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Government Spending

As soon as the United States accepted the Communist challenge in Korea, it became clear that our defence expenditure must grow. No-one, indeed, has explained why the large sums spent every year since 1945 should have left our Navy, Army and Air Force unready for war. Pearl Harbour ought to have taught governments that they may be at war with less than 12 hours' warning. In 1914 we had large reserves of taxable capacity, and some smaller reserves even in 1939; with surtax rising to 19s. 6d. in the £, it is clear that there is no margin of taxable capacity among the higher-income groups. What, then, can the Chancellor of the Exchequer do to meet the emergency? In its 317th broadsheet, PEP (Political and Economic Planning) examines the present expenditure by the Government and other public authorities and finds that it is dangerously large. This spending absorbs resources which might be used in other ways, and it may restrict, to a dangerous degree, the country's supply of new machinery and other equipment needed by industry. Then the high taxation involved will lessen incentive and thus put a brake on production. So far, there has been no indication that governments will spend less; indeed, many items on the outgoing side seem likely to increase unless the House of Commons puts its foot down and listens to the advice of its committees examining in detail the activities of the spending departments.

Which is the more important—spending by the "Welfare State," improving the defence forces, or providing industrial equipment? Defence, as Adam Smith said, is greater than opulence; indeed, it is a condition of national existence, but much of the taxpayer's and ratepayer's money is spent on services which fail to secure universal approval. PEP points out that more than two-fifths of the £4,464 million raised by taxation, rates, and insurance contributions was paid out in the form of debt interest, subsidies, and "in various forms of the process of taking from Peter to pay Paul, or even to pay Peter himself." Insurance contributions ought not to be reckoned as taxation; they are really investments or premiums.

A table shows how enormously certain items of Social Services have grown since 1936—for example, Health from £41 million to £414 million, and food subsidies from a trifling sum (mainly on beet sugar) to £465 million. Meanwhile, official policy works in opposite directions—consumption is at once stimulated by subsidies and the system of transfer incomes, and held in check by high taxes, and by restraint of wages increase. After looking round, PEP thinks that it would be difficult "to make any great release of resources for defence at the expense of consumption." Direct controls are used to limit investment in the private sector, *e.g.*, through the Capital Issues Committee, or through building licences. Another possibility is a higher rate of interest as a curb on investment, but this has been rejected because it would mean raising the interest charge on the national debt.

Part of the resources needed for defence may be obtained through the expected increase in industrial production, possibly at the rate of 2½ per cent. per annum, though the steady decrease in the population of working age may check this growth. All kinds of projects are in the air demanding new capital, such as schools, hospitals, health centres, sanatoria, and perhaps an improvement in our old-fashioned prisons. These things are all desirable in themselves. The question is—can we afford them and expand our armed forces at the same time? The broadsheet finds "a strong case for new classifications of Government spending," and suggests that the Government hardly knows what its various departments are doing; official statistics do not give the facts.

Foundry Trades' Equipment and Supplies Association

Annual General Meeting

The Report of the Council of the Foundry Trades' Equipment and Supplies Association, presented at the Annual General Meeting, held on October 19, was as follows:—

Membership.

The number of members of the Association on December 31, 1949, was 50, six new members having been admitted during the year. The Council feel that the Association is gaining prestige, but they would like to impress upon members the importance of making full use of the Association's services and of fostering a co-operative spirit in the industry.

Accounts.

The accounts for the year ended December 31, 1949, showed an excess of expenditure over income of £130 2s. 9d. The balance carried forward is £44 6s. 3d. The administration expenses of the Association for the year amounted to £487 6s. 7d., which compares with £360 4s. 8d. in 1948. The increase appears to be amply accounted for by the growing membership and activities and particularly by the fact that the Association took over the functions of the Foundry Equipment Export Group as at October 19, 1948. The expenses of that Group in the last full year of its existence were £239 0s. 5d.

Handbook.

During the year, 25 copies of the handbook "British Foundry Plant and Supplies" were distributed.

Exhibitions.

Members of the Association exhibited at the Mechanised Handling Exhibition in July, 1950, and arrangements have been made for a Foundry Trades Section to occupy the annexe at Olympia at the Engineering and Marine Exhibition to be held in 1951.

Tariffs and Exports.

From time to time since the last annual general meeting the Association has approached Government departments on behalf of its members, regarding exporting difficulties. During March, representatives met officials of the Ministry of Supply to discuss tariffs and exports. The Ministry officials were informed that the Association considered that existing preferential tariffs in Commonwealth countries should be adhered to, particularly in view of German competition. The seriousness of this competition was stressed throughout the interview.

The Association's representatives drew particular attention to the importance of obtaining better import licence facilities, particularly in India and France, where members had obtained valuable orders they were unable to fill because of the restrictions. The Ministry officials were of the opinion that this situation was likely to be easier in the near future.

"Supplies" Members.

There has been no separate meeting of "Supplies" members since the last annual general meeting, but the interests of this section of the membership are being closely watched by the supplies sub-committee which meets from time to time. The Association's representatives have continued to serve on the sub-committee of the Factories Department dealing with fumes from core compounds, which has drawn up recommendations to be printed by HM Stationery Office. Members have been asked to co-operate by distributing this publication to foundries through their selling organisations.

Research.

Liaison has been maintained with research associations and certain of their publications are distributed to those members who have signified they are interested in receiving them. Mr. W. Rawlinson is serving as the Association's representative on the British Standards' Institution Committee on Standardisation of Chilled Shot and Grit.

Mr. V. L. Cashmore and Mr. J. C. W. Lowe are representing the Association on the Institute of British Foundrymen Sub-Committee TS.34, which deals with the standardisation of moulding boxes.

General Activities.

Assistance has been given to members in securing increased steel allocations.

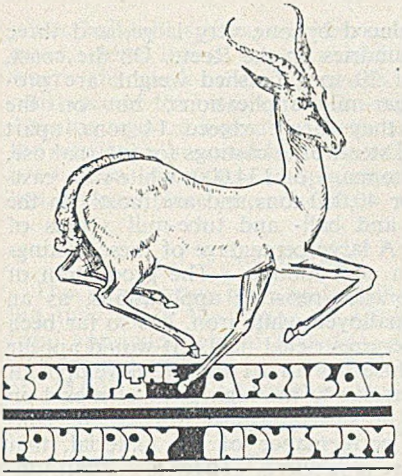
Additional service has been given by obtaining information for individual members on such matters as:—

(*a*) the activities of the Central Office of Information;
(*b*) means of finding suitable agents abroad;
(*c*) terms of sale to foreign countries.
(*d*) foundries abroad, and
(*e*) customs and import licences.

The Report is signed by T. A. Hammersley, President, and Peat, Marwick, Mitchell & Company, Secretaries.

PRINTING INDUSTRY DISPUTE

The dispute in the London printing industry prevented publication of the "JOURNAL" last week, and has compelled us to omit many normal features from the make-up of the editorial pages in this issue, and restrict drastically the advertisers' anno·ncements except those on the cover pages. We dislike token issues of this nature and hope this is the last we shall have to publish—they are unfair to both readers and advertisers, and have a particularly unfortunate effect abroad at a time when exports are of paramount importance. At the moment, it is impossible to foresee what may happen next week. We are not a party to the dispute, and if there is again a break in publication, our readers will understand that we are powerless to prevent it. Normal publication will, of course, be resumed at the earliest opportunity. Special queries can be dealt with from this office.



Review of the South African Foundry Industry*

By H. G. Goyns

This Paper deals with the extent and scope of the South African foundry industry, and makes certain comparisons with foundries in other countries. Inso-far as is possible, the Paper pursues a logical progression and describes extent of the local market; types and number of foundries; tonnages involved; types of castings; plant; laboratory facilities; raw materials; sands; clays; refractories; design and feeding technique; costing and estimating; personnel and welfare.

In submitting this Paper, the Author asks the indulgence of the members present, for any discrepancies which may arise in the figures quoted. These are, in certain cases, an approximation, accurate information regarding many of the industry's activities being difficult to obtain.

In South Africa, founders are not unacquainted with instances wherein certain visitors from overseas seem to descend from the skies and, after a lightning survey, return to their native heath and produce volumes on the living and industrial conditions, the native problems and other relevant matters which have exercised the concern of the local authorities for many years. The Author, however, must humbly confess that after three years, having had so many problems to solve in his own "sand heap," he has collected comparatively little information to justify making detailed comparisons with overseas foundry practice. Apart from the inadequacy of his knowledge, statistical records regarding the ramifications of the industry have been unable to keep pace with the rapid growth and expansion which has taken place in the last few years. However, to enable foundrymen to bring South Africa and the United Kingdom into relative perspective, the following details may be of interest.

Market

South Africa is a land of vast spaces and it is perhaps difficult to realise that, in a country which covers an area of 470,000 square miles, or more than five times the area of the United Kingdom, the foundry industry caters for a white population of 2¼ million, which is about one-third the population of Greater London, or one-twentieth of the population of Britain as a whole. The non-European population of 9¼ million is of relatively minor significance as regards the market for castings, apart from the demand for kaffir cooking pots, boot lasts and flat irons. Foundry products are largely for internal consumption, though the Rhodesias do, to a limited extent, draw on the Union for certain classes of castings. The quantities which would justify a high degree of mechanisation have, until recently, been confined to railway, mining and builders' castings and kaffir pots.

There is a flourishing market in products which can be taken off the foundry floor and manufactured by semi-mechanised methods. However, one must face the fact that South Africa is still at the stage where jobbing quantities and methods, while accounting for a minor tonnage, are an important factor in the man-hours worked. Estimated outputs for the various sections of the industry are quoted in the following pages under the relevant headings. The production at present, is not a true reflection of the potential market as, due to the number of overseas organisations which have recently established factories in this country, there is an increasing demand for local castings for use in assemblies which were formerly manufactured overseas.

NUMBER AND TYPES OF FOUNDRIES

Any review of the South African foundry industry will at once reveal one major factor in common with Britain, namely, the foundries range from one extreme to another in size, output and efficiency; from the very ancient to the ultra modern. The number of small, one might almost say "owner-driven" foundries is considerable and they are not, as might be expected, scattered throughout the length and breadth of the land, but are largely concentrated in the most populous area in the Transvaal, around the gold and coal mines. About 85 per cent. of the foundries are on the Witwatersrand which, from the mining and engineering viewpoint, is the hub of South African industry. The remainder are mostly situated on the

* Paper contributed by the South African branch of the Institute of British Foundrymen and read at the Institute's Buxton Conference.

coast, and cater for sugar-mill, marine and general engineering requirements.

Almost without exception one finds a laudable attempt, in the planning of towns, to avoid the admixture of living quarters and industrial buildings which was, and will be for some years, a familiar feature of the English industrial town. Industries are located in selected sites and the residential areas are grouped in more pleasant surroundings, but not so isolated as to cause difficulty regarding transport. To one familiar with the British foundries, there is an air of spaciousness in the layout of the South African ones. Most of the buildings have plenty of space outside but, like foundries in other lands, very little room inside; and the grass grows around, in some cases in a civilised fashion, and in others just high enough to hide the box parts for which one is looking.

In the Union there are approximately 180 foundries, in many cases producing castings in more than one type of metal. There are 124 foundries producing castings in grey iron, white iron and Meehanite, 17 steel foundries, and malleable is represented by two blackheart foundries and one small producer of whiteheart. There are 85 foundries, mostly of very small capacity, which produce non-ferrous castings. Mechanised foundries are few and far between. There are a number of semi-mechanised plants and various projects are being considered which aim to increase the number of foundries employing mass-production methods. At present there are eight mechanised units in operation. Table 1 shows comparative figures for South Africa, Great Britain and the United States, as to tonnages and number of foundries.

TABLE I.—*Annual Tonnages (in Thousands of Tons) and Employees in South African Foundries Compared with Great Britain and the United States.*

	Total tonnage produced.	Employees.	Iron foundries.		Steel foundries.		Malleable foundries.	
			No.	Tonnage.	No.	Tonnage.	No.	Tonnage.
South Africa* ..	181	14,400	124	134	17	45	3	2.5
Great Britain* ..	3,700†	185,000‡	1,800	3,364	102	238	130	111
United States ..	12,500	400,000	3,460	10,800	300	800	100	900

* Output given in long tons. † Iron and steel foundries only. ‡ Figure not definitely established.—ED.

Iron Castings

It would appear, from the figures quoted in the overseas journals, that the output of iron castings in the United Kingdom will be in the region of 3.3 million tons for the year 1949, from a total of 1,800 foundries employing 145,000 people. The comparable figure for South Africa's production, as far as can be ascertained, will be 134,000 tons from approximately 124 foundries employing 7,500. For the United States and Canada, the output is estimated at 10.8 million tons from 3,460 foundries.

There are few classes of iron castings which are not made in the Union. General engineering, mining, builders', railway and public-utility castings are all represented. While grey iron is naturally the most popular, Meehanite is made in 12 foundries and high-duty iron is produced to meet customers' requirements. The bulk of the white-iron tonnage is produced by one very large, and three medium-size foundries on the Reef. On the coast, iron castings of 20 tons finished weight, are produced for sugar-mill applications; but on the Witwatersrand they rarely exceed 14 tons, apart from occasional steelworks castings for internal use.

Of the total tonnage of 134,000, white-iron castings account for 40,000 tons and are mostly in the form of balls and ball- and tube-mill spares of simple design. A large percentage of these castings are produced in chill moulds. The production of Ni-hard for abrasion-resisting applications, as an alternative to unalloyed white iron, has so far been confined to a very restricted field. It would appear that a great future lies ahead for the development of this alloy; but due to the high price of nickel on site, this may be delayed until buyers are convinced, by the performance of the material, that the extra expense is justified. There is a small tonnage of cast iron produced for heat-resisting and other special purposes.

Malleable

The malleable production is about 2,500 tons per annum which compares with 111,000 for Britain and 900,000 for the United States and Canada. The bulk of South African malleable is in blackheart. While there are three foundries producing malleable, one foundry is responsible for 84 per cent. of this tonnage. This will be considerably augmented when production commences in the next few months in one of the most modern plants. This foundry, it is understood, will introduce gaseous malleablising in the country for the first time.

Steel Castings

Again basing an estimate on figures which have appeared in overseas reviews, 238,000 tons of steel castings have been produced in Britain during 1949, from about 102 foundries employing 19,000, and in the United States 800,000 tons from 300 foundries. South Africa's production has been 45,500 tons from 17 steel foundries employing 3,300. Castings in straight-carbon, carbon-chrome and austenitic-manganese steel constitute the bulk of the tonnage, and here the mines, the railways and other public bodies are the chief customers. In steel, the heaviest casting which could be produced under normal condtions, would be about 16 tons. Austenitic-manganese steel for the mines accounts for about 11,000 tons annually. Ball-mill shell liners, weighing from 200 to 500 lb. each, are one of the "plums," being in the best sense of the term, "nice and lumpy," without intricate cores or any of the complications which harass the life of the foundryman. The remainder of the tonnage comprises ball-mill spares, crusher jaws, mantles, concaves, chute liners, scrapers and similar castings where the work-hardening properties and impact resistance of the material can be used to advantage. The tonnage of high-alloy steels is low, but with the restriction imposed by Import Control, the local production of castings in special steels will, doubtless, become more of a necessity.

Non-ferrous

The non-ferrous tonnage is difficult to estimate, but may be in the region of 4,500 tons annually, from approximately 85 foundries employing 3,700. This compares with an estimated British tonnage of 45,000. The heaviest casting normally produced in non-ferrous metal is around 6 tons.

PLANT

South Africa, as a land of gold and diamonds has, since its industrial awakening, been the happy hunting ground of plant manufacturers from all over the world, and one is amazed at the cosmopolitan collection of gear which is found. Australia, America, Britain, Canada, France, Germany, Switzerland, Sweden, all have contributed their quota to building up the industry. It would be gratifying to say that the cream has been skimmed from the products of each nation to give us the best possible world of all worlds. But unfortunately, here as elsewhere, experience must bow to expediency and, in many cases, one cannot buy the best plant, but what one can afford, and even then, one may be restricted to what is obtainable. Nevertheless, to prevent a wrong impression, it should be made clear that there are many examples of the most modern types of plant; a fact which pays tribute to the progressiveness of the foundries concerned, without casting odium on the others who might invest in similar plant if they could afford it.

The South African foundryman is well served in the field of constructional engineering, and the more recent plants are housed in light, airy shops of modern construction. Unfortunately, many of the buildings are not modern, or even light, or even well ventilated, but one is consoled by the fact that these are diminishing in number and gradually being replaced by more modern shops. Due to the recent birth of the local engineering industries and the comparatively small market for foundry plant, coupled with deliveries from overseas which, these days, involve periods of time which can only be apprehended by someone with a geological training, many of the refinements, open to the smaller concerns in Britain and America, are missing from our industries here. To take but one instance:—Box parts of the rolled-steel precision-manufactured type, which delight the heart of the anti-cross-joint brigade and defy the efforts of the knock-out squad to bring their useful life to an untimely end, are few and far between (with one or two notable exceptions among the more modern concerns), and productivity suffers accordingly.

Melting Plant

Ironfoundry melting plants, being similar to overseas, need little comment. Many of the cupolas are provided with some form of mechanical charging. There are two air furnaces in use, the larger, a 20-ton unit, melts metal for malleable production. Converters are represented by three Bessemers, and there are, at present, eight Tropenas side-blown units ranging from one to three tons in capacity, apart from installations in course of construction. Non-ferrous melting is carried out in an assortment of the usual tilting, reverberatory and pit furnaces, fired by coke, coal and oil. There are six open-hearth furnaces, capacities of which range from 35 to 150 tons.

Electric Furnaces

The bulk of the tonnage of steel castings is produced from electric furnaces. As may be seen from the figures in Table II there is a total of 41 electric-arc melting furnaces in the Union. Of this total, 39 are of the orthodox direct-arc type, and two operate on the Soderberg principle. There are several indirect-arc rocking furnaces and three high-frequency installations of small capacity.

Dealing first with the direct-arc: examples range from the very ancient to the latest product of the furnace manufacturers. The majority are basic-lined and have hand-operated electrode control, are operated by native labour, and are notable for the low electrode voltage and, in many cases, inadequate transformer capacity. What with fixed roofs, hand charging through slide doors, lack of adequate seals and manual control for electrode operation, the tap-to-tap times on the older furnaces are high by modern standards. In most cases, single-shift five-day week operation is carried out and the refractory life suffers accordingly. The improvement in electric-furnace design is markedly evident when one contrasts, almost side by side, the performance of the modern with the older furnaces. Watford, Westinghouse, Rotodyne and Arnas operating gear are utilised on the electrode-control systems of the newer furnaces. Electrical-power costs vary considerably and, at present, certain furnaces run on maximum demand and others on "per unit" charge. The largest furnaces are of a rated capacity of 10 tons. The two Soderberg-type furnaces use electrodes of 30 in. dia., and are engaged in the production of ferro-alloys and calcium carbide. The manufacture of direct-arc furnaces, incorporating the latest advances in design, is now being tackled in a determined manner, and the first ten-ton unit, of

TABLE II.—*Melting Furnaces in South Africa.*

Type.	No.
Direct-arc	41
Open-hearth	6
Air	2
Tropenas	8
High-frequency	3

completely local manufacture, is expected to be in operation by the end of this year.

Moulding and Core-making Machines

Moulding machines range from the humble hand press and plain jolter to jolt-rollover machines, the largest on record being a jolt-rollover which takes a 7-ft. by 4-ft. box. The total number in the Union is approximately 440, and jolt-squeeze types are the most popular, accounting for over 32 per cent. Table III is the percentage analysis of the various types in use.

Table III.—*Moulding Machines in South Africa.*

Type.	Per cent.
Jolt	18
Squeeze	1
Jolt-squeeze	32
Jolt-strip	1
Jolt-squeeze-strip	21
Jolt-rollover-pattern draw	18
Jolt-squeeze-rollover-pattern draw	8
Down-sand frame	1

The machines, generally speaking, are mechanised voices in the wilderness of manual operation and are, at times, subject to contumely which should be more justly visited on the inadequate provisions for sand supply and, on the larger machines, for removing completed moulds. In addition, the more complicated machines suffer through lack of spares and insufficient attention to preventive maintenance. All reputable manufacturers are well represented and good outputs are obtained, comparable with overseas, on machines which are adequately serviced as regards ancillary plant.

The types of moulding boxes in general use do not permit the machines to give of their best. The boxes, in many cases being of cast iron, are heavy and cumbersome to handle, and it would be disturbing to calculate how much extra and unproductive tonnage is moved around each day in using tackle of this nature. It would be idle to debate on the merits and demerits of the many types of machines in use but, perhaps, one might be forgiven the remark that the more popular types owe their popularity not so much to their superiority in performance, but to the virility and resourcefulness of the particular salesman who is selling them.

Approximately 65 coreblowers are in use throughout the country. There are eight Sandslingers, including three Speedslingers which have recently been imported from America.

The most recent of these Sandslingers is installed in one of the foundries belonging to South Africa's largest engineering corporation. Although the machine shop and fabricating plant in this organisation are equipped with everything that one could desire in the way of modern plant, the foundry deserves special mention in so far as the plant is of the very highest quality, and is the envy of every right-thinking South African foundryman. This foundry is an excellent example of how South Africa has drawn from international sources in foundry plant to equip her industries. The sand plant uses two of the three Speedmullers at present in the country, and the cleaning department boasts the latest version of the Hydroblast.

Shake-outs

With the exception of three South African foundries, mechanical shake-outs are conspicuous by their absence. The knock-out is carried out, in many cases, by the back-shift gang whose chief characteristic is a fervid desire to test the strength and durability of the boxparts. No doubt, more of the foundries might be induced to install a simple mechanical shake-out but, as this operation is carried out by native labour, the initial outlay and expense involved in the installation of shake-out and sand conveyors has proved a very effective deterrent. Few plants work more than the normal day shift and, therefore, the floor is taken over at night by the knock-out squad, without the general upset which would result if normal production was being carried on at the same time.

Sand Plant

Usually sand preparation is carried out in sand mixers which, if one was quite honest, would be called sand mills, only 14 per cent. of the total being modern imported mixers. Nevertheless, despite what the acknowledged experts in the field of sand preparation would term the maltreatment of sand, it will need some very definite demonstration of the improvements to be expected to convince the users that the installation of more expensive plant is justified. Skip hoists for feeding the mills are also in evidence but, with a few exceptions, there is much scope for mechanisation in the handling and preparation sections of the foundries.

Arrangements for the internal transport of sand are of a simple nature, in which an important part is played by the humble wheelbarrow. True, these methods call for small initial outlay, but perhaps few realise to what extent the overheads are increased, directly and indirectly, by the unproductive man-hours involved in sand handling and waiting for sand on the floor itself.

Furnaces and Stoves

Heat-treatment furnaces are, in many cases, of straightforward design with fireboxes opening directly into the heating chamber and from thence, the products of combustion find their exit from flues at bogie level to the stack. Quenching tanks are usually of an elementary, in fact, almost primitive construction, and one finds evidence of a simple faith in the beneficence of Providence, when viewing the altogether inadequate capacity of the tanks which, in some cases, are devoid of circulating systems of any kind. Mould and core stoves are also of straightforward design and while the majority are coal-fired, there are several core ovens which are electrically heated. There are two examples of the modern vertical core-drying oven.

Patternshop Plant

Patternshop plant consists, in the main, of the usual circular saws, band saws, thicknessers, lathes, discs and bobbins. The outstanding shop is in the large engineering factory which has already been mentioned. This is a well-laid-out shop, fitted with the latest in patternmaking machinery, including one of the few Universal woodworking machines in the country

Fettling-shop Plant. Fettling-shop plant is similar to that found in the United Kingdom and requires no special mention.

Laboratory Equipment

The bulk of the foundries are provided with laboratory equipment of some kind. In the smaller establishments, only the bare minimum of equipment is provided to cater for the routine chemical analyses. About a dozen foundries possess facilities for physical testing and the preparation of metallographic specimens, and one foundry has recently installed a one-million-volt X-ray plant. Control instruments are in general use for hot-metal temperatures, heat-treatment furnaces and, occasionally, for mould and core ovens. Many of the furnaces and stoves are fired by automatic stokers and are thermostatically controlled, Chromel-Alumel thermocouples being employed in most cases.

It will be understood that the market in this country for temperature-measuring instruments is too small to justify local manufacture. It is, therefore, necessary to import complete units and furthermore, to maintain an adequate supply of spares in the way of sheaths, bare wires, insulators and lead wires. There are several local firms which undertake the repair of the electrical instruments, but the industry seems to suffer from a chronic shortage in the matter of sheaths, both of the refractory and metal types. Refractory sheaths do not stand up to the rough handling to which they are subjected by the unskilled native furnace boys, and the incidence of breakages is abnormally high. Thus, one is regularly confronted in the morning with a situation which inevitably reminds one of a parallel in the days when Britain was *not* quite so democratic, in other words, the native equivalent of "It just fell out o' me 'and." These breakages are doubly unfortunate, as the industry is entirely dependent on overseas sources and Ni-chrome sheaths are in very short supply at present. The only people who could manufacture these locally are much too busy fulfilling bulk orders of standard materials, to concern themselves with meeting the small demands for components of this type. Another factor which tends to reduce the lives of sheaths of the Ni-chrome, 18-8 stainless and Inconel types, are the gases generated from the high-sulphur content of some of the coals. For these applications, chrome irons have proved most successful.

There are three immersion pyrometers of the indicating recording type at present in use for the measurement of liquid-steel temperatures. These, as far as the Author is aware, are the only instances in the industry where platinum-platinum/rhodium thermocouples are employed, although optical pyrometers are common in the larger foundries for the measurement of pouring temperatures.

RAW MATERIALS

Pig-iron

The United Kingdom production for the year will probably reach 9½ million tons of pig-iron and ferro-alloys, from a total of 100 furnaces in blast. In South Africa, the production for the year will be 700,000 tons of pig-iron and ferro-alloys, from a total of five furnaces in blast. The capacities of the local furnaces are as follow:—3 furnaces, 450 tons per day each; 1 furnace, 270 tons per day; 1 furnace, 130 tons per day.

An additional unit will come into operation in 1950. This will be a 800-ton-per-day furnace and will increase the pig-iron production by 40 per cent. The development in this section of South Africa's industry is noteworthy when it is considered that, while pig iron was made in Natal as early as 1918, the first of the large furnaces now in blast did not come into operation until 1934; the others followed in 1936, 1938, 1942, and 1945.

The following grades of pig iron are available: Foundry, five grades; hematite, two grades; basic, one grade; phosphoric, two grades. In view of the relatively small market, users are restricted to the above grades, as no special pig irons are produced in the country. Ferro-silicon, ferro-manganese and ferro-chrome are manufactured locally, and the tonnage for 1949 was 12,300 tons, which compares with 180,000 to 190,000 tons in the United Kingdom.

Coke

Coke production is approximately one million tons per annum, and for the general-engineering industries there are only three sources of supply. South African coke is high in ash, and the sulphur content is also a matter of concern.

Table IV gives some comparative prices of pig iron and coke:—

TABLE IV.—*Pig Iron and Coke Prices.*

	Foundry pig iron.	Foundry coke.
	£ s. d.	£ s. d.
South Africa*	8 9 0	2 16 0†
Great Britain[2]	10 0 0	5 8 10
Belgium[2]	14 17 3	8 12 9
United States[2]	20 5 0	9 3 6

* Figures modified to suit long tons.
† Delivered Reef.

The steel scrap position is difficult at times owing to the increasing demands of the industry and the inadequate loading and transport facilities available. The country possesses vast resources of the raw materials used in the foundry industry.

TABLE V.—*Annual Tonnage of Imported Foundry Materials.*[3]

Material.	Tonnage.
Graphite powder	50
Aluminium metal	20
Ferro-titanium	35
Nickel shot	30
L.C. ferro-manganese	20
L.C. ferro-chrome	15
Ferro-tungsten	10
Ferro-vanadium	2

According to published figures, annual imports in this respect are of minor significance, as is shown in Table V.

Moulding Sands

The Reef foundries have access to a number of sources for sand supply. In the Pretoria-Magaliesberg area there are large deposits of sands containing 98 to 99 per cent. SiO_2, and red and yellow sands with 9 to 10 per cent. clay grade substance. The clay-containing grades are used extensively as natural moulding sands. The silica sands contain a large percentage of fines, and facilities exist for washing and classifying them to give a range suitable for various applications; the range extending from A.F.S. fineness No. 32 to 44 in the coarsest grade, to A.F.S. fineness No. 160 to 180 in the finest grade.

Pretoria sands have excellent durability and react favourably when subjected to the high-temperature conditions of steel foundries. The clay in the naturally-bonded sands appears to be of the illite type and in this instance the clay possesses very low durability. The Rand foundries are able to draw upon vast quantities of mine-dump sands which have accumulated from the crushed gold-bearing quartz reefs. These sands vary considerably in grain size from dump to dump. The methods adopted in recent years in the gold-mining industry have resulted in a sand which is too fine for many foundry purposes, but some of the older dumps contain sand of convenient grain size. These sands may be graded to A.F.S. fineness 60 to 130; their refractoriness values vary according to the proportions of harmful impurities present.

Silica sands of a high degree of purity (99.5 per cent. SiO_2) are found in the Cape Province. These sands are said to be too coarse for iron and non-ferrous work, and disintegrate to a marked degree when subjected to thermal shock. Deposits discovered recently in the Orange Free State are being used successfully for green-sand moulding of baths, soil pipes and stove parts. An excellent naturally-bonded sand is quarried on the Vaal river, near Vereeniging, but the transport charges make the price of this sand prohibitive to all but a few of the local foundries. The most popular " non-ferrous " sand is found at Barkley Bridge, near Port Elizabeth; this sand contains 12 to 14 per cent. clay-grade substance.

Bonding Clays

Until recently, imported clays were used extensively throughout the Union for sand bonding. Sad to relate, the bentonite position has now deteriorated and it would appear that South African founders are faced with a future in which bentonite gets rarer and rarer and costs more and more. This is a matter which is causing concern, as the local deposits have yielded few clays which possess the desirable qualities found in bentonite. There are a number of local clays marketed under proprietary names, which are being used as substitute materials. Although inferior in some respects to bentonite, mixtures containing certain of these clays have a higher moisture retentiveness, and the castings strip well. While the Author feels that in this instance detailed technical considerations are uncalled for, Table VI gives a comparison in properties and price relationship between imported and local clays. For the purpose of comparison, clay additions were varied to give 4.5 lb. per sq. in. green compression, moisture was held at 3.5 to 4 per cent., and milling time was standardised at 5 min. The Council of Scientific and Industrial Research is carrying out further investigations regarding local deposits and their suitability for foundry use.

Table VI.—*Comparisons of Imported and South African Bonding Clays.*

Type of clay.	Per cent. clay by wt.	Compression strength (lb. per sq. in.).			Permeability	Price index.
		Green.	Dry.	Baked.		
Bentonite	2.06	4.5	60	90	95	1.00
Imported clay	2.16	4.5	40	63	88	1.14
South African clay No. 1	2.88	4.5	30	67	80	0.60
South African clay No. 2	3.66	4.5	35	51	75	0.94
South African clay No. 3	5.16	4.5	35	45	65	0.31

Refractories

South Africa is practically self-supporting in respect to the supplies of refractories. Six works produce firebrick and fireclay goods and two of these plants also manufacture a comprehensive range of silica and basic refractories. Production methods in these two largest works are comparable with the best overseas practice, bricks being formed by mechanical and hydraulic presses and fired in modern tunnel kilns, by producer gas, or in coal-fired down-draught kilns.

Firebricks are manufactured from first-quality fireclays which are found within a 60-mile radius of Johannesburg. Normal high-duty and super-duty qualities are produced in the standard-brick series, as well as in special shapes. A complete range of specialties, including high-temperature bonding mortars, ramming mixtures, castable blends, plastic firebricks, maintenance coatings and insulating firebricks is also available. Magnesite refractories are produced from Transvaal and Rhodesian magnesite. Rhodesian chrome ore is used in the manufacture of chrome and chrome-magnesite products.

Silica brick is available in two qualities; the normal quality, manufactured from crystalline silica, which compares well with the overseas brick, and " super-duty " silica brick made from a unique crypto-crystalline type of silica rock occurring in the Cape Province, which resembles in character the "Findlings" quartzite of Germany. The so-called "sillimanite" type of refractories are locally produced from beneficiated andalusite sands found in the Western Transvaal. South African Refractories, in general, compare favourably with overseas products. A comparison of the properties of some selected South African firebricks are given in Table VII.

TABLE VII.—*Refractories Produced in South Africa Compared with Imported Varieties.*

	Alumina content per cent.	Cone fusion point, deg. C.	Apparent porosity, per cent.	"Re-heat" volume change, per cent. contraction or expansion.	
				2 hrs. at 1,400 deg. C.	2 hrs. at 1,600 deg. C.
British siliceous fireclay	27.30	1,550	24.26	4.0 exp.	—
South African normal duty	30.35	1,665	20.25	0.8 con.	—
United States intermediate	32.35	1,665	18.22	0.5 con.	—
South African high duty	35.38	1,723	20.23	0.4 con.	—
British normal fireclay	35.38	1,710	20.23	0.6 con.	—
United States high duty	37.40	1,723	16.20	0.5 con.	—
South African super duty	40.44	1,752	18.20	—	0.5 con.
British, 42 per cent. alumina	42.44	1,750	15.18	—	0.3 exp.
United States super duty	42.44	1,752	14.18	—	0.2 con.

Timber for Patternmaking

During the war years, local timber was used in many of the pattern shops, but on reversion to peace-time conditions, a decided preference has been shown for the imported material, the bulk of which comes from North America. The types of timber used are governed by their availability, but Monticola, Idaho and Clear pines are the most popular. Where patterns and coreboxes or loose pieces of a more durable nature are required, mahogany (local or imported) and teak, where obtainable, are used. The African mahogany, like many of the indigenous woods, is, in the opinion of users, inferior in texture and working qualities.

The Department of Forestry is in the process of developing plantations of Pinus Pseudostrobus and Pinus Montezumæ, which, it is hoped, in the fullness of time will provide woods suitable for patternmaking. At present, the volume of locally-grown timber, which is old enough and likely to be available annually, is very small. During recent years, the use of plywood and laminated wood has increased considerably. Aluminium is, by far, the most popular medium employed in the manufacture of metal patterns for quantity production.

Design and Feeding Technique

Under the heading of design and feeding techniques the Author largely confines his remarks to steel castings, as it is generally accepted that the quality of iron castings has improved to a marked degree in recent years. In the last decade, the methods adopted to ensure sound, dense steel castings have undergone many developments and what might be termed a more scientific note has crept into what was once considered the rather mysterious and mystical rite of "putting the hole where it could do the least harm."

The introduction of whirl-gate heads, atmospheric heads, Washburn cores and other advanced methods has played its part in improving the quality, while non-destructive inspection technique has proved invaluable in assessing the efficacy, or otherwise, of the methods adopted. In these advances, the customer and inspecting bodies have played an important part, in as much as their constant demand for improvement in castings in all directions has stimulated producers to study and apply any developments which may help in attaining a higher standard of product. In Britain and America, the adoption of these methods has, in many cases, improved the yield and cut fettling costs; but steel foundries still show a high ratio of runners and feeders to finished castings. In South Africa, as elsewhere, there is still much room for improvement in the running and feeding technique.

To the Author, who, perhaps unfortunately, is inclined to think in terms of pressure-resisting steel castings, the yield in some of the local steel foundries seems high. In the field of general engineering there is evidence of a more enlightened attitude regarding the necessity for adequate and correctly-designed gating and feeding in producing sound castings. In this trend, the growing number of inspecting bodies are playing their part. In addition, South Africa's first foundry X-ray plant is now installed. It is to be hoped that this revealing medium will cause many to pause and further consider problems of unsoundness in their castings. The old habit of attempting to produce good castings from bad designs is dying out, and there is a salutary move to query and modify the design of components where improvement can be effected in physical properties and production technique without interfering with the functional purpose. In this respect, there is a spirit of hearty co-operation between engineers and founders, and it is seldom that any reasonable request is refused except, of course, when someone tables a request to make the job an inch thicker all over. In the matter of design in relation to casting defects, South Africa is taking advantage of the considerable literature published on this subject.

Costing and Estimating

The difficulties of the South African industry with regard to costing and estimating are largely common to overseas foundries, but one particular aspect should be mentioned which adds greatly to the problem of maintaining an economic and profitable establishment.

The significance of an adequate costing system.

which would enable estimating to be carried out on a reasonably accurate system of price per piece, has yet to be realised. Owing to the widely accepted system of generalising which is prevalent, there has been, and are, instances where the estimating department has presented the works with an impossible task in trying to meet the quoted prices. Despite the warning rumblings which are heard from time to time, there is yet no concentrated move in the steel-foundry industry to learn the lesson which actuated the excellent publications of the cost committees of the Institute and the American Foundrymen's Society. In this connection, the necessity for detailed planning regarding methods and available plant is not given the attention which it merits at the estimating stage. The result is that the individual who gives the prices from carefully-detailed estimating, may well lose the business to someone who quotes a low price on a weight basis without due consideration of all factors involved and who, while eventually gaining the order, may well lose money on the making of the casting.

It is a fundamental principle in any business that accurate production costs are essential to enable accurate quotations to be made. Some day, no doubt, through sheer force of necessity, there will arise a body similar to that existing in Britain, which will guide the Union on the subject of price levels for their products.

Personnel

Europeans: The total number of employees in the South African foundry industry is approximately 14,400, which compares with 400,000 in the United States and Canada, and approximately 185,000* in Britain.

The scarcity of skilled tradesmen is acute, no doubt in part due to the rapid development of the industry. There is a total of 250 patternmakers in the Union and, with the improvement at present proceeding in production technique, the increasing attention to pattern finish and dimensional accuracy, patternmakers are in great demand. There is, especially on the Witwatersrand, a tendency for patternmakers to change from one shop to another, chiefly for the benefit of experience and for higher rates; but a patternmaker without prospects of a job, is almost unknown in the Union to-day. This state of affairs, while adding to the difficulties of production, does make for conditions which, in some cases, have proved of considerable benefit to apprentices; enabling them to tackle more intricate work and to advance in the practical side of their craft more quickly than would be the case if more journeymen were available. In December, 1949, the total number of apprentice patternmakers was 202. The standard of the boys employed, from both practical and technical aspects, is fairly high and, as one finds overseas with the higher levels of management, the South African foundries are plentifully besprinkled with men who have graduated from the bench.

* Figure not definitely established.—Ed.

Throughout the Union, there is a total of 840 skilled and 326 production moulders. There are, at present, no moulders unemployed, despite periodical influx from other countries. Apprentice moulders number 400 and boys do not exhibit the enthusiasm for entering the foundry which the managements would like; but this reaction of youth does not appear by any means to be confined to South Africa.

The opportunities for a boy in the moulding shops of the larger foundries are good, as a wide variety of castings is made and he has the opportunity to gain insight into many facets of the trade. In this country, where native labour is available for the more mundane but nevertheless indispensable tasks, an apprentice can spend his working hours learning his trade and not acting as messenger boy and general factotum.

These two classes of workers constitute the main groups where there is a shortage of personnel and there is a fairly plentiful supply of other workers. It is of interest to note that, in the Transvaal alone, there is a total of 6,000 journeymen employed in the engineering industry, and of this total there are over 700 welders. This would point to the fact that South Africa has been quick to appreciate the advantage of this branch of engineering. It should also be noted, especially by sceptical buyers, that these welders are not all employed as "backroom boys" in the steel foundries.

Non-Europeans:—The handling of metal, preparation of sand, fettling, grinding and all other general labour is carried on by natives. This at one time was doubtless a cheap source, but, apart from the increase in natives' wages which has taken place in the last twenty years, the economy of native labour as compared with mechanical handling, from the long-term view is very much open to question. In many cases, the native African shows an aptitude for mechanical tasks which is much to be admired, but accidents are fairly frequent among them. Although the causes are obvious, the cure is not so easy, as the remedy would strike fairly deeply at the roots of habitual procedure. Whilst absenteeism does not assume any alarming proportions, there is a large turnover of labour due to dismissals and the loss of natives who periodically return to their kraals.

The native is taken on at the gate, more or less summarily given a job inside or outside the foundry and, in many cases, is moved around to suit production requirements. In the absence of vocational training of even the most elementary nature, his experience must inevitably be gained the hard way. It follows that accidents do occur when the raw recruits to industry are called upon to handle heavy weights and strange tools, tasks which, no matter how simple, do require some experience if accidents are to be avoided.

Welfare

In the matter of hygiene, South Africa has, generally speaking, made greater strides than in many other directions. The legislative measures, while at times irksome and expensive to struggling foundrymen who are chiefly concerned with production (and what goes over the weighbridge), are enlightened and far-reaching in their repercussions in the health and welfare of the individuals employed in the industry. The Factory Acts are concerned, apart from safety regulations and other considerations, in providing adequate facilities for each workman employed—European and non-European—in the way of clothes-lockers and washing facilities. While in practice the amenities are not always up to the high standard which is laid down under the Act, and again, while in isolated instances the privileges are abused by the individuals to whose comfort they minister, one is agreeably impressed by the clean and tidy appearance of both Europeans and natives leaving the works; in marked contrast to what the Author remembers of conditions in the times of the gentlemen in the moleskin trousers.

Full advantage is taken of these amenities by the non-European workers. During the installation of a new native changehouse, complete with wash-basins and showers, the Author experienced some little trouble with the compressor cooling system. Investigation revealed the fact that, due to temporary lack of washing facilities, the cooling-water tank contained soap suds and was being use as a communal bath. While this speaks well for the inherent desire for cleanliness in certain sections of the Bantu race, it will be appreciated that the dusky gentlemen were concerned more with the cleansing of their persons than with the more scientific aspects of compressor efficiency.

Industrial Disease

Occupational disease in the Union foundries is of negligible proportions as far as is known. There is no recorded case of silicosis in the industry and this state of affairs may be due, it is suggested, to the fact that comparatively few shot-blast plants are in use and that grinding is carried out in buildings which, apart from whatever dust-collecting provision has been made at the source, are subject to a considerable degree of natural ventilation. In some cases, the building consists of roof, and one or more sides are left open to the usually not very boisterous breezes. Respirators and goggles are provided but, at times, in common with overseas experience, persuasion is necessary to ensure that advantage is taken of these protective devices.

The incidence of silicosis has been so low as far as surface workers are concerned, that it has been considered unnecessary to make provision for this disease under the schedule of compensatable diseases of the Workmen's Compensation Act.

Housekeeping

Good housekeeping is a subject which in foundries all over the world receives to-day much publicity and in dealing with this aspect one is reminded of the famous ecclesiastic who advised a member of his flock to change the subject when the truth was inconvenient. Before doing so, it should be mentioned that there *are* one or two tidy foundries in the country, notably those belonging to the railways and a few of the larger units. In general, however, a delightful sense of irresponsibility exists in the siting of plant and the resultant layouts are not conducive to the efficient running of the shops. In many cases, frequent additions and alterations to meet prevailing needs are such that it would be difficult to improve the flow of material without recourse to major alterations.

Institute of British Foundrymen

The Institute of British Foundrymen (South African Branch), from a technical viewpoint, is a virile and expanding body. There is a total of 291 members and other grades. Meetings are well attended and Papers are usually followed by full and hearty discussions in which the ability of the South African foundrymen to appreciate their own deficiencies is often manifest.

Conclusion

The necessity for replacements of a wide variety of castings to meet breakdown emergencies has developed in the South African foundryman, a flair for improvisation which is one of their greatest assets. The experience gained in the last twenty years, and the gradual shift from empirical to more scientific methods, are combining to offset the difficulty of obtaining castings from overseas, and production work of a more intricate nature is now being tackled and, in many cases, castings are produced to the customer's satisfaction as regards both price and quality. The rough and ready methods which were employed when the Rand was a heterogeneous collection of gold-mining camps have served their purpose and, lest anyone should scoff at the early efforts of the South African foundries, it is germane to note that the individuals who introduced these same methods were largely the roving spirits from overseas, men, in many cases, who had in their youth gained their experience in some of Britain's most famous foundries.

What lies ahead is mercifully hidden from us all, but it would appear, if the present demand increases with the development of the country's industries, that partial mechanisation and more advanced technique will be forced upon the foundries by the continued shortage of skilled labour. With the improvement in plant and technique which will come in the future, it is to be hoped that the costing and estimating methods will develop to the stage where the foundries are not only sound from the technical viewpoint, but also from the economic viewpoint.

In conclusion, the Author would record his appreciation of the help and co-operation received from friends in South Africa and the United Kingdom in the preparation of this Paper, and would take this opportunity of sending greetings from the South African Branch of the Institute to the parent body.

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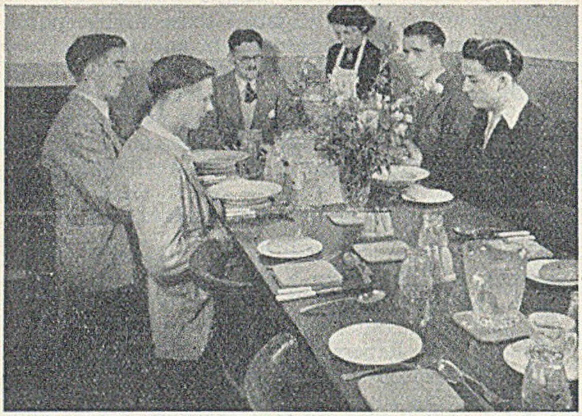

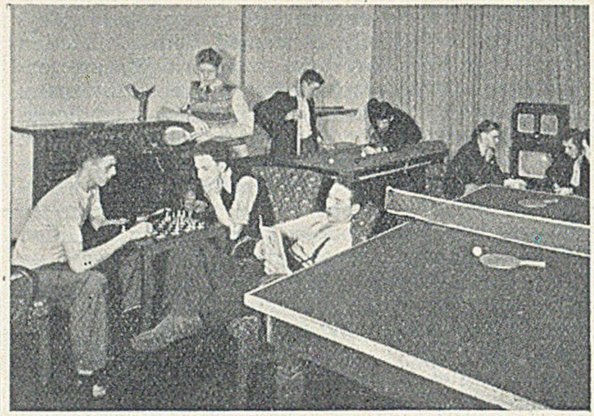

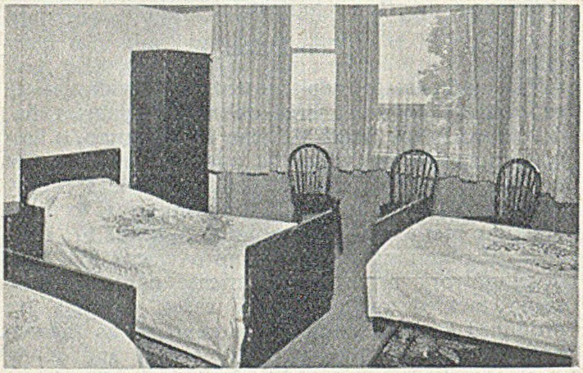

The National Foundry Craft Training Centre Hostel

Upper left : the Dining Hall

Upper right : the Recreation Room

Left : one of the Dormitories

Delegates to the Annual Meeting of the V.D.G (German Foundrymen's Association). *In the centre, the President, Mr. Kuster, is seen talking to Commendatore Olivo, President-elect of the International Committee. On Mr. Kuster's right is Dr. Hugo, V.D.G. Secretary and Editor of "Die Neue Giesserei."*

The Foundry, the Engineer and the Future*

By Dr. J. G. Pearce, O.B.E., M.I.Mech.E., F.I.M.

The engineering castings section of the industry is by far its most important branch, absorbing one-half to two-thirds the total output of iron castings. What is to be its future? It is important not to take for granted a future like the past, because it will be found that competitors in the plastic and welding industries and in other branches of the casting industry are highly technical and straining every nerve to get business Furthermore, initial low cost and weight for its own sake are likely to become factors of less and less importance in the industry unless they can be combined with technical suitability and absolute uniformity of quality in deliveries over a long period. Mere cheapness in itself, in other words, is an asset of diminishing importance. More importance will be attached to functional qualities—"will it do the job better than anything else."

THERE is no need to recapitulate the advantages of the cast form. From mainly home-produced raw materials, the engineer can be provided with a variety of sections in one piece ready for the machine shop, or, indeed, for immediate use, without a long chain of operations such as the wrought materials involve, creating problems of capital required and heavy stocks or, unless the "pipe line" be full, lengthy delivery times. This talk, it is not a Paper, is intended to stimulate thought and discussion, and does not pretend to offer evidence for all the suggestions made, but I believe that we are gradually building up the information and data on which the scientific design of iron castings can be based and that by using this and taking advantage of the higher strengths becoming available, we can ensure greatest satisfaction to our clients, the best results for ourselves, and make minimum demands on our native resources—in other words, become economic in a national sense.

Within the last 25 years, founding has changed from a locally-practised craft industry to a highly-technical industry. The implications of that must be accepted. Highly-skilled managers, trained technicians, men who are skilled and adaptable without necessarily in all cases being craftsmen in the old sense of the term, are needed. The industry needs a full organisation, a strong Institute of British Foundrymen, and Research Association, a group of fully-representative trade associations backed by the Joint Iron Council, and the National Foundry College and Craft Training Centre. With a positive policy and the right psychological outlook on production, I believe the next quarter of a century could win for iron castings enough of the much larger business now going to wrought materials to offset any decline in present levels of production.

The design of many of our castings has in the past been traditional or empirical, only modified by occasional failure. Can it be improved? I am going to suggest that it can and propose to direct your attention to three points which indicate a line of approach to the problem of re-designing, as a step to increasing our market, but which can be fully exploited only in the industry itself.

(1) The connection between composition or structure and strength of the material in a test-bar, and the connection between strengths of test-bars of various sizes.

(2) Relations between engineering tests.

(3) The connection between strength of the test-bar and strength in the corresponding castings.

Design

In dealing with this question of design, I will only refer in passing to the common engineering basis of design—Hoke's Law and the elastic limit. I have repeatedly stressed that the existence of this limit if largely a convention. The more accurate the methods of taking this test, the more does it appear that in fact there is no such thing as an elastic limit and we are well aware that in many applications, even the so-called ductile materials break with a brittle fracture, or so-called fatigue fracture, where alternating stresses exist. The cast crankshaft has proved itself—why not in static structures not subject to stress-reversal or stress-fluctuation? McCance said recently† that "the elastic limit marked the transition from elasticity to plasticity" and that "the stress at which the transition takes place will vary according to the conditions.

Composition and Test-bar strength

For purposes of this discussion we can confine our attention to carbon and silicon as elements of composition. You know we have to have carbon in order to make the material castable and silicon to make it grey. For these we sacrifice ductility. Now, when looking at a variety of analyses it is difficult to compare one with another end to estimate whether one is stronger than another or more

* Talk to the Lancashire branch of the Institute of British Foundrymen (abridged). The Author is director of the British Cast Iron Research Association.

† Journal of the Iron and Steel Institute, 1949, v. 163, November, pp. 241-249. "The Plastic Behaviour of Solids." by Sir A. McCance

castable, or more grey in a given section than another on account of the complexity and number of elements present. A convenient device which helps here is to get the carbon equivalent value, that is, the carbon the iron might have if it had no silicon and phosphorus in it at all. If it had not, of course, it would be quite white, but the conception is convenient. The C.E. value is the total carbon actually present by analysis plus one-third of the silicon and phosphorus (also by analysis), or in hematites, one-third of the silicon. Thus an iron with 3 per cent. carbon, 3 per cent. silicon and 1.2 per cent. phosphorus has a C.E. of 3.0 + 1.4 = 4.4 per cent. A malleable with 3.5 per cent total carbon and 0.6 per cent. silicon and no phosphorus has a C.E. value of 3.7 per cent. If the C.E. is over 4.2 per cent. the metallurgist says the metal is above the eutectic; it has kish graphite and is very open and coarse in heavy sections, and very few engineering castings should be so unless the graphite is compelled to take the nodular form. If under 4.2 per cent., the iron is below the eutectic; few irons are below 3.5 per cent. for reasons of castability, shrinkage and chill. The higher the C.E. the more easily melted, the more easily poured and cast and the mechanically weaker the metal is. The lower the C.E. the less easily melted, the higher the shrinkage and the greater the need for generous runners and risers, but the stronger the metal is. This is why the eternal compromise between the two is so important to the founder and each foundry has to find its own particular compromise for its products in one or a group of mixtures. Conditions of melting vary and are responsible for slight differences between one foundry and another. I am concerned at the moment solely with strength. If we take transverse strengths of hundreds of 0.875 in. dia. bars and plot them against C.E. we get strength rising as C.E. falls. The results[1] lie in a band and not on a line, but they do lie in the band. If we do the same for tensile strengths, we also get a band and a narrower one[2]—as we well know, the spread of transverse-strength results is greater unless you skin-machine the bars. If we take the mid-rib of these bands for each standard size if bar we get a series of roughly parallel straight lines, showing lower strengths as bar size increases.[3] If we plot bar size against strength (figures given in B.S.I. Specification 1,452 for the 1.2 in. dia. bar) we get for all grades roughly parallel curves showing the fall in strength with rise in section of bar.[4] Grade numbers represent the strength of the 1.2 in. bar. Dr. Angus has provisionally extended these curves to cover thicker castings (the great weakness of the B.S.I. specification at present), and Fig. 1 shows the result. I want to make it clear that these results are based on bars melted, cast and tested by many foundries. In any one foundry, the zone of uncertainty shown shaded in the figure may be much narrower. Dr. Angus finds that, plotted on a log-log scale, these curves become straight lines, so that they can be represented by simple exponential equations, and hence with the right constants, experimentally determined for individual conditions, the strength for any section of test-bar can be calculated without even a diagram, if the strength of one size of bar of similar material, similarly made, is known. (Since this talk was given, this relation has also been shown by Schneidewind and McElwell.)

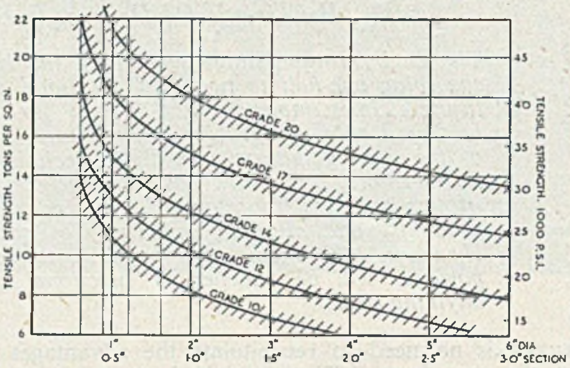

Fig. 1—Section Sensitivity of Cast Irons in relation to Tensile Strengths based on B.S. 1452 Grades.

It is clear that starting from a given metal mixture, made into a casting represented by a particular bar, you can get from the C.E. a very good idea of the strength you can expected. If it is low, there is case for examination. If it is high, it would pay to know why. If you cannot reach a desired strength you can soon work out what has to be done to the carbon equivalent to ensure that required. Conversely, you can work back from a strength needed by an engineer to the C.E. of your mixture and hence to the mixture itself. Of course, alloying, heat-treatment, inoculation, etc., will all affect the C.E.-strength relation.

Thus, from Fig. 1, a 17-ton iron (1.2 in. bar) or 19-ton iron (0.875 in. bar) would have about 12 tons in a 5 in. bar or a 2½ in. plate. This is another step forward in giving the designer what he wants.

Structure

Structure is only of secondary importance, since most engineering castings are pearlitic and remain so over a fairly wide range of compositions and strengths. However, you want to avoid mottling and so you should keep away from the danger line separating pearlite from cementite/pearlite. Although the connection between C.E. value and the production of white or mottled edge is not direct, Fig. 2 serves to indicate that the nearer you get to the zone separating pearlite and cementite for a given size of bar, the harder the metal becomes and the greater the risk of free carbide being present. In that region, the metal is so sensitive that, other things being equal, one coke might yield a mottle and another a grey iron. Note that, as the C.E. drops, the section to avoid free carbide increases; i.e., with C.E. 3.9, even a 0.6-in. bar is just grey (although the ends may be chilled), but at 3.5 a 1.2-in. bar is barely grey. Inoculation helps to offset chilling and mottling.

At the time of the first world war, engineering castings were about 14 or 15 tons tensile and 18 tons

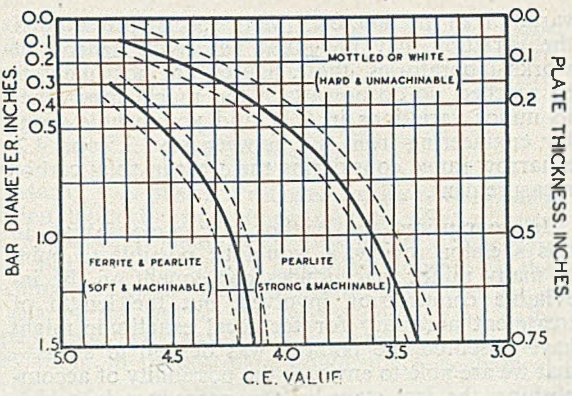

Fig. 2—Relation between Section Size C.E. Value and Structure.

was exceptional. When improvement began it was directed to the improvement of the matrix, following the lines which had proved so successful with the steels. Alloy additions and heat-treatment were explored. As nothing could be done to improve graphite flakes short of casting the iron white and malleablising it, then the quantity of carbon was cut down and the flakes became smaller as well as less in aggregate. Steel scrap was melted in the cupola as a charge addition and it reduced carbon. This brought about increased risk of chilling or risk of that kind of graphite (undercooled) which results from the breakdown of a chilled structure, and inoculation was used to offset this. Even so, the ironfounder was fast becoming subject to the handicaps of the steel founder, needing higher melting temperatures, more refractory sands and furnace linings and having castings of greater shrinkage and needing bigger runners and risers This whole situation seems likely to be modified by the development of nodular-graphite iron or ductile cast iron.

We have to execute a metallurgical somersault in order to think about it. We get high strengths even with relatively high carbon and silicon contents. We need low sulphur and phosphorus. Subject to this, we can get the nodular structure in all that remarkable range of alloys which the previous quarter of a century has evolved—ferritic, pearlitic, austenitic, martensitic, acicular, cementitic. Strength is greatly improved, but particularly ductility and shock-resistance.

Cerium alone gives some nodules and a modified form of graphite called "quasi-flake" which gives a much stronger metal than flake graphite. The addition a few seconds later of some ferro-silicon or other graphitiser gives a very fine, completely nodular structure, and in the magnesium process this double treatment is also found advantageous, which is essential to irons below the eutectic and to thin-section irons. Heavy sections can give a fully nodular structure without the double treatment. Considerable information has been published on the strengths and structures of nodular irons, which need not be repeated here, and most of the lantern slide illustrations are not reproduced. However, here is strength if the engineer cares to use it. We can give irons of a higher fatigue resistance (as measured in a Wohler fatigue test), or even yield point or proof stress, to-day than they had ultimate strength a few years ago. I do not suggest that the production of these irons is a simple matter. If they are to be made, a definite decision respecting policy is needed, not merely a desire to meet a specific order.

Relations Between Tests

I have to digress a moment to reply in advance to the objector who says that I am speaking constantly about the tensile (or the transverse) test and that these are not the only tests required by the engineer. That is true, but we can now substantially express any test in terms of the tensile result or transform the tensile results into the others.

You know the B.S.I. specification enables either tensile (T) or transverse (R) to be used, and if you convert the breaking load of the latter into tons per square inch, a simple and desirable procedure, the two are related roughly as T.R.S. = 1.8 U.T.S., or R = 1.8 T.

Approximately, Compression = 3 T
Torsion = 1.3 T
Shear = 1.2 T
Fatigue = 0.5 T

E—Young's Modulus—rises or falls with T.

The tensile test is not a particularly good test for cast iron, but it improves as the iron gets better. The technique of conducting the test is fairly well understood. It is well known that the transverse gives more "scatter," i.e., many results on the same iron vary over a wider range than with the tensile. There is no necessary relation between impact or shock strength and tensile.

The above figures do not hold entirely for both good and poor irons, but they suffice to convey the point. Of course, some designers may need magnetic permeability, electrical resistance, thermal conductivity, wear-resistance, etc., and these are not to be expressed in terms of mechanical stress. They can all be determined and the nodular irons behave substantially in accordance with the base structure.

Test-bar and Casting

The final stage is to link test-bar and casting. To do this I am going to suggest that there is a useful connection between the tensile test and the Brinell hardness number. The Brinell hardness, of course, can be taken on a casting without destroying it. The suggestion is that, in a trial case, two different sizes of test-bar should be cast with each casting (most appropriate to the casting involved) and the tensile strength and Brinell hardness taken on each. By plotting these two values, tensile against Brinell, and joining the two points, a characteristic slope for the particular grade of metal is obtained. If now, the casting itself is tested for hardness at various points, the appropriate tensile strength at these points can be obtained by reference to the graph. It is important to remember that the slope of this curve is characteristic only for the metal put into the particular casting and test-bars and cannot be applied under different conditions. There is no direct relationship between Brinell hardness and tensile strength for cast irons of widely differing structure, *e.g.*, austenitic, pearlitic, etc., but the relationship between Brinell and tensile in a given casting of one structural type can be fairly well established for a given melting regime in a particular foundry. Both the late Dr. Dübi and Dr. A. Collaud have done very useful work in this field, but it requires to be suppplemented by further work both in the research laboratory and in the foundry, and I hope this may stimulate it. To put it another way, suppose you cast a range of test-bars from the same metal as the casting and you get their strengths and B.H.N.s a part of the casting having a B.H.N. the same as one of the test-bars has the strength of that bar.

You may argue that, if this can be done on castings, it can be done on test-bars and the answer is that it can. In other words, the tensiles of a set of bars will be approximately related as their B.H.N.s and the hardness of one will serve to give the tensile strengths of the others. If this works out, we may look forward to being able to estimate the strength in any casting from tests on separately-cast bars of two sizes, any two sizes that are grey for the mixture and section involved, the strength of any section being estimated from the relative hardness values.

Conclusion

I hope the steps are now clear. From the composition you are compelled to use for a given casting you can get a good idea of test-bar strength from the C.E. value, and you can estimate the strength in an actual section by the relative B.H.N.s of that section of the casting and the test-bar. From the tensile or transverse you can get a good idea of any other strength in which the engineer is interested.

Some experience this way may help you to work in the opposite direction. If an engineer needs x tons tensile in a given section of a casting, you could estimate the strength needed in the appropriate test-bar and then obtain the composition (C.E.) required to reach it. Some handicaps must be mentioned. Unfortunately, ball hardness is not an easy test to make *in situ* by portable apparatus. The results are liable to vary and to be susceptible to some margin of error, but in its early stages this scheme will in any case contain various errors which the engineer's factor of safety can take into account.

Among others is variation in analytical carbon results. In our laboratory, duplicate determinations of the same sample by different chemists have to agree by ± 0.02 per cent., *i.e.*, a total variation of 0.04 per cent., the same as silicon or manganese. For high carbons and coarse graphite this reproducibility cannot be realised, due mainly to sampling difficulties rather than the personal equation, variation in method, etc. With special precautions, the variation may be ± 0.04 per cent. In routine works laboratories, these figures are not likely to be reached, so do not attach too much importance to minor variations in C.E. and your whole range for engineering irons lies between say, 3.5 and 4.2, a narrow range considering the error in total carbon measurement.

In conclusion, the Author is conscious that, in this skeleton review, it would be possible to point to many minor inaccuracies consequent on the inevitable compression involved, but the length of treatment necessary for technical exactitude might have obscured the point it was desired to stress—that we are able to envisage the possibility of accomplishing the last stage in the procedure in which the B.S.I. specifications to date have been steps, namely, that of providing a relation between the test-bar and the casting which goes beyond anything previously available.

REFERENCES

[1] Angus, Dunn & Marles, B.C.I.R.A. *Journal of Research and Development*. 1949, April, Fig. 8, p. 394. (Also given to the A.F.S., 1949, St. Louis.)

[2] *Ibid*, Fig. 2, p. 388.

[3] *Ibid*, Figs. 6 and 11, pp. 392, 397.

[4] *Ibid*, Fig. 14, p. 400.

VOTE OF THANKS

MR. T. MAKEMSON, O.B.E., proposed that a very hearty vote of thanks be accorded to Dr. Pearce for his extremely interesting and instructive Paper. They had listened to a very comprehensive review not merely of the present position with regard to cast iron, but they had received also some inkling as to what was likely to occur in the future. A very successful attempt had been made to show how the results of research work could be translated into the everyday work of design and the making of castings.

Dr. Pearce had a good many irons in the fire. Not only was he responsible for the technical direction of the Association he represented but a great deal of his time was occupied also in its administration so that it had now become a very strong and flourishing organisation of world-wide repute. In spite of the many urgent calls which were made upon him, however, he still found time and opportunity to deliver a lecture with a view to effecting further progress in the foundry industry.

MR. C. VAN DER BEN, who seconded, said that he could really only echo what had been said already about the lecturer. Dr. Pearce certainly held a unique position in the industry, and had displayed a breadth of view with regard to its interests and progress which was worthy of all praise. It was always a pleasure, as well as an education, to hear him lecture at any time.

The vote of thanks was carried unanimously by acclamation.

DR. PEARCE, responding, said that it was always a very great pleasure to him to return to Lancashire, which he regarded as having been his technical home for quite a number of years. He considered that whatever they could get Lancashire industrialists to adopt, would be accepted elsewhere without question.

DISCUSSION

Mr. C. van der Ben referred to the test-bars and their relationship to castings from the point of view of a practical metallurgist. He regarded the test-bar not as being in any direct relationship to the casting, but more as a guide when the foundryman was more or less off the beaten track in his daily operations. He was not quite sure just how far deviations in the test-bars would affect mechanical properties in the castings.

What was Dr. Pearce's opinion with respect to the degree of variation which might obtain on a comparatively small test-bar in contact with heavy castings? His own view was that the casting was not affected to the same degree as the test-bars which was only a guide to the quality of the particular casting.

He had been considering the question of nodular irons for some time. What were the most likely lines of development of that kind of material? Obviously, the cost of castings would be increased by such treatment and those who were concerned with the financial position would naturally desire to know what they were going to get out of it. Some use would have to be made of the increased strength by a reduction in the weight of castings or by a reduction of section. This rather presented a problem of design where it would not be easy further to reduce sections from considerations other than those of strength.

There was, of course, the problem of the castability of the material in sections which were already fairly light. It was not possible to bring the section down in relation to the increased strength obtained. Therefore it would seem to be a little doubtful how far such a suggestion would be commercially practicable.

Dr. Pearce thought that Mr. van de Ben was quite right in regarding the test-bar as developed at the present time as a test of uniformity of practice from day-to-day, and as a test of the strength of the metal in the casting rather than of the casting itself. Nevertheless, he did not think they ought to stop at that point. They had to face the fact that the day would come when engineers would expect to be able to infer, at any rate, from the strength of the test-bar what was the strength they might expect to get in the casting. He quite agreed that the test-bar represented the casting and that the variation in the casting itself would be less than that which would be got from a series of test-bars. Dr Pearce then illustrated the point by a sketch on the blackboard.

He did not think it was for him to say for what nodular iron should be used, but he imagined that its main application would be in the engineering field. It should be borne in mind that, if it was desired to use hematite iron, its availability placed some limit upon the purposes for which it could be applied. Particularly in the field of the smaller engineering castings for automobiles and oil engines, his own impression was that the extra strength could be used in order to trim design. Therefore it was a little alarming to be told that the design could not be trimmed, because of other reasons.

Of course, he knew what those other reasons were. If one was designing a Diesel engine, and then sought to design a liner on the theory pointed out by Lamé with regard to hollow cylinders, one would probably finish up with a liner ¼ in. thick for quite a large engine. Such a liner would not survive a passage through the machine shop; it could not be dropped two or three feet on to the floor without sustaining damage. Perhaps founders must take a new view with regard to the preciousness of the product they were making and not submit it to so many stresses in manufacture. As a matter of fact, he thought the new irons would so survive. One must expect to dispense with a great deal of weight, but a design where such saving could least be afforded should be not be the starting point.

Importance of Productivity

Mr. E. Longden thought that Dr. Pearce had dealt with the intrinsic properties of cast iron rather than covering the wider aspect of the foundry industry. The future of the industry certainly depended to some extent upon improving the values of cast iron, but they were all thinking at the present time in terms of productivity. The major benefits got out of the industry were really due to manufacturing capacities or productivity as represented by the number of articles produced, and their cost. Whilst the value of improved cast iron was very real, they must look forward to the need for increased productivity and, in this, great credit must be given to the mechanical and foundry engineer, the foundry planners and the foundry technicians.

The work of the Research Association had much to do with the problems of the production of castings of improved strength and soundness, but he did consider it necessary to balance the values of what they had been told during the course of the lecture. Dr. Pearce had referred to the intrinsic properties of cast iron and the increasing difficulty of castability and producing sound castings from metals of greater strength. But, after all, steelfounders had to produce sound castings from a metal with greater casting difficulties. If he was asked to express an opinion respecting the properties of a steel casting as against an iron casting when just merely increased strength was required, then he would prefer the steel casting. To ascertain the relative values of the sectional thicknesses of a casting as represented by test-bars was very optimistic. He would refer to experiments made on oil-engine beds which occasionally fractured. The tensile strengths varied from 7 tons in one part of the casting to double that in another part of the casting, with the same section and metal.

Personally, he did not suggest that for a very long time to come anything could be done in the way of estimating the strength of all parts of a casting through the agency of the test-bar.

Dr. Pearce said he would be the last to deny the importance of planning and productivity. His Association had announced already that they were proposing to set up a team for the express purpose of visiting foundries by invitation to ascertain if any advice could be tendered in order to increase the production rate of castings.

The question of the other cast metals raised a very difficult and controversial point for consideration. In France, the body which had recently been organised to deal with research in the foundry industry dealt with all the cast metals. In his, Dr. Pearce's view, the similarities of technique between one branch of the foundry industry and another were pronounced, yet all those techniques were very different from everything else in the engineering industry, so that he thought there was good ground for suggesting that they were best dealt with by one body. As long as steelfounders and ironfounders considered themselves as competitors, and both of them to be competitors of the light-alloy founder, then there would be difficulty in realising what was desirable on purely technical grounds while there were diverse commercial interests at stake.

He agreed that the question of ascertaining strengths of the actual castings in all parts would be a difficult and tedious one to solve, but he was not quite so pessimistic as Mr. Longden with regard to reducing such a problem to law and order: even to getting a bedplate in which all the metal in each of the various parts of the same section had pretty much the same strength or a strength which was predictable from its rate of cooling.

Relations between Castings and Test-bar

Mr. D. Fleming thought it was very refreshing to find that Dr. Pearce, together with Mr. Longden to some extent, had the courage to tell them they could at least see some way out of the fog of trying to assess a casting from determinable test-bar characteristics. Merely coincidentally, because of some reading he had been doing in the past few days, he had been impressed by the relation between the process that Dr. Pearce was suggesting and others used by metallurgists in different fields of research.

Turning to wrought-steel heat-treatment, the behaviour of steel on hardening was assessed on a test-bar on hardness at one end. After quenching on one end there were curves shown which, in many cases, were very similar to those which had been displayed upon the screen. The quenched end would be at Dr. Pearce's test-bar figure. The cooling rate was varying in the case of the quenched end, and was getting slower and slower as they went along the test-bar. In a second case, the smaller section corresponded to faster cooling-rate. The metallurgists used figures obtained in that way in order to predict quite confidently what was going to happen on a section in a given medium where he knew his cooling rates. Dr. Pearce was suggesting they should use the property which they could assess on a bar which was being cooled at a given rate in order to assess castings cooled at a given rate. He thought the words he had used were that the cooling rates were much more important than the section. He suggested to Dr. Pearce that a casting might have several places where it would be uniform but the cooling would be nothing like uniform. The cooling rate might not correspond to the section in quite so uniform a manner.

He hesitated to raise one further point because he understood there were engineers present. There was an assumption that much of what might be termed hypothetical casting was perfectly sound. This would seem to be rather a dangerous assumption. He had a feeling that the metallurgy of cast iron was advancing rapidly in some of the "high spot" fields, but there was still much that was not known about the handling of the commonest engineering irons on the foundry floor.

He assisted in making castings of varying sections which occasionally cracked, and he must confess that this was a source of worry to him. Another common problem was that of the casting which suddenly started to "leak" or suffered from external sinks. Much time might be spent in investigating such faults without one being really satisfied at the end of it that all the theories held on the subject had any solid and complete background. Was Dr. Pearce aware of any advances in research work in minor fields of investigation of that sort?

Dr. Pearce was very interested in Mr. Fleming's parallel analogy; it had not occurred to him but it certainly was interesting when one thought about it. He agreed with it really, and it was pertinent that Mr. Longden had raised the point that similar sections of a casting did not always cool at the same rate, and, therefore, in spite of the fact that they were of similar section they would not have similar strength. It was one of the things to take into account. Similar sections cooled at different rates on account of the presence of other masses in close proximity.

He had mentioned earlier that he could not deal with soundness except quite incidentally, but he thought that with suitable running technique the nodular irons were likely to be as sound as the high-strength engineering castings they would replace. This was partly for the reason they were relatively high in carbon and silicon.

He would like to assure Mr. Fleming that there was research work in active progress with respect to soundness, cracking and sinking, and it might be possible to say something about it at a later date. It was very important that even a cheap casting of low tensile strength should be sound, and that they should never be in the position of being forced to use extra metal to offset a possible risk of unsoundness. All the points which had been raised were valid, and he could assure everyone he had taken them to heart.

(*Continued on page* 350)

Making Aluminium-bronze Alloys*

By Marcel Cirou

The composition of aluminium/copper alloys is, in general, fairly complex. The alloy formed with 80 to 90 per cent. copper and the rest aluminium is the normal basis for foundry purposes. The addition of small quantities of iron or nickel and often both these elements together, to make up a total of which the maximum is from 10 to 12 per cent., yields alloys of high mechanical strength and showing good corrosion-resisting properties. Moreover, some of these alloys are capable of improvement by heat treatment.

The elements added should be contained in a specially-prepared master alloy. It is also laid down that practically the whole of the aluminium should be incorporated before the final alloying is undertaken. The mechanical properties of the aluminium/copper alloys vary widely with the composition. Thus it is recommended:—(1) Only to work with high-grade standardised materials, because, for example, the presence of zinc is undesirable, and (2) to calculate with meticulous care the composition of the charges, taking cognisance of the melting losses, which for aluminium will be of the order of 0.30 per cent.

Preparation of the Master Alloy

Starting off with virgin metals, it is necessary first to prepare a master alloy made from 33 per cent. copper and 67 per cent. aluminium, using a melting temperature of about 550 deg. C. The iron should be introduced as being part of a master alloy yielding the following composition Cu 50; Al, 25, and Fe, 25 per cent. The nickel is carefully added as cupro-nickel in small pieces, such as manufacturing scrap or 70/30 condenser tubes according to whether one uses copper alloys of 50 per cent. or 30 per cent. nickel broken into pieces of a size of a cube having a width of about an inch. When preparing a 67/33 copper/aluminium alloy the copper and the aluminium should be melted simultaneously in a pit-fired plumbago crucible. The crucible, after preheating to cherry red, is first charged up with the copper and then with the aluminium. The whole is covered with dry charcoal and the lid replaced. The melting should be carefully controlled so that upon the formation of a bath, it should be stirred with a graphite rod. The remaining copper and aluminium are then added.

When the metals are melted, after a further vigorous stirring and careful skimming, the alloy is cast as slabs in cast-iron moulds. For the preparation of a copper/aluminium/iron alloy, the same conditions are instituted. The crucible being heated to cherry red, sheets of mild steel cut into 2 by 3½-in. pieces are placed in the bottom of the crucible with the aluminium and copper. The whole is covered with quite-dry charcoal and the lid is put on. When this first charge sinks, the rest of the copper is added. On melting, there must be a vigorous stirring using a graphite rod, and without superheating, the alloy is cast as previously into cast-iron slab moulds, so as to set up rapid cooling and so avoid any chance of segregation. The preparation of the cupro-nickel is a little more delicate. It requires a fast-melting furnace. A tar-oil-fired furnace of 200-lb. capacity is the most suitable. Plumbago crucibles are again used. Cathode copper and nickel cubes or rondelles are charged together and the melting is carried out under slightly oxidising conditions, using a flux of the following percentage composition:—Manganese dioxide, 50, soda ash, 20, and silica sand, 30.

Progressively, as the charge descends, the rest of the nickel and copper is charged. When the whole is melted, about 0.2 per cent. of manganese is added. A vigorous stirring is given and, after skimming off, the alloy is cast as in the earlier cases into slabs or is granulated by teeming into water.

Making the Final Alloy

To obtain the final alloy, the proportions of the crucible charge must be meticulously calculated. It is possible to make-up the charge with 50 to 70 per cent. of scrap of the same composition. The scrap must be cut up small, be very clean, and come from a reliab'e source, and its composition must be correct. It is best to incorporate 30 per cent. new metal and master alloy. No matter what is done, it is necessary, in the calculations, to allow for a loss of about one per cent. of aluminium and then to add this proportion as virgin metal at the end of the melting period. The melting process for the compounding of complex aluminium bronze alloys, including the normal conditions of working on which some complementary details are added is dealt with in the following statement.

Complex Aluminium Bronze Alloys.—In the case of complex aluminium bronze, the final alloy is obtained by charging a pre-heated crucible and using the following sequence. On the bottom of the crucible, a little copper is placed; then the necessary quantity of the master alloy which will carry the requisite quantity of iron to be incorporated. This is fo lowed by the scrap, the copper and the aluminium/copper master alloy.

Heating should be carried out in a slightly oxidising atmo.phere and as soon as the metal has settled down and there is a liquid bath, it is then necessary to charge in the manganese and then the rest of the constituents except a small quantity of "make-up" aluminium which is to be added only when the bath is completely liquid. The alloy will then be vigourous!y stirred, but when doing this, the alumina skin covering the bath must not be broken. This stirring should be carried out by a rotary movement of an agitator within the bath. A careful slagging must then be undertaken by throwing on the bath either zinc chloride or cryolite or manganese chloride. The bath is then allowed to stand for 5 or 10 minutes and the surface of the bath skimmed, taking care not to disturb the alumina film. The temperature is controlled to

* Translated from the July issue of Fonderie

Making Aluminium-bronze Alloys

that envisaged for the job to be cast. This will depend upon the average section thickness of the casting and should be as low as possible, but for thin castings 1,200 deg. C. ought to be regarded as the maximum.

By way of example, should one desire to make an alloy consisting of 9 per cent. aluminium; 4 per cent. iron, and 3 per cent. nickel alloy, starting off with virgin metals, it will answer if one uses a crucible charge made up as follows:—

Cathode copper	66.530 kg.
Copper/aluminium	5.970
Cupro-nickel	10.00
Copper/aluminium/iron	16.00
Virgin aluminium	1.30
Pure manganese	0.20

Simple Aluminium Bronze Alloys.—The method indicated above is followed, with, however, the difference that the materials to be melted do not include either copper/aluminium/iron alloy or cupro-nickel. The order of charging thus will be: —first the copper, then the calculated amount of scrap; then the master alloy and finally the 0.2 per cent. of manganese and the remainder of the aluminium. There is the same need for vigorous stirring, for skimming, and for casting at the lowest possible temperature, 1,200 deg. C. being always the maximum. Attention should be drawn to the fact that all aluminium-bronze alloys should be cast as far from turbulence as possible.

The Foundry, the Engineer and the Future

(*Continued from page* 348)

MR. POLLOCK said that there were two points he would like to raise with respect to the production of nodular cast iron. He had been reading reports that the sulphur content was very low, that much research work had been done at Birmingham, and that its reduction was a long-drawn-out operation. Had any progress been made in the manufacture of nodular cast iron by the cupola process?

Low-manganese Iron for Nodular

Secondly, he had been assisting in doing some work on nodular cast iron; it was found that the hematite they used was low in manganese, and they got some very good results which were probably due to the low manganese.

DR. PEARCE was very interested in the last point, because one of the difficulties some people had was that the only hematite they could get had too high a manganese content to be any good. When the sulphur was taken out, the manganese was no longer required to take care of the sulphur and some of it began to take its place as a carbide-stabilising agent. If Mr. Pollock was right about the low manganese content then it might be possible to say something with respect to it later.

The first of the three objects of the addition which was made for the purpose of nodulising was to eliminate the sulphur. The process could not take effect until the sulphur was down to about 0.02 per cent., and it was fortunate that the cerium was a powerful de-sulphuriser. On account of the cost of the addition it was obviously desirable to get the sulphur down to its lowest possible figure to begin with. There had been no difficulty experienced in keeping it down to a treatable figure by the use of soda ash. Many tons of nodular iron had been poured from the cupola when treated in that way. Much of their own work had, however, been done in crucible furnaces as they could not otherwise handle the volume of metal required. One of the operations much under consideration at the present time was the possibility of introducing a metallic de-sulphuriser.

MR. H. MILLS remarked that there must be many castings of medium section in which the strength of the casting could be closely related to test-bar strength. During the war, he had found that the strength of a casting related very closely to the 1.2 in. diam. bar; sometimes it was exactly the same, sometimes slightly less, and sometimes slightly above it. The determination of the strength of a casting from the Brinell hardness would have to be worked out by everyone for his own particular class of metal. The Brinell hardness was so much affected by the phosphorus, apart from the pearlite.

DR. PEARCE said it was necessary to find some bridge between the strength of the test-bar and the strength of the casting that it represented. Evidence of that kind would be required in quantity in order to see how in a particular case the two sets of values could be linked and documented.

MR. MURRAY asked if frosty conditions could vary the structure of castings, especially in the case of moulds for light castings exposed to cold wintry conditions.

DR. PEARCE did not think that frost in the sand could affect the casting, subject to the sand itself being usable.

MR. E. LONGDEN said that the people in cold countries had used frozen moulds as an expedient for the closing of the grain of cast iron.

MR. MAYOR, speaking as a marine engineer, asked whether is was correct that nodular irons were much more steel-like than the usual cast irons. With regard to damping capacity, he would be interested to know how much difference there was from steel. If the modulus of elasticity remained at 25×10^6 lb. per sq. in. there would be an appreciable advantage for the same tensile strength. At the present time, there was a lowering of confidence in steel for certain applications. He suggested that if nodular cast iron could fill the gap there should be more propaganda devoted to this aspect.

DR. PEARCE said that the damping capacity of nodular iron was very much less than that of flake-graphite iron. It came, in that respect, intermediate between the steels and the flake-graphite iron. He thought there was no doubt whatever about that point. The modulus of elasticity was higher than that of ordinary grey iron. He had an example of a 0.875-in. diam. bar, tensile strength 27 tons per sq. in., with an elastic modulus of 22×10^6 lb. per. sq. in. Another example had a tensile of 30 tons, and elastic modulus of 25×10^6 lb. The figure for a good engineering grey iron was about 12×10^6.

Distribution of Industry Act 1950

By F. J. Tebbutt

THE DISTRIBUTION OF INDUSTRY ACT, 1950—an agreed measure of all parties—arises out of the Distribution of Industry Act, 1945, and contains new provisions and amendments of former provisions. These 1945 and 1950 Acts relate to certain parts of Great Britain, called Development Areas (being areas where there is or is likely to be much unemployment ordinarily) and to the provision of premises for industrial undertakings and to the distribution of industry in Great Britain.

Powers as regards Acquisition

Under the 1945 Act the Board of Trade can acquire land and on it erect factories and ancillary buildings (e.g., offices, canteens and houses for workmen) and means of access and so forth. For improving such services (officially "basic services") as power, lighting, heating, transport facilities, housing, health services, etc., the relevant Government Department, responsible for any such service, can make loans towards the cost of improving the service, which in practice means that any improvement made arising out of the Act would not be a charge on the rates of a local authority. The 1945 Act, however, while allowing the Board of Trade to acquire land and to build factories, gives no power to acquire existing factories. But this new Act does so if such a factory is not in substantial use, the method to be used being by way of a compulsory-purchase Order. If the owner or occupier is not in agreement with the Board as to whether the factory is or is not in substantial use (or will be within a reasonable period, e.g., three months), the matter can be taken to the High Court for a determination.

Grants and Loans

Financial assistance by way of loans and grants (grants mostly towards payment of interest on loans) can be obtained through the 1945 Act through the Treasury, via an Advisory Committee, but this is mostly allowed when finance is not easy to obtain from any other source. By the 1950 Act, however, new provisions concern grants, these being that if it is proposed to establish an undertaking in a development area or to transfer the whole or part (e.g., a new foundry) of an existing undertaking for it to be carried on in such an area, the Board of Trade can make a grant in respect of expenditure or loss arising in connection with the establishment or transfer. But for an applicant for such a grant to be successful, there must be exceptional circumstances present. The Act does not expressly define what are exceptional circumstances in this connection, but it has been stated in Parliament that, suppose a firm contemplated removing part of their existing works to a Development Area, but the cost of the removal and the setting up of the establishment or part would be prohibitive for an industrial concern, this would be a likely case for the Board of Trade to cover any abnormal and exceptional cost of removal and resettlement, subject to Treasury consent. The idea has been advanced also that this grant provision might cover any loss in the early stages of operation of the factory by the necessary employment of "green" labour.

In connection with the provision, the Ministry of Labour can make payments towards the cost of transferring key workers to a development area, in an undertaking which is being established by way of extension of, or in connection with, or by way of transfer of the whole or part of the undertaking. This would cover payments towards the cost of removal and resettlement of workers and their dependants, and towards their maintenance and welfare in the course of their removal pending their resettlement.

Special Notes

The listed development areas are now the South Wales and Monmouthshire; West Cumberland; Scottish; Wrexham; South Lancashire; North Eastern (this includes the County of Durham and such places as Newcastle-upon-Tyne, Middlesbrough, Sunderland, West Hartlepool, etc.) and Merseyside (includes Liverpool, Bootle, Birkenhead). In these areas there are 3,500,000 insured persons. These Development of Industry Acts are, of course, designed to give encouragement to the opening of industries in the specified areas to prevent unemployment figures rising in those areas, and the provisions are confined to those areas. But at the same time it is pertinent to note that in pursuance of this "encouragement" object, the Government has a certain amount of control over industrial development in other areas. By the Town and Planning Act, 1947, it is provided that before a factory of more than 5,000 square feet aggregated floor space can be commenced, the Board of Trade must certify that this is in consonance with the policy of distributing industry. No certificate is required, however, for new buildings of less than 5,000 square feet, or if the question applies to adaptation or conversion of an existing building, or in relation to some special cases.

Promoting British Trade

Private enterprise is responsible for the opening of a British trade promotion centre at 677, Fifth Avenue (at 53rd Street), New York City. The bodies sponsoring the project are the Dollar Exports Board; the Federation of British Industries; the National Union of Manufacturers; Scottish Council (Development and Industry); and B.E.T.R.O. The new offices will furnish full commercial services to businessmen, whether or not they are members of the organisations cited.

Commercial Vehicles. Commer Cars, Limited, of Luton, have sent us a folder which on opening-up illustrates and describes a wide range of lorries and a motor bus. With the folder there is a current price list.

Pistons from High-duty Cast-iron Bar

By "Tramp"

MANY jobs which were formerly made in ordinary cast iron are now required to be in high-duty iron to withstand the heavier loads imposed on them. Occasionally these castings do not lend themselves to easy production due to the presence of details which require thin sections of sand mould to form them. At these places the sand may either wash away or the metal burn into it, causing defective castings.

A typical case recently coming to the writer's notice was a particular form of piston approximately 4½ in. diameter and 5 in. long with a 2½-in. hole passing through, which had to be threaded to screw on to the piston rod. One end of the casting was shaped down and six slots ½ in. wide and ¾ in. deep were required cast to form, just like the castellation on a lock nut and for a similar purpose—the retaining of a pin passing through the piston rod.

When made in ordinary grey iron these slots were easily cast, but when using a higher grade metal trouble was experienced. Not only were some of the castings defective because of the sand burning-in and thus making the slots too small for the retaining pin—a defect which could be remedied to a degree by a machining operation—but they were often rejected after machining due to dirt inclusions in a very important part.

This casting had to be spotless, consequently the percentage of rejects was very high, and it was even suggested by the machine shop to substitute for the casting a piston turned out of mild-steel bar, with the slots subsequently machined, although the high-duty iron was preferred because of its properties. To overcome this objection due to the difference in section, but to incorporate the advantage of using a bar, it was decided to cast a number of plain bars of high-duty iron each long enough to make four pistons. By adding a heavy feeding head on top of the casting, bars of exceptional soundness were obtained and each piston machined up perfectly with the result that the price of the job was less than when made from single castings.

New Catalogues

Ductile Iron. Lloyds (Burton), Limited, Wellington Works, Burton-on-Trent, have successfully permeated their new brochure with a background of enthusiasm. This spirit is seldom encountered in trade literature. but where it is found it has a great sales potential, as enthusiasm, like measles, is catching. The catalogue is devoted to nodular, spherulitic, spheroidal, graphitic, or more simply ductile cast iron of the nickel/magnesium variety. The photographs are excellent and reveal instantaneously the marked difference between the old and new. The essential properties are clearly stated and engineers should be convinced that ductile iron as representing this new type of alloy, extends, and very usefully extends, the range of cast products at their disposal. The progress reported is substantial and the future of ductile iron would appear to be more than ordinarily promising.

Electric Motors. Higgs Motors, Limited, of Witton, Birmingham, 6, have sent us an abridged list of the more popular ratings for a.c. and d.c. motors and control gear. The amount of information contained within its sixteen pages is indeed prodigious, yet the reviewer believes that the service it undoubtedly gives to buyers would be improved by the addition of a code word for each model.

Dr. Dadswell presenting, on behalf of the Sheffield Branch of the Institute of British Foundrymen, a stainless steel tea set to Mr. V. C. Faulkner in recognition of his services, as a "Sheffielder," to the industry and the Institute.

Notes from the Branches

Newcastle-upon-Tyne

The first meeting of the session of the Newcastle-upon-Tyne branch of the Institute of British Foundrymen was held on Saturday, September 9, in the Neville Hall, when some 50 members and visitors were present.

Mr. N. Charlton, in the course of his presidential address, expressed some personal feelings on the subject of productivity in relation to the foundry industry. Whilst it was appreciated that higher productivity was vital to the economic recovery of the country, he thought it was not realised that its attainment was the personal responsibility of each individual connected with the industry. Although published figures showed that productivity in British foundries was slowly increasing, there was room for much improvement. He was of the opinion that the basic solution of the problem rested with personnel—planning and mechanisation were of no value unless personnel carried out the plans and operated the machinery efficiently and intelligently. Reluctance to accept new methods and adopt new ideas was not conducive to progress and, although there was a shortage of skilled and unskilled labour (a situation which must be accepted), this could not be used as an excuse for no increased productivity until it was definitely established that the best possible results were being achieved by the available labour force. Waste of labour and effort, particularly in the case of skilled men performing unskilled operations, must be checked. The defence programme would bring increased problems regarding shortage of power and probably materials, but this should give an extra spur to founders' effort.

Productivity Role of the Institute

The president was confident that the Institute would play a great part in assisting increased production. Discussion of various problems and the distribution of technical knowledge were of major importance, but the practical application of such knowledge was of still greater importance, and called for personnel capable of taking advantage of new developments in technique and able to train and guide workers in their use.

Mechanisation was a factor to be considered and, whilst in many foundries the type of work, numbers off each pattern, and other details would not justify the installation of elaborate mechanical plant, mechanical aids to production could be used to advantage. Often, simple and ingenious devices aided production, by saving time and reducing the amount of manual labour needed. Workers and plant were, in fact, interdependent and must be used to full advantage in any production scheme. Stoppages due to inadequate lifting facilities, lack of moulding boxes or supplies of raw materials must be avoided and a careful study of the handling and routing of materials to and from the various points at which they were required would be amply repaid.

Incentives

Mr. Charlton then continued with reference to time and motion study, and stated that to achieve maximum productivity this could be used to advantage, not from the point of rate fixing, but that of tracking down and eliminating unnecessary movements and operations with benefit to both workers and management. The provision of good conditions affected productivity and it was the duty of each employee to play his part in maintaining those conditions once they were provided. Foundries could be clean, well-lighted, -heated and -ventilated, and still produce castings efficiently and economically. In any remarks relating to productivity, it was impossible to exclude the term "incentive," and here the President said he did not wish to refer to the acquisition of money, but to the goods which money might buy. We have been subjected to austerity conditions for so long that many people accepted them as standard and appeared to be quite satisfied. Taxation, being extremely high, had a frustrating effect on both employers and employees, but if our standard of living was to be raised and taxation reduced, all must work for increased production.

Ironfounders' Productivity Team

Mr. Charlton then referred to the visit to America by a team of British ironfounders, of which he had the honour and pleasure of being a member, to study conditions in American jobbing foundries. Twenty-six foundries of various sizes were visited and every possible facility was given for the collection of data valuable to foundries in this country. Since the return of this team, a report had been prepared and would be available shortly,* and it was hoped that the remarks made in the course of this address would encourage members to study the report. There would be opportunities for discussion, when the full value of the visit would be extracted, the December meeting of the branch being devoted to this subject. Several members of the team, it was hoped, would be able to attend and answer questions.

Finally, the president said he felt that in the problem of increasing production, a great deal depended upon the development of a spirit of close co-operation between managements and workers. Both sides must recognise that increased productivity was a necessity over-riding all the petty differences and personal feelings which they might have. Common sense would play a vital part in the solution of the problems.

Mr. E. B. Ellis proposed a vote of thanks for the address and Mr. J. Walton seconded.

By kind permission of F. H. Lloyd and Company, Limited, two excellent sound films, "Flawless and British" and "All Star Casting," were then shown; these concluded the evening's programme.

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* Since issued by the Anglo-American Council on Productivity.