the enamelling plant, and realise that with the best will in the world the enameller can only minimise these variations. Similarly, the enameller should appreciate the colour makers' problems and co-operate to obtain the best possible results.

British and Foreign Steel Prices

We are indebted to Darby & Company, Guildhall Buildings, Navigation Street, Birmingham, 2, for the comparison below of the prices of coke and of iron and steel products in this country and abroad. The table gives the price at which foreign engineers buy iron and steel in their own home markets, but the figures have been converted into British currency and British weights. Prices in the home market of any country may, of course, be very different from the export prices. All the prices shown are net, per 2,240 lb., delivered to a typical consuming point, and including a fair average rail carriage, but in countries like America and South Africa, especially, there will be some prices appreciably higher and a few lower than those shown. Prices are for basis sizes and qualities and have been calculated at current official rates of exchange.

	Foundry coke.	Cast-iron scrap.	Foundry pig-iron.	Re-rolling billets, 2½ in. sq.	Merchant bars, 1 in. dia.	M.S. plates, ¼ in. thick.
	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.
Gt. Britain	6 2 8	7 8 8	11 2 0	21 11 6	27 11 0	27 9 0
Belgium ..	13 11 0	25 18 0	28 17 0	28 7 6	31 7 0	35 5 3
Germany ..	—	—	20 10 5	26 4 3	29 19 0	30 19 6
U.S.A. ..	7 18 6	18 11 6	20 18 0	23 8 0	31 1 6	31 1 6
Canada ..	10 15 6	—	19 16 0	—	35 0 0	37 6 0
S. Africa ..	3 3 0	—	11 2 0	22 13 0	30 11 6	33 7 6

In the case of Great Britain, the first four prices are delivered to Black Country stations, and bars and plates to the Midland area. The figures are for Durham coke, heavy cupola scrap, pig-iron of 1.5 per cent. minimum phosphorus, untested billets, and ordinary mild-steel bars and plates. Some prices for billets for delivery in Belgium are very much higher than the prices shown, depending to some extent on the ultimate destination of the rolled product. The price given can be regarded as the bottom price at which semis are being delivered. It has not been possible to secure prices of foundry coke and cast-iron scrap for Germany. For the United States and Canada, figures have been calculated for delivery to substantial consuming points in the Eastern area. In the case of South Africa, an average delivered price is difficult to determine because of the location of the consuming points, the probable weight to be attached to each district, and also the long rail hauls; for these reasons figures will vary considerably.

France's Scrap Situation

Considerable satisfaction is felt in French steel circles over the substantial drop in French exports of scrap, as revealed in figures published for the first eight months of 1951. During this period exports fell to 127,850 tons, compared with 235,456 tons in the corresponding period of last year, and though exports of scrap to France's overseas possessions have increased six-fold, they are still a small fraction of the total. When scrap dealers were ordered to declare their stocks this year (figures were subsequently published in an O.E.E.C. report) it became evident that France's days as an exporter of scrap in world markets were over. France is already heavily behind on deliveries, and it is expected that scrap will shortly disappear as an item in her trade agreements. Increasingly dependent on supplies of scrap for her expanded steel production, French industry views with alarm the prospect of more plant standing idle for want of supplies.

Some criticism has been levelled at the functioning of the two organisations within the scrap industry on which the task of assuring supplies to the French steel industry mainly devolves. They failed to prevent both a large outflow of scrap during 1950 and a sharp increase in prices, now roughly double the prices fixed for the trade by the Government. Naturally the impact of high world prices, forced up by the urgent needs of rearmament, must take most of the blame, but efforts to stabilise domestic prices have been consistently upset by the existence of a marginal free market. This has called the tune with its abnormally high prices paid for scrap. It appears, also, that the Government, having an adverse balance of payments, has not been averse to getting these high prices for scrap. Any advantages accruing from this course of action are surely offset, the industry argues, by the long-term effect of a scrap shortage on the nation's ability to maintain exports.

A freight famine in the shipping industry has further aggravated the shortage, as obsolete vessels due for scrapping, an important source of supply, are being retained beyond their time. It is felt that with the attraction of high world prices, only firm Government action can ensure an adequate supply of scrap for French steel industry, and this today means all that France can get.

THE FULMER RESEARCH INSTITUTE of Stoke Poges, Bucks, announce that Sir David Brunt, M.A., Sc.D., F.R.S., has been appointed to the board of directors.

Scumming of Enamels

At the Annual Meeting of the Institute of Vitreous Enamellers in October, Mr. H. Laithwaite, chairman of the sub-committee of the Institute appointed to enquire into scumming of vitreous enamels, presented a number of interim findings. The sub-committee members were not unanimous in their views and a special session at the Conference was held with a view to explaining the position and collecting further evidence and experiences from the enamellers assembled. What follows is a report of the discussion which took place, with Mr. S. Hallsworth in the Chair.

MR. H. LAITHWAITE (chairman of the Scumming of Enamels sub-committee of the Institute of Vitreous Enamellers) presenting the interim statement* said it was not a final document in any sense. Members of the sub-committee had felt it would be a good thing to present to the Annual Conference of the Institute some of the information obtained and some explanations. It was hoped that as the result of presenting the interim findings, the sub-committee would gain some further ideas; any offers of practical evidence would be welcome, since the sub-committee were very keen to build up a factual statement covering the subject, which was a wide one, and the experimental work anticipated was likely to extend over a considerable period. It was only fair to make it clear that to some extent the statements enumerated were pushed forward before they were fully matured. There were various reasons for that. One member of the sub-committee, Mr. S. E. A. Ryder, felt that the time was not quite ripe for presenting an interim report. While agreeing with much of the work which had been done and the facts which had been established, he differed on a number of points.

Points of Varying Opinion

Mentioning some of those points specifically, Mr. Laithwaite said that in the first place Mr. Ryder felt that the definition of scumming as given in the report was rather too narrow. Asking for further opinions on that, he said there should be no misunderstanding as to what they were talking about. Secondly, in the last paragraph of the interim statement it was said that "there is some evidence to suggest that SO_2 is most active in causing scumming in the presence of high concentrations of water vapour." That had been adduced by one experimental worker, but it would appear to conflict with work which had been done in the past and published in part by Ryder and Culshaw.† Whilst that might not seem to be of great practical significance to the ordinary enameller, the sub-committee were anxious to have definite scientific explanations as to the factors responsible for the defect. Another matter which was being discussed at some length by the sub-committee was the theory or the suggestion set out in the section of the published statement headed "(*a*) Sulphates in Enamel Slurry," concerning the effect of calcium sulphate and water hardness on scumming tendencies. Mr. Laithwaite emphasised that there was quite a lot of information to support the statement that hard water accentuated scumming. There was room for disagreement as to whether or not the explanation given in the report was the right one.

Influence of the Frit on Scumming

Turning to the chief features of the sub-committee's work, Mr. Laithwaite said the first important factor was the frit itself. That was, of course, essentially a matter for the manufacturer of the frit; but it was true to say that frit compositions as such could have a very powerful effect on scumming tendencies. Some of the ideas of the sub-committee on the subject were set out, and further experimental work was proceeding. Broadly speaking, the sub-committee felt that high-solubility frits with low B_2O_3 content generally led to more scumming. Those conditions meant that, in the mill, that type of frit would lead to a relatively high concentration of sodium salts leached out in the mill liquor, and it would seem that it was that soda in the mill liquor which had an important effect. It must come mainly from the frit; it might also come from other mill additions, but generally to a very much smaller extent. Some years ago, much experimental work showed that sulphate accrued in varying amounts in practically every raw material the enameller used; that knowledge had been incorporated.

Colouring Oxides

Among the worst offenders years ago were certain types of colouring oxides, and he believed that the type of trouble was very much less frequent today than it was 10 or 12 years ago. Nevertheless, there had been well-authenticated cases placed before the sub-committee in which a change of oxide, other things remaining entirely the same, had led to an elimination of scumming troubles. In one case at least it was known that the sulphate content of the frit in question was appreciably different.

Water Hardness

Reference was made to the effect of hardness in water, particularly the permanent hardness which was caused by sulphates, as opposed to temporary hardness. It should be made clear in the report that the solution of that particular problem was not to use a base-exchange water-softener. The point was to remove the salts from the water as far as possible, and the best way to do that was to use the type of water softener which he knew as "de-ionising." There were proprietary products available, but the main idea was to pass the water through suitable equip-

* Summary of the Sub-committee's interim findings on this subject printed in the JOURNAL on November 1.

† "Furnace Atmospheres in Vitreous Enamelling," FOUNDRY TRADE JOURNAL, November 3, 1949.

Scumming of Enamels—Discussion

ment to remove the calcium or magnesium salts and then through another which removed the an-ions. Those who had used distilled or condensate water had in effect used de-ionised water. In several cases it had been brought to the sub-committee's notice that by that means an improvement had been obtained.

Drying of the Biscuit Enamel

Mr. Laithwaite said it seemed very clear that it was easy for the biscuit enamel to absorb sulphur-oxide gases during drying. It was very difficult to ascertain quantitative data under production conditions, and much easier under laboratory conditions; but, unfortunately, it happened sometimes that results obtained under laboratory conditions, indicating perhaps that a certain concentration of SO_2 would have an effect, could not be applied directly to practice, since under production conditions the amounts of SO_2 present were very much smaller, but would still give more trouble than had been experienced in laboratory conditions.

The absorption of SO_2 during drying would seem to lead to the formation of sulphates at the surface of the biscuit, and it was very largely sodium sulphate which was responsible for the trouble. Whether calcium sulphate as such was also responsible was not established. Sodium sulphate certainly occurred in practically every scumming deposit which had been analysed.

Furnace Atmospheres

Finally, and most important, Mr. Laithwaite came to the effect of fusing and of furnace atmospheres on scumming. Most enamellers, he said, had experienced furnace trouble at one time or another. The sub-committee felt that in most cases the furnace atmosphere was important, and he suggested that it was necessary always for the enameller to ensure first that the furnace was satisfactory. Nevertheless, it was important not to overlook the other aspects of the process where sulphur came into the picture, because even with a furnace atmosphere which was in every way normal or standard, certain types of enamel would show scumming, which could be minimised by attention to those other aspects.

Controversial Matters

Mr. S. E. A. Ryder emphasised that the interim statement was rushed in order that it could be presented to the Conference, and the sub-committee had not had an opportunity to iron out controversial points which had arisen. He could not agree with either the general tone of the report or with many of the details. He thought the report would give the general impression that the principal source of scumming was in the enamel slurry, but he was quite certain that the condition of the dryer and furnace atmospheres far outweighed, in importance, any other factor.

Causes of Defect

Elaborating one or two of the points, he said that our present knowledge indicated that sulphur compounds were the only definitely known cause of scumming. Other things such as water-vapour had been suggested, but there was no proof so far that anything else but the sulphur compounds could cause the trouble. From that point of view, he commented on the reference in the report to the effect of water-vapour in enhancing the effects of the sulphur oxides. As had been stated in the paper by Culshaw and himself two years ago, their experiments had shown that water-vapour in either large or small amounts had no effect on the amount of scumming produced by sulphur oxides in the muffle. Further work they had done since had confirmed that view. He called attention to an experiment described in the report suggesting that water-vapour from the atmosphere of a laboratory muffle derived from the clay in the biscuit enamel had had an effect on scumming. According to this experiment, frit ground with water only and fused in an atmosphere containing sulphur oxides was free from scumming whereas normal enamel slurry scummed when fired under similar conditions. It was suggested that the water-vapour given off by the clay in the second case was responsible for the trouble, but it must be pointed out that there were other explanations which appeared to be much more likely than this one. For instance, the slurry containing clay and electrolytes was probably more alkaline than the suspension of pure frit and water. The suggested effect of water-vapour, it was stated, was borne out by the common experience that scumming was more prevalent in winter because during the damp winter months there would be more water-vapour in the furnace atmosphere. Mr. Ryder pointed out that he could not agree with this suggestion, and thought that the amount of water-vapour in the atmosphere had been confused with *relative* humidity. The relative humidity was certainly higher in the winter, but the *amount* of water-vapour carried by warm summer air was considerably greater than that in cold winter air, and the amount of water-vapour in the muffle atmosphere would be greater in the summer than the winter. Scumming was more prevalent in winter than in summer because of the higher *relative* humidity in the winter causing moisture to separate out on enamelled surfaces and develop scumming which would not otherwise be apparent.

Difficulty of Shop Testing

He also wished to point out the danger of drawing conclusions from results obtained in the enamelling shop. There were so many factors operating that it was impossible to sort them out and draw correct conclusions. It was realised that small-scale laboratory experiments had drawbacks, but on the laboratory scale it was possible to control the various factors operating.

Mr. Ryder expressed disappointment that nothing had appeared concerning work by the sub-committee on the effect of frit composition. In the case of white frits it was known that the titanium frits were virtually free from scumming trouble and this was a line of work which the sub-committee, he was sure, would pursue. Dealing with that part of the report on the solubility product of calcium sulphate, he felt that this would be particularly misleading to the practical enameller. The suppositions here appeared to be based on the idea that undissociated calcium sulphate and not calcium or sulphate ions was responsible for scumming, but there was no supporting evidence. In fact, it was generally agreed that scumming was due to sulphur compounds and any effect which calcium sulphate had on scumming one would expect to be due to the sulphate ion. It was stated in the report that at works " B " six times as much SO_4 in the form of potassium alum as was provided by the water hardness of works "A" could be tolerated without scumming trouble arising, and he was of the opinion that the solubility product of calcium sulphate was not the reason for this. In an earlier draft report circulated to the sub-committee it was stated that works "A" besides having a much harder water than works " B " also used fuel with a much higher sulphur content, namely 2.0 as against 0.8 per cent., and this extra sulphur in the fuel was probably the reason for the greater scumming trouble at " A."

Mr. Laithwaite mentioned in his remarks that a water softener working on the normal base-exchange principle, would not remove sulphate ions from the water, and this point needed emphasising in connection with this part of the report. Some other points of the report with which he did not agree had been cleared up by Mr. Laithwaite in his introductory remarks, and Mr. Ryder had no doubt that at the meeting of the sub-committee in the near future, the delegates would get down to those points and obviously they would need considerably more experimental evidence in order to support a number of them.

Conversion of Insolubles

A MEMBER said the report seemed to have established that sulphur was a cause of scumming. It had also established in effect that the hydration of sulphate was a cause of scumming; and that was cumulative. He suggested that the best way in which to tackle that problem was that the soluble sulphate, *i.e.*, that which could be hydrated, should be rendered insoluble, so that it could not be hydrated. He could support the contention that this procedure did in fact cure very bad scumming, at least temporarily. Again, in connection with firing, scumming might be avoided by converting the soluble sulphur to insoluble sulphur.

MR. LAITHWAITE said the use of barium chloride to precipitate the sulphate after solution would seem to work in some cases, but not in others. He was not prepared at the present stage to go beyond that. Commenting on a previous statement that very often scumming was more pronounced with an acid-resisting type of enamel, he said that at first sight that would appear to be something of an anomaly. The real point, however, was that with acid-resisting enamels, using titania, the slurry was more alkaline, and the important factor was the free alkali and not necessarily the total concentration, since in certain types of enamels there was a very high content of boric oxide in the liquor; that had a buffering effect which reduced the penetration of the free alkali.

MR. J. H. GRAY said, assuming that sulphates were the cause of scumming, he considered it should be emphasised quite strongly that the preliminary sources of the trouble were in drying and in fusing. He said that because he felt that scumming was caused by a sulphate film on the surface of the enamel, which hydrated after a time, whereas the very small percentage of sulphate which might be in the frit or the mill addition was distributed through the thickness of the enamel, and not on the surface.

MR. LAITHWAITE said he had stated that fusing seemed to be the " nigger in the woodpile." But it was not quite true to say that the sulphate in the liquor was distributed evenly through the biscuit of the enamel. What happened was that, on drying the biscuit, the alkalies, the electrolytes, concentrated at the surface, and therefore there was a very much higher concentration of soda and anything else that was soluble at the surface, than occurred throughout the mass. Hence, if the surface layer of the biscuit enamel, in which SO_2 had been absorbed during drying, was removed, the portion from which the very thin shaving had been taken would fire perfectly. That reference recalled to his mind a point mentioned by Mr. Ryder and in regard to which there had been some misunderstanding; it was that, under the same conditions, the frit gave no scumming, but the slurry did. He emphasised that that frit was not ground with water or anything else; it was gradually heated until it melted. Without the soluble salt, from wherever it was extracted, the SO_2 concentration under the muffle conditions obtaining was not sufficient to give scumming.

DR. D. K. B. NIKLEWSKI said that his works were not very far from a large gasworks, and on a foggy day there was rather bad scumming of the enamel: it arose mainly from SO_2, due to the fog. Secondly, he referred to a drier in which the combustion gases were blown straight on to some of the ware. It was found that all the ware which went near the blowers was scummed, but that in the middle of the drier was not. By altering the distribution of the gases through the drier, the scumming trouble was cured.

Black Enamel

Discussing the composition of the enamel, he said a black enamel would scum more easily than any other. He had tried increasing and reducing the black oxide which coloured the enamel, and when it was increased to 9 per cent. scumming was very pronounced. That result indicated that the black-oxide content had to be kept as low as possible.

Referring to the use of barium carbonate in a frit, he said that a large amount of it would make the frit more susceptible to scumming. Not only were soluble sulphates in the slurry responsible for the scumming, but also, sulphides formed during the molten stage. Dry-process black enamels also scummed severely, and they had no slurry. There were two types of scum, the first being soluble on

Scumming of Enamels—Discussion

the surface and removable by washing, and even by touching the surface with a wet finger. The other type, which was not removable, he believed to be due to absorption of sulphur during firing process. This sulphur formed sulphates of barium, calcium or sodium. When the ware first came from the furnace and was still warm, it did not show scum, but it appeared on touching the surface with a wet finger.

Micro-examination

MR. LAITHWAITE referred to some recent work in which an endeavour was made to identify some of the scum chemically and by other means. It had not yet been carried far enough to enable conclusions to be drawn, but some interesting observations had been made. When a specimen of black enamel was taken from the furnace it had in every way the normal appearance—high gloss, and so on. When examined under the microscope it still appeared to be quite normal. But when the enamel surface was wetted, the scum appeared. The surface was then washed and examined again at various magnifications, and photo-micrographs were taken. The surface exhibited a pattern which at first sight looked like frit particles with little channels between them. He did not claim that they were frit particles, but the pattern did support strongly the idea he had advanced that the soluble salts in the liquor were absorbing SO_2 and forming sulphate, and during firing the thin channels were leached out, leaving islands.

Possible Effects of Barium Chloride

MR. A. H. SYMONDS, emphasising the importance of the effect of the pick-up of sulphates on the biscuit, said that if the ware were fired immediately after spray drying, it would be right, but if it were left for long it would scum.

A matter which might with advantage be investigated, he continued, was whether the state of the biscuit had any effect on the way in which sulphate was picked up. It might be that the particular conditions of spraying, as in dry spraying, would expose a greater surface area to gases containing small amounts of sulphur than would other conditions of spraying.

Mr. Symonds asked if the sub-committee considered that scumming was more prevalent on acid-resisting enamels than on non-acid-resisting enamels. That might be true of cast-iron enamels, but in the case of sheet-iron enamels he felt that the non-acid resisting enamels such as the antimony and zircon opacified were far more prone to scumming than either acid-resisting enamels antimony opacified or super-opaque titanium enamels. With regard to the previous remarks about the effectiveness or otherwise of the use of barium chloride in the mill addition, he suggested that the variable effects might be due to the fact that while the barium chloride in the mill liquor was effective in precipitating sulphates which might be present due to frit, clay, oxide etc., barium chloride in solution could not be effective when enamel biscuit was being dried or fired in an atmosphere of sulphurous gases, and would therefore have no useful effect at this stage.

MR. LAITHWAITE said the point made by Mr. Symonds about delaying the firing of the biscuit and the limitations of barium chloride was a useful lead. The sub-committee, he continued, had no experimental evidence of the effect of the condition of the biscuit on sulphate absorption.

With regard to the incidence of scumming on soft enamels as opposed to the acid-resisting enamels, Mr. Laithwaite said that when he was speaking of acid-resisting enamels he had had in mind the more or less straightforward introduction of titanium to an older type of enamel to impart acid resistance. Scumming was usually said to be associated with the higher alkalinity of the slurry; but the problem was not so simple. The zircon enamels referred to by Mr. Symonds were rather out of the ordinary in their composition. He believed that one of the most significant factors with regard to the titanium enamels was that, under given conditions, only a fraction of the salts were absorbed as compared with the old antimony enamels.

Early Experiences

MR. W. BALL said the supposition that the high Na_2O/B_2O_3 ratio in the mill liquor increased the tendency to scum might not be quite the easy explanation that it appeared to be at first sight. Scumming was most serious at the moment on popular acid-resisting black enamels. In the past, scumming was something which had occurred on red enamels. It was caused by the fact that the oxide contained a cadmium sulphide, and this was a case where one could definitely expect scumming. Frits in those days were comparatively insoluble; the amount of soluble salts in the liquor was very small compared with the amount today, due very largely to the fact that in those days very much more attention was paid, particularly with that type of enamel, to fritting to completion. Cost did not matter; a good enamel only was required. It was not a question of whether there was a high Na_2O/B_2O_3 ratio in the mill liquor; it was a question of how little soluble salt there was.

A second serious cause of scumming, when the very soft non-acid-resisting black enamel was first introduced, was that the liquor had an exceptionally high content of B_2O_3 as compared with Na_2O; and the tendency to scumming, he believed, was just as great as with the acid-resisting; very little of that type of enamel was used now. Was it not possible, he asked, that the question was not so much what was in the mill liquor as how much there was.

Chromates Blamed

Putting forward his ideas gathered over a period of years of experience rather than from direct laboratory experiments, Mr. Ball said that, whilst enamellers were satisfied that sulphates were the primary cause of scumming, at the same time the tendency to scumming could be very much increased by other soluble salts in the mill liquor, and the most serious were the chromates. Blacks nearly always scummed more than any other colour, apart from the fact that scum showed more on blacks. He suggested that the first thing to do was to take the potassium dichromate out of the standard frit, because it introduced an unnecessary complication. He did not know how much chromate would be found in the mill liquors either from the frit or from the oxide; there was very little sulphate from the oxide, and indeed there should not be. If the composition of the frit or of the electrolytes or the mill liquor were such that chromates were formed no matter how small the quantities, in the mill liquor, he was quite sure the tendency to scumming would increase very considerably.

Sulphur Content

MR. LAITHWAITE was at variance with Mr. Ball concerning the statement that it was the quantity of sulphate in the liquor which mattered most for in many cases, with the soft non-acid-resisting enamels, the total concentration of sulphate in the liquor was very much higher than in another type which showed scumming. So that perhaps there was room for both points of view, and neither was a full explanation.

Expressing interest in Mr. Ball's remarks concerning chromates, he said the sub-committee had found qualitatively that the chromate factor appeared to be significant. They had discussed the matter informally, and at least one other member had confirmed his (Mr. Laithwaite's) observation, but they had not discussed why it should cause scumming. So far the explanation was not forthcoming, although he endorsed that chromate did increase the scumming tendency. Unless he was mistaken, he continued, the chromate effect did not appear only in black enamels, but also in other colours, and that should not be overlooked. He recalled Dr. Niklewski's point that black showed it far more than did other colours.

MR. J. A. CLARKE said he felt the interim findings were useful to the conference as a basis for future work, which no doubt would take a long time, and also to stimulate discussion so that the sub-committee might have some guidance for the future. He believed the objects had been achieved, and the sub-committee could go forward with confidence to arrive at a nearer solution of the problem.

For practical enamellers, the object was to find a fundamental explanation of scumming. He agreed with Mr. Ryder that shop tests were not always convincing, in view of the many variables; for that reason they could not be admitted as fundamental work. Such work should be done in the laboratory, where conditions could be closely controlled. However, some of the things that could be done in the laboratory could not be reproduced in the shop. He had found that by replacing tap water, which was relatively hard, with condensed steam, which was in effect distilled water, the scumming was drastically reduced. There was still a slight residual scumming however.

Recalling a point made earlier, that, by rendering the sulphate insoluble by means of barium chloride, one could remove the sulphate in the mill liquor, he said enamellers did not remove any alkaline salt which might react with the sulphur in the furnace gases. He believed it was agreed that sodium sulphate was a big offender; whether calcium sulphate was or was not was still a moot point. As a trial, however, he had used barium fluoride, on the assumption that the barium would precipitate the sulphate as barium sulphate, and the fluoride would precipitate the calcium as calcium fluoride. The idea was that calcium fluoride, being insoluble, would remain more or less evenly distributed throughout the biscuit instead of concentrating in the surface layer during drying. It was a purely empirical assumption, but the addition had helped very materially to reduce scumming.

MR. S. E. A. RYDER, commenting on Mr. Symonds' point that titanium enamels did not scum, said they could be made to scum in a laboratory muffle if sufficient sulphur oxides was introduced; but the amount of sulphur oxide required was more than would be met with in normal practice. He could confirm Mr. Clarke's point that barium chloride precipitated sulphate in the slurry and mill liquor, and if the scumming were being effected by the sulphate in the liquor, barium fluoride had a good effect, but if the scumming were due to sulphur oxides in the muffle atmosphere, then barium salts had no effect. There was no doubt that sulphur picked up at the various stages of the enamelling process had an additive effect. Therefore, if soluble sulphate were removed by the addition of barium chloride at an early stage a larger amount of contamination of the muffle atmosphere could be tolerated without scumming appearing. There was no doubt, however, that sulphur oxide in the muffle atmosphere was the over-riding consideration in respect of scumming.

Commenting on the remarks of Dr. Nicklewski and others, concerning the possible effect of chromates, Mr. Ryder stated that various experiments he had done and microscopic examination of scumming deposits rather suggested that the mechanism of scumming of black enamels was different from that of white frits. Whether that was because there was chromate in the black but not in the white, he did not know, but it was worth investigating. Obviously the composition of the frit was most important. It was not possible completely to do away with sulphur in the driers and muffles and mill liquor, and the ideal solution would be to find a frit that would not be affected when normal amounts were present.

Conclusion

THE CHAIRMAN, at the conclusion of the discussion, said it had been very valuable, and he felt certain that the final report of the sub-committee, which would be the result of a considerable amount of further work, would be well worth publishing.

MR. W. S. GRAINGER, proposing the thanks of the Institute to Mr. Laithwaite and his fellow members of the sub-committee for their work, said the elusive problem of scumming was one of great concern to the industry, and all must be very grateful to the members of the sub-committee for their work.

Notes from the Branches

West Riding of Yorkshire

The opening meeting of the session of the West Riding of Yorkshire branch of the Institute of British Foundrymen was held at Bradford Technical College, when the recently-elected president, Mr. R. L. Simpson, gave his inaugural address, in the course of which he said that this was a unique occasion, in that the new president was a patternmaker by training and long experience. This in itself was, perhaps, an indication of the commendable tendency of the foundry industry to become increasingly democratic in its outlook and attitude towards its sister craft, and the willingness to accept advice and assistance of the other craftsmen in grappling with its varied problems. It was indeed gratifying to realise that foundrymen and patternmakers had come to recognise that full co-operation in all directions was not only advantageous, but essential, in the creation and maintenance of a well-organised unit.

Recent Advances

The past few years had witnessed a considerable advance in the development of the foundry industry and much progress had taken place in the fields of mechanisation, research, development of plant and equipment, workshop amenities and training facilities. All of these had been instrumental in stepping-up production and aiding the accomplishment of the post-war recovery programme. Many obstacles had, of course, been encountered, particularly in the sphere of raw materials, but these difficulties had been greatly mitigated by the admirable work of research and laboratory staffs who had forewarned users of the effects of many deficiencies and provided them with remedies.

Wherever the topical subject or greater productivity in any industry was discussed, the advantages of improved and increased mechanisation were inevitably put forward as main factors in the solution of the problem. The foundry industry had demonstrated its awareness of this aspect and, particularly in the larger concerns, mechanisation was being increased in an effort to offset the shortage of skilled moulders, by eliminating fatigue, increasing man/hour production and, at the same time reducing costs and minimising the effects of the constant fluctuation of materials charges. Many foundries, both large and small, had conscientiously endeavoured to carry out the provisions of the "Garrett Report," particularly in regard to such items as brighter paintwork, additional washing facilities, better lighting and ventilation, etc.

Other Attractions

It was hoped the provision of these and other amenities would encourage the much-needed influx of young craftsmen. He emphasised the importance of the skilled moulder, for it must not be imagined for one moment that any measure of mechanisation, no matter how great or how perfect, would eliminate the need for the craftsman. It was, therefore, essential that intensive efforts be made to encourage the recruitment of apprentices and to foster their progress and permanent place in the industry.

He suggested that members of the West Riding branch made a special feature of inviting parties of schoolboys to visit works with a view to convincing them of the importance of the foundry industry, the advantages of modern amenities and the personal benefits to be derived from serving in the industry, proving to them that foundrywork was not as objectionable as they might have been led to believe and that in fact it compared very favourably with other branches of the engineering industry.

Presentation to Mr. A. S. Worcester

After Mr. Blakiston and Mr. Anderson had expressed the thanks of the meeting, Mr. Simpson presented to Mr. A. S. Worcester the Meritorious Service Medal of the Institute and read the following citation.

> "Mr. A. S. Worcester was elected a member of the Institute in 1914. He has been president of the West Riding of Yorkshire branch on three occasions, in 1931-2, 1932-3, and 1938-9, and has been a member of the Council of the Institute at least since 1930. Mr. Worcester's main activity has been on the educational side. He has served on the Educational Committee continuously since 1935 and has represented the Institute on the advisory committee for the City and Guilds Examinations in Foundry Practice and Patternmaking since 1934. Mr. Worcester was also an active member of the International Dictionary Committee between 1936 and 1939 and served as a member of the Technical Council and its Cast Iron Sub-committee from 1932-36."

When Mr. Worcester had made suitable acknowledgement, Mr. Simpson asked Mr. Colwell to read his Paper on "The Training of Apprentices for the Foundry."

London—Annual Dinner

The annual dinner-dance of the London branch of the Institute of British Foundrymen, the largest ever held by the branch, took place at the Café Royal, Regent Street, London, last Thursday. Mr. L. G. Beresford, the branch-president, with Mrs. Beresford, received the guests, who numbered over 250. Amongst them were Mr. Colin Gresty, president of the Institute; Dr. C. J. Dadswell, the senior vice-president; Mr. Tom Makemson, M.B.E., Dr. Ballay (Paris), Dr. Galletto (Italy), Mr. R. L. Handley, Mr. F. Hooper, Mr. J. Berthelier (Belgium), and Dr. Waehlert (Germany), many of whom were accompanied by their ladies. An excellent cabaret was provided by Eric Ross and his Eight Grosvenor Girls. The function, which was organised by Mr. A. R. Parkes, with Mr. L. A. S. Harbourne acting as M.C., was an outstanding success.

Gold Bracelet Found

There is at present in the offices of this Journal a plain gold bracelet which must have been lost by a guest at the recent dinner-dance of the London branch of the Institute of British Foundrymen, held at the Café Royal. Will the owner please apply to the Editorial Department of the Journal, 49, Wellington Street, London, W.C.2.

Training of Apprentices*

By J. Colwell

It used to be generally accepted by the outsider that the foundry apprentice's main requirements were "Plenty of brawn and no brain." Nowadays, however, due to enlightened leadership and the work of the Institute of British Foundrymen, this fallacy has become obsolete, and it is now appreciated that for the apprentice to-day there is a high standard to be reached in his daily work and in his technical training. The training of the apprentice must be a studied technique and not a haphazard duty. He must not be accepted merely for filling the personnel gap, or because he is cheap labour. He must be accepted from the point of view that he is to carry on the trade and maintain and advance the traditions of the foundry industry in the years to come.

The point arises, "Where does he start?" He must commence where the foundryman commences, with a pattern. He should spend at least a month in the patternshop, finding out why a pattern is made, what it is for and why it is made a particular way. It should be impressed upon him the necessity for a job to be planned to detail at the beginning. He must understand coreboxes, the advantage of joints, dowel pins, drawbacks and loose pieces. Above all, he must see for himself what patience, skill, and time are put into making the foundryman's task as easy as possible, and that a pattern or corebox are not made to be hammered beyond recognition in the foundry.

Background Training

He should then have a short period of training in the fettling shop, so that he can always have in his mind's eye a picture of the requirements of the finished article. He could be instructed in the methods of cleaning castings in the sand-blast or Hydroblast, and learn the results of bad venting, crushing, poor jointing of drag and cope, cores lifting in the mould and many other useful points which would help him considerably in his own training as a moulder.

From the fettling shop, the apprentice should go to the core shop. In many core shops to-day the apprentices' bench is made up of a plate on top of wooden blocks or old core-boxes. His tools are scattered far and wide, and his sand seems to be everywhere except on his bench. One of the first things an apprentice must learn are tidiness and method. It would be to advantage if the core-making bench be high enough so as not to cause unnecessary stooping, with a level metal plate on which to work. There should be a shelf for core-boxes under the bench, and a small rack for tools, sprigs, etc., within reach. The bench should be near the drying stove. The bench core-making by an apprentice should always be under proper supervision, so that any minor faults and wasted effort in work could be pointed out before they become habits. He can be taught the methods and reasons for venting, the correct method of using tools, the importance of joining cores without closing the vent holes, and the reasons for using different sands for different cores. After about twelve months on various types of small cores, he should be allowed to work with one of the core-makers on larger cores.

Moulding Training

The next step in the apprentice training should be to the moulding floor where small repetition castings are made. He should be taught the art of conditioning the sand, correct methods of ramming the mould, drawing of the pattern and, if necessary, the insertion of cores. The size of gates and runners, the methods of releasing gases, the planning of moulds so as to utilise existing floor space, and for casting should be important parts of the training. Any labour-saving methods of making moulds should also be inculcated.

From the small-castings section to the medium-size castings is only a short step, in theory, yet only those who understand the work really know how important must be the correct training in this section. From a plate pattern to a loose pattern; from a straightforward draw to loose-pieces and draw-backs; from ramming sand in a small box-part, to lifters and strengthening irons and chaplets, step-by-step advances must be made.

The large-castings sections of the foundry are usually manned by men working in twos, threes, or teams, and the apprentice's last year of training should be spent here. The methods of producing large castings, whether repetition or singly, should be part of the training The making of these castings is a great responsibility and in most foundry departments only those with years of experience and proved reliability have been allowed to make such moulds. To rely, however, on the selected few is a great mistake, and others should be trained to be able to accept responsibility for this type of work. The knowledge a youth gains during this period is dependent upon the type and size of the foundry, but he should, if possible, become conversant with the skin-drying and full-drying of moulds, the methods of "coring-up" to ensure the right thicknesses of the casting, and the most efficient ways of venting. He would learn the "pouring" methods and means of easing the mould at the right time and in the correct places.

If the foundry has a non-ferrous foundry attached to the main works, or has a non-ferrous section, it would be an advantage if the apprentice could have a working knowledge of this type of work. He would gain valuable experience in the different methods of melting.

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* Paper presented to the West Riding of Yorkshire branch of the Institute of British Foundrymen, with Mr. R. L. Simpson in the Chair.

Training of Apprentices

Supervision

During the whole course of apprenticeship, the boy should be properly supervised, but at the same time he must be allowed to gain confidence in his work and be able to talk to the foundry manager whenever he needs his help and guidance. Too many foundry managers have ancient and obsolete methods of doing a job, and the youngster with his "modern" ideas gets nowhere in making suggestions. The tendency to ridicule failure and give no encouragement in success gives the young foundryman a frustrated attitude very quickly, and there is no greater enemy to the progressive apprentice than lack of interest.

Every boy is an individualist, with a different opinion and temperament from his fellows. Where one might respond after being severely reproved, the other, with applied psychology, may give of his best. It is a profound axiom that "boys will be boys," and though one cannot curb the full exuberance of the boy it must be impressed on his mind, the dangers of practical jokes and carelessness. Not only his own, but the safety of others is of the utmost importance in the foundry, and tidiness and alertness go hand in hand in preventing accidents. A boy should not be allowed to become the errand boy.

Technical Training

The opportunities for studying are better to-day than ever they have been, evening classes, technical colleges and schools, public libraries, and the many trade societies offer wide scope for the modern student. Foundry apprentices nowadays have a great opportunity for educational advancement and the honours to be gained are fully recognised throughout the field of industry. Many firms are fortunate in being able to send their apprentices to school one day a week. Others encourage them to go in the evening. Whatever may be the circumstances, arrangements should be made for a full report of the student's progress to be made to the foundry manager at regular intervals. It is helpful to the student, if, on passing examinations he is rewarded with a small gift of books or tools. This encourages him to study harder, and the fruits of his studying may some day be recognised in the industry. Visits may be made by the apprentice to other foundries; thus, the jobbing-foundry apprentice could visit the mechanised foundry, and *vice versa,* and a more comprehensive knowledge of the trade could be obtained. Every foundry has something different to teach.

DISCUSSION

Mr. Johnson asked why Mr. Colwell specified only one month in the patternshop as he felt that a comprehensive knowledge of patternmaking was essential. The ability to read drawings and the supreme importance of dimensions would combat the rule-of-thumb method which was sometimes encountered.

Mr. Colwell in reply, said the reason he did not emphasise patternshop practice was much the same as for non-emphasis on metallurgy. He felt that the student should learn such matters at his technical college. Possibly, if he was allowed a certain amount of time to grasp the fundamentals of patternmaking, he might by his own reading be able to enlarge his knowledge at the schools and technical colleges. That was why he allowed one month. Personally, his experience was that an appetite for study has to be created and then he believed the boy would try to find out more from his own study. The reading of drawings could be left to the technical college.

Mr. Blakiston said he felt there was no point in putting a foundry apprentice in the patternshop to learn about woods. He should be placed there at a later period of his training, preferably studying pattern checking and finishing. The knowledge gained would bear a direct relation to his ability as a moulder. He would know the time necessary to make a good pattern, therefore he would respect the pattern when it arrived in the foundry. Secondly, if a pattern was going badly out of shape, he would have some knowledge to make rectification without returning it to the patternshop. The other point of checking would assist him in reading drawings. There was once a time in industry when a patternmaker was given a rough pencil sketch, and he had to create the mould by various means which was part of his craft and that of a moulder. There were still some countries where a moulder could not work to a pattern, but only to a sketch or a view of the object he had to produce.

Suiting Individual Needs

Mr. Colwell thought that there was more in coremaking than met the eye, as it was amazing the mistakes young people could make. The point was that these mistakes must be corrected in the early stages and one of the things an apprentice must learn at the beginning was discipline and, if he learnt that, then he would make progress in his future training.

A member said a month's training in the patternshop was out of all proportion and, also, it was at the wrong time in his training; he should not enter initially. The lads who went into the shop as patternmakers would stay there; they would not go into the foundry. If they had two years in the foundry and then 12 months in the patternshop, they would be more satisfactory. It was ridiculous to put them in as pattern checkers. In the curriculum of the apprentice there certainly should be some knowledge of how metals were melted and behaved, and so forth, and at least two months should be spent with the cupola operator.

Mr. Colwell pointed out that much depended upon the type of foundry in which one worked. He personally was hoping one day a lad would become a moulder, but he might through his own initiative become part of the executive staff and, if so, a more general training would be invaluable. Some firms could get apprentices quite easily; some could not. Some could give a boy a day off to go to school. It would be interesting if the meeting could hear from a foundry manager how he trained his apprentices.

Other Views

MR. SIMPSON said the method at his works for the training of an apprentice was to start the boy in the laboratory for a period of six months. He then went into the small foundry for a further period on small work by himself with the help of the foreman. From there he passed to the large foundry. After a period there he returned to the laboratory for a further period, and then he eventually arrived at the patternshop. He could affirm that his firm had trained good apprentices and they were capable now of taking executive positions.

MR. ANDERSON referred to the type of youth available. One might be a rough boy who was quite content to stay on the foundry floor and be a good craftsman. Once youths were obtained, the lines the lecturer suggested for training were very efficient.

MR. SIMPSON said he could still get boys from the secondary school into his foundry. It could be done, and with better amenities available the industry would get more.

MR. BLAKISTON said he knew of cases where properly-trained apprentices when they were 21 yrs. could beat and earn as much money as the older highly-skilled craftsmen on piece-work.

MR. JOHNSON said if all boys were to beoome executives the industry would be top-heavy with no skilled men to carry on the daily work. Apprentices were of different natures, and though given the same training could not emerge to the same pattern. One or two would be capable of executive positions, and the rest would become skilled craftsmen and take a pride in their work.

Vote of Thanks

MR. NEATH in proposing a vote of thanks said Mr. Colwell had thrown down a challenge. The success of the meeting was due to the fact that his challenge had been responded to, some in support and some against. All of which justified the purpose for which it was given and the objects of the Institute. It did appear there should be a great deal of flexibility. The industry needed skilled moulders, and future executives. Everybody had heard criticisms of this new educational system which had been thrust upon us, whereby at the tender age of 11 a child's future was decided. This had something to do with this question of apprenticeship. No one could decide what sort of a man he was going to make. If he was a boy of strong ideas he should be helped along. As each year came along, some different aspect would crop up with the system of training, and the system should have sufficient flexibility to take that, so that at the end of the period one had partly segregated the various groups of apprentices somewhere in the direction where it would be best for them to finish up. Those groups comprised the craftsman who would never be anything else, others could be brought along on the executive side.

MR. JOHNSON seconded and MR. COLWELL suitably acknowledged the compliment.

Publications Received

"At the Turn of the Century." Issued by the General Electric Company, Limited, Magnet House, Kingsway, London, W.C.2.

By contrasting the manufactures of about 50 years ago with current output, the editor of this pamphlet certainly arouses the reader's interest. The tramway car, the fire engine, the telephone, generating machinery, electric irons and stoves are all illustrated. In the last case, the elderly one, sold in 1902, is unbelievably ornate. As for the decorated electric-light switch of 50 years ago, in certain rooms it would still look quite nice. It is ornamental but not blatantly so, which makes it a little more presentable than those now going out of fashion. It is difficult to visualise a better method of showing progress than by exhibiting these very striking contrasts.

Northern Aluminium Company's Foundry and Forge at Handsworth, Birmingham. Published by the Northern Aluminium Company, Limited, Banbury, Oxford.

This is a well-illustrated 16-page booklet and tells much of the history and development of the company, especially the Handsworth works. In the introduction it is stated that during the post-war reorganisation "The aims were to cut internal transport costs ... .; yet a photograph of the main gravity-die foundry shows stacks of castings resting on the floor. Surely this is case for the installation of stillages and fork-lift trucks, as roller paths or the like would not be quite suitable. The core-shop and piston foundry, on the other hand, have a very good appearance. The reviewer was pleased to read of the efforts made in the direction of ventilation, for a die-casting shop, with its rows of open-topped liquid metal holding furnaces, can be quite uncomfortable during a heat wave. This, together with the provision of baths and canteens well illustrates the efforts the management have made to make the foundry "a good place to work in." The forge is equally up-to-date.

Journal of Research and Development, Vol. 4, No. 2. Published by the British Cast Iron Research Association, Alvechurch, Birmingham.

This contains four Papers, two on malleable, and one each on basic refractories and the fluidity of cast iron. The first malleable Paper by Mr. P. H. Shotton deals with the composition and quality of blackheart malleable, whilst the second by Dr. K. Roesch describes the production of a high-grade whiteheart iron by secondary annealing and the use of a low-sulphur, low-silicon composition carrying higher manganese. The third Paper, Basic Refractories, by Mr. C. S. Hedley, is a well-balanced statement on the present position of those materials *vis-à-vis* with cupola and ladle practice. In the latter, patching is still a problem to be solved. The Paper on the fluidity of molten cast iron details the results of a research undertaken in the laboratories of the B.C.I.R.A. by Mr. E. R. Evans. Not only has a fresh type of test-spiral been devised but a new formula—$\text{C.E.F.} = \text{TC} + \frac{\delta}{3} + \frac{\rho}{2}$ (C.E.F. being the carbon equivalent fluidity) has been put forward. The influence of many elements on fluidity were determined. The illustrations for this Paper are clear, but Figs. 7, 8 and 12 to 14 have been insufficiently reduced for reproduction and are ugly. The whole is a very important and useful piece of work. This bulletin is available to all members, and any ironfoundry can become a member free of charge by signing on a dotted line. Interested firms should write to Alvechurch.

Imports and Exports of Iron and Steel in October

The following tables, based on Board of Trade returns, give figures of imports and exports of iron and steel in October. Figures for the same month in 1950 are given for the purposes of comparison and totals for the first 10 months of this year and of 1950 are also included.

Total Exports of Iron and Steel (tons)

Destination.	Month ended October 31.		Ten months ended October 31.	
	1950.	1951.	1950.	1951.
Channel Islands ..	1,002	876	7,345	7,434
Gibraltar	62	87	1,445	705
Malta and Gozo ..	307	327	3,606	2,748
Cyprus	800	418	7,600	4,088
Sierra Leone	450	424	3,820	4,399
Gold Coast	1,905	1,460	20,418	15,353
Nigeria	4,681	4,901	48,988	45,139
Union of South Africa	18,316	11,165	151,749	112,126
Northern Rhodesia ..	1,822	2,674	23,995	14,136
Southern Rhodesia ..	4,335	3,423	59,368	32,321
British East Africa ..	8,909	5,660	83,393	63,020
Mauritius	656	629	7,393	5,628
Bahrein, Kuwait, Qatar and Trucial Oman ..	871	244	6,346	6,051
India	6,282	7,473	83,573	74,978
Pakistan	8,449	7,034	84,310	64,248
Malaya	5,443	5,585	64,608	61,711
Ceylon	2,436	2,398	29,074	22,687
North Borneo ..	326	126	4,691	3,999
Hongkong	6,425	2,364	40,907	43,897
Australia	60,070	25,826	359,820	272,934
New Zealand ..	16,516	11,680	148,413	88,220
Canada	28,835	24,402	174,190	225,545
British West Indies ..	5,076	5,565	51,846	55,162
British Guiana ..	735	309	6,295	4,486
Anglo-Egyptian Sudan	1,003	1,360	15,044	8,406
Other Commonwealth	1,134	1,130	13,601	9,976
Irish Republic ..	10,932	3,453	82,233	68,552
Soviet Union ..	9	—	538	2,258
Finland	6,740	6,243	60,758	34,143
Sweden	11,525	12,613	75,877	95,804
Norway	7,190	5,986	72,198	51,855
Iceland	227	141	3,634	2,250
Denmark	6,906	6,367	95,147	65,301
Poland	157	3	1,438	662
Germany	146	163	828	1,040
Netherlands	6,280	7,683	65,497	73,108
Belgium	1,655	973	11,191	9,819
France	2,198	296	21,033	4,668
Switzerland	918	711	9,154	9,367
Portugal	938	399	17,215	11,082
Spain	312	388	6,382	3,608
Italy	1,819	1,503	10,856	28,591
Austria	22	18	894	385
Hungary	1	—	330	23
Yugoslavia	176	183	11,130	7,340
Greece	394	133	6,589	2,263
Turkey	527	631	7,953	5,121
Indonesia	248	2,159	10,066	8,483
Netherlands Antilles ..	623	1,288	7,306	7,822
Belgian Congo ..	354	81	1,572	1,841
Angola	39	50	1,948	1,749
Portuguese E. Africa	546	453	4,006	3,503
Canary Islands ..	200	36	1,947	1,541
Syria	406	1,313	1,643	5,753
Lebanon	2,514	1,707	10,685	11,591
Israel	2,354	2,261	19,763	26,404
Egypt	4,614	1,753	49,823	35,203
Morocco	1,345	28	3,842	1,368
Saudi Arabia ..	82	404	2,178	1,327
Iraq	1,706	2,073	29,321	22,182
Iran	6,806	15	85,943	58,080
Burma	1,573	2,194	10,520	12,284
Thailand	1,780	633	7,488	13,113
China	1,176	1	4,383	4,613
Philippine Islands ..	661	287	8,014	2,907
U.S.A.	11,869	4,348	34,219	127,611
Cuba	379	539	1,920	3,480
Colombia	931	562	5,854	7,137
Venezuela	2,025	3,743	27,007	36,565
Ecuador	492	1,018	3,244	2,603
Peru	862	1,005	10,061	10,373
Chile	1,148	617	13,781	6,891
Brazil	2,519	1,437	27,123	18,635
Uruguay	1,438	712	8,631	9,852
Argentina	4,654	3,479	54,605	37,311
Other foreign ..	1,920	896	16,576	14,921
TOTAL	301,782	210,419	2,526,191	2,221,798

* The figures for 1951 are not completely comparable with those for previous years.

Total Imports of Iron and Steel (tons)

From	Month ended October 31.		Ten months ended October 31.	
	1950.	1951.	1950.	1951.
India	—	—	22,930	12
Canada	3,076	5,438	32,730	41,646
Other Commonwealth and Irish Republic	138	304	1,411	1,575
Sweden	1,480	2,181	10,888	18,048
Norway	4,518	4,027	42,187	42,708
Germany	2,182	13,920	65,182	30,474
Netherlands	2,221	7,906	41,132	64,299
Belgium	3,800	20,117	81,771	148,490
Luxemburg	2,624	7,873	35,738	72,159
France	26,118	23,668	247,752	211,234
Austria	63	99	3,349	10,112
U.S.A.	5,605	7,737	50,154	39,237
Other foreign ..	137	2,162	6,115	6,554
TOTAL	51,962	95,882	647,339	695,548
Iron and steel scrap and waste, fit only for the recovery of metal	117,688	43,917	1,789,829	513,016

Exports of Iron and Steel by Product (tons)

Product.	Month ended October 31.		Ten months ended October 31.	
	1950.	1951.	1950.	1951.
Pig-iron	5,215	591	26,141	15,282
Ferro-alloys, etc.—				
Ferro-tungsten ..	92	—	972	372
Spiegeleisen, ferro-manganese ..	517	54	2,122	877
All other descriptions	142	99	1,294	895
Ingots, blooms, billets, and slabs	519	12	5,415	5,172
Iron bars and rods ..	397	411	3,676	7,528
Sheet and tinplate bars, wire rods ..	3,950	365	15,068	11,171
Bright steel bars ..	4,565	1,752	36,681	26,394
Alloy steel bars and rods	1,208	1,686	12,091	13,699
Other steel bars and rods	30,013	11,461	213,286	147,995
Angles, shapes, and sections	18,101	12,602	126,346	134,577
Castings and forgings	787	1,585	6,811	10,346
Girders, beams, joists, and pillars (rolled)*	8,171	1,419	56,929	31,097
Hoop and strip ..	14,271	7,463	98,702	64,431
Iron plate	239	28	2,182	1,708
Tinplate	18,894	16,174	205,742	196,174
Tinned sheets ..	126	148	2,382	2,054
Terneplates, decorated tinplates	55	120	767	1,430
Other steel plate (min. $\frac{1}{8}$ in. thick)	37,423	19,319	278,076	221,550
Galvanized sheets ..	9,826	4,288	97,658	45,913
Black sheets	13,446	13,044	117,563	127,844
Other coated plate ..	828	441	10,319	7,156
Cast-iron pipes up to 6 in. dia.	6,326	6,869	63,535	68,140
Do., over 6 in. dia. ..	6,442	6,101	67,296	58,465
Wrought-iron tubes ..	28,316	31,140	285,665	320,257
Railway material ..	25,739	14,696	257,519	182,807
Wire	11,004	4,909	69,635	49,550
Cable and rope ..	3,074	2,451	28,008	24,412
Wire nails, etc. ..	4,001	1,809	21,153	22,285
Other nails, tacks, etc.	396	386	4,170	3,462
Rivets and washers ..	670	861	6,838	6,410
Wood screws	566	430	3,345	3,397
Bolts, nuts, and metal screws	2,677	2,677	25,929	23,762
Baths	1,410	1,511	11,763	12,229
Anchors, etc.	819	604	7,022	7,680
Chains, etc.	1,074	992	8,697	9,379
Springs	466	717	6,920	5,418
Holloware	6,866	1,400	56,671	14,728
TOTAL, including other manufactures not listed above	301,782	210,419	2,526,191	2,221,793

Pig-iron and Steel Production

Statistical Summary of September Returns

The following particulars of pig-iron and steel produced in Great Britain have been extracted from the Statistical Bulletin for October, issued by the British Iron and Steel Federation. Table I summarises activities during the previous six months; Table II gives the production of steel ingots and castings in September, Table III gives deliveries of finished steel, and Table IV the production of pig-iron and ferro-alloys in September. (References applicable are given at the foot of column 2.)

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

Period.	Iron-ore output.	Imported ore consumed.	Coke receipts by blast-furnace owners.	Output of pig-iron and ferro-alloys.	Scrap used in steel-making.	Steel (incl. alloy).			
						Imports.[2]	Output of ingots and castings.	Deliveries of finished steel.	Stocks.[3]
1949	258	160	199	183	188	17	299	233	1,071
1950	249	174	197	185	197	9	313	239	907
1951—April	279	149	201	179	195	6	323	261	800
May[1]	287	159	204	182	180	7	305	242	762
June	315	159	204	183	182	7	308	262	737
July	299	162	202	182	153	9	256	226	706
August[1]	280	176	203	181	147	8	266	190	713
September	303	184	207	190	175	10	303	252	659

TABLE II.—*Weekly Average Production of Steel Ingots and Castings in September,* 1951. (*Thousands of Tons.*)

District.	Open-hearth.		Bessemer.	Electric.	All other.	Total.		Total ingots and castings.
	Acid.	Basic.				Ingots.	Castings.	
Derby, Leics., Notts., Northants and Essex ..	—	2.4	11.6 (basic)	1.4	0.2	14.9	0.7	15.6
Lancs. (excl. N.W. Coast), Denbigh, Flints., and Cheshire .. .. } Yorkshire (excl. N.E. Coast and Sheffield) ..	1.4	18.8	—	1.9	0.5	21.6	1.0	22.6
Lincolnshire	—	27.9	—	—	0.2	27.9	0.2	28.1
North-East Coast	1.7	56.2	—	1.2	0.5	57.7	1.9	59.6
Scotland	4.2	34.3	—	1.4	0.8	38.8	1.9	40.7
Staffs., Shrops., Worcs. and Warwick	—	10.0	—	0.9	0.7	16.1	1.5	17.6
S. Wales and Monmouthshire	8.2	55.2	6.0 (basic)	0.9	0.1	69.9	0.5	70.4
Sheffield (including small quantity in Manchester)	9.3	22.2	—	8.8	0.6	38.8	2.1	40.9
North-West Coast	0.3	1.8	4.9 (acid)	0.4	—	7.2	0.2	7.4
Total	25.1	234.8	22.5	16.9	3.6	292.9	10.0	302.9
August, 1951[1]	18.7	213.1	19.4	12.5	2.7	258.7	7.7	266.4
September, 1950	25.6	261.9	20.0	15.2	3.5	317.4	8.8	326.2

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

Product.	1949.	1950.	1950.	1951.	
			Sept.	August.	Sept.
Non-alloy steel:					
Ingots, blooms, billets and slabs[4]	4.5	3.6	3.4	3.4	4.5
Heavy rails, sleepers, etc. ..	9.8	11.3	10.6	7.1	10.6
Plates ⅛ in. thick and over ..	39.2	40.0	42.7	33.8	43.0
Other heavy prod.	37.5	40.2	43.1	34.2	40.8
Light rolled prod.	46.4	47.6	52.4	36.8	49.3
Hot-rolled strip ..	17.1	19.4	21.9	15.9	21.6
Wire rods	15.4	16.3	17.8	13.5	16.5
Cold-rolled strip ..	4.9	5.5	6.1	4.7	6.8
Bright steel bars ..	5.6	6.2	7.2	5.3	6.3
Sheets, coated and uncoated ..	27.6	30.5	32.1	29.6	36.9
Tin, terne and blackplate ..	13.7	14.3	14.4	10.3	15.5
Tubes, pipes and fittings	18.5	20.0	20.2	16.3	23.2
Mild wire	12.0	12.6	14.4	9.2	12.3
Hard wire	3.2	3.5	3.8	2.6	3.5
Tyres, wheels and axles	4.1	3.5	3.9	2.5	4.5
Steel forgings (excl. drop forgings) ..	2.4	2.2	2.2	1.9	2.3
Steel castings ..	3.6	3.5	3.3	3.9	2.5
Total	265.5	280.2	299.5	231.0	300.1
Alloy steel .. .	10.4	10.6	11.8	9.7	12.4
Total deliveries from U.K. prod.[5] ..	275.9	290.8	311.3	240.7	312.5
Add imported finished steel	9.5	3.8	4.2	3.8	7.3
	285.4	294.6	315.5	244.5	319.8
Deduct intra-industry conversion[6] ..	52.8	55.6	60.0	54.5	67.6
Total net deliveries ..	232.6	239.0	255.5	190.0	252.2

TABLE IV.—*Weekly Average Production of Pig-iron and Ferro-alloys during September,* 1951. (*Thousands of Tons.*)

District.	Furnaces in blast.	Hematite.	Basic.	Foundry.	Forge.	Ferro-alloys.	Total.
Derby, Leics., Notts., Northants and Essex	24	—	16.8	23.4	1.6	—	41.8
Lancs (excl. N.W. Coast), Denbigh, Flints., and Cheshire .. } Yorkshire (incl. Sheffield, excl. N.E. Coast) ..	6	—	8.0	—	—	0.7	8.7
Lincolnshire ..	15	—	21.3	—	—	—	21.3
North-East Coast	23	8.2	36.6	0.1	—	1.4	46.3
Scotland	9	0.7	12.9	2.8	—	—	16.4
Staffs., Shrops., Worcs., and Warwick ..	9	—	9.2	1.5	—	—	10.7
S. Wales and Monmouthshire	8	3.2	24.9	—	—	—	28.1
North-West Coast	8	15.1	—	0.1	—	1.0	16.2
Total ..	102	27.2	129.7	27.9	1.6	3.1	189.5[7]
August, 1951[1] ..	100	23.2	125.4	27.2	1.4	3.7	180.9
September, 1950	101	27.7	126.0	28.8	1.3	2.9	186.8

[1] Five weeks, all tables.

[2] Weekly average of calendar month.

[3] Stocks at the end of the years and months shown.

[4] Other than for conversion into any form of finished steel listed above.

[5] Includes finished steel produced in the U.K. from imported ingots and semi-finished steel.

[6] Material for conversion into other products also listed in this table.

[7] Including 100 tons of direct castings.

Personal

MR. J. W. MURFIN, of the hardening shop, has retired after 40 years' service with Rolls-Royce, Limited, Derby. His colleagues presented him with a wallet of notes.

MR. JOSEPH CLARK, office manager of John Spencer & Sons (1928), Limited, engineers, of Newburn-on-Tyne, has retired after 50 years' service with the company.

MR. H. SLADE, chief rate fixer with the Brush Electrical Engineering Company, Limited, Loughborough, is giving up the engineering industry, and has now left the company.

THE DIRECTORS of Lion Foundry Company, Limited, Kirkintilloch, announce that, as from November 23, MR. D. C. MILLER, their works manager, has been co-opted to the board.

SIR BEN LOCKSPEISER, F.R.S., secretary to the Committee for Scientific and Industrial Research, has been appointed president of the Engineering Section of the British Association.

THE SENIOR REPRESENTATIVE of Thomas Green & Son, Limited lawn mower and road-roller manufacturers, etc., of Leeds, MR. W. ROBERTSON, has retired after 55 years' association with the company.

AT THE autumn general meeting of the Iron and Steel Institute in London recently CAPT. H. LEIGHTON DAVIES was nominated to be the next president of the institute. He joined the institute in 1918 and has served on the council for the past 20 years.

AFTER 50 years with the Wallsend Slipway & Engineering Company, Limited, MR. ANDREW SPROT, the secretary, is due to retire in January on reaching the age of 65. He will be succeeded by MR. F. G. APPLETON who is at present assistant secretary.

FOUNDER of Hattersley & Ridge, Limited, saw and tool manufacturers, etc., of Sheffield, which has now merged with the Neepsend Steel & Tool Corporation, Limited, MR. A. HATTERSLEY has left this week for South Africa, taking his wife and two children. He is joning a firm near Johannesburg.

MR. WALTER HACKETT, joint managing director of Accles & Pollock, Limited, presented prizes valued at £400 to employees, on November 27, for successes in a material-saving campaign. The campaign, in which every department took part, began last July when the firm was particularly short of steel, and so enthusiastic was the response and so intelligent and resourceful the many suggestions that a committee is now being formed to investigate means of continuing the campaign in a more permanent form.

ON THE EVE of completing his one thousandth job, Major E. C. Peckham, chairman and managing director of Metalock (Britain), Limited, has left London for a two weeks' visit to New York and Canada to report on progress to the head office in Long Island City, New York, and the Canadian office in Niagara Falls, Ontario. Major Peckham has already travelled more than 30,000 miles this year on business trips to ten countries, and has opened agencies in India, Pakistan, France, Portugal, the Iberian Peninsula, and Australia. Subsidiary companies have already been formed in Holland, Italy, Norway, South and East Africa. It is only four years since Major Peckham first brought this cold-repair process to this country from Canada, and opened his London office. Then Major Peckham had a staff of one —now there is a large administrative staff and fifty trained Metalock operators, who are sent daily to any part of the world to repair shipping and industrial machinery on the spot. A new branch of Metalock is opening in Australia, and will be known as Metalock of Australia (Pty.), Limited, 63, Perth Street, Prahran, Melbourne.

Obituary

MR. J. W. LAKE, welfare officer of the Consett Iron Company, Limited, has died suddenly at the age of 65. He was due to retire at the end of the year.

MR. GILBERT HALL, assistant manager of Jones' Sewing Machine Company, Limited, Guide Bridge, near Manchester, died on November 17, at the age of 42.

MAJOR GEOFFREY PHILLIPS, who was for many years associated with various colleries in Yorkshire and with the Midland Institute of Mining Engineers, died suddenly on November 18.

MR. G. W. P. BESWICK, C.B.E., J.P., who died recently at the age of 67, was formerly a director of Beswick's Lime Works, Limited, which was taken over by the Staveley Coal & Iron Company in 1947.

THE DEATH has occurred at the Manor Hospital, Walsall, of Mr. H. E. Hind, of Walsall, chairman and managing director of the Triplex Foundry, Limited, grate manufacturers, Tipton. He was due to retire on November 30.

THE DEATH occurred last week of MR. ARCHIBALD MACNAB, a member of the Scottish branch of the Institute of British Foundrymen, who was formerly with the Aluminium Castings Company, Limited, Greenock, and the Renfrew Foundries Limited, Glasgow, in his forty-eighth year. Mr. Macnab was well known in the light-alloy industry in Scotland.

FOR MANY YEARS chief draughtsman of the Furness Shipbuilding Company, Limited, Haverton Hill-on-Tees, Billingham (Co. Durham), MR. JOHN GOLDSBROUGH, who joined the company in 1918, has died at the age of 65. He was a member of the Institution of Naval Architects and of the North East Coast Institution of Engineers and Shipbuilders.

JOINT MANAGING DIRECTOR of Ransome & Marles Bearing Company, Limited, Newark (Notts), since 1941, MR. JOHN A. ROSS died on November 26. He joined the company as secretary in 1924 after practising as a chartered accountant with Wilson Stirling & Company, Glasgow. In 1936 he relinquished the secretaryship on being appointed joint general manager and in the following year he joined the board.

MR. FRANCIS FRASER, who was secretary of the British Thomson-Houston Company, Limited, Rugby, for 40 years, and had been a director of the company for 27 years before his retirement in 1941, died on November 21. Born in Scotland in 1863, he began his career with a commercial and shipping concern and later joined a solicitor's office in Edinburgh. After a period of training he went to the United States and in 1890 joined the Edison General Electric Company in Denver. He returned to England in 1901 to become secretary to the British Thomson-Houston Company, being appointed a director in 1914.

THE DEATH occurred on November 26 at his home in Bridge of Weir, Renfrewshire, of Emeritus Prof. ALEX. L. MELLANBY, D.Sc., LL.D., who for 31 years occupied the Chair of Civil and Mechanical Engineering at the Royal Technical College, Glasgow. He was 80 years of age. Prof. Mellanby retired in 1936, when world-wide tribute was paid to his eminence in mechanical science. He was made Prof. of Mechanical Engineering at the Glasgow College in 1905. With the passing of the years his duties increased in Glasgow, until ultimately he was in full charge of the entire Department of Civil and Mechanical Engineering and Applied Mechanics. Glasgow University conferred the degree of LL.D. on him in June, 1936. He was a member of the Council of the Institution of Mechanical Engineers and a representative of the Institution of the Joint Committee for National Certificates in Mechanical Engineering in Scotland.

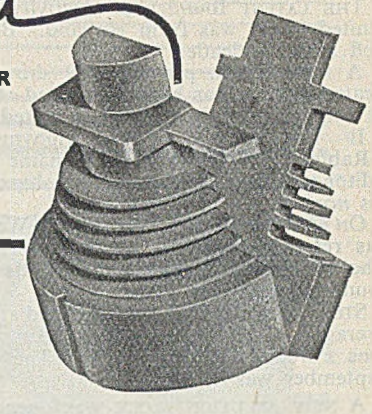

Illustration of 'STOLIT' pattern by courtesy of The Watford Foundry Co. Ltd.

News in Brief

THE LATEST foundry productivity team to visit the United States was from Holland. Baron van Krayenhoff acted as leader.

A NEW BLOCK, providing 49 shower baths and 400 heated lockers, has been completed at the Derby works of International Combustion, Limited.

IF THE WRITER of the anonymous letter signed "Rabbit" will forward us his name in confidence, the Editor will be pleased to publish his contribution under his *nom de plume*.

ON HIS APPOINTMENT as Lord-in-Waiting, Lord Lloyd has resigned from the Board of Horseley Bridge & Thomas Piggott, Limited, constructional engineers and founders of Tipton, Staffs.

STEEL PRODUCTION in the Sheffield area during October averaged 42,500 tons a week, compared with 46,200 tons a week in October, 1950. The weekly average in September was 40,900 tons.

A NEW ABLUTION BLOCK was opened recently at the works of F. Parramore & Sons (1924), Limited, ironfounders, of Chapeltown, near Sheffield, providing facilities for all the company's 250 workers.

A PRODUCTION RECORD was established recently at the billet mill at the steelworks of Samuel Fox & Company, Limited, Stocksbridge, near Sheffield, when 4,810 tons of ingots were produced in a 15-shift week.

TO STIMULATE INTEREST in the company's activities, fortnightly lectures are being arranged by the Consett Iron Company, Limited, to give men in one part of the plant an insight into the work of other sections.

AN INFORMAL MEETING of members in the Yorkshire area of the Association of Bronze and Brass Founders will be held at the Great Northern Hotel, Leeds, 1, on December 14, commencing with luncheon at 12.30 p.m.

A 15,000 SQ. FT. FACTORY at Carfin Industrial Estate (Lanarkshire) has been taken over by the Glacier Metal Company, Limited, Wembley (Mddx). Production is expected to begin in February. Most of the 60 people to be employed will be recruited locally.

A PRIVATE EXHIBITION HALL AND CINEMA has been equipped by Babcock & Wilcox, Limited, at Salisbury Square House, Salisbury Square, London, E.C.4, to provide facilities at a central point in London and convenient to the head office in Farringdon Street.

THE PRICE OF SCRAP IRON in Sweden has been increased by 40 per cent., in the hope of stimulating collection. In the meantime merchants, desperate for supplies, have gone as far afield as Portugal to make purchases. It is estimated that 60 per cent. of Sweden's anticipated production of 1,500,000 tons of castings this year is based on scrap.

ORDERS for four 10,000-ton vessels, three for foreign owners and the fourth for U.K. owners, have been secured by Wm. Pickersgill & Sons, Limited, Sunderland. Three of the vessels will be engined by the North-Eastern Marine Engineering Company (1938), Limited, Wallsend-on-Tyne, and the fourth by Harland & Wolff, Limited, Belfast.

AN EXTENSION of the engineering departments of the universities and a development of work at university level in the technical colleges would be needed to cure England of a comparative weakness in technological education, Lord Simon of Wythenshawe, chairman of the Council of Manchester University, told members of the court of governors on November 21.

A UNITED STATES GOVERNMENT ORDER, to take effect on February 1, virtually reserves machine-tool production for military and defence-supporting needs. Because the scarcity of machine tools is slowing up the defence industries, the order will place a ban on retooling by manufacturers of motor-cars, refrigerators, washing-machines, and other non-essential consumer goods.

DISCUSSING the post-war development of a motor and tractor industry in Poland in the 6-Year Plan, Mr. Tokarski, Polish Minister of Heavy Industry, said that two large motor-car factories will be put into operation at the end of this year. They will only be engaged on assembly work until next year, full production not being expected until 1953. The factories will be situated at Zervan and Lublin.

DESPITE a drop of 28,000 tons in the Tees imports of scrap, the total imports into the river in September, amounting to 277,942 tons, showed an increase of 18,500 tons compared with September, 1950. This was principally due to a 35,000-ton rise in the arrivals of foreign ore. September exports recorded the lowest monthly total since August, 1949, the shrinkage being most marked in coastwise shipments of coal and overseas exports of manufactured iron and steel.

THREE MOTOR-DRIVEN AIR COMPRESSORS, with a stand-by fourth, will supply each of the two extensive pneumatic schemes to be carried out at Pleasley and Sutton collieries, in Area No. 6 of the East Midlands Divisional Board, by the Westinghouse Brake & Signal Company, Limited. The company has also secured orders for equipment at Waunlwyd and Ffaldau collieries, in the South-Western Divisional Coal Board's area.

THE ENGINEERING CENTRE, 351, Sauchiehall Street, Glasgow, C.2, has now opened a catalogue library which contains the literature of more than 3,000 firms, and also a complete set of British Standard Specifications. Frequent additions supplied by firms and constant supervision by the technical staff of the Centre ensure that the library contains only the most recent publications. Manufacturers of foundry plant who have not yet included the Centre on their mailing lists for publicity matter are invited to do so.

KEITH BLACKMAN, LIMITED, of Mill Mead Road, Tottenham, London, N.17, announce that their chief London representative, Mr. J. C. Campbell, retired last month after 50 years' service. During this time he has represented the company both in Edinburgh and Glasgow, and has been chief London representative for the past 14 years. His successor is Mr. D. J. Auld, who has been with the company since 1914, and a representative for the past 27 years, including service in Manchester. His new appointment commenced on December 1.

Warmest congratulations are offered to Mr. T. Makemson, M.B.E., on his completion of 25 years as secretary of the Institute of British Foundrymen. It was on December 1, 1926, that he took up his duties, and twelve days later, with Mr. V. C. Faulkner he travelled to Belgium to be present at the inaugural meeting of the International Committee of Foundry Technical Associations. The late Mr. Paul Ropsy presided and Mr. Makemson was elected honorary secretary—a position he still holds.

Blanaced Cores in Production Moulding.—The Author of the article under this title published in last week's issue has pointed out that an additional safeguard could be added to make the core-setting foolproof. For this, one corner should be cut off on each of the rectangular core-prints and an equivalent piece placed in the core-boxes in correct relative position. Without this it is possible to set the core wrongly, so having the boss in the core directly underneath the plain part of the casting.

Raw Material Markets

Iron and Steel

A big improvement is needed in the supply of all grades of foundry pig-iron to relieve existing production difficulties. Some units are receiving barely sufficient iron to keep their plants in operation and frequent stoppages are reported. Shortage of scrap is a further handicap to foundrymen. Any improvement in outputs at the blast furnaces is received by the steelmakers, who are in urgent need of supplies to offset the shortage of scrap. The supply of sufficient and suitable quantities of coke not only adversely affects production of pig-iron from the furnaces in blast, but is apparently the primary reason why new furnaces cannot be blown in.

Outputs of the low- and medium-phosphorus irons are fairly well maintained, but are quite inadequate to cover the needs of the engineering and speciality foundries. Hematite producers are sending any tonnages they can spare to the foundries, but these quantities are small. Refined-iron makers are short of their base materials—hematite and scrap—and this has considerably curtailed production. Scotch foundry iron, when available, is readily accepted by the foundries, many of which would take supplies of foreign irons of suitable analyses if these could be obtained. Some relief is expected to be given to the light and jobbing foundries and some of the engineering foundries by the blowing-in of another furnace in the Derbyshire area for the production of the high-phosphorus grade.

Foundry coke supplies are coming forward regularly, deliveries being sufficient to meet current requirements, but users' stocks are low. Ganister, limestone, and firebricks are available as required, while foundries needing ferro-alloys can generally obtain the supplies needed for their mixtures.

Many re-rollers are working short time and some are even closed for want of steel semis. There is an acute shortage of the small sizes of sections, bars, and strip. Efforts continue to be made to procure Continental steel semis, but the tonnages reaching the re-rollers are only small. The sheet re-rollers are also in need of larger tonnages of sheet bars. With the dearth of prime material, there is a heavy call for all arisings of defectives and crops.

Non-ferrous Metals

On the tin market yesterday (Wednesday) the cash price fell to £930 and three months to £910—the lowest levels seen for some considerable time. The backwardation stood at £20, compared with £15 on Wednesday of last week.

Warrant stocks are, however, slow to improve. On the falling market consumers, as usual, have rather held off in the United Kingdom, and on the Continent buying has declined in volume.

London Metal Exchange official tin quotations were as follow:—

Cash—Thursday, £960 to £970; Friday, £950 to £955; Monday, £945 to £950; Tuesday, £937 10s. to £942 10s.; Wednesday, £925 to £930.

Three Months—Thursday, £943 to £946; Friday, £932 10s. to £937 10s.; Monday, £922 10s. to £925; Tuesday, £915 to 920; Wednesday, £907 10s. to £910.

In the United States the R.F.C. price remains at 103 cents (£824), but there is an outcry from users who are not getting anything like as much metal as they want. Here, with a free market operating, the trade is fully supplied. Stocks in America are running down and the Longhorn smelter is reported to be on short time owing to reduced stocks of concentrates.

A state of deadlock continues in the negotiations between the Bolivian producers and the administrator of the Reconstruction Finance Corporation. Probably the Bolivians have stiffened in their attitude in holding out for a minimum basis price of $1.50 per lb. for concentrates, for the Americans have allowed their stocks to deteriorate to an unduly low level, and have, therefore, it would appear, rather played into the hands of potential suppliers.

Although the figures of consumption of copper in the UK have not yet been published, it is believed that October was a busy month with consumption of both virgin and secondary metal at a high level. Considering the great difficulties that exist in regard to supplies generally, the details of usage of copper this year are remarkably good. It is, of course, a fact that our consumption this year has so far exceeded last year's figure by a handsome margin.

In zinc, however, we have fallen behind. What is to happen next year remains to be seen, but it is too much to expect that the trade will again be able to draw on reserves to make up for the shortfall in the supplies of virgin copper and zinc. Lead looks pretty comfortable both as to primary and secondary tonnage. The outlook for scrap copper and brass is not promising.

Natural Gas in Alberta

Potential Markets for Appliances

A long-term market for gas ranges, refrigerators, radiant and water heaters, gas furnaces, etc., is envisaged in a report by the Trade Commissioner at Alberta to the Board of Trade. The demand for these appliances will stem largely from the growing use of natural gas.

The trend in the use of natural gas is and has been upward at a substantial rate, and over the past decade there has been a very rapid increase in the total consumption of gas. During the last few years, as the economy of Alberta has been expanding and population has been increasing, there has been a large demand for gas appliances. According to the two general utilities, Northwestern Utilities, Limited, Edmonton, and Canadian Western Natural Gas Company, Limited, Calgary, additional new customers have been made at the rate of some 7,000 to 9,000 per annum.

There are, however, many firms in the field and competition is keen. If United Kingdom manufacturers are hoping to break into the market it is essential that they design and style their appliances to meet Canadian tastes. Illustrated leaflets relating to appliances at present on the market can be seen at the Commercial Relations and Export Department of the Board of Trade, Thames House North, Millbank, London, S.W.1.

Once exportation of natural gas is permitted by the Alberta Government there should be an increased market for appliances in British Columbia and possibly Saskatchewan and Manitoba. If exportation to the United States is also permitted, the States of Washington, Oregon, Idaho, and Montana may be concerned.

CUSTOMS AND EXCISE authorities have reviewed the conditions under which tax-free dispensing packs of proprietary or branded preparations of official drugs or medicines may be supplied to works' first-aid rooms, and they have decided that, where a factory claims entitlement to receive supplies tax-free, orders must be authenticated by the doctor and the drugs must be consigned to him.

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

(Delivered, unless otherwise stated)

December 5, 1951

PIG-IRON

Foundry Iron.—No. 3 IRON, CLASS 2:—Middlesbrough, £11 10s.; Birmingham, £11 4s. 6d.

Low-phosphorus Iron.—Over 0.10 to 0.75 per cent. P, £13 0s. 6d., delivered Birmingham. Staffordshire blast-furnace low-phosphorus foundry iron (0.10 to 0.50 per cent. P, up to 3 per cent. Si), d/d within 60 miles of Stafford, £13 12s. 3d.

Scotch Iron.—No. 3 foundry, £13 1s., d/d Grangemouth.

Cylinder and Refined Irons.—North Zone, £15 7s.; South Zone, £15 9s. 6d.

Refined Malleable.—P, 0.10 per cent. max.—North Zone, £15 17s.; South Zone, £15 19s. 6d.

Cold Blast.—South Staffs, £17 5s. 6d.

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 17s.; Scotland (Scotch iron), £13 3s. 6d.; Sheffield, £13 13s. 6d.; Birmingham, £14 0s. 6d.; Wales (Welsh iron), £13 3s. 6d.

Spiegeleisen.—20 per cent. Mn, £22.

Basic Pig-iron.—£11 15s. 6d. all districts.

FERRO-ALLOYS

(Per ton unless otherwise stated, delivered.)

Ferro-silicon (6-ton lots).—40/55 per cent., £40 15s., basis 45% Si, scale 15s. 6d. per unit; 70/84 per cent., £56 2s. 6d., basis 75% Si, scale 16s. per unit.

Silicon Briquettes (5-ton lots and over).—2lb. Si, £48 5s.; 1lb. Si, £49 5s.

Ferro-vanadium.—50/60 per cent., 15s. per lb. of V.

Ferro-molybdenum.—65/75 per cent., carbon-free, 9s. 6d. per lb. of Mo.

Ferro-titanium.—20/25 per cent., carbon-free, £175; ditto, copper-free, £190.

Ferro-tungsten.—80/85 per cent., 33s. per lb. of W.

Tungsten Metal Powder.—98/99 per cent., 35s. per lb. of W.

Ferro-chrome (6-ton lots).—4/6 per cent C, £74, basis 60% Cr, scale 24s. 6d. per unit; 6/8 per cent. C, £70, basis 60% Cr, scale 23s. 3d. per unit; max. 2 per cent. C, 1s. 8½d. per lb. Cr; max. 1 per cent. C, 1s. 8¾d. per lb. Cr; max. 0.15 per cent. C, 1s. 9½d. per lb. Cr.; max. 0.10 per cent. C, 1s. 9¾d. per lb. Cr.

Chromium Briquettes (5-ton lots and over).—1 lb. Cr, £78 9s.

Cobalt.—98/99 per cent., 17s. 6d. per lb.

Metallic Chromium.—98/99 per cent., 6s. to 6s. 3d. per lb.

Ferro-manganese (blast-furnace). — 78 per cent., £40 8s. 9d.

Manganese Briquettes (5-ton lots and over).—2lb. Mn, £50 6s. 6d.

Metallic Manganese.—96/98 per cent., carbon-free, £215 per ton.

SEMI-FINISHED STEEL

Re-rolling Billets, Blooms, and Slabs.—BASIC: Soft, u.t., £21 11s. 6d.; tested, 0·08 to 0.25 per cent. C (100-ton lots), £22 1s. 6d.; hard (0.42 to 0.60 per cent. C), £23 19s.; silico-manganese, £29 15s.; free-cutting, £24 15s. 6d. SIEMENS MARTIN ACID: Up to 0.25 per cent. C, £27 16s.; case-hardening, £28 4s.; silico-manganese, £30 16s. 6d.

Billets, Blooms, and Slabs for Forging and Stamping.—Basic, soft, up to 0.25 per cent. C, £25 15s.; basic, hard, over 0.41 up to 0.60 per cent. C, £26 15s.; acid, up to 0.25 per cent. C, £28 4s.

Sheet and Tinplate Bars.—£21 16s.

FINISHED STEEL

Heavy Plates and Sections.—Ship plates (N.-E. Coast), £25 6s. 6d.; boiler plates (N.-E. Coast), £26 14s.; chequer plates (N.-E. Coast), £26 15s. 6d.; heavy joists, sections, and bars (angle basis), N.-E. Coast, £23 15s. 6d.

Small Bars, Sheets, etc.—Rounds and squares, under 3 in., untested, £27 11s.; flats, 5 in. wide and under, £27 11s.; hoop and strip, £28 6s.; black sheets, 17/20 g., £35 15s. 6d.; galvanised corrugated sheets, 17/20 g., £49 18s. 6d.

Alloy Steel Bars.—1-in. dia. and up: Nickel, £44 17s. 3d.; nickel-chrome, £65 2s. 9d.; nickel-chrome-molybdenum, £72 10s. 3d.

Tinplates.—52s. 1½d. per basis box.

NON-FERROUS METALS

Copper.—Electrolytic, £227; high-grade fire-refined, £226 10s.; fire-refined of not less than 99.7 per cent., £226; ditto, 99.2 per cent., £225 10s.; black hot-rolled wire rods, £236 12s. 6d.

Tin.—Cash, £925 to £930; three months, £907 10s. to £910; settlement, £927 10s.

Zinc.—G.O.B. (foreign) (duty paid), £190; ditto (domestic), £190; "Prime Western," £190; electrolytic, £194; not less than 99.99 per cent., £196.

Lead.—Good soft pig-lead (foreign) (duty paid), £175; ditto (Empire and domestic), £175; "English," £176 10s.

Zinc Sheets, etc.—Sheets, 15g. and thicker, all English destinations, £210 10s.; rolled zinc (boiler plates), all English destinations, £208 10s.; zinc oxide (Red Seal), d/d buyers' premises, £205.

Other Metals.—Aluminium, ingots, £124; antimony, English, 99 per cent., £365; quicksilver, ex warehouse, £73 10s. to £73 15s.; nickel, £454.

Brass.—Solid-drawn tubes, 25d. per lb.; rods, drawn, 32⅞d.; sheets to 10 w.g., 30⅛d.; wire, 31⅞d., rolled metal, 28⅞d.

Copper Tubes, etc.—Solid-drawn tubes, 26d. per lb.; wire, 254s. per cwt. basis; 20 s.w.g., 281s. per cwt.

Gunmetal.—Ingots to BS. 1400—LG2—1 (85/5/5/5), £245 to £280; BS. 1400—LG3—1 (86/7/5/2), £260 to £300: BS. 1400—G1—1 (88/10/2), £330 to £360; Admiralty GM (88/10/2), virgin quality, £330 to £360 per ton, delivered.

Phosphor-bronze Ingots.—P.Bl, £340 to £370; L.P.Bl, £295 to £315 per ton.

Phosphor Bronze.—Strip, 38⅞d. per lb.; sheets to 10 w.g., 41d.; wire, 43⅛d.; rods, 38d.; tubes, 37d.; chill cast bars: solids 4s., cored 4s. 1d. (C. CLIFFORD & SON, LIMITED.)

Nickel Silver, etc.—Ingots for raising, 2s. 7¾d. per lb. (7%) to 3s. 7½d. (30%); rolled metal, 3 in. to 9 in. wide × .056, 3s. 1⅛d. (7%) to 4s. 1½d. (30%); to 12 in. wide × .056, 3s. 2d. to 4s. 1⅞d.; to 25 in. wide × .056, 3s. 4d. to 4s. 3⅞d. Spoon and fork metal, unsheared, 2s. 10⅞d. to 3s. 10½d. Wire, 10g., in coils, 3s. 7¾d. (10%) to 4s. 7½d. (30%). Special quality turning rod, 10%, 3s. 6⅛d. 15%, 3s. 11½d.; 18%, 4s. 3½d. All prices are net.