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PRINCIPAL CONTENTS

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Olympia

We were a little disappointed with the attendance by foundrymen at Olympia last Friday, which was their special day. Whether it was due to the working of a five-day week or the incidence of the holiday period, it was difficult to say. Relatively, Saturday was better, and it was pleasing to note that an offer by a works at Bognor Regis to their 200-odd employees to visit the exhibition at the firm's expense was accepted by 35. Nevertheless, the business done by the suppliers of foundry plant and materials seems to have been satisfactory. The exhibits are thoroughly representative of modern plant, except that sand preparation might have been given more prominence. The presentation of the machines is on a high level, but in a few cases the choice of colour was a little disappointing. For instance, whilst we like bright red for agricultural implements, it seems unsuitable for indoor application.

A matter about which we are perhaps a little pernickety is that of the lettering on important machines. The one that appealed to us most was for a line of compressors where the name of the makers was picked out in gold. At the other end was machinery where the name was carelessly splodged over with white, but perhaps it was unfinished. We expect a very high level for goods entering into the category of "exhibition" finish, and this has not been invariably achieved. On one stand we were informed that all the castings shown had been doubly "shot-blasted." This we could well believe, for they had the appearance of having been so treated continuously for a couple of days, as the surfaces had been, here and there, almost hollowed out. Again, there were cases where the castings sent for exhibition had been selected without proper scrutiny and, while they were quite adequate for purposes of commerce, they were not of "exhibition" finish. Other castings had been packed in damp straw, to the temporary detriment of their surfaces. We are well aware that engineers know quite well that there is a difference between "commercial" and "exhibition" finishes, but visitors to Olympia mentally compare only the latter.

An outstanding feature of the Olympia show is that it is truly a great market-place, for one meets friends from all over the country and from abroad. This year, the number of oriental visitors is extremely high, and where they are accompanied by their ladies, the gorgeous saris outshine the most colourful of the exhibits. Surely, if it be worthwhile for visitors from Rangoon and Bangkok to spare time for the examination of Britain's latest engineering productions, then obviously the foundrymen of this country should make a special effort to emulate their example.

Institute of Vitreous Enamellers

Annual Conference, Birmingham, October 3 to 6

The Institute of Vitreous Enamellers is holding its seventeenth annual conference this year in Birmingham, with headquarters in the Grand Hotel, and a full programme has been arranged. It will be noted from the programme that more time has been allowed for the discussion on the Papers, this being done following the outstanding discussions which took place during the most successful Spring Conference. By the kind permission of the directors, a visit to the works of S. Flavel & Company, Limited, Leamington Spa, where a new enamelling shop has just been put in operation, has been arranged. On the Friday afternoon, for the discussion session on "Defects," members are urged to bring along any example which they consider will be of interest. The "Question Box" will again be provided at each technical session and the discussion on the questions placed therein will be held on the Saturday morning. It is hoped that members will endeavour to bring their ladies to the social functions and thus ensure complete success. The ladies will, of course, have their own programme.

PROGRAMME

Wednesday, October 3.

4.30 p.m., Council meeting in the No. 3 Westminster suite, followed at 8.0 p.m. by Council dinner in the Jubilee Room.

Thursday, October 4.

9.30 a.m., annual general meeting (Windsor room); 10.30 a.m., film, "Dust Flow," presented by W. B. Lawrie, H.M. Inspector of Factories; 11.30 a.m., depart Grand Hotel for Manor House Hotel, Leamington Spa, for luncheon; 2.0 p.m., depart for visit to S. Flavel & Company, Limited, and 6.0 p.m., arrive Chadwick Manor Hotel, Knowle, for informal dinner and dance. The ladies' programme includes a mannequin parade at the Manor House Hotel, Leamington Spa.

Friday, October 5.

9.30 a.m., technical session. Paper on "Colour," by W. Ball (Windsor room); 10.45 a.m., report of the Scumming of Enamels Sub-committee; 12.30 p.m., luncheon; 2.30 p.m., discussion on "Defects," presented by A. Biddulph; 7.0 p.m., reception by the president, Dr. J. E. Hurst, and Mrs. Hurst, and the chairman, Mr. S. Hallsworth and Mrs. Hallsworth in the Grosvenor suite, followed by the annual dinner (evening dress) and dancing. For the ladies' party, tickets will be available for attending a film trade show in the morning at one of the cinemas in Birmingham.

Saturday, October 6.

10.0 a.m., reports from Sub-committees; general discussion and "Question Box," followed by luncheon.

All communications regarding these events should be addressed to the secretaries, John Gardom & Company, Ripley, Derbyshire, but hotel accommodation should be individually arranged.

The FOUNDRY TRADE JOURNAL *has a stand at the Engineering, Marine, Foundry and Welding Exhibition at Olympia (Grand Hall, Row F, No. 13, telephone number RENown 5122). This is in charge of Mr. L. Holt, the advertising director, and members of the Editorial staff are also in attendance to assist with technical enquiries. Readers and especially foundrymen from overseas are invited to visit the stand to meet our staff or to use it as a rendezvous for appointments with other foundrymen. Copies of the* JOURNAL *and sister publications—"Iron and Coal Trades Review," "Metal Treatment and Drop Forging," "Sheet Metal Industries" and "Rylands Directory"—will be available.*

Profitable Social Event

Fairbairn Lawson Combe Barbour, Limited, is still another concern which had adopted the policy of issuing invitations to the families of the operatives to spend an afternoon touring the factory. No fewer than 4,000 on August 25 were welcomed by the chairman of the company, Sir Digby Lawson, Bart. Tea and music were provided. The most popular part of the visit was the mechanised foundry.

One of the most extraordinary features was that the event more than paid for itself. A certain amount of preliminary cleaning up was done, and in the process 93 tons of scrap were unearthed, 60 tons of steel and 33 tons of cast iron, which at today's market prices represent a considerable sum. The scrap was of many kinds, from pieces weighing a pound or two to one weighing two tons. Some of the scrap was over 50 years old. How much scrap would be unearthed throughout the country if every firm had a "spring clean" with similar results. Some of the pieces of scrap had been there so long that even the foreman who found them there when he started work 30 years ago thought they were part of the building.

Forty Years Ago

In our issue of September, 1911, a full Report is given of the annual meeting of the British Foundrymen's Association which had been held in Glasgow during the previous month. Dr. Longmuir presided and of those present—as far as we can ascertain—only three are living to-day. Two of them were authors of Papers, Mr. A. Campion and Dr. C. H. Desch, the first of whom dealt with steel castings and the latter with metallography. These and other Convention Papers make up the bulk of the issue. In the news were the firms of Carron Company, where the foundry had been extended at a cost of £6,000; E. R. & F. Turner, Limited, whose premises were very badly damaged by fire; and Stirling Metals, Limited, of Coventry, whose plant extensions were also being undertaken. From France came the news that the works of André Citroen & Company at Quai de Grenelle had been officially opened.

New Association

There has recently come into being an association known as the Engineer Buyers and Representatives Association. Its office is situated at 47, Victoria Street, London, S.W.1; the president is Sir Herbert G. Williams, M.P., and the secretary Capt. Arthur J. Dronsfield. Already it has 374 members, and is forming area branches. It is debatable whether there is any real need for such an association, as other bodies cater for the purchaser and separate ones for the commercial traveller. The notion of bringing buyer and seller together in one association may have advantages, but also there could be objections. However, we wish the new association every success.

Measurement of Plastic Flow in Moulding Sands

By A. Jamieson

The purpose of this investigation was to establish, if possible, a means of evaluating the working properties of moulding sands, and to define in scientific terms the properties of plasticity and flowability.

It seems unfortunate that in spite of the present-day widespread use of sand-testing equipment, and in spite of the useful information which is steadily being collected with this equipment, little effort appears as yet to have been made to measure what to the foundryman is perhaps the most important property of all. By squeezing a handful of sand, a moulder can judge whether or not it is suitable for moulding purposes and whether it requires more or less milling, or more or less moisture, yet no other single method of testing has been devised to do this in the laboratory.

It had long been the Author's belief that the amount of work required to deform various sands could be measured, and an answer given to the problem of why one sand will stall a mixer, while another will not, and why one sand can be worked by the moulder at a greater speed than another (*i.e.*, more moulds or cores per day). This view was largely brought on by the regular necessity to supervise the milling and moulding of sands both during regular production and also during full-scale trials with new materials. Using sand with a normal "bond strength" the mixer or mill will churn away steadily at approximately the same speed throughout the entire milling operation, but if the "strength" is slightly above average the machine can be made to stall by either increasing the weight of the batch or prolonging the milling time. This is, of course, common knowledge, and almost every foundryman must at some time or another have caused such a machine to trip out simply by trying to make it do more work than it was capable of. In such instances the batch of sand has acted at a brake and has completely absorbed all available work generated by the motor.

Physical Properties of Sand

It is common knowledge that although the "feel" of a sand alters continuously throughout a milling time of, say, eight minutes, the actual measurable strength scarcely alters at all. It therefore seems reasonable to conclude that what is actually altering is the capacity of the material to absorb work. That is to say, by absorbing work from the mixer in the first instance, the capacity to absorb further work is continually increased, up to a limiting value of course. This limiting value will depend on the nature of the bonding agents employed, the efficiency of the machine, and various other factors. On two occasions in the past, the Author's theories regarding the relationship which exists between the various physical properties were put on record, but these attempts were based on theory alone and were therefore incomplete, and on some points incorrect. Since then, however, a compression machine has been built which has enabled a start to be made to the practical aspects of flowability measurement, by allowing deformation readings to be taken during the application of load to a sand specimen.

Flowability

The method of approach to the problem was influenced by the following considerations. When grains of sand move past one another, they may do so by two separate mechanisms. First, the grains may remain united by the plastic bonding agent and yet still be free to move a limited distance, and secondly, the bond may be ruptured and the grains left free to move an unlimited distance.

The first phenomenon may conveniently be referred to as plastic flow, and the second as non-plastic flow. Plastic flow should be capable of measurement, but non-plastic flow is liable to have any value for distance moved or applied load, provided the stresses involved are in excess of the ultimate stress of the sand. For this reason, therefore, it seemed likely that plastic flow would be the only one of the two which could be profitably examined.

Apart from possessing the property of plasticity, moulding sands also possess the property of being able to increase in apparent density when compressed in a confined space. All sands do not take up the same degree of compaction, however, when subjected to the same degree of ramming, and it was therefore decided to conduct this investigation with the sand grains in the condition of maximum possible compaction. All tests could therefore be said to be conducted with the grains in the position of closest approach to one another, irrespective of size or size distribution. By doing this, any movement of the grains which might occur during the compression test, could be regarded as tending to produce a separation, whereas if the sand were only partly rammed, there would be a tendency for some of the grains to move closer together. So far it has been found that 40 rams (20 in each direction) with the A.F.S. standard rammer is sufficient.

The instrument used in the experiments is a modification of the "Buchanan" compression tester, and is illustrated in Fig. 1, together with a clock gauge for checking the height of specimens prior to test. The first stage in the procedure consists of ramming a specimen with a ground steel disc at the bottom of the tube (inserted after the first 20 rams), so that when the latter is inverted and the specimen stripped, the disc will be to the top and

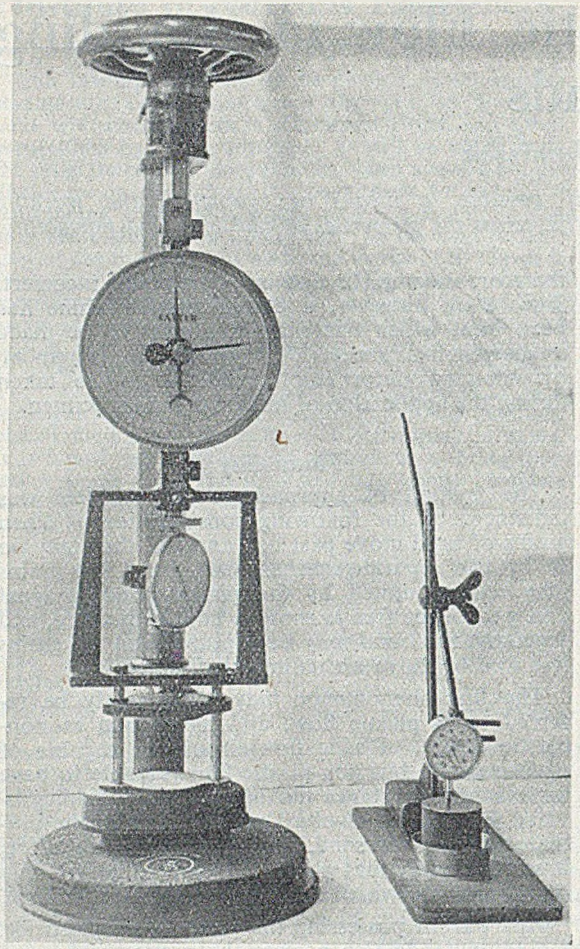


FIG. 1.—*Modified Compression Machine and Specimen Height Gauge.*

will offer a suitable surface on which to clock the height. The specimen is then inserted in the compression machine and when the top surface of the specimen touches the stationary surface of the machine the deformation recorder is set to zero.

Definite increments of load are applied, and time is allowed after each increment for deformation to cease before the next is applied. The deformation is noted for each load. Two load gauges were supplied with the machine, one reading to 20, and the other to 50 lb., but as the latter was not available at first, tests were commenced with a synthetic mixture having a strength within the range of the smaller gauge.

Effect of Moisture

The basis of the mixture was Southport sand, and the bond consisted of 2 per cent. Harbond "C," 0.5 per cent. bentonite, 1.0 per cent linseed oil, with tests being carried out at moisture contents of 2, 3, 5, and 7 per cent. (All batches milled ½ min. dry, and 4 min. wet.) Three load/deformation graphs were drawn for each mixture, and it was

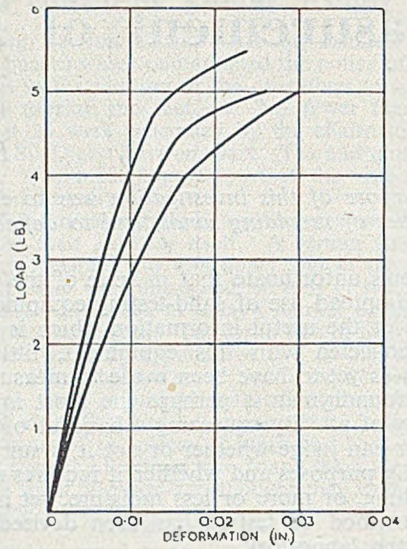


FIG. 2.—*Tests with 7 per cent. Moisture in Synthetic Sand (three Specimens Tested).*

immediately found that although all three lines did not coincide exactly, the greater part of each corresponded closely to a straight line. When the average line was then drawn for each mixture, it was seen that the slopes of the lines became steeper with increasing moisture, and the laws of these lines were therefore found. The tailing-off portion at the ends was ignored, as this represented only a small proportion of the total length and was in any case caused by the breakdown of the property which it was desirous to measure. Fig. 2 shows the three graphs obtained at 7 per cent. moisture and Figs. 3, 4, 5, and 6, the average line at each moisture content. The tabulated results are seen in Table I.

TABLE I.—*Average Results for deformation of Sand against Load.*

Moisture (per cent.) ..	2	3	5	7
C/s area of specimen ..	3.173	3.173	3.173	3.173
Length of specimen (in.)	1.986	2.024	1.971	2.005
Load (lb.)		Deformation (in.)		
0.5	0.002	0.0015	0.0015	0.001
1.0	0.0045	0.005	0.004	0.0025
1.5	0.007	0.0075	0.006	0.004
2.0	0.0095	0.010	0.0075	0.005
2.5	0.012	0.011	0.009	0.0065
3.0	0.015	0.013	0.011	0.009
3.5	0.017	0.015	0.013	0.011
4.0	0.020	0.017	0.0145	0.013
4.5	0.023	0.019	0.016	0.0165
5.0	0.0255	0.020	0.019	0.024
5.5	0.029	0.0225	0.0215	0.027 (5.2)
6.0	0.033	0.025	0.0235	—
6.5	0.038	0.027	0.027	—
7.0	0.042	0.029	—	—
7.5	—	0.0315	0.033	—
8.0	—	0.036	—	—
8.5	—	0.0365	—	—

The load/deformation lines were found to obey approximately the following straight-line rules, for stresses below the ultimate compression stress.

With 2 per cent. moisture, $y = 202x$; with 3 per

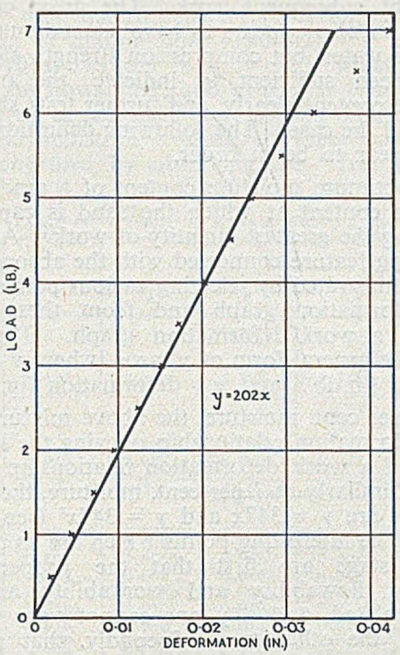


FIG. 3.—*Average Line for Synthetic Sand; Moisture 2 per cent.*

cent. moisture, $y = 229x$; with 5 per cent. moisture, $y = 270x$; with 7 per cent, moisture $y = 347x$. (Where y = load and x = deformation.)

It can be seen that the gradient of the line is increasing with increasing moisture, or in other words, that the load required for any given deformation is increasing with increasing moisture, *i.e.* the sand is becoming tougher. From personal observation, it can be confirmed that this is correct, as the sand

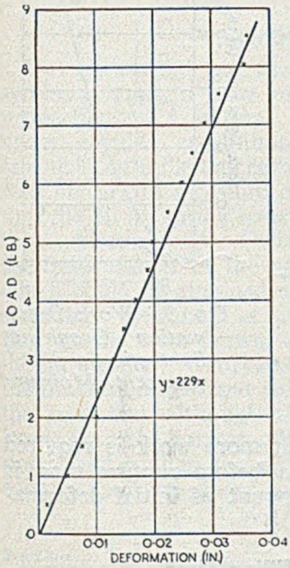


FIG. 4.—*Average Line for Synthetic Sand; Moisture 3 per cent.*

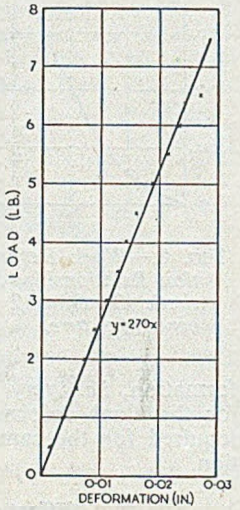


FIG. 5.—*Average Line for Synthetic Sand; Moisture 5 per cent.*

"feels" tougher or more plastic, and from experience it is known that as the toughness increases, the flowability decreases. By taking the constants of the lines to unity, it is now possible to show that an increase in toughness or plasticity is synonymous with an increase in modulus of plasticity. $\frac{\text{(Stress)}}{\text{(Strain)}}$

$$\text{or, Modulus of Plasticity} = \frac{\text{Ultimate Stress}}{\text{Ultimate Strain}}$$

With 2 per cent. moisture, the modulus of plasticity is 126 lb. per sq. in. per in.; with 3 per cent. moisture, the modulus of plasticity is 146 lb. per sq. in. per in.; with 5 per cent, moisture, the modulus of placticity is 168 lb. per sq. in. per in. and with 7 per cent. moisture, the modulus of plasticity is 219 lb. per sq. in. per in.

If one sand flows a greater distance than another when subjected to the same load, then the former can be said to flow more easily than the latter, or to have a greater flowability.

Taking flowability as a certain distance (in.) of deformation per pound of applied load, then the

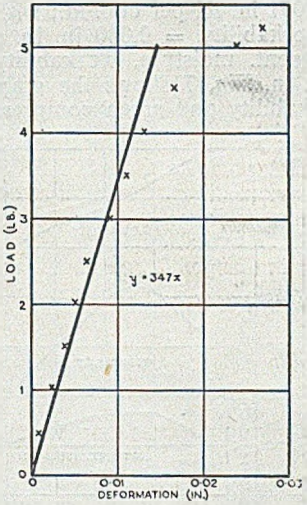


FIG. 6.—*Average Line for Synthetic Sand; Moisture 7 per cent.*

reciprocal of the modulus of plasticity expresses this function in unit terms:—

$$\text{Flowability} = \frac{\text{Strain}}{\text{Stress}} = \frac{1}{\text{Mod. of Plasticity}}$$

With 2 per cent. moisture, flowability = 79.3 × 10 lb per sq. in. per in.; with 3 per cent. moisture, flowability = 68.5 × 10^{-4} lb. per sq. in. per in., with 5 per cent. moisture, flowability = 59.5 × 10^{-4} lb. per sq. in. per in.; with 7 per cent. moisture, flowability = 45.6 × 10^{-4} lb. per sq. in. per in., *i.e.*, the 2 per cent. moisture mixture will deform 0.00793 in. for every inch of length of specimen when subjected to a stress of 1 lb. per sq. in., while the mixture at 7 per cent. moisture will only deform 57 per cent. of this distance.

Measurement of Plastic Flow in Moulding Sands

Absorption of "Work"

If any point on the load deformation graph is selected, then the work absorbed during deformation is represented by the area under the line up to that point. This, however, only applies to gradually-increasing loads, for if the load is applied instantaneously, the work absorbed is double this value and is equal to the product of load and deformation. Since, in the foundry, the deformation of sand is generally accomplished by live loading (*e.g.*, ramming and jolting), the larger value of absorbed work (or maximum value) has been used in all of the following cases, and for convenience the maximum total work absorbed has been referred to as "workability" and expressed in unit terms.

$$\text{Workability} = \frac{\text{ultimate load} \times \text{ultimate deformation}}{\text{volume of specimen}}$$

with 2 per cent. moisture, workability = 0.042 in. lb. per cub. in.; with 3 per cent. moisture, workability = 0.051 in. lb. per cub. in.; with 5 per cent. moisture, workability = 0.040 in. lb. per cub. in.; with 7 per cent. moisture, workability =0.019 in. lb. per cub. in. Fig. 7 shows the graphs of flowability, workability and green compression and, as can be seen, the greatest amount of work is required when the moisture content is at approximately 3.5 per cent.

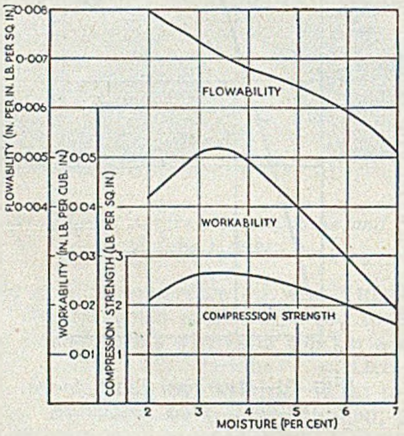


FIG. 7.—*Effect of Moisture on the Properties of a Synthetic Sand Mixture.*

It might be expected that with the drop in flowability (*i.e.*, greater efforts for any given movement), the workability would increase, but, as can be seen, this is not entirely the case, as the latter is governed by the total load and total deformation, both of which drop after 3 per cent. moisture.

With the moisture content at the maximum point on the workability graph, the sand was judged, by several persons, to have a better "feel" than the other mixtures, and this observation has been confirmed by subsequent work. The green compression graph also appears to have a maximum at 3.5 per cent. water, but compression strength alone has never been sufficient to indicate the optimum moisture content clearly, and further tests show this to be still the case. The following definition would now appear to be in order.

The optimum moisture content of a sand is that moisture content at which the sand is capable of absorbing the greatest quantity of work. A further interesting feature connected with the absorption of work is illustrated by selecting various points on the load/deformation graph and from these points drawing a work/deformation graph. The latter taking the general form of $y = ax^2$ (where y = work absorbed (in.-lb.), and x = deformation (in.)).

At 2 per cent. moisture, the above mixture has a load/deformation relationship obeying the law $y = 202x$ and a work/deformation relationship of $y = 202x^2$. Similarly at 7 per cent. moisture, the respective laws are $y = 347x$ and $y = 347x^2$ (see Figs. 8 and 9). The interesting points which are emphasised at this stage are first that the properties of plasticity, flowability and workability are very closely related, and any one cannot vary without affecting the other two. Secondly, that on continuous deformation of a sand, the load is directly proportional to the deformation, while the work absorbed is proportional to the square of the deformation, *i.e.*, very much more work is required for the final deformation before rupture than is required for the same amount of initial deformation.

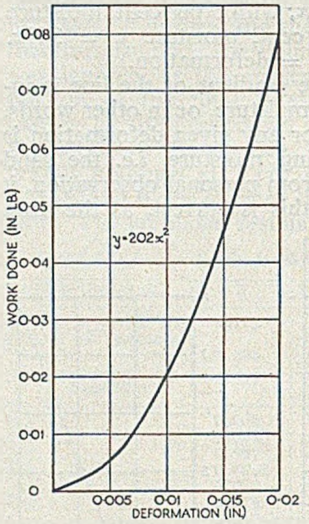


FIG. 8.—*Work/Deformation Relationship; Synthetic Sand at 2 per cent. Moisture.*

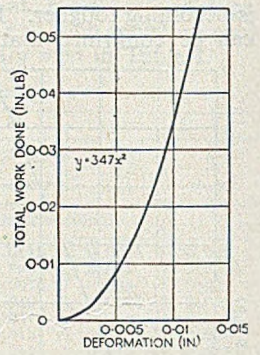


FIG. 9.—*Work/Deformation Graph of Synthetic Sand at 7 per cent. Moisture.*

Effect of Milling Time

From Fig. 7 it would appear that the optimum moisture is in the region of 3.5 per cent., and this quantity was therefore used in a series of tests on the effect of milling time (Table II).

Fig. 10 shows the rapidity with which milling lowers the flowability, and also, that four minutes appears to be the optimum milling time for this particular moisture. Both of these conclusions were confirmed by observing the "feel" of the sands.

TABLE II.—*Tests on the Effect of Milling Time.*

Milling time* (mins.)	2	4	6	8	10
C/s area of specimen (sq. in.)	3.173	3.173	3.173	3.173	3.173
Length of specimen (in.) ..	2.047	2.032	2.046	2.027	2.053
Load (lb.)	Deformation (in.)				
0.5 ..	0.003	0.003	0.002	0.002	0.0015
1.0 ..	0.005	0.0055	0.005	0.0035	0.0035
1.5 ..	0.008	0.007	0.0065	0.005	0.005
2.0 ..	0.011	0.0085	0.0085	0.0065	0.0065
2.5 ..	0.0135	0.010	0.010	0.0085	0.008
3.0 ..	0.016	0.012	0.012	0.010	0.0095
3.5 ..	0.019	0.014	0.0135	0.011	0.0105
4.0 ..	0.023	0.016	0.015	0.013	0.0125
4.5 ..	0.025	0.018	0.0165	0.0145	0.014
5.0 ..	0.0285	0.0195	0.018	0.016	0.0155
5.5 ..	0.032	0.0215	0.020	0.0185	0.018
6.0 ..	—	0.024	0.022	0.0205	0.0195
6.5 ..	—	0.028	0.0265	0.024	0.024
$y =$	$182x$	$235x$	$241x$	$303x$	$311x$
Plasticity	117	151	155	193	202
Flowability	85.2×10^{-4}	66.2×10^{-4}	64.5×10^{-4}	51.8×10^{-4}	49.5×10^{-4}
Workability	.027	.0282	.0265	.0242	.0239

* Plus ½ min. dry mixing.

Moulding Sand

Having carried out the preliminary work on a synthetic sand, it now remained to find how the properties of a natural clay-bonded sand varied under similar conditions. Mansfield sand was selected and milled as before (½ min. dry and 4 min. wet) at various moisture contents, but it was found that the 50 lb. spring scale was insufficient to record the maximum load. Owing to the zero setting and the deformation of the specimen, the highest load which could be obtained was 46 lb. and none of the specimens fractured at this load. Load/deformation graphs were drawn, however, in order to find the flowability. Workability was calculated from the maximum load and deformation obtained during the test, and although the figures obtained were lower than the correct value, they were nevertheless much higher than those obtained for the synthetic mixture, and are shown in Table III.

TABLE III.

Moisture (per cent.)	4	6	8	10
Plasticity ..	1,285	890	965	1,142
Flowability	7.78×10^{-4}	11.2×10^{-4}	10.3×10^{-4}	8.74×10^{-4}
Workability	0.137	0.193	0.175	0.177

Fig. 11 shows these results graphically, and in this case it can be seen that there is a maximum point on the flowability, as well as on the workability, graph. As these results are only approximations, however, and as other available raw sands, and the foundry system sands, all had strengths at least as great as Mansfield, it was decided to dilute

TABLE IV.—*Effect of Moisture on 55 per cent. Mansfield, 45 per cent. Southport Sand Mixture.*

Moisture (per cent.)	2	4	6	8	10
C/s area of specimen ..	3.173	3.173	3.173	3.173	3.173
Length of specimen ..	2.032	2.046	2.046	1.983	1.970
Load (lb.)	Deformation (in.)				
2 ..	0.002	0.003	0.0015	0.004	0.0035
4 ..	0.0035	0.005	0.004	0.007	0.0055
6 ..	0.005	0.0075	0.0065	0.010	0.009
8 ..	0.0065	0.010	0.0095	0.0135	0.0125
10 ..	0.0085	0.0115	0.0115	0.0145	0.015
12 ..	0.009	0.0135	0.014	0.0165	0.018
14 ..	0.010	0.015	0.016	0.0185	0.021
16 ..	0.011	0.0175	0.0185	0.0205	0.024
18 ..	0.012	0.0195	0.0205	0.023	0.028
20 ..	0.0135	0.021	0.0225	0.0255	0.0345
22 ..	0.0145	0.0225	0.0245	0.0285	—
24 ..	0.0155	0.025	0.0265	0.032	—
26 ..	0.0165	0.0275	0.0295	0.036	—
28 ..	0.0175	0.0295	0.052	—	—
30 ..	0.019	0.0325	0.0365	—	—
32 ..	0.0205	0.057	—	—	—
34 ..	0.0225	0.041	—	—	—
$y =$	$1,430x$	$907x$	$884x$	$749x$	$675x$
Plasticity	922	588	570	468	418
Flowability	10.8×10^{-4}	17×10^{-4}	17.5×10^{-4}	21.4×10^{-4}	29.3×10^{-4}
Workability	0.110	0.216	0.169	0.135	0.110

the Mansfield with Southport, in order to examine a clay-bonded sand. It was found that 55 per cent. Mansfield and 45 per cent. Southport gave a mixture with a suitable strength range. Table IV shows the effect of moisture on this sand mixture.

Unlike the synthetic sand, the flowability increased with moisture content throughout this series (Fig. 12). The workability graph had a maximum at about 4.5 per cent. water and a milling test was therefore conducted with this quantity present. The results are shown graphically in Fig. 13.

General Observations and Conclusions

In the ramming, squeezing, or jolting of sand into a mould, the grains are subjected to a compressive stress and only take up the impression of the vertical surfaces by reason of being displaced at right angles to the direction of the applied force. The greater part of this displacement will take place within the plastic limits of the bonding medium, and tests wherein the deformation is measured during the compressive loading of a sand specimen, are likely, therefore, to offer a good qualitative comparison of the flowability of various sands. Plasticity is generally regarded as the ability of a material to take up and retain any given

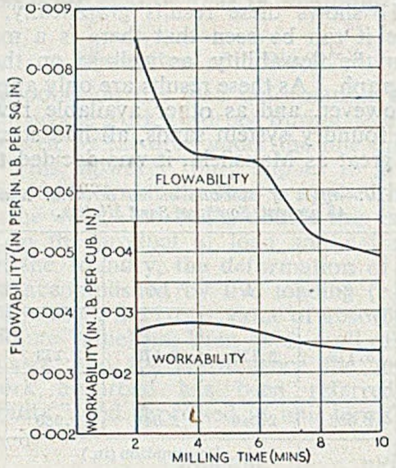


FIG. 10.—*Effect of Milling Time on Synthetic Sand at 3.5 per cent. Moisture.*

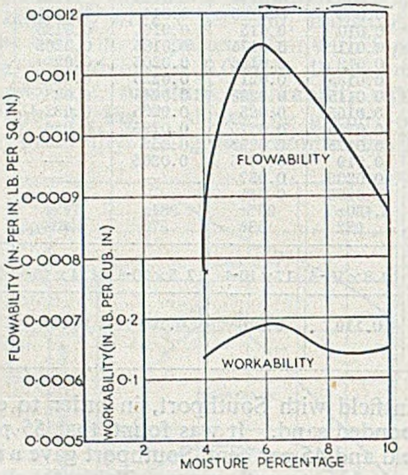


FIG. 11.—*Effect of Moisture on Mansfield Sand (Specimens Unbroken).*

shape, but as these two functions are the opposites of one another, it seems likely that for a proper understanding of the property, each function should be defined separately, as follows:—

Plastic Flowability is the ability of the grains of a moulding material to take up new positions when subjected to an external stress. It may be represented by strain per unit stress.

Modulus of Plasticity is a measure of the ability of the grains of a moulding material to resist displacement when subjected to an external stress. It may be represented by stress per unit strain.

Obviously, therefore, a high flowability indicates a low plasticity, and conversely, a high plasticity indicates a low flowability. (N.B. The use of the term "plastic inertia" might perhaps convey more meaning than modulus of plasticity.)

Two ways of looking at the same property have, therefore, been explained, and for all practical purposes it is recommended to report only one of them. The values for modulus of plasticity seem to be more convenient to use than those of flowability and it is likely that these will be used in subsequent work on the subject.

Future Lines of Investigation

Owing to the fact that the Author of this report is no longer engaged in this type of work, it would probably be as well to point out the following problems which will be worthwhile investigating.

1. So far, most sands examined have shown a load-deformation relationship closely approaching a linear value, but there are indications that the

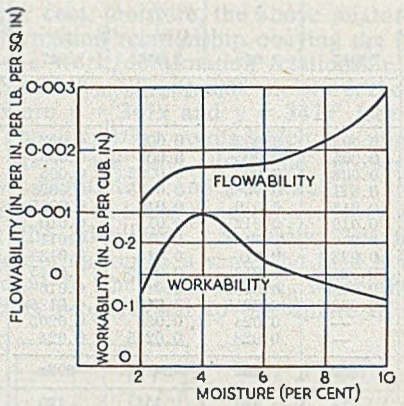


FIG. 12.—*Effect of Moisture on 55 per cent. Mansfield, 45 per cent. Southport Sand Mixture.*

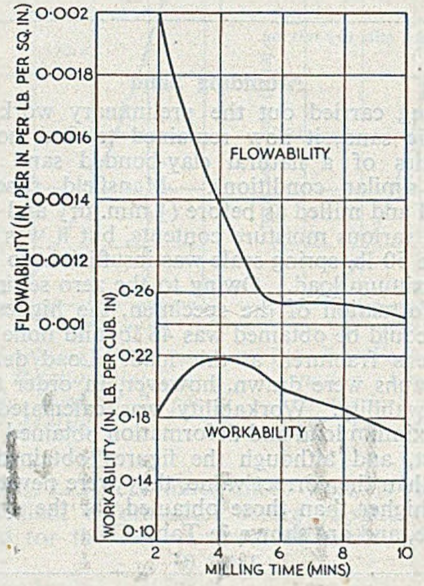


FIG. 13.—*Effect of Milling Time on 55 per cent. Mansfield, 45 per cent. Southport Sand Mixture at 4.5 per cent. Moisture.*

load may not always vary directly as the deformation, and in one moulding sand recently examined, it seemed to be nearer to the square of the deformation.

2. It will be necessary to confirm whether or not it is correct to define the optimum moisture of a sand as:—"that moisture content at which the sand is capable of absorbing the maximum quantity of work."

3. By using specimens of various sizes, it may be possible to find if the values for various properties hold good for larger masses of sand.

4. Examine whether or not the slope of the load/deformation line varies with the number of rams given to the specimen or whether it is only the ultimate strength which varies.

5. Examine whether or not the slope of the load/deformation line varies with the quantity of binder present or whether it is only the ultimate strength which varies.

6. Examine the effect of time on flowability and workability. It takes a definite interval of time for a sand to deform after the application of a load and once this is examined, a better understanding will be obtained of the problem of sagging cores. The spring scale does not give an instantaneous application of a definite load, and in addition the load tends to fall off a little during deformation, so that a "dead-load" type of apparatus would be required for this work.

7. It is still not possible simply by looking at the properties of flowability and workability, to tell whether or not a sand is in its optimum condition for working, and it the Author's belief that this also will not be possible until rate of deformation (or rate of absorption of work) has been examined. It is likely, however, that a relationship will exist between the co-efficient of internal friction and the "time" factor and if the latter proves difficult to examine (due to air-drying specimens or prolonged test) then the former could be used.

The Author wishes to thank the directors of Argus Foundry, Limited, for permission to publish this report, and especially Mr. J. G. Arnott for his very great personal interest in the work.

Publications Received

La Fonte Malléable—La Technique; ses Utilisations. Published by the *Association Française des Fondeurs de Malleable*, 9, Rue Alfred-de-Vigny, Paris.

This 60-page booklet has been prepared by the French employers' association with the object of informing their customers as to the manufacture and general properties of malleable cast iron, both white- and blackheart and then to help them by indicating defects due to faulty design or showing modifications contributing to ease of moulding.

Mitteilungen aus dem Giesserei - Institut der Rheinisch - Westfälischen Technischen Hochschule, Aachen. Edited by Professor Piwowarsky. Eighth edition. This is a collection of Papers emanating from the Foundry Institute at Aachen, which have been printed in *Die Neue Giesserei*. They cover a very wide range of subjects, most of them written by Prof. Piwowarsky, and include studies of developments in cupola practice and the newer types of cast iron.

House Organs

600, Vol. 25, No. 115. The magazine of George Cohen Sons & Company, Limited, Cunard Works, Chase Road, London, N.W.10.

This issue tells of Mr. George Levy's business jubilee; of the purchase of a gold mine on the Gold Coast and a chemical plant in Norway, of taking photographs in Switzerland, of "cabbages and things" and lots of *risqué* stories embellished by dozens of really funny pictures.

Steel Horizons, Vol. 13, No. 3. Published by the Allegheny Ludlam Steel Corporation, Pittsburgh, Pa.

Perhaps the cover of this issue of this most beautifully-got-up magazine is not quite so colourful as usual, but there are many other delightful pages which combine to make this publication merit the appellation: "The world's best-dressed house organ." Readers whose duty it is to take an interest in publicity should certainly write to Pittsburgh to be favoured with a copy.

F.P.A. Journal. Issued by the F.O.C. Fire Protection Association, 84, Queen Street, London, E.C.4.

This issue contains a study of a fire which took place on the Birmingham to Glasgow express when five passengers lost their lives. The cause was attributed to a lighted match or cigarette making its way to an uncleared corner beneath a seat, where rubbish was set on fire. The lesson is obvious—that lack of cleanliness can be disastrous. There are the usual illustrated articles containing accounts of historical fires and the early apparatus used.

Wiggin Nickel Alloys, No .15, published by Henry Wiggin & Company, Limited, Wiggin Street, Birmingham, 16.

This issue contains articles on forming by spinning and on high-nickel-alloy spring materials, both subjects of interest to designers. Corrosion problems involved in using potassium dichromate and phosphorus oxychloride are also described. Other interesting articles deal with the use of nickel alloys in thermal de-icing, industrial drying, gas safety devices and vapour-spray cleaning apparatus. Copies of this publication may be obtained on application to Birmingham.

"Mettle" Summer, 1951. Issued by the Marshall Organisation, Stafford House, Norfolk Street, London, W.C.2.

It would appear from the editorial that the publication of "Group" has ceased and is replaced by the new house magazine. They are quite different, however; the former was entirely domestic, whilst the latter is primarily meant for customers. The change is good, for internal magazines catering for four widely-separated works lack the advantages of one devoted to one works only. In one case Mr. Jones is a person, and in the other merely a name to the bulk of the readers. Thus in its new form outsiders are to be informed of the more interesting aspects of what is being done in the four works at Gainsborough, Leeds, Crook and Sprotborough. For this reason, it was wise to carry an article telling of the work done at each establishment and their interconnections. Accounts of new machinery and sales efforts at exhibitions interest overseas agents, whilst a final article on the training of apprentices stresses continuity of high-grade workmanship. The Editor, Mr. Gavin Starey, has made a very creditable job of his first issue.

Export Guarantees Act 1951

By F. J. Tebbutt

Previously, there have been published explanations of different Acts concerning export guarantees, there having been numerous measures since the first 1920 Act, and it will be remembered that this legislation concerns schemes of insurance, power being given the Government to give guarantees against possible loss in export trading on payment of premiums, the operating body being the Export Credits Guarantee Department, under the Board of Trade. The Principal Act is the 1949 Act containing much of what had gone before, but with new provisions also, and now there is a new one: the Export Guarantees Act, 1951.

This new Act makes clear that the E.C.G. Department can give cover for transactions by an overseas subsidiary of the parent company of United Kingdom firms. This cover can be given in either of two ways; by means of guarantees given to the parent company in the U.K. in respect of possible losses incurred by its overseas subsidiary, or by means of guarantees given direct to the overseas subsidiary. It is pertinent to note that this Act will be particularly useful as regards exports to North American countries, as in many cases the business is done by overseas subsidiaries for which guarantees are desirable. There are special guarantees for U.S.A. and Canada, that is, for the export drive to dollar countries there are special policies. Two policies mostly guaranteeing 50 per cent. of net loss are called "Market Survey" policy, and "Products Test" policy. Then there are the "Advertising" and "Promotional Expenses" policies, and important policies called "Joint Venture" policies. These "Joint Venture" policies roughly mean that the exporter takes the profits and the Department is remunerated by its premiums; losses, however, are shared on agreed proportions, mostly "fifty-fifty."

Policies and Premiums

Although in former articles have been explained many general provisions of the schemes, some reference to these may be useful as reminding information to some, yet new to others. For exports anywhere the policy mostly favoured is the E.C.G. Contracts V Policy, a comprehensive one covering practically all possible losses in connection with export trading, perhaps the most important being cover against losses through the insolvency of the debtor (i.e., bad debts) or through protracted default in payment.

For the bad debts, etc., insurance, the cover is 85 per cent. of the contract price (90 per cent. for the other risks covered by this contract) with possibilities of more cash coming along afterwards if there is anything gathered from debtor's estate. This Contracts policy covers an exporter from the time he makes his export contract to the time he is paid for the goods. There is also the E.C.G. Debts (Shipments) Policy V(S) under which insurance only starts from date of shipment; under this contract, however, premiums are lower than under the other one.

As regards premiums ordinarily, these must vary somewhat, as account must be taken of country of export and the risks involved, and so may vary from a premium as low as 5s. or as high as 40s. per £100 of turnover. If the business is, however, of a reasonable amount, on average, premiums works out in most cases to £1 per £100 of turnover or even less (in many cases 15s.). For capital goods, machinery and plant, etc., special policies mostly apply, as there may be special circumstances of the particular contract, but, even so, these are mostly based on the standard policy.

Miscellanea

There are two main schemes, one where guarantees can only be given by the E.C.G. Dept. after consultation with the Advisory Council (comprised of business people), this scheme relating to ordinary commercial transactions. Under the other, the Department can operate without reference to this Council and guarantees given in relation to what could not come under the head of ordinary commercial transactions, for example in relation to such things as fixed price contracts for capital goods where materials may rise in price and costs of labour increase between receipt of order and delivery of goods, and for goods requiring a lengthy period for manufacture. Transactions can be covered in relation to capital equipment (e.g., machinery and plant) contracts which may mean large sums being laid up for lengthy periods. In general, it can be stated that the Department has discretion to insure any transaction if considered as being in the national interest and likely to encourage trade with and result in earnings from places outside the U.K.

Not only goods come under the schemes, the execution of works or services outside the U.K. including the provision of labour and materials, and the installation costs of machinery and plant, the erection of buildings, etc., can be covered. Fees of experts and consulting engineers; cost of training employees abroad; and the use of a U.K. contractor's own equipment in connection with the execution of engineering works abroad are within the schemes.

Invisible exports, meaning U.K. merchants exporting raw materials and primary products produced abroad (fully manufactured foreign goods not allowable) and shipped to another foreign country without coming here, can be covered, and this applies to entrepot trading.

Sales by merchants, and sales from stocks abroad of U.K. goods can be covered, as well as cost of financing overseas sales agencies.

Ironstone Adviser

Following the passing into law of the Minerals Workings Act, 1951, which makes special finincial arrangements for the restoration of land worked open-cast for ironstone, including the restoration of land left derelict in the past, the Minister of Local Government and Planning, Mr. Hugh Dalton, has appointed Sir Henry Prior to be Ironstone Adviser to the Ministry with effect from August 27.

For the past four year Sir Henry has been Principal Regional Officer of the Ministry of Local Government and Planning (formerly Town and Country Planning) in the North Midland Region.

Conference on Heat Insulation

The proceedings of the conference on heat insulation, held under the auspices of the Joint Committee on Materials and their Testing, in conjunction with the Institution of Gas Engineers, in London, last November, have now been published. They embody the text of the following four papers presented at the conference, together with full discussions of them:—"Heat Insulation in the Refrigeration Industry," by S. Richards; "The Economics of Thermal Insulation in Building Construction," by C. W. Glover; "High-temperature Insulating Materials, their Properties and Testing," by J. F. Clements; "Medium-temperature Insulation," by E. G. Cawte. Copies of the proceedings can be obtained from the secretary of the Institution of Gas Engineers, 17, Grosvenor Crescent, London, S.W.1, at 13s. 6d. a copy, post free.

Operation and Design of Hot-blast Cupolas

*By F. C. Evans, F.I.M.**

(Continued from page 251)

ENGINEERING DESIGN OF HOT-BLAST CUPOLAS

There is nothing new in the conception of hot blast for cupolas or in the idea that cupola top gas could be used for heating the blast. Practically everyone who has been on a cupola charging stage has wondered whether the waste heat leaving the top of the charge could be utilised. Nevertheless, the recuperation of this heat, both latent and sensible, is no easy problem, as there is not actually a great excess of heat from a well-run cupola if the blast is to be heated to 500 deg. C. without external aid. Great care has to be taken with the whole of the design and building of the apparatus to prevent losses, both of heat and volume, otherwise disappointing results will be obtained. One of the main difficulties, due to the dust problem, is to obtain consistent results throughout the blowing period, hour by hour, and week by week.

Dust Problem

It was partly the reduction of efficiency of the recuperators by dust deposits that made many early designs of hot-blast cupolas so ineffective and such a nuisance to foundry operators that they were abandoned. The significance of this problem can be realised by most foundrymen when they consider the state of their roof gutters. There is, of course, no standard quantity of dust produced by a cupola and actual figures are hard to come by. The quantity for an average cupola, however, seems to be in the region of 0.03 oz. per cub. ft. of exhaust gas, or, in terms of iron melted, about 45 lb. per ton. In an average size cupola producing, say, 5 tons an hr., about 225 lb. per hr. of finely-divided dust is produced, and is available to blanket the heat-conducting surfaces of a recuperator.

Part of this dust can be removed by suitably-designed cyclones before it reaches the recuperators (see Figs. 5 and 6). The cyclone, however, has to be insulated to prevent loss of the valuable sensible heat and must be constructed of materials which will withstand the highly erosive action of the dust. The blast mains carrying the cupola top gas to and from the cyclone must also be similarly constructed of insulating and abrasion-resisting materials. Sizes and shapes of the mains have to be so arranged that the gases are travelling at the correct speeds to prevent undue dust deposit on the one hand and excessive abrasion and pressure loss on the other.

Even so, there remains a considerable quantity

* The Author is on the staff of Metallurgical Engineers, Limited.

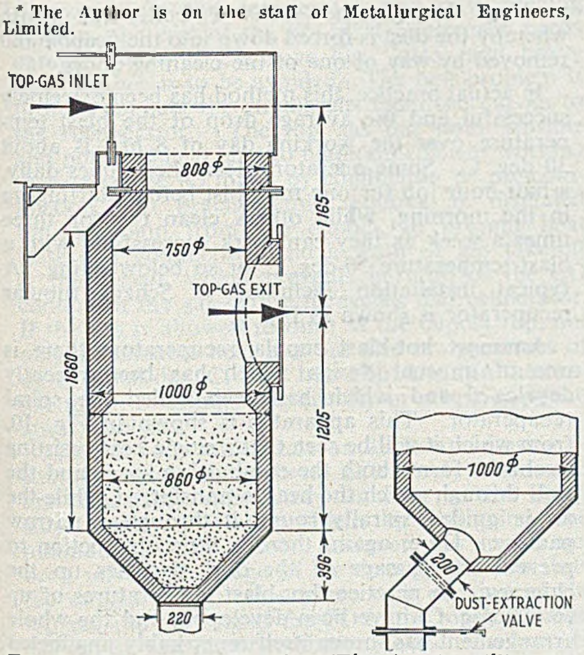


FIG. 5.—*Dust-trap at Cupola. (The sizes in millimetres are relative.)*

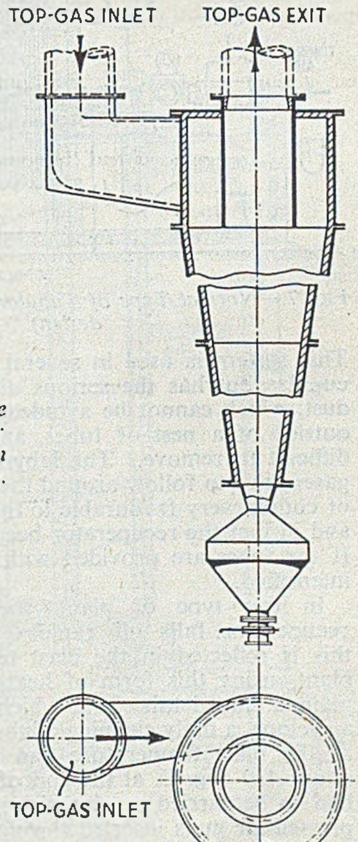


FIG. 6.—*Cyclone designed for Dust Collection from the Cupola.*

Operation and Design of Hot-blast Cupolas

of dust, mostly finely divided, which passes from the mains and cyclones into the recuperator. In a hot-blast cupola plant on a test run a cupola producing 5 tons per hr. of grey iron with a 9½ per cent. coke charge deposited 132 lb. of dust an hr. in the cyclone, or about 26 lb. per ton of iron melted. Therefore, even with elaborate systems of cyclones, there is left a considerable quantity of dust in the gases as they pass to the recuperative system and this tends to coat the conducting surfaces.

Recuperator Design to Overcome the Dust Problem

So far, all designs of hot-blast cupola recuperators except one have followed normal heat-exchanger designs and have consisted of tube bundles with the hot gas on one side and the air to be heated passing in a counter-flow manner on the other. In all conventional heat-exchangers, the maximum efficiency is obtained by putting the heating medium outside the small diameter tubes and passing the medium to be heated (the air) through the tubes (see Fig. 7).

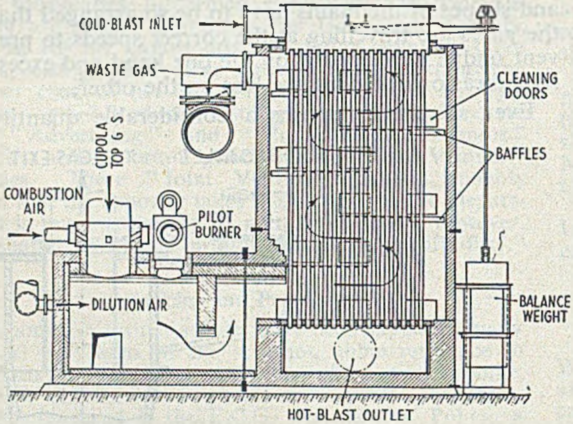


FIG. 7.—*Normal Type of Tubular Recuperator (Schack design).*

This system is used in several designs of hot-blast cupolas but has the serious disadvantage that the dust, which cannot be avoided, is deposited on the outside of a nest of tubes, and is therefore very difficult to remove. The labyrinth path which the gases have to follow around the tube bundle is also, of course, very favourable to the deposition of dust, and in fact the recuperator becomes a dust catcher. If the tubes are provided with fins the problem is intensified.

In this type of plant, the efficiency of the recuperator falls off rapidly during service and this is reflected in the blast temperature. In one plant, using this form of heat-exchanger but with plain unfinned tubes and which was provided with a cyclone, a daily cleaning of the tubes was essential as the blast temperature had fallen from 500 to about 430 deg. C. at the end of the day. Cleaning had to be carried out by blowing down with compressed-air guns inserted through cleaning doors in the recuperator shell, an operation both unpleasant and lengthy.

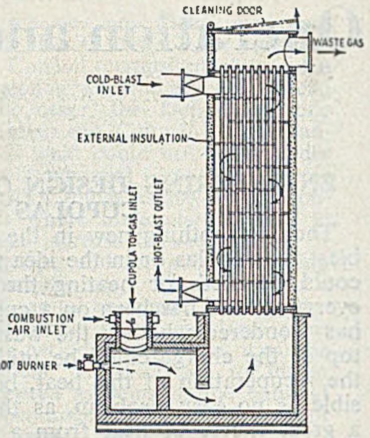


FIG. 8.—*Special Recuperator for Hot-blast Cupolas with heating medium passing through the Tubes. (Schack design).*

To overcome this problem, a new type of recuperator was developed by Dr. Schack of Rekuperator K-G., Dusseldorf, whereby the heating gases pass through the tubes and the blast to be heated outside the tubes (see Fig. 8). This reverses normal practice and does, of course, give a lower thermal efficiency. However, by the use of special materials and ingenious forms of construction the thermal efficiency of the recuperator is maintained at 58 per cent. within a recuperator of very small bulk. In addition, the tubes are made of fairly large diameter. The dust-laden gases therefore pass upwards through vertical tubes of large diameter with virtually no obstruction. In consequence, the majority of the dust, helped by careful calculation of gas speeds, passes through the tubes and out to the exhaust. A fine deposit of dust, of course, does adhere to the tubes, but this is readily removed by pushing through the tubes a boiler-flue brush whereby the dust is forced down into the firebox and removed by way of one of the cleaning doors.

In actual practice, this method has been extremely successful and the average drop of the blast temperature over the working day of 8 hrs. is about 30 deg. C. Some operators clean their tubes daily, a half-hour job for one man just before starting-up in the morning, while others clean two or three times a week as they can work successfully with a blast temperature 50 deg. C. or so below rating. A typical installation including a Schack tubular recuperator is shown in Fig. 9.

Amongst hot-blast cupola recuperators there is one of unusual design which has been recently developed and which has been called the spiral recuperator. This apparatus is shown in Fig. 10, from which it will be seen that a single heat-resisting steel tube forms both the combustion space and the wall through which the heat is transferred, while the air is guided spirally round it through a narrow passage. Here, again, there is little obstruction to prevent the passage of the dust particles up the chimney. In practice, hot-blast temperatures of up to 500 deg. C. have been developed, and the whole arrangement has shown itself remarkably unaffected by dust. In any case, the large diameter firebox-*cum*-heat-exchanger is easy to get at and clean.

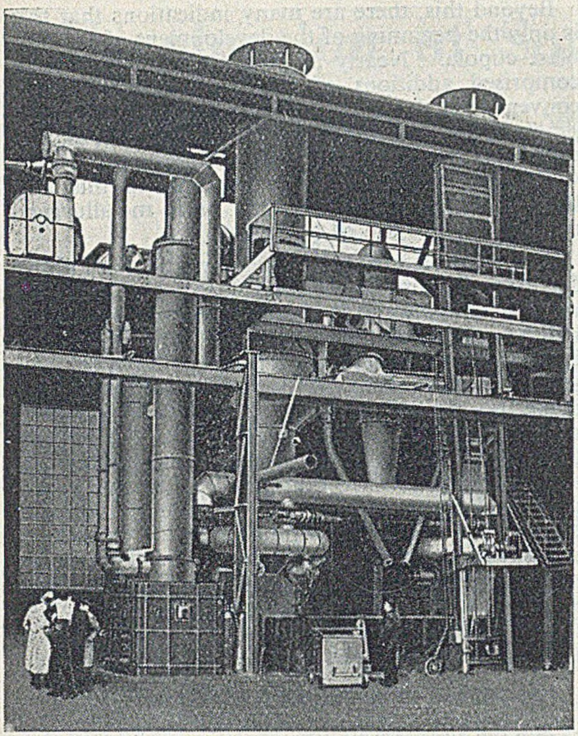


FIG. 9.—*Pair of 6-ton per hour Hot-blast Cupolas just before completion at the works of Knorr-Bremse, Volmarsteim. The Schack Tubular Recuperator is on the left.*

Rest of the Equipment

Apart from the recuperator and dust-catching systems, the rest of the hot-blast equipment needs careful design if excessive heat losses and heavy maintenance is to be avoided. The first problem is how to conduct the cupola gas from the cupola to the recuperator. The top gas has both sensible and potential heat, and to maintain efficient working there must be no losses by conduction or pre-combustion. In practice, this requires an insulated top-gas main from the cupola, to prevent heat losses by conduction, and a form of gas take-off at the cupola which prevents burning of the CO content of the gas before it reaches the recuperator. If the gas is allowed to burn at the cupola top, not only is valuable heat lost but also temperatures of up to 1,000 deg. C. may be reached within the top-gas main, resulting subsequently in severe maintenance problems.

Gas take-offs which rely on automatic closing of charging dors have been extensively used and are reasonably satisfactory as long as the doors close tightly. The problem of designing and maintaining such a door, however, has so far not been solved. Leakage of air through the door into the cupola always takes place with dilution of the top gas and burning of the CO in the top-gas mains. The most satisfactory solution found has been to withdraw the gases from the cupola below the charging door through a specially designed throat.[9]

As most installations are coupled to a pair of cupolas it is necessary to have within the top-gas mains a valve for shutting off whichever cupola is under repair. These valves have to withstand high temperatures and must close tightly under dusty conditions. Unless a tight joint is obtained, air will be sucked in through the valve, again with the disadvantages of dilution and burning of the CO within the top-gas main. Also, some dust is deposited within the intricacies of the valve during the period of working and the valve must be so designed as to shut in spite of this obstruction.

On reaching the recuperator firebox, the top-gas is burnt by the admission of air, which is usually supplied by a separate fan. The method of mixing the air and gas is important if maximum heat values are to be developed within the firebox. Combustion of the low-calorific-value top-gas is barely spontaneously maintained and a pilot flame must be provided. This can either be a gas or oil flame and can be made of such a size that when fully extended it can be used for preheating the recuperator so that blast can be supplied almost at maximum temperature at the starting-up. After starting, the burner

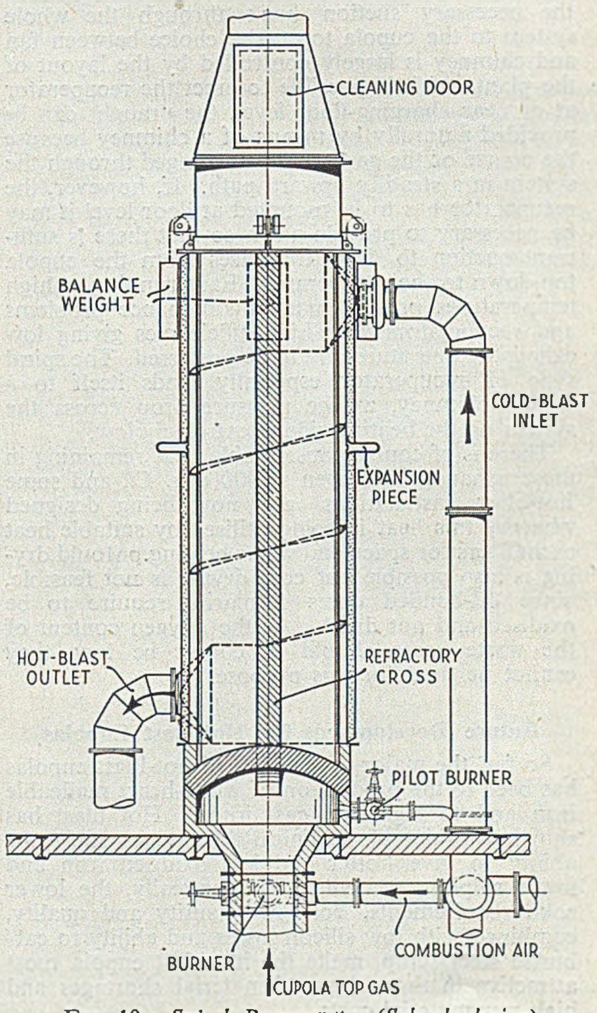


FIG. 10.—*Spiral Recuperator (Schack design).*

Operation and Design of Hot-blast Cupolas

is turned down to pilot size, when the fuel consumption is negligible. From the firebox, the burnt gases pass through the recuperator, the general requirements of which have been already described.

The hot blast, at 500 deg. C., has of course to be conducted to the cupolas and, if excessive heat losses are not to result, the blast main must be suitably insulated. The wind belt has also to be insulated and some designers favour a ring-type main, similar to that of a blast furnace, to overcome the expansion difficulties. Other designers insist that this is not essential. The cupola tuyeres have to be re-designed for hot blast, but up to blast temperatures of 550 deg. C. cast iron and steel are suitable constructional materials.

The exhaust gases after leaving the recuperator will be at a temperature of between 380 and 700 deg. C., depending on the efficiency of the recuperator; the higher the efficiency of the recuperator the lower the temperature of the exhaust gases. Depending on the design of the apparatus, these gases either pass to a fan or to a chimney, both of which provide the necessary suction back through the whole system to the cupola top. The choice between fan and chimney is largely controlled by the layout of the plant. If it is possible to erect the recuperator at or near charging-floor level, the draught can be provided naturally by means of a chimney because the course of the gases can be arranged through the system in a steadily upward path. If, however, the recuperator has to be mounted at floor level it may be necessary to provide a fan so that there is sufficient suction to draw the gases from the cupola top down to the recuperator. Fans running at high temperatures present many maintenance problems and recuperators with high efficiencies giving low exhaust-temperatures are to be preferred. The spiral type of recuperator especially lends itself to a simple chimney, as the pressure drop across the system on the heating side is extremely low.

There is of course considerable heat remaining in these exhaust gases even at 400 deg. C., and some hot-blast installations are now being designed whereby this heat is being utilised by suitable heat exchangers for space and water heating. Mould drying is also possible but core drying is not feasible, since oil-bonded cores primarily require to be oxidised and not dried. As the oxygen content of the waste gases should of course be low, they cannot be used for this purpose.

Future Development for Hot-blast Cupolas

So far, the major application of hot-blast cupolas has been to the production of white-heart malleable iron and to high-duty cast irons. Hot blast has shown considerable technical advantages due to its ability to give hotter and less oxidised iron and lower sulphur contents. Economically, the lower coke requirements, both in quantity and quality, combined with low silicon losses and ability to carburise steel scrap, make the hot-blast cupola most attractive in these days of material shortages and high raw-material costs.

Beyond this, there are many indications that this is only the beginning of the development of the hot-blast cupola. Nearly all installations so far have comprised additions of hot-blast equipment to a conventional design of cold-blast cupola. Cupola practice, too, has largely followed cold blast experience with minor adjustments. While many worthwhile advantages are to be obtained in this way there is much room for some basic metallurgical research on the use of hot blast.

The higher temperature ranges, particularly above 500 deg. C., are as yet unexplored, but from the work already done at the lower temperatures the indications are promising. On the design side there is much work being done on the development of a small, compact and cheap recuperator which will make the addition of hot blast to short-blow cupola operation economically possible. At the present time, the larger tubular types of recuperator are relatively expensive to build, and unless daily campaigns of 6 hrs. or more are possible it is difficult to justify the capital expenditure on the grounds of the direct financial saving alone. The cheaper and simpler spiral recuperator is the solution for providing a suitable hot-blast system for the smaller foundry, as capital expenditure on this can often be justified for daily campaigns as short as 4 hrs.

REFERENCE

Brit. Pat. Application 31297/49.

B.I.F. Space Booking

The organisers of the 1952 British Industries Fair, which will be held in London and Birmingham, in May, have accepted the suggestion of certain trade associations, which want to put on special group displays at the fair, that the closing date for space allocations be extended from August 25 to September 20, and have decided to apply it to exhibitors in all sections of the London centres at Earls Court and Olympia. The heavy engineering section at Castle Bromwich, of course, is not affected, there being no specific closing date for space applications at that section. Until trade associations have formulated plans for their members no final decision will be taken by the organisers on special features at the 1952 fair. The allocation of trade groups to the three centres of the 1952 B.I.F. has been completed and includes the following:—

CASTLE BROMWICH, BIRMINGHAM: Agricultural equipment; architectural aluminium work; art metalware; bathroom fittings and equipment; civil engineering contractors' plant; constructional aluminium works; dairy utensils and plant; die-casting machines; domestic washing machines; electrical appliances; electro-magnetic appliances; electronic devices; electrostatic paint spraying; high-frequency equipment; hotel, bar, and canteen fittings; industrial ceramics; industrial gas equipment; infra-red heating and drying; laundry machines and appliances; marine equipment; mechanical-handling appliances; metals (ferrous and non-ferrous); metal windows and building sections; mining equipment; mobile cranes and delivery trucks; plantation tools; plastic moulding machines; pumps; radio and television transmission apparatus; stainless steel equipment and appliances; steam power appliances; tools; tubes and tubular constructions, and welding equipment.

OLYMPIA, LONDON: Baby and invalid carriages; brushmaking machinery; chemicals and allied products; cutlery; gold and silver ware; medical, surgical, dental, and ophthalmic instruments; musical instruments; office machinery and equipment; photographic and cine equipment; plated ware; printing machinery and accessories; public address equipment; radio and radar apparatus; safes, strong boxes, etc.; scientifis glassware; scientific and optical instruments; watches and clocks.

Evaluation of Soundness in Cast Iron*

Report and Recommendations of Sub-committee T.S.20 of the I.B.F. Technical Council

(*Continued from page* 260)

DENSITY DETERMINATIONS

Introduction

It was considered that the estimation of density could be made with sufficient accuracy to enable even small voids in cast iron to be detected. This method for the evaluation of unsoundness was therefore thoroughly explored on several types of specimen as follows:—

(1) Relatively large and small samples of grey and white iron.

(2) Samples known to be sound and unsound.

(3) Samples of varying chemical composition.

(4) Samples of similar composition cast into different sized sections.

General

Relative density is expressed as weight per cubic centimetre (water = unity). Estimations were made by both (*a*) weight and measurement and (*b*) the water displacement method. The effect on the density value of variations in (1) accuracy of weighing and measuring, (2) temperature, and (3) surface finish of specimens was investigated at the same time.

(a) Weighing and Measuring

Measurements to the nearest 0.001 in. and weighing to 0.001 gramme produce values with an accuracy of ±0.02 with specimens over about 50 gms. in weight. This is considered to be the limit of accuracy to be expected in routine testing. In making comparison between the two methods, determinations were also made on centreless ground and polished specimens 1 in. long with an accuracy of measurement within ±.0005 in. and weighing within .0004 gm.

These results are shown in Table V.

(b) Water Displacement Method

Effect of temperature variations can be shown by calculation to produce a change in relative density of 0.012 per 10 deg. C. For routine testing therefore this factor can be ignored for practical purposes, but if necessary a correction factor can be applied to reduce results to a standard temperature (say 15 deg. C.). Efficiency of wetting of the surface of the specimen affects the value obtained and various modications in technique were tried to overcome this. (See Table V.)

Type of Iron

It is obvious that with completely sound cast iron the density will vary with:—(*a*) changes in composition—in particular the amount of graphitic carbon present, and (*b*) changes in structure, *e.g.*, coarse pearlitic-ferrite-graphite structure, or fine pearlite-graphite high strength irons. For this reason any true assessment of unsoundness from density values can only be made on castings or specimens of the same iron cast under similar conditions.

Experimental Results

In the first series of tests suitable specimens were cut from a selection of different irons and their density determined by both methods. Serious variations were found between the two methods and the efficiency of wetting of the specimen in the water displacement method was suspected as a possible cause.

A second series of determinations was therefore made comparing the measurement and weight method (*a*) with (*b*) normal displacement method

* Presented at the Newcastle-upon-Tyne Conference of the Institute of British Foundrymen by Mr. A. Tipper, with Mr. E. Longden, M.I.Mech.E., in the chair.

TABLE V.—*Comparison of Various Methods of Determining Density of Cast Iron.*

Sample No. Type of iron	Code II 1 Centrifugal cast grey iron	Code II 2 Centrifugal cast grey iron	Code II 3 Centrifugal cast grey iron	Code I 4 Ordinary grey iron	Code I 5 Ordinary grey iron
Composition					
T.C.	3.39	3.30	3.25	3.63	3.71
G.C.	0.10	0.03	0.08	0.46	0.48
Si	1.94	2.20	2.17	2.29	2.29
Mn	0.36	0.46	0.47	0.86	0.89
S	0.076	0.072	0.070	0.086	0.081
P	1.09	1.06	1.19	0.72	0.69
Method.					
(*a*) Weight and measurement	7.060	7.035	7.003	6.992	6.952
(*b*) Displacement in distilled water	7.203	7.173	7.176	7.096	7.133
(*c*) Water and wetting agent	7.190	7.162	7.158	7.084	7.110
(*d*) *Lanolin coated	7.116	7.151	7.138	7.071	7.103

* Corrected for weight of lanolin.

Evaluation of Soundness in Cast Iron

using distilled water, (*c*) the same using a small addition of a wetting agent to overcome the tendency for air to be trapped against the surface of the specimen whilst in water, and (*d*) using specimens coated with a thin film of lanolin to prevent any absorption of water.

Samples 1, 2, and 3 were centrifugal cast grey iron specimens from pipes of 0.875 in. thickness, selected as a satisfactory standard for soundness; 4 and 5 were ordinary sand-cast grey iron test bars of 0.875 in. diameter. All samples were approximately 1 in. long by 0.8 in. diameter with accurately ground and polished surfaces. The results obtained are given in Table V.

These results, which represent the best of a number of determinations made by different investigators, show the appreciable reduction in the density figures obtained by slight differences in treatment of the specimen when using the water displacement method.

These variations are in some cases considerably greater than the accepted limits of accuracy to be expected in routine testing by the weighing and measuring method, and in view of the inconsistent results obtained throughout by the water displacement method, all further determinations were therefore made by weighing and measuring.

Effect of Varying Section Thickness on Density

To illustrate the effect of section thickness on the density of a particular iron, a series of specimens was cut from bars of increasing diameter from ¼ in. to 3 in. The results obtained are set out in Table VI and show no marked effect of increase in thickness, although there are signs of a slight drop in density as thickness increases.

TABLE VI.—*The Effect of Section Thickness on Density of Cast Iron.* (Determined by measurement and weight method).

Type of iron	Cylinder iron (Code J)	General iron (Code J)	Grey iron (Code M)
Composition			
T.C.	3.06	3.09	3.59
G.C.	2.45	2.52	—
Si	1.49	2.09	2.10
Mn	0.67	0.61	0.85
S	0.11	0.12	—
P	0.64	0.70	0.20
Cr	—	—	0.02
Cast dia. in in.	Density value		
0.25	—	7.15	—
0.5	—	7.11	—
0.625	—	—	7.15
1.0	—	—	7.30
1.25	7.18	7.06	—
1.5	—	—	7.17
2.0	7.16	7.12	—
2.75	7.17	—	—
3.0	—	—	7.09

Influence of Graphitic Carbon Content

Because of the marked difference in density of iron and carbon (graphite)—(values of 7.75 for iron and 2.25 for graphite are used in calculating the theoretical densities), it is obvious that the density

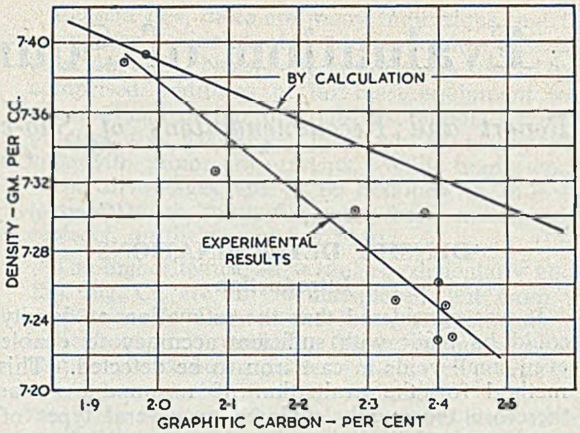


FIG. 18.—*Density of Pearlitic Malleable Cast Iron related to Graphite-carbon Content. (All Density Determinations were corrected to 15 deg. C.) For Calculation the Graphite Density was taken as 2.25 and the Matrix Density at 7.75. In the Experimental Results the Graphite Determination may be Low due to Mechanical Loss in Sampling.*

of any particular grey cast iron will depend not only on its soundness but also on the proportion and state of graphitic carbon present and that for similar irons the higher the G.C. the lower will be the density.

The relationship between graphitic carbon content and density of pearlitic malleable cast iron produced by progressive annealing is shown in graphical form in Fig. 18, together with the calculated relationship, assuming standard densities for pearlite and graphite and that the sum of pearlite and graphite = 100 per cent. volume. In comparing the density of cast iron samples the influence of graphite must therefore be taken into full consideration.

Comparison of Sound and Unsound Specimens of Similar Irons of Various Types

It was convenient for this purpose to use the same specimens as prepared for radiographic and ultrasonic examinations, particularly as the degree of unsoundness and its position was now known in these specimens. The first set of results given in Table VII compares results on both the as-cast condition and after surface grinding to remove any roughness which might cause variations. The bars examined included white iron bars (series A1), annealed white iron (series A1) and grey iron bars (series A2).

TABLE VII.—*Density Determinations on Sound and Unsound Cast Tes Bars. Codes A1, A1 and A2.* (All by measurement and weighing.)

	White iron		Annealed white iron		Grey iron	
	Sound	Unsound	Sound	Unsound	Sound	Unsound
Machined ..	7.74 7.75	7.68 7.70	7.36 7.31	7.32 7.34	7.05 7.09	7.08 7.06
As cast ..	7.66 7.66	7.53 7.65	7.38 7.09	7.32 7.48	6.95 7.08	7.00 6.93

TABLE VIII.—*Density Determinations in Two Series of Graded Bars*

Annealed white iron bars		Grey iron bars	
Bar No.	Code G Graded unsoundness	Bar No.	Code E Graded unsoundness
2	7.36	0	7.09
2a	7.45	2	6.98
3	7.19	3	6.99
5	7.31	4	7.00

Table VIII shows results of density determinations on the two series of bars of graded unsoundness (series G and E). These show no marked or definite relationship to the order of unsoundness as determined by radiography and confirmed by visual examination of sections or to the nature of the unsoundness.

Summary

From a consideration of the results obtained on a variety of irons, both sound and unsound, the following conclusions are drawn:—

(*a*) Whilst density determinations can readily be made with a sufficient degree of accuracy by weight and measurement methods to distinguish between sound and unsound castings under the most favourable conditions, there are a number of factors which can have at least as great an influence on density. These factors include composition, particularly graphite content and state, and coarseness of structure.

(*b*) Under suitable conditions, *e.g.*, comparison of exactly similar metal, including composition, casting and cooling conditions, density is directly related to soundness, although it cannot differentiate between either type or distribution of unsoundness.

(*c*) As a practical method of determining unsoundness in cast iron these complicating factors severely limit its usefulness.

PRESSURE TESTING

Introduction

Pressure testing has been extensively used as an acceptance test for many types of casting, using both water and air pressure. Safety considerations have led to the more general use of hydraulic testing. This also has the advantage that since water is practically incompressible, a very small amount pumped into an enclosed container raises the pressure considerably. Consequently a small amount of leakage is readily detected by an appreciable drop in pressure. Factors to be taken into consideration in applying the method are the ability of cast iron to absorb water, the resistance to the flow of water along channels of porosity and the need for sound joints. On the other hand, owing to the low viscosity of air, experience has shown that an air pressure of 50 lb. per sq. in. will detect leakages that would only be revealed by a water pressure of 400-500 lb. per sq. in.

Experimental Method and Results

A simple experiment was carried out taking as specimens two cast-iron plates 6 in. diameter. These were cast $1\frac{1}{2}$ in. and 1 in. thick and machined down to 1 in. and $\frac{1}{2}$ in. thick respectively taking $\frac{1}{4}$ in. from each cast face. They were assembled in a simple apparatus as shown in Fig. 19, and water at 100 lb. per sq. in. applied. Leakage occurred immediately through the test pieces and continued in spite of a reduction in the pressure to a very low value.

The apparatus was then emptied and connected to an air supply. At 2 lb. per sq. in. the thicker test specimen showed leakage at one point in the centre and subsequently leaked at several positions as the pressure was increased up to 6 lb. per sq. in. No fresh points of leakage occurred when the pressure was increased to 20 lb per sq. in

The thinner test piece showed signs of leakage at two points at 4 lb. per sq. in. These channels sealed up after a while, but leakage occurred through two other points at 8 lb. per sq. in. There were no other points of leakage as the pressure was increased further to 20 lb. per sq. in. After stripping the apparatus the test specimens were broken and although in both cases the grain of the metal was fairly open there were no obvious porous areas in the fracture

Further tests were then carried out on fourteen circular plates $1\frac{1}{2}$ in. and 1 in. thick. In all instances the plates were tested in the as-cast condition and some were further tested after $\frac{1}{8}$ in. thickness had been removed by machining. Two series of plates (Codes K and L) were prepared similar in composition except for the phosphorus content. The analyses were as follow:—

Series	T.C.	Si	Mn	S	P
(1) 1 to 8 (Code K) ..	3.11	2.37	0.33	0.090	1.30
(2) 9 to 14 (Code L) ..	3.19	2.26	0.46	0.110	0.76

As already stated, all fourteen tests were carried out in the as-cast condition and eight retested after machining. The results are summarised in Table IX.

TABLE IX.—*Results of Pressure Tests.*

Series	No. of plates	Thickness, in in.	Leakages		Soundness as indicated by fracture
			As cast	Machined	
1 to 8 ..	5	1	nil	nil	2 sound 3 unsound
	3	$1\frac{1}{2}$	1	,,	1 ,, 2 ,,
9 to 14 ..	3	1	nil	1	1 ,, 2 ,,
	3	$1\frac{1}{2}$	,,	1	3 ,,

Conclusions

The limitations of this test are immediately apparent from the fact that whereas three unsound plates were indicated by the pressure test, there were actually ten instances of blowholes or porosity. The penetration of gases or liquids through a mass of cast iron obviously depends on the inter-connection of voids, passages or general porosity between the faces under test. The work outlined above has led to the conclusion that a pressure test cannot be used to evaluate unsoundness either qualitatively or quantitatively.

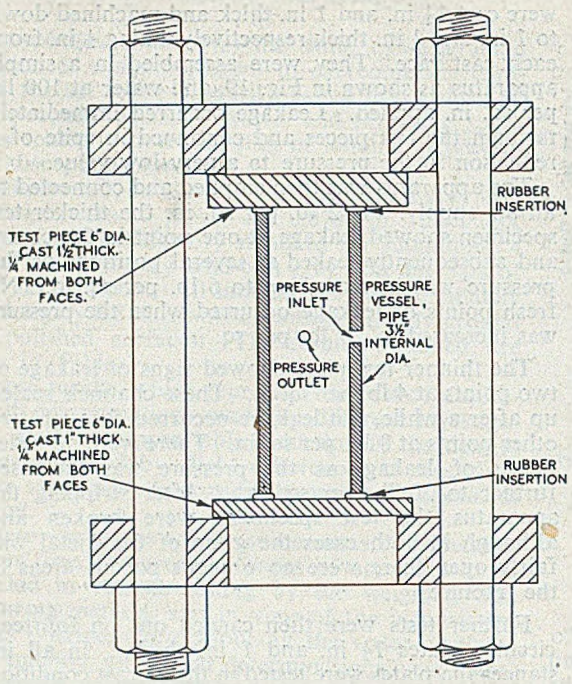


FIG. 19.—*Apparatus Used for Pressure Testing with Water.*

OTHER METHODS

Vitreous Enamelling

When vitreous-enamelling cast iron, severe blistering of the enamel coat is often found where porosity exists under the surface. The accompanying photographs (Figs. 20 to 22) show such blistering over locally thick sections of electric cooker castings. Identification of porosity by this means would be limited to castings of reasonably uniform and thin section, which have been produced under conditions suitable for the enamelling process, and which satisfy certain limits of analysis. The method would only have limited value as a test for porosity due to the many other factors which can produce local blistering.

Indentation Hardness Measurement

A series of tests was made on four cast-iron bars exhibiting various degrees of shrinkage porosity, by means of both Brinell and Vickers machines, the first using a 3,000 kg. load with a 10 mm. ball and the other a 120 kg. load with a 2 mm. ball. These bars were duplicates of series D1 used in the radiographic tests after annealing. The surfaces were explored at various depths from the cast surfaces. Typical results are given in Table X.

The Brinell test is the better for indicating unsoundness because of the heavier load and greater area covered by the impression. In considering the possibility of using the Brinell test to discover or evaluate unsoundness, it is clear that the impressions must cover the whole area of the casting unless there were prior knowledge of the approximate extent and situation of the unsoundness. A geometrical grid could be used for locating the tests, which would have to be repeated at various depths throughout the section. In the case of blackheart malleable these depths would be at, say, 7/32 in. intervals. It might then be possible to use the summation of all the Brinell numbers (rejecting any obviously erroneous results) as an evaluation of the unsoundness.

The clumsy and laborious nature of the work, coupled with the uncertain results, since hardness is affected by factors other than unsoundness, renders the method of very little practical value.

GENERAL CONCLUSIONS AND RECOMMENDATIONS

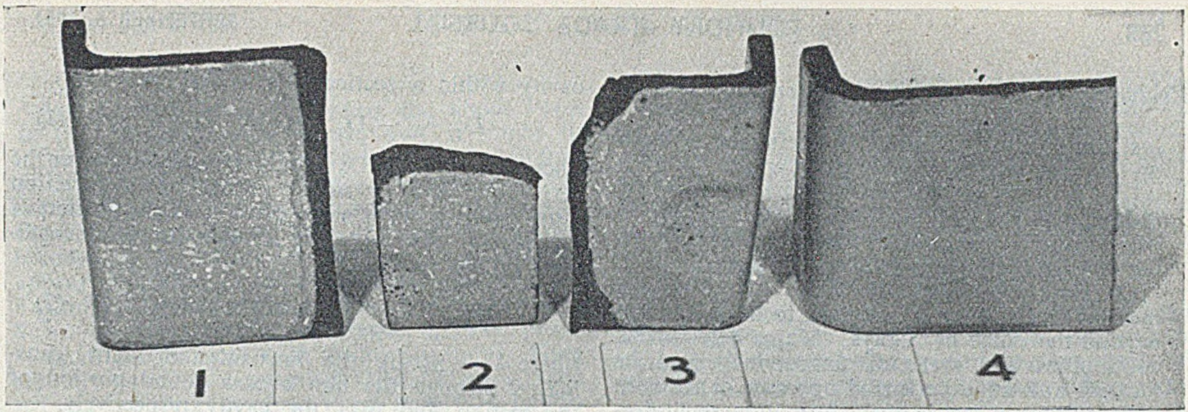
After a detailed investigation of various non-destructive methods of detecting and measuring the extent of unsoundness in iron castings, the conclusions reached by the Sub-committee can be summarised as follow:—

(1) For the precise location and delineation of any form of unsoundness which produces a local variation in opacity to γ- or X-rays, radiography can be recommended. Limitations are imposed by (*a*) section thickness much in excess of 6 in. to 8 in., and (*b*) the failure of radiography to identify evenly distributed porosity of small size in grey

TABLE X.—*Brinell Hardness Numbers, 3,000 Kg. Load, 10 mm. Ball, 15 Sec.*

Test bar	Depth	Position						
	In.	A	B	C	M	C1	B1	A1
P/S	50th	111	116	116	114	116	114	114
,,	⅛	118	118	121	118	118	116	116
,,	¼	109	109	105	105	105	107	105
P/SS	50th	116	123	123	116	123	116	118
,,	⅛	126	123	123	123	126	123	126 (see note (*a*))
,,	½	116	103 (*c*)	92 (*c*)	82 (*c*)	99 (*c*)	99 (*c*)	116
P/MS	50th	123	123	123	121	121	123	123
,,	5/32	126	126	114	107	116	126	126
,,	½	118	84	*c*	*c*	*c*	*c*	116
P/GS	50th	118	(*c*) 126	126	121	123	121	116
,,	5/32	121	121	105	92	107	107	121
,,	½	116	88 (*c*)	70 (*c*)	*c*	66 (*c*)	79 (*c*)	118

NOTE.—(*a*) Readings taken between A and B 116, and between B1 and A1 118.
(*c*) Indicates partial or complete collapse.



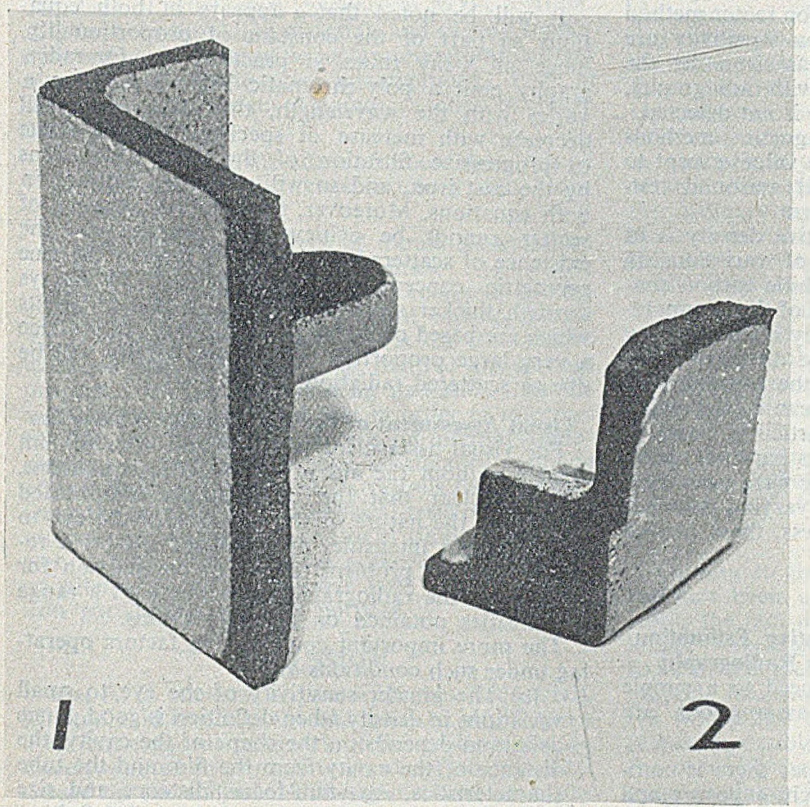
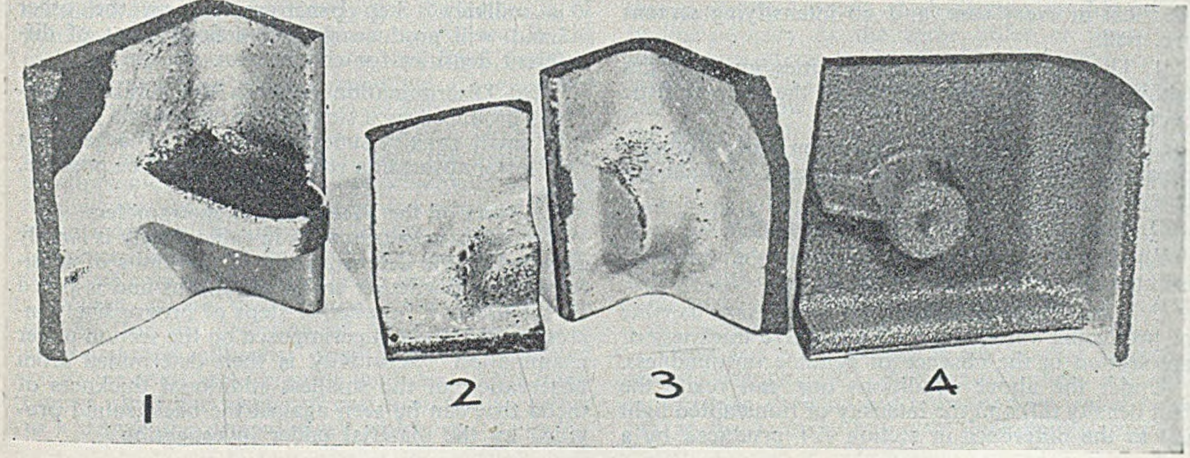


FIG. 20 (*above*).—*Examples of Blistering on Portions of Vitreous-enamelled Domestic Castings.*

FIG. 22 (*centre*).—*Enlarged View showing Relative Positions of Bosses and Blister Defects and the Relationship of Porosity of a Boss and the Blistering of the Enamel.*

FIG. 21 (*above*).—*Views of the Same Specimens as shown in Fig. 20, turned so as to Show the Positions of the Bosses.*



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cast iron. This may affect its usefulness in work on the influence of moulding materials.

(2) Quantitative evaluation of unsoundness by radiography can only be achieved by comparison with carefully prepared comparator charts, bearing in mind the factors detailed in Appendix 1.

(3) The principal advantage of ultrasonic methods lies in their application to thick sections beyond the range of X-rays. Major defects, discontinuities and areas of unsoundness can be located, and an experienced operator can obtain a quantitative measure of the unsoundness, preferably by using the relative absorption factor method described herein. Limitations on sensitivity are imposed in examining grey cast iron by the presence of free graphite and, as with radiography, uniformly dispersed fine porosity is not detected.

(4) The electrical and magnetic methods examined proved of very limited value, except to distinguish between sound and unsound test-pieces of simple geometrical form.

(5) The determination of relative density is of limited value, since the effect of variations in coarseness of structure and graphitic carbon content severely limits the usefulness of this comparatively simple test. Under suitably controlled test conditions, density is found to be directly related to soundness, although neither the type nor the distribution of the unsoundness can be defined.

Other methods of detecting particular forms of unsoundness such as indentation hardness, pressure tests and vitreous enamelling were examined, but owing to the appreciable and varying influence of factors other than unsoundness, these proved unsuitable for general use.

APPENDIX I

Factors Influencing the Quantitative Estimation of Unsoundness in Cast Iron by Radiography

Before the problem can be reduced to a simple theoretical basis, the following assumptions are necessary:—

A. All films are of the same type; there is complete uniformity from batch to batch; exposure and processing conditions are fully controlled and are identical in every case, and no intensifying screens are used.

B. The full range of film densities involved lies within the straight-line portion of the characteristic curve.

C. All measurements are taken on a densitometer capable of quantitative measurements of light intensity.

D. The X-ray beam is monochromatic.

E. There is no scatter within the material examined.

F. There is no segregation in the cast iron capable of producing variations in the effective thickness of the section in the absence of genuine unsoundness.

Under the above conditions one can relate the film density (D) and the intensity of transmitted light (L) to the difference in section ΔT produced by a cavity within a section (T), as follows:—

$$D_{T-\Delta T} - D_T = 0.434\ \gamma\mu T \quad \ldots\ldots \quad (1)$$

where $_{T-\Delta T}$ and D_T are the film densities over the cavity and over a sound portion of the section respectively, γ is the slope of the straight portion of the characteristic curve and μ is the absorption coefficient of the material.

$$\log. 10 \frac{L_T}{L_T - \Delta_T} = 0.434\,\gamma\mu T \quad \ldots\ldots \quad (2)$$

where $L_T - _{\Delta T}$ are the intensities of light transmitted through the film over a sound portion of the section and over the cavity respectively.

It will be noted that μ appears in both equations as part of the constant of proportionality. Since all X-ray tubes in practical use for radiography emit a poly-chromatic beam and since μ varies with the wavelength, the value of μ will decrease with increase of specimen thickness due to progressive filtration of the softer radiations by the cast iron, and so will alter the constant in both equations. Moreover, the complete absence of scatter cannot be achieved in practice and the existence of scattered radiation will destroy the true geometric conception of the passage of X-rays through thicker sections and will invalidate results which are based on such an assumption. In practice a very large proportion of the film density will be due to scattered radiation.

Visual Assessment of the Basis of Equal Densities

For visual assessment of the significance of film density without the aid of photometric equipment, it will be clear that the relations are complicated further by the nature of the response of the eye to different light intensities and this necessitates a reduction of the problem to one of comparison for equality of the radiographic densities with a range of densities obtained on known sections.

The more important complicating factors operating under such conditions are:—

(*a*) The greater sensitivity of the eye to small variations in density when definition is good. Since definition depends on the shape of the cavity, the distance of the cavity from the film and the tube characteristics, *e.g.*, film-focus, distance and size of focal spot, it will be clear that good definition is unlikely. Step penetrameters, on the other hand, will produce sharply defined areas of different densities for comparison.

(*b*) Discrimination between the similar densities produced by a single large cavity or a number of small cavities superimposed, or of large areas of lower absorption coefficient, will not be possible.

Note on the Function of Penetrameters

The use of penetrameters in radiography is largely confined to the determination of the limits of sensitivity for a particular set of conditions and is based on the use of a number of steps of progressively increasing thickness superimposed on the section under examination. Sensitivity is then determined from observation of the smallest additional thickness of metal that can be seen against the background provided by the material under investigation.

* * * *

MR. TIPPER, before presenting the above Paper at the Newcastle Conference, said it might be helpful to explain that the work of Sub-committee T.S.20 was one part of a general investigation into the part played by mould materials on the soundness of iron castings. That explanation was due because of the nature of the work, which might appear unfinished in some directions. In 1945, the Technical Council of the Institute had appointed a Sub-committee to explore and report upon the possibility of carrying out such an investigation. Their report, issued in September, 1946, after a wide search of existing literature, which revealed a noticeable lack of satisfactory evidence as to the relationship between moulding materials and casting soundness, made certain specific recommendations for two comprehensive long-term investigations. Each of these could be sub-divided into a series of short-term projects, *viz.*:—

(*a*) To examine the effect of mould materials on internal defects (shrinkage, porosity and blowholes), and

(*b*) to examine the effect of mould materials on surface defects and discontinuities.

Those recommendations were accepted by the Technical Council and as a result Sub-committee T.S.21 (later reconstituted as T.S.33) commenced work on the investigation of thermal (insulating) properties of specific moulding materials. At the same time, it was realised that in order to interpret the influence of mould materials on internal soundness it was necessary to have satisfactory methods of assessing unsoundness in its various forms. Apart from the commonly-used physical tests on prepared test-bars, or destructive bend or crushing tests, there was very limited authentic published information on alternative non-destructive tests applied to cast iron particularly for that purpose.

DISCUSSION

MR. A. C. RANKIN, Kelvin & Hughes (Industrial), Limited, said he could not add much to Mr. Tipper's brief but eloquent summary of the position and he merely wanted to say a few words of an historical nature on the subject. Ultrasonic testing as it was used at the present time was introduced during the second world war particularly for the detection of hair-line cracks in rolled armour plate, and in the early stages there was an Iron and Steel Institute *ad hoc* committee which carried out a very extensive survey of the application of ultrasonic waves, particularly on the steel side. As time wore on it became more and more clear that the application of ultrasonic flaw detection was principally of value to the wrought-steel industries and wrought light-alloy industries as opposed to the foundry side. However, there were one or two exceptions to this, the most conspicuous case being one in the north-east area, where the ultrasonic test proved very suitable for the detection of transverse cracks in large cast-steel mill rolls. Apart from a few isolated examples, there was no prior guidance on the question of ultrasonic testing of cast iron, and therefore to a degree the present work which was being reported by the Sub-committee was original. The Sub-committee had started off from scratch, feeling its own way rather than consolidating known work, and it was as well to bear in mind that as the work had gone on fresh ideas had arisen, so that in some respects it might be said that the results reported in the Paper could now be improved considerably.

Recent Developments

In particular, the various diagrams which were shown in Figs. 13, 14, 15, 16 and 17 referred to tests which were carried out with quartz crystals of 20 mm. accurately aligned on opposite sides of the specimen, as was shown in the diagram illustrating the principles. Since that date, further development had taken place and fresh equipment had become available whereby greater sensitivity could be produced, and that had enabled the extension of that type of work by virtue of the fact that one could satisfactorily use smaller quartz crystals. Actually he had privately repeated one or two shadow tests of that character, using 6-mm. dia. crystals with the ordinary equipment which had been used for the tests mentioned in the Paper, and the sensitivity had been pretty low due to the high attenuation in the grey iron. By putting up the output power by a factor of approximately ten times, results could be achieved with those small crystals, and a very brief look at Fig. 8 would show that the minimum size of flaw which would produce a complete shadow was purely a function of the receiver diameter. Therefore, ideally, one should use a fairly large diameter transmitted probe and as small a receiver probe as was practicable.

Reflection Method

Turning to the reflection method of test, which had not been used to any degree in the present work, the fact that by using lower frequencies and longer wavelengths one could detect fairly large flaws in the presence of comparatively coarse free graphite had already been mentioned in the Paper. He would like to re-emphasise the limitation that it was impossible to detect something which was of the order of the size of the graphite. A cluster of graphite flakes was, ultrasonically speaking, a discontinuity which produced scatter effects, and there was a certain amount of absorption resulting from it; fine porosity of the same order of magnitude would give precisely the same results—that was an inherent limitation of both the reflection method and the shadow method of ultrasonic testing. On the other hand, there was no appreciable difference between a fine grey iron or a white iron and steel, and he showed the audience an example which he had prepared, illustrating the comparative reflection tests for mild-steel and for a fine-grain iron. To the uninitiated eye the oscillograms were precisely similar although there were one or two very minor differences if one knew a good deal about the ultrasonic technique.

There was no difference in the case of reflection testing, but alongside those results there was also an example showing not only the first signal arriving at the receiver but also showing the multiple

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reflections within the mass of the specimen. While the steel specimen showed that the reverberations went on for a considerably longer time than the reverberations in the iron, indicating that indeed there was increased scatter in the iron but not sufficient to give results as described for a coarse-grain iron in the actual Paper.

Mr. Elijah asked if there were any limitations in the ultrasonic method as far as the surface of the casting was concerned: whether a rough surface would give incorrect results with either the ultrasonic or the other method, and secondly whether it would be possible to check up a defect in a longitudinal or rectangular casting?

Mr. Rankin, replying to the first part of the question, said it was true to say that the ultrasonic test, particularly the shadow test, was a function of the surface condition and it was also true to say that there had been a certain amount of criticism in connection with the foundry industry and the surface condition. However, a degree of progress had been, and was being, made in that field. In the shadow method of testing they were introducing the energy at one and measuring it on another surface, and clearly loss of energy at the two interfaces was of some importance in determining the final signal amplitude which arrived at the receiver. In the reflection method that was not so important, because there was an echo from the bottom which could be measured and which could be used as a standard signal provided the amplifier was not overloading. In the case of a specimen in a water-bath, there was somewhere around about 90 deg. of the energy reflected at the inter-face; in the case where it was weighed, normally using oil in the past, that loss could be greatly cut. (Here, the speaker illustrated his remarks on the blackboard). In other words one obtained a function which repeated itself, going through maximum reflection at quarter wavelength and through the minimum at half a wavelength, so that by making it very thin indeed the reflected amplitude was virtually zero on a good-surfaced specimen.

Comparatively recently, there had been worked out a technique which was as yet unpublished, although it had been mentioned at several meetings of the Institute of Physics and elsewhere.

(The remainder of Mr. Rankin's reply was given by means of a blackboard demonstration of which it is hoped to publish details shortly, together with the results of further experiments.)

Hardness Testing as an Indication

Dr. R. V. Riley said he noticed from the Paper that unsoundness was interpreted as including all forms of internal porosity, inclusions and gas holes, and he would like to ask Mr. Tipper whether a gas-hole gave a different response to a shrinkage-cavity because he had noticed in Figs. 1 and 2 (the latter in particular), and at other points in the Paper, that there appeared to be unsoundness due to gas holes in one section of the specimen and also unsoundness due to shrinkage. Did those give the same response when tested radiographically and also by the ultrasonic method?

Secondly, he would like to know how Mr. Tipper produced the unsoundness when he wanted it. Thirdly, the Sub-committee had dismissed hardness testing as a test for unsoundness but he would like to make it clear that from his own observations hardness testing was sometimes a very satisfactory means of obtaining a qualitative if not quantitative indication of micro-unsoundness, *i.e.*, intergranular unsoundness, in irons having a hardness of, say, 500 Brinell. For the determination of degree of unsoundness in soft irons it was probably of no value, but with hard irons the method was particularly satisfactory.

Mr. Tipper, replying to the point with regard to gas holes as against shrinkage radiographically, said they could definitely show the shape, particularly with the two-shot technique, and then interpreting the unsoundness was purely a matter of experience. On ultrasonics, with his limited knowledge he would say it would be difficult to distinguish, and they lacked a lot of experience in that field, but it did seem commonsense that unless it was a very large round hole they would be able to say " Yes, it is located there," and it would be most unusual to find a similar sort of space produced by shrinkage. It was a matter of commonsense, but when all was said and done this work was in its infancy, particularly as it applied to cast iron.

Other Limitations

They had not thoroughly dealt with all types of unsoundness: he felt they had not really done as much on that as they could have done, particularly as regards inclusions. It might be asked why they had not produced radiographs and charts of all types of inclusions which might be found in iron castings, and the answer was that they just had not got the time to do it. They had already been working on it for three years or more, and one got out of date unless something was published.

As regards harness testing it was most interesting to learn that Dr. Riley found it a useful method, particularly for fine porosity. Mr. Peace in particular had done work on hardness testing and he undoubtedly had worked on the unannealed as well as on annealed irons. He had gone to the trouble of cutting specimens through—slices of about $\frac{3}{16}$ in.—and had determined the minimum width of a slice to give a reliable result from the total thickness being tested, but it was an awfully laborious method of investigating and unless there was some particular job in mind the Sub-committee would not recommend it. For an example of an exception, they might be producing a precision casting and it might be that porosity was expected in one particular section, when quick hardness test might prove it straight away and would be much cheaper to carry out than a radiographic test.

Unexpected Difficulty

Mr. K. E. Walker said that on the question of producing the unsound test-bars the Sub-committee's first efforts were a dismal failure as they could only produce relatively sound bars! They

(*Concluded at the foot of facing page*)

Pickling of Aluminium Bronze*

This process, compared with that used for ordinary copper alloys (bronzes and brasses) is made more difficult because of the presences of aluminium.

A number of laboratory tests have been carried out. The usual method embraces the three following phases:—(1) Actual chemical treatment. The table printed below sets out the experimental conditions (composition of bath, temperature and time of immersion) and the finished surface appearance. (2) Careful rinsing in cold running water. (3) Drying with rags (drying which would be replaced in workshop practice by clean sawdust).

Composition of the bath.	Temp., deg. C.	Duration of immersion.	Surface finish obtained.
Hydrochloric acid 22 deg. Baumé .. 0.2 ml.; Water .. .. 0.8 ml.	100	10 min.	Lightly brilliant
Nitric acid 40 deg. Baumé 1 litre; Water .. .. 1 litre	20	15 sec.	Lightly pickled and brilliant
Sulphuric acid 66 deg. B. 1 litre; Crystallised sodium bichromate .. 75 gm.; Water .. .. 4 litres	80	10 min.	
Then— Sulphuric acid 66 deg. B. 2 litres; Nitric acid 40 deg. B. 1 litre; Water .. .. 1 litre	45	15 sec.	Yellow matt with light etching effect (satin-like appearance.
Sulphuric acid 66 deg. B. 1 litre; Nitric acid 40 deg. B. 2 litres	70	A few seconds	Very light yellow matt

In the case of castings showing porosity or of which the design carries narrow recesses, rinsing in cold running water can be usefully followed by immersion in a bath made up of 5 gm. anhydrous sodium carbonate dissolved in a litre of water. The neutralising action *vis à vis* traces of acid retained by the castings adds to the speed of drying of the castings.

* Translated from *Fonderie*.

Evaluation of Soundness in Cast Iron

(*Continued from facing page*)

tried all the conventional methods which were normally the explanations for unsound bars: they had mixed some moulding sand with about 10 per cent. of moisture, they had used oil on the face of the mould, they had tried pouring metal from high temperature and from low temperature and none of those methods had worked, so, in desperation, they had simply added ferro-silicon until they had a silicon content of about 4 per cent., which produced quite unsound bars. It had been found almost impossible to guarantee a "blown" condition in a given casting, but whether that was of any assistance to foundrymen he did not know. The silicon content of the most grossly unsound bars was in the region of 4 per cent., and the bars were cast at a relatively high temperature.

The Chairman, Mr. E. Longden, drawing the discussion to a close, proposed a formal vote of thanks to Mr. Tipper and Mr. Rankin, which was carried with acclamation.

Lead and Zinc Mining in Scotland

An explanatory circular has been issued to stockholders by the Bangrin Tin Dredging Company, Limited, concerning an option taken by the Siamese Tin Syndicate, Limited, which is to be financed jointly by both companies, to acquire mineral rights in lead and zinc fields on the Lanarkshire and Dumfriesshire borders in Scotland. The circular points out that where the fields are situated there are upwards of 60 veins in a small area, most of which had been worked in the past near the surface but only a few to any depth. It is stated that when the mines were open the price of lead and zinc varied between £8 and £15 a ton, compared with the present price of about £180 a ton. It is considered that there is a reasonable chance of discovering quantities of ore which are workable at a profit with metal at £100 a ton and upwards.

Should a definitely favourable opinion be formed, stockholders will be called together to decide whether or not they desire to proceed. It is not proposed that the company, in conjunction with the Siamese Tin Syndicate, should bear the full burden of financing this enterprise right up to the point of production, but it is proposed to review the financial situation from time to time and, if necessary and desirable, to take steps to find further finance.

Coke and Scrap Shortage in France

The production index level of the French iron and steel industry in May remained at 160, as in March and April. The industry is limited by shortage of both coke and scrap and in May worked at 90 per cent. of capacity, although provisional figures for June indicate an improvement. Iron and steel production in general is 15 per cent. above last year, but home demand is unsatisfied. Order-books are overloaded, with the result that delivery dates are abnormally distant. Steel exports, which in December last amounted to 451,000 tons, were cut to 263,000 tons in May.

Some indication of the seriousness of the coke situation as far as the steel industry is concerned may be seen from the fact that the authorities have allocated 700,000 tons a month to the industry against the minimum requirements of 950,000 tons. The scrap shortage is attributed partly to the need for France to fulfil her trade agreements with regard to scrap exports, and partly to the lack of coke, since the steelmakers are using more scrap in seeking to increase their production of Martin steel to compensate for the smaller production of Bessemer steel.

Training Instrument Mechanics

As the complexity of industrial instruments increases, the necessity of providing users with an adequate explanation of the theory and practice of instrumentation becomes more apparent. George Kent, Limited, engineers, of Luton, have for many years given a thorough training to individuals sent to its works by user firms, and have now begun a series of integrated courses for instrument mechanics and engineers from customers. The courses last for four or five weeks, during which whole-time instruction is given by a qualified training staff. A workshop and lecture room have been specially provided and equipped so that trainees get the full benefit of working and comparing notes together.

First results are stated to have been very encouraging, and there is now a greater demand for places on the courses than can be satisfied in the immediate future.

Pig-iron and Steel Production

Statistical Summary of June Returns

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

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

Period.	Iron-ore output	Imported ore consumed.	Coke receipts at blast furnaces.	Output of pig-iron and ferro-alloys.	Scrap used in steel-making.	Steel (incl. alloy). Imports.[2]	Output of Ingots and castings.	Deliveries of finished steel.	Stocks.[3]
1949	258	169	199	183	188	17	299	233	1,071
1950	249	174	197	185	197	9	313	239	997
1951—January[1]	258	163	200	183	183	7	306	236	920
February	262	164	202	186	193	7	326	252	875
March	267	167	204	184	187	6	318	253	848
April	279	149	201	179	195	6	323	261	800
May[1]	287	159	204	182	180	7	305	242	762
June	315	159	204	183	182	7	308	261	737

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

District.	Open-hearth. Acid.	Open-hearth. Basic.	Bessemer.	Electric.	All other	Total. Ingots.	Total. Castings.	Total ingots and castings.
Derby, Leics, Notts, Northants and Essex ..	—	2.7	10.8[7] basic)	1.5	0.2	14.5	0.7	15.2
Lancs. (excl. N.W. Coast), Denbigh, Flints, and Cheshire; Yorkshire (excl. N.E. Coast and Sheffield) ..	1.4	20.7	—	1.8	0.5	23.3	1.1	24.4
Lincolnshire	—	29.4	—	—	0.1	29.3	0.2	29.5
North-East Coast	1.9	59.3	—	1.1	0.5	61.0	1.8	62.8
Scotland	4.7	34.5	—	1.2	0.8	39.2	2.0	41.2
Staffs, Shrops, Worcs and Warwick	—	16.1	—	0.8	0.7	16.1	1.5	17.6
S. Wales and Monmouthshire	7.2	54.9	5.6 (basic)	0.9	0.1	68.2	0.5	68.7
Sheffield (incl. small quantities in Manchester) ..	7.8	23.1	—	8.8	0.6	38.3	2.0	40.3
North-West Coast	—	2.9	4.7 (acid)	0.4	0.1	8.0	0.1	8.1
Total	23.0	243.6	21.1	16.5	3.6	297.9	9.9	307.8
May, 1951[1]	21.8	243.0	21.4	15.4	3.5	295.9	9.2	305.1
June, 1950	27.0	246.6	21.0	14.4	3.5	303.9	8.6	312.5

TABLE III.—*Weekly Average Deliveries of Finished Steel. (Thousands of Tons.)*

Product.	1949.	1950.	1950. June.	1951. May.[1]	1951. June.
Non-alloy steel:					
Ingots, blooms, billets and slabs[4]	4.5	3.6	3.7	3.9	3.9
Heavy rails, sleepers, etc. ..	9.8	11.3	12.5	11.1	13.1
Plates ¼ in. thick and over ..	39.2	40.0	40.1	41.4	45.5
Other heavy prod.	37.5	40.2	40.3	41.4	44.1
Light rolled prod.	46.4	47.6	45.9	48.0	47.5
Hot rolled strip ..	17.1	19.4	19.1	18.9	21.1
Wire rods	15.4	16.3	15.7	16.8	16.6
Cold rolled strip ..	4.9	5.5	5.6	5.6	6.6
Bright steel bars ..	5.6	6.2	6.4	6.6	7.1
Sheets, coated and uncoated ..	27.6	30.5	33.6	32.3	34.7
Tin, terne and blackplate ..	13.7	14.3	14.8	15.7	15.6
Tubes, pipes and fittings	18.5	20.0	20.7	20.5	23.5
Mild wire	12.0	12.6	13.1	11.8	12.3
Hard wire ..	3.2	3.5	3.2	3.6	4.0
Tyres, wheels and axles	4.1	3.5	3.7	3.1	4.5
Steel forgings(excl. drop forgings) ..	2.4	2.2	2.4	2.2	2.4
Steel castings ..	3.6	3.5	3.7	3.6	4.6
Total ..	265.5	280.2	284.5	284.5	307.1
Alloy steel ..	10.4	10.6	10.7	11.6	13.4
Total deliveries from U.K. prod.[5] ..	275.9	290.8	295.2	296.1	320.5
Add imported finished steel ..	9.5	3.8	5.3	3.0	4.0
	285·4	294·6	300·5	299·1	324·5
Deduct intra-industry conversion[6]	52.8	55.6	55.2	57.4	63.7
Total deliveries..	232.6	239.0	245.3	241.7	260.8

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

District.	Furnaces in blast.	Hematite.	Basic.	Foundry.	Forge.	Ferro-alloys.	Total.
Derby, Leics, Notts, Northants and Essex	24	—	15.5	23.9	1.2	—	40.6
Lancs (excl. N.E. Coast), Denbigh, Flints and Cheshire; Yorkshire (incl. Sheffield, excl. N.E. Coast)	6	—	8.0	—	—	0.8	8.8
Lincolnshire ..	14	—	24.7	—	—	—	24.7
North-East Coast	23	7.4	34.0	0.1	—	1.4	42.9
Scotland	9	0.7	11.3	2.5	—	—	14.5
Staffs, Shrops, Worcs, and Warwick	9	—	9.0	1.5	—	—	10.5
S. Wales and Monmouthshire	7	3.3	22.6	—	—	—	25.9
North-West Coast	7	13.7	—	—	—	1.0	14.7
Total ..	99	25.1	125.1	28.0	1.2	3.2	182.6[7]
May, 1951[1] ..	99	24.3	125.8	26.7	1.7	3.7	182.3
June, 1950 ..	98	27.8	124.1	26.3	1.1	2.8	182.2

[1] Five weeks.

[2] Weekly average of calendar month.

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

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

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

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

[7] Including 100 tons direct castings.

Lectures in Foundry Practice

The Borough Polytechnic, Borough Road, London, S.E.1, has organised a course of nine lectures on "Some Interesting Aspects of Foundry Practice," which will be given by specialist lecturers on Thursdays at 7 p.m., beginning on October 11.

This course of lectures has been arranged by the governors of the Polytechnic at the request of the Regional Advisory Council for Higher Technological Education for London and the Home Counties.

The fee for the complete course is two guineas. Students wishing to enrol should apply to the secretary of the Polytechnic for a form to complete.

Programme

October 11, 1951, "Centrifugal Castings," by M. M. Hallett, M.SC., F.I.M.; October 18, "Precision Casting," by J. S. Turnbull; November 1, "Malleable Iron Castings," by H. G. Hall, F.I.M.; November 8, "Art Foundry Practice," by A. Wizard; November 15, "Foundry Sands," by W. Davies, D.SC.; November 29, "Non-ferrous Foundry Alloys," by E. C. Mantle, M.SC., A.I.M.; December 6, "Foundry Mechanisation," by J. W. Gardom, A.M.I.MECH.E., F.I.M.; December 13, "Nodular Cast Iron," by H. Morrogh; January 10, 1952, "Technical Controls in the Modern Steel Foundry," by A. C. Brearley, B.SC.

Scientific Film Show

A great deal of work has already been done in Great Britain by a working-party of the Scientific Film Association international committee to ensure that this country shall be as well represented as possible in all fields of scientific film using and making at the Fifth Congress of the International Scientific Film Association, to be held from September 15 to 22, at The Hague, Netherlands. The research film committee of the International Association is hoping to show large numbers of photographs of special applications of scientific cinematography and the apparatus used in research film-making. Anyone who can contribute to the British section of the exhibit is particularly asked to get into touch as soon as possible with the British S.F.A. at 4, Great Russell Street, London, W.C.1.

Course on Refractories

The Northampton Polytechnic, St. John Street, London, E.C.1, through the Department of Applied Chemistry, the head of which is Dr. Garside, is organising a course covering lectures on refractories—their manufacture, properties and uses. The lecturer is Mr. L. R. Barrett. They will start at 7 p.m. on October 2 and continue every Tuesday evening. The fee for the course is 30s. This department also organises courses of study for entrance to the Institution of Metallurgists and many other examinations.

Index to Volume 90

Readers are advised that the Index to Volume 90 of the FOUNDRY TRADE JOURNAL covering the period January 4 to June 28, 1951, has now been printed. Copies are available free of charge on writing to the Publishing Office, FOUNDRY TRADE JOURNAL, 49 Wellington Street, London, W.C.2. Regular subscribers are invited to apply for inclusion in a special list to whom copies of the index are sent automatically as published.

Personal

MR. ARCHIBALD BOWIE has retired after having completed 31 years' service with the Darwen & Mostyn Iron Company, Limited, as chief engineer and works manager.

MR. D. F. W. MCNAIR, manager of the export sales branch of F. Perkins, Limited, Peterborough, and MR. G. R. GUEST, head of new sales projects, have left for Canada, where they will travel extensively to develop the market for Perkins Diesel engines.

Aged only 25, MR. PETER KAY, a traction design engineer with Metropolitan-Vickers Electrical Company, Limited, Trafford Park, Manchester, has been appointed lecturer in electrical engineering at the South-east London Technical Institute, Lewisham.

The new employer vice-chairman of the Midland Regional Board for Industry is MR. S. F. BURMAN, who, in addition to being managing director of Burman & Sons, Limited, manufacturers of hair clippers, etc., is also a director of W. & T. Avery, Limited. He has also served as a member of the Midlands Electricity Board.

Obituary

The death has occurred of MR. JOHN ALLSOPP, formerly traffic manager of the Staveley Coal & Iron Company, Limited, Chesterfield.

MR. G. R. INSHAW, managing director of the Unicone Company, Limited, manufacturers of tube joints, tubes, and fittings, of Rutherglen, Glasgow, died on August 27.

MR. WILLIAM MOSTYN WATSON, a director of A. Wood & Sons (Middlesbrough), Limited, iron and steel stockholders and scrap merchants, has died at the age of 42.

MR. NICHOLAS C. MUNRO, managing director of Thomson & Stewart (Aberdeen), Limited, ironfounders, which he joined 32 years ago as a foreman, has died at the age of 64.

While visiting New Zealand during the course of a world tour, MR. PATRICK W. MCDONOUGH, president of the McDonough Steel Corporation, of Oakland, California, died suddenly in Wellington.

MR. A. V. VENABLES, welfare officer of John Baker & Bessemer, Limited, steel tyre and axle manufacturers, etc., of Rotherham, and Rotherham Forge & Rolling Mills, Company, Limited, died recently at the age of 63.

SIR ROBERT JOHNSON, for many years an outstanding personality in the shipbuilding industry, died on August 28 at the age of 79. He was chairman of Cammell Laird & Company, Limited, Birkenhead, his retirement from the position of managing director having been anonunced on July 24 last, when his son, Mr. Robert W. Johnson, was appointed to succeed him.

I.B.F. Activities at Doncaster

With the object of fostering interest in the activities of the Institute of British Foundrymen in the Doncaster district, the Sheffield branch is holding three meetings in this area during the coming session. The first will be held at 7.30 p.m. on Wednesday, October 3, at the Technical College, Doncaster. Mr. W. J. Colton, president of the Sheffield branch, will be in the chair and will be supported by Mr. E. Burgess, managing director of John Fowler & Company (Leeds), Limited. Their talks, outlining the activities of the Institute, will be followed by a Paper, "Cast Design in Relation to Production," by Mr. J. H. Pearce (secretary of the Sheffield branch) and Mr. G. D. Whitehouse.

News in Brief

AN ELECTRICITY POWER CUT due to load shedding at Keighley on August 27 seriously affected several industrial concerns in Keighley.

IN A BALLOT for an assistant general secretary of the Amalgamated Engineering Union, Mr. C. W. Hallett obtained 37,909 votes and Mr. W. Hannington 29,267.

THE STATE ELECTRICITY COMMISSION of Victoria has placed an order with the Metropolitan-Vickers Electrical Company, Limited, for 31 units of metalclad switchgear.

THE U.S. GOVERNMENT on August 28 called 400 industrialists to an emergency conference at Washington on September 11 to organise a more effective campaign of iron and steel scrap salvage.

C. A. PARSONS & COMPANY, LIMITED, Newcastle-upon-Tyne, has formed a company to look after its interests in Rhodesia. Mr. M. Coote is acting as manager and director of the new organisation.

ORDERS for three cargo motorships, each of about 10,000 tons d.w., have been placed on the Clyde by the New Zealand Shipping Company, Limited. Two are to be built by John Brown & Company, Limited, and the third by Alexander Stephen & Sons, Limited.

THE WHOLE of the share capital of A.B.C. Motors, Limited, aero engine builders, of Walton-on-Thames (Surrey), has been acquired by Vickers, Limited. An executive director of A.B.C. Motors for many years, Mr. R. M. Dennis, has been appointed managing director.

A WEEK'S COURSE, designed to give basic knowledge of iron and steel manufacture to careers masters, science masters, and youth employment officers, held at Stewarts and Lloyds, Limited, Bilston, includes daily lectures and group discussions on subjects of special or general interest

ADDITIONAL PREMISES at Peterborough, with an area of some 13,000 sq. ft., which formerly belonged to F. Perkins, Limited, Diesel engine manufacturers, have been purchased by W. Pinder & Son, Limited, manufacturers of fabricated machine-tool components, doubling the size of the existing works.

THE RECENT INCREASE in the price of heavy fuel oil will, it is estimated, add more than £200,000 a year to steel production costs in the Sheffield area. Steelmaking furnaces in the area now use more than 150,000 tons of oil a year, a quarter of the entire consumption of oil by the British iron and steel industry.

THE DISCOVERY of rich deposits of iron, zinc, copper, and gold in Quebec has been announced by Mr. Maurice Duplessis, Premier of Quebec. Over 1,000,000 tons of copper and gold ore have been located on Merril Island, in Lake Dore, while the zinc discovery is described as one of the richest in the world.

RESOLUTIONS increasing the authorised capital of General Refractories, Limited, from £650,000 to £1,250,000 and capitalising £390,000 of reserves for a three-for-five capital bonus to ordinary shareholders registered on September 10 will be placed before an extra-ordinary general meeting on that date.

THE DIRECTORS of Aeroplane & Motor Aluminium Castings, Limited, have announced a proposal to increase the capital to £200,000 by the creation of 125,000 4s. ordinary shares and their issue as a capital bonus by capitalisation of £25,000 from general reserve. The new shares will be distributed to holders registered on September 6.

AN EXHIBIT OF FOUNDRY INTEREST which escaped our attention last week was that of Leicester, Lovell & Company, Limited, North Baddesley, Southampton. The firm manufactures core-bonding materials based on P.F. and U.F. resins, and shows both cores and castings on the stand which is located in the gallery of the National Hall (stand 10, outer row).

THE REPUBLIC OF IRELAND imported 2,598 tons of pig-iron, valued at £39,656, in the first half of this year, against 2,525 tons (£36,910) in the corresponding period of 1950. The total import value of iron and steel and manufactures (excluding cutlery and machinery) during the first half of 1951 was £4,739,011, against £3,903,785 in the corresponding 1950 period.

IT WAS SUGGESTED by the jury at the inquest at Chesterfield, on August 29, on Arthur Bertram, of Sheffield, who died in Chesterfield Royal Hospital after an accident in a foundry in the area, that if certain safety regulations had been properly carried out, the accident need never have happened. Bertram, an electrician, was struck by a crane while at work, and the coroner commented: "It is clear that these people were working in a position of danger and that proper warning should have been given to the driver of the crane."

A TWO-PRICE SYSTEM for essential commodities was advocated by Mr. J. R. D. Tata, chairman of the Tata Iron & Steel Company, Limited, at the recent meeting. There was no real remedy for inflation, he said, in an increase in money payments to meet an increase in the cost of living. He favoured instead the adoption of a dual-price policy which would lay down a relatively low price for supplies required to meet Government's minimum commitments and a higher price for supplies above this limit. Such a measure, he believed, would be more realistic than the proposal to freeze wages, profits, and dividends.

UNDER the Road Vehicles (Registration and Licensing) Regulations, 1951 (SI No. 1381), and the Road Vehicles (Index Marks) Regulations, 1951 (SI No. 1380), which came into effect on August 15, there is special provision for the exhibition of registration marks on works trucks, which are defined as vehicles designed for use in private premises and used on roads only in passing to various parts of the same premises or to other private premises in the immediate neighbourhood. Their registration marks may be exhibited either on both sides of the vehicle or only on the back of the vehicle, instead of on both front and back as previously, and these marks need no longer be illuminated at night.

Forthcoming Events

SEPTEMBER 11

Institution of Works Managers

Birmingham Branch Dinner and Annual General Meeting, at the Grand Hotel, at 7 p.m.

Incorporated Plant Engineers

Glasgow Branch:—"Electronics in Production," by a member of the laboratory research staff of Mullard, Limited, at 7 p.m., at the Engineering Centre, 351, Sauchiehall Street, Glasgow.

Institution of Production Engineers

Birmingham Graduate Branch:—Film evening, with sound films, including "The Sharp Edge of the World," by Gillette Industries, Limited, and "Precision Tools," by Weir Precision Engineering, Limited, by R. A. Bishop, at 7 p.m., at the James Watt Memorial Institute, Great Charles Street, Birmingham, 3.

SEPTEMBER 12

Institute of Vitreous Enamellers

Official Visit to the Engineering, Marine and Welding Exhibition at Olympia, London.

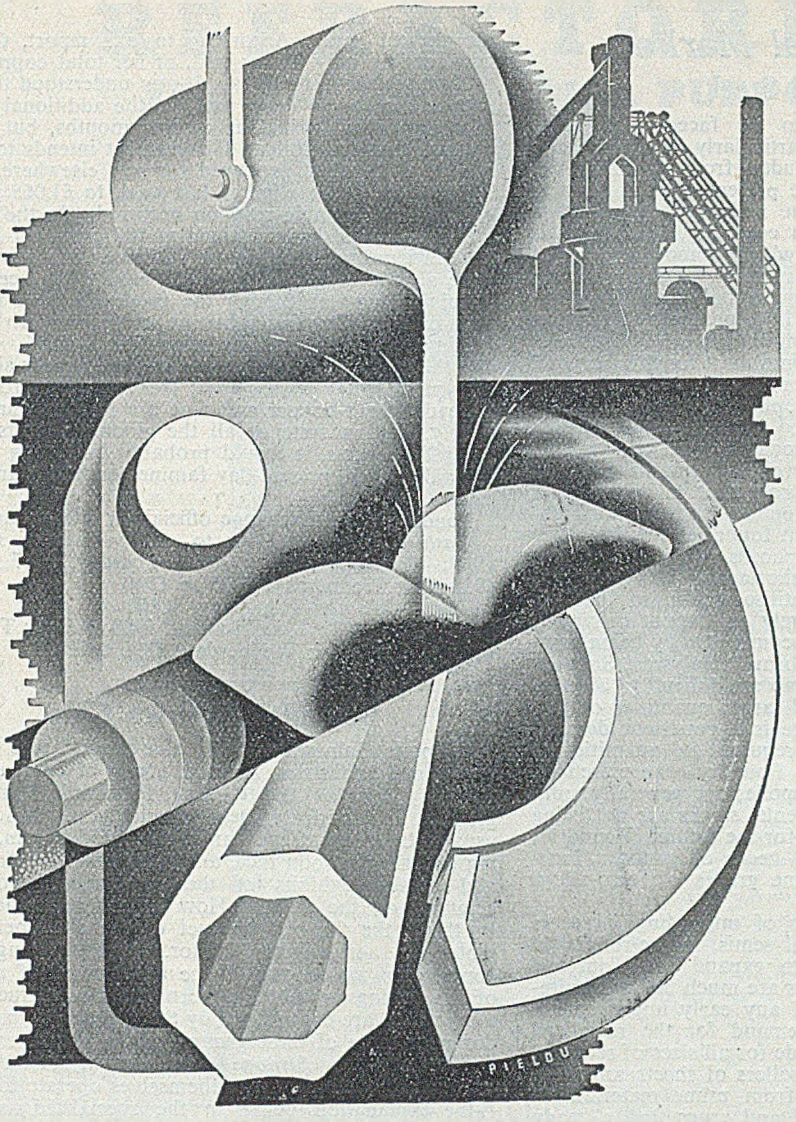
SEPTEMBER 13

Incorporated Plant Engineers

Kent Branch:—"Electric Motors—Characteristics and Application," at 7.30 p.m., at the Queens Head, Maidstone.

Newcastle-upon-Tyne Branch:—"Pulverised Fuel" (film and discussion), by P. R. Bettle, of Babcock & Wilcox, Limited, at 7.30 p.m., at Roadway House, Oxford Street, Newcastle-upon-Tyne.

South Yorkshire Branch:—Works Visit to Steel, Peech & Tozer's steelworks.



Raw Material Markets

Iron and Steel

The foundries continue to be faced with acute shortages of raw materials, particularly in pig-iron and scrap, and are thereby precluded from obtaining the outputs of castings which the present rate of business calls for. Pig-iron makers are making every effort to distribute available tonnages equitably, but there is a large outstanding demand which cannot be satisfied from the furnaces at present in blast. Apart from the needs of the foundries, pressure is maintained for steel-making pig-iron, and there is little prospect of furnaces being changed over to supply more iron to the foundries or of new furnaces being put into blast for this purpose.

Increased imports of iron ore should eventually lead to some improvement in supplies of pig-iron to the general engineering, motor, and textile foundries, which are urgently in need of additional supplies of low- and medium-phosphorus iron, as well as hematite pig-iron, but so far, little, or no, improvement in deliveries is evident. Refined and Scotch foundry irons are also very scarce. The jobbing and light foundries require much larger tonnages of high-phosphorus pig-iron than they can obtain. The continued shortage in deliveries has compelled all foundries to utilise stocks, so that the foundries are dependent entirely on current deliveries.

The foundries are further incommoded by being compelled to accept iron of abnormal analyses. Supplies of both cast-iron and steel scrap are difficult to acquire, which necessitates the use of larger quantities of pig-iron in their mixtures. There is a persistent demand for cupola scrap, which is required in quantities in excess of available tonnages. Foundry coke presents a further problem; although supplies are generally sufficient for immediate requirements, stocks are not being built up, thus causing anxiety for the future. Foundries are able to secure their full needs of ganister, limestone, and firebricks, but some grades of ferro-alloys are tight.

Although there are reports of impending increases in deliveries of imported steel semis, the re-rollers, in the meantime, are unable to expand their outputs. Supplies from home steelworks are much below requirements, with little prospect of any early improvement. There is no reduction in demand for the re-rollers' products. Heavy calls are made for all sizes of sections, bars, and strip, while the re-rollers of sheets are inundated with business. Apart from prime material, all arisings of defective material and crops find a ready market.

Non-ferrous Metals

The anxiety felt over the possibility of a prolonged nationwide strike in the United States, calculated to bring copper production virtually to a standstill and to cut the output of zinc and lead by nearly 50 per cent., was to some extent relieved on Saturday when news came through that a settlement had been reached in the wages dispute at the Utah plant of the Kennecott Copper Corporation, probably the largest copper mine in the United States. It has been reported that the National Production Authority estimated that about 15,000 tons of copper, as well as zinc and lead, were lost last week through the strike.

This interruption to non-ferrous output has come at a bad time, for the drive for rearmament is well under way in the United States and it is not surprising that the President has appointed a board to enquire into the whole matter. Even before the events of last week, there was a serious shortage of metals in the United States, if only because imports have declined during the present year. According to one report, Chile is now sending only 80 per cent. of her total copper production to North America. It was understood that this proportion was to apply only to the additional output to be achieved during the coming months, but it now appears that the Chilean Government intends to retain a fifth of the total produced for sale elsewhere.

The price of tin climbed last week to £1,065 per ton before the inevitable reaction occurred. In the United States the price has remained at 103 cents per lb., but negotiations with Bolivia for purchases of concentrates were approaching finality on the basis of 112 cents. It certainly seems as though the producers were not too keen on accepting this valuation, even for a fairly short trial period. The sterling equivalent is £896. Prices of other metals are unchanged and the supply situation very much what it was, apart from some improvement in lead. Both copper and zinc are in somewhat short supply, but, in spite of all the gloomy reports about future prospects, it would probably be wrong to presume that these present-day famine conditions are going to last indefinitely.

London Metal Exchange official tin quotations were:

Cash—Thursday, £915 to £920; Friday, £925 to £930; Monday, £950 to £955; Tuesday, £947 10s. to £952 10s.; Wednesday, £935 to £940.

Three Months—Thursday, £860 to £870; Friday, £882 10s. to £887 10s.; Monday, £900 to £905; Tuesday, £895 to £897 10s.; Wednesday, £890 to £895.

Birmid Industries Gala

A Sports Gala with novel "side-shows" was held by the Birmid Industries, Limited, group of companies on Saturday last at the "Percy Pritchard Memorial" grounds at Woodgate, near Birmingham. Among the usual attractions at such an event—model train, shooting galleries, balloon race, and the like—were marquees and outside exhibits of the companies' productions arranged on the theme "How Birmid helps industry." In these, the finished product of the customer, be it motor-car aero-engine, tractor, stationary engine or compressor, was shown in the background of a group of the castings, sheet-metal formations or extruded sections which are contributed by the Birmid companies. A dozen or more of these groups, out of the 20 exhibited were of castings. Strange to relate, many of these were supplied to customers who themselves operate foundries —the explanation being in the specialised nature of Birmid contributions in high-duty iron, aluminium or electron, chiefly for the motor trade. This is indeed a novel way of bringing home the ramifications of a large concern, not only to the general public, but especially to the operatives who often possess very sketchy ideas of the detail items and ultimate purpose of a large group's productions.

The rest of the afternoon's attractions—all manner of sporting events, inter-works competitions, arts and crafts exhibitions, prize-giving, and refreshment marquees, all were commendably organised and graced by kind weather. "Noises off" were impressively produced by the close-up antics of a Westland helicopter (for which the group makes light-alloy parts). This latter was just that high-light of showmanship much appreciated by the gathering.

Mammoth Weld. Mr. Le Thomas writing in the *Journal d'Information Techniques des Industries de la Fonderie* rightly praises a metallurgical accomplishment he personally witnessed. It related to the provision of eight tons of alumino-thermically prepared steel for mending some outsize casting.

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

(Delivered, unless otherwise stated)

September 5, 1951

PIG-IRON

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

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

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

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

Refined Malleable.—P, 0.10 per cent. max.—North Zone, £14 12s.; South Zone, £14 14s. 6d.

Cold Blast.—South Staffs, £17 5s. 6d.

Hematite.—Si up to 2½ per cent., S. & P. over 0.03 to 0.05 per cent.:—N.-E. Coast and N.-W. Coast of England, £12 17s.; Scotland (Scotch iron), £13 3s. 6d.; Sheffield, £13 13s. 6d.; Birmingham, £14 0s. 6d.; Wales (Welsh iron), £13 3s. 6d.

Spiegeleisen.—20 per cent. Mn, £18 15s. 9d.

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

FERRO-ALLOYS

(Per ton unless otherwise stated, delivered.)

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

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

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

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

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

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

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

Ferro-chrome (6-ton lots).—4/6 per cent C, £74, basis 60% Cr, scale 24s. 6d. per unit; 6/8 per cent. C, £70, basis 60% Cr, scale 23s. 3d. per unit; max. 2 per cent. C, 1s. 8¼d. per lb. Cr; max. 1 per cent. C, 1s. 8¾d. per lb. Cr; max. 0.15 per cent. C, 1s. 9½d. per lb. Cr.; max. 0.10 per cent. C, 1s. 9¾d. per lb. Cr.

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

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

Metallic Chromium.—98/99 per cent., 5s. 11d. per lb.

Ferro-manganese (blast-furnace).—78 per cent., £39 17s. 1d.

Manganese Briquettes (5-ton lots and over).—2lb. Mn, £49 10s.

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

SEMI-FINISHED STEEL

Re-rolling Billets, Blooms, and Slabs.—Basic: Soft, u.t., £21 6s. 6d.; tested, 0.08 to 0.25 per cent. C (100-ton lots), £21 16s. 6d.; hard (0.42 to 0.60 per cent. C), £23 14s.; silico-manganese, £29 10s.; free-cutting, £24 10s. 6d. Siemens Martin Acid: Up to 0.25 per cent. C, £27 11s.; case-hardening, £27 19s.; silico-manganese, £30 11s. 6d.

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

Sheet and Tinplate Bars.—£21 16s.

FINISHED STEEL

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

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

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

Tinplates.—54s. 8½d. per basis box.

NON-FERROUS METALS

Copper.—Electrolytic, £234; high-grade fire-refined, £233 10s.; fire-refined of not less than 99.7 per cent., £233; ditto, 99.2 per cent., £232 10s.; black hot-rolled wire rods, £243 12s. 6d.

Tin.—Cash, £935 to £940; three months, £890 to £895; settlement, £935.

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

Lead.—Good soft pig-lead (foreign) (duty paid), £180; ditto (Empire and domestic), £180; "English," £181 10s.

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

Other Metals.—Aluminium, ingots, £124; antimony, English, 99 per cent., £390; quicksilver, ex warehouse, £73 5s. to £73 15s.; nickel, £454.

Brass.—Solid-drawn tubes, 25½d. per lb.; rods, drawn, 28¼d.; sheets to 10 w.g., 30⅛d.; wire, 31¾d. rolled metal, 28⅞d.

Copper Tubes, etc.—Solid-drawn tubes, 26⅞d. per lb.; wire, 261s. 9d. per cwt. basis; 20 s.w.g., 288s. 9d. per cwt.

Gunmetal.—Ingots to BS. 1400—LG2—1 (85/5/5/5), £277 to £281; BS. 1400—LG3—1 (86/7/5/2), £282 to £300; BS. 1400—G1—1 (88/10/2), £330 to £360; Admiralty GM (88/10/2), virgin quality, £350 to £360 per ton, delivered.

Phosphor-bronze Ingots.—P.Bl, £355 to £390; L.P.Bl, £316 to £322 per ton.

Phosphor Bronze.—Strip, 38¾d per lb.; sheets to 10 w.g., 40⅞d.; wire, 43⅜d.; rods, 38¾d.; tubes, 37d.; chill cast bars: solids 4s., cored, 4s. 1d. (C. Clifford & Son, Limited.)

Nickel Silver, etc.—Ingots for raising, 2s. 7½d. per lb. (7%) to 3s. 7¼d. (30%); rolled metal, 3 in. to 9 in. wide × .056, 3s. 1½d. (7%) to 4s. 1¼d. (30%); to 12 in. wide × .056, 3s. 1¾d. to 4s. 1½d.; to 25 in. wide × .056, 3s. 3¼d. to 4s. 3½d. Spoon and fork metal, unsheared, 2s. 10½d. to 3s. 10¼d. Wire, 10g., in coils, 3s. 7¼d. (10%) to 4s. 7d. (30%). Special quality turning rod, 10%, 3s. 6¼d.; 15%, 3s. 11d.; 18%, 4s. 3¼d. All prices are net.