FOUNDRY TRADE JOURNAL

EST. 1902

VOL. 90
No. 1817
Registered at the G.P.O. as a Newspaper

WITH WHICH IS INCORPORATED THE IRON AND STEEL TRADES JOURNAL

JUNE 28, 1951

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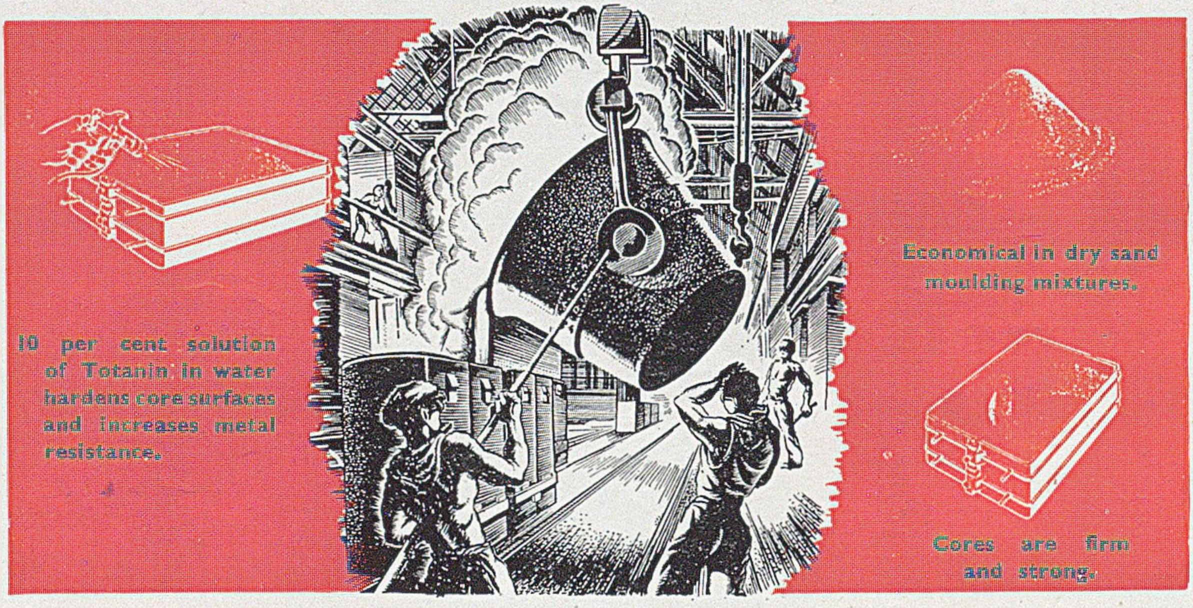

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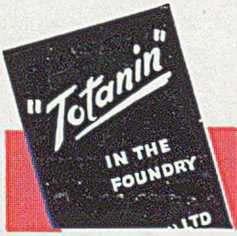

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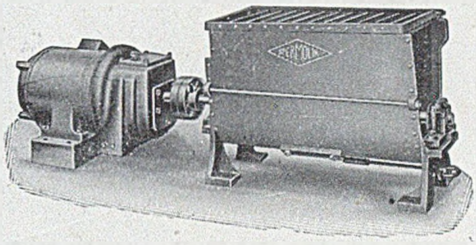

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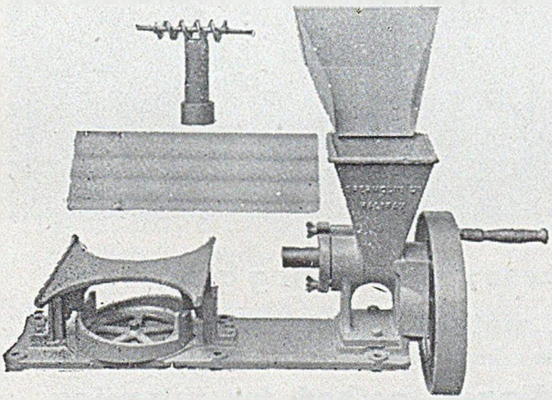

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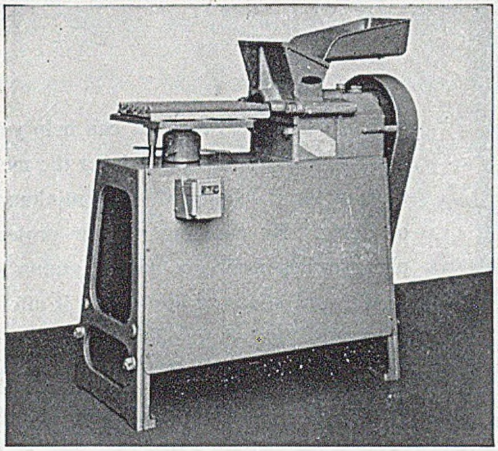
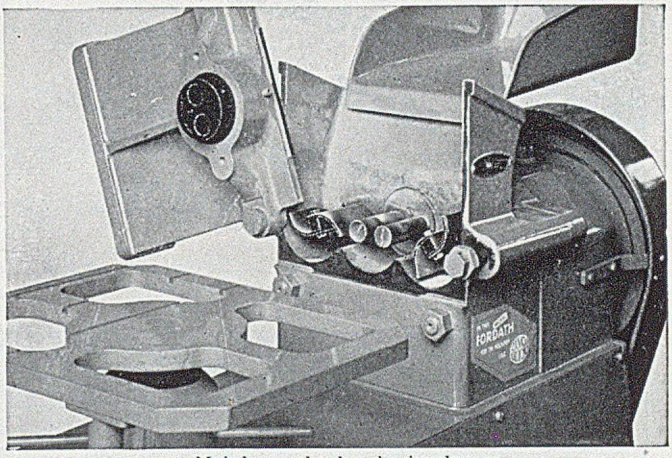


Fordath "Multiplunger" Core Machine, showing extruded cores



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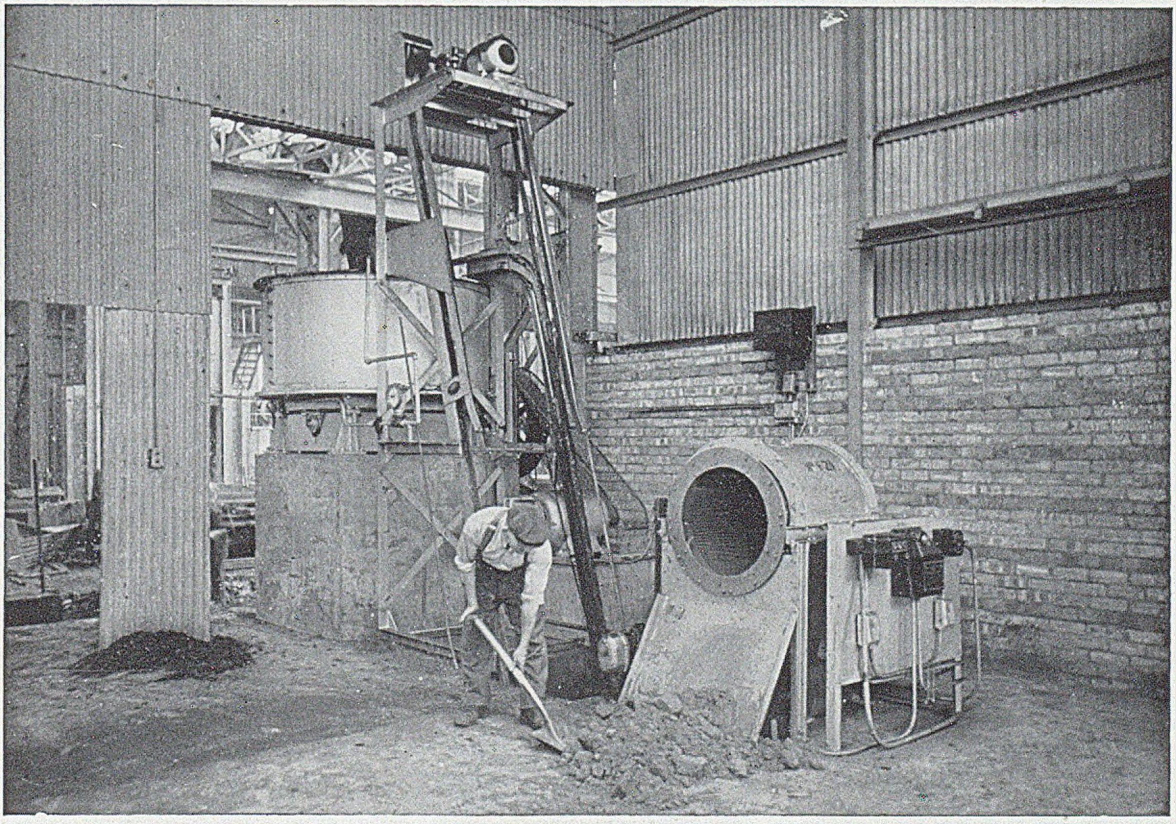

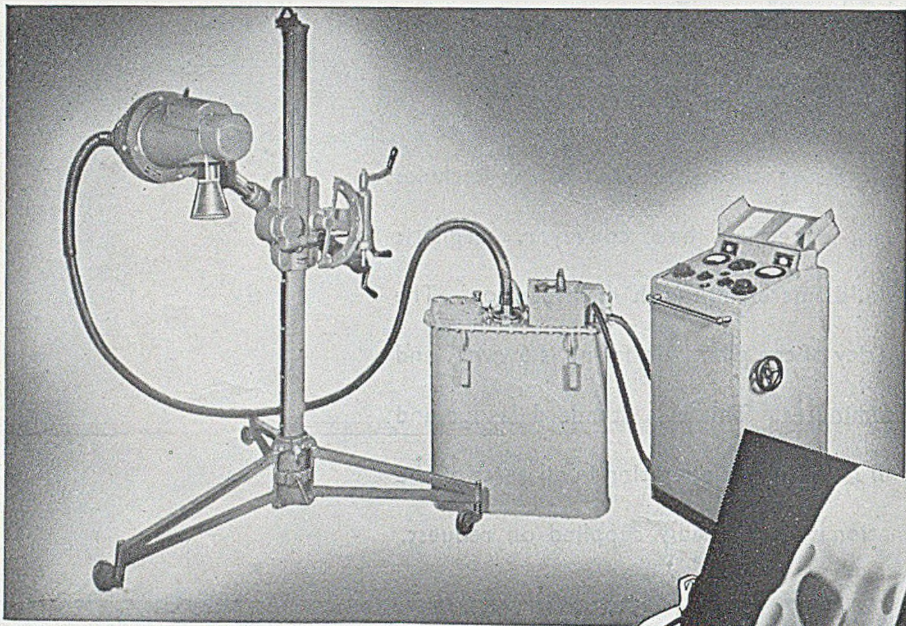

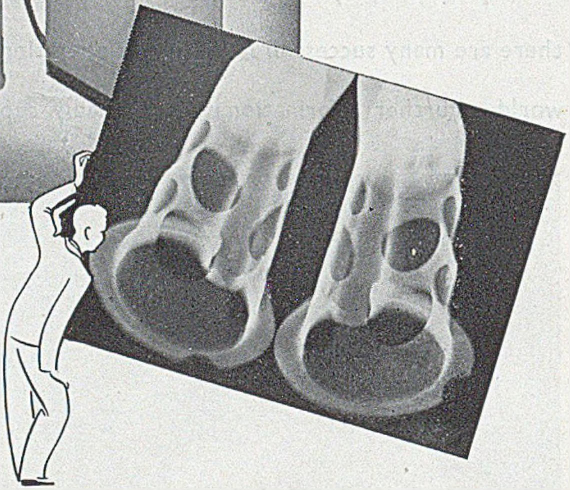

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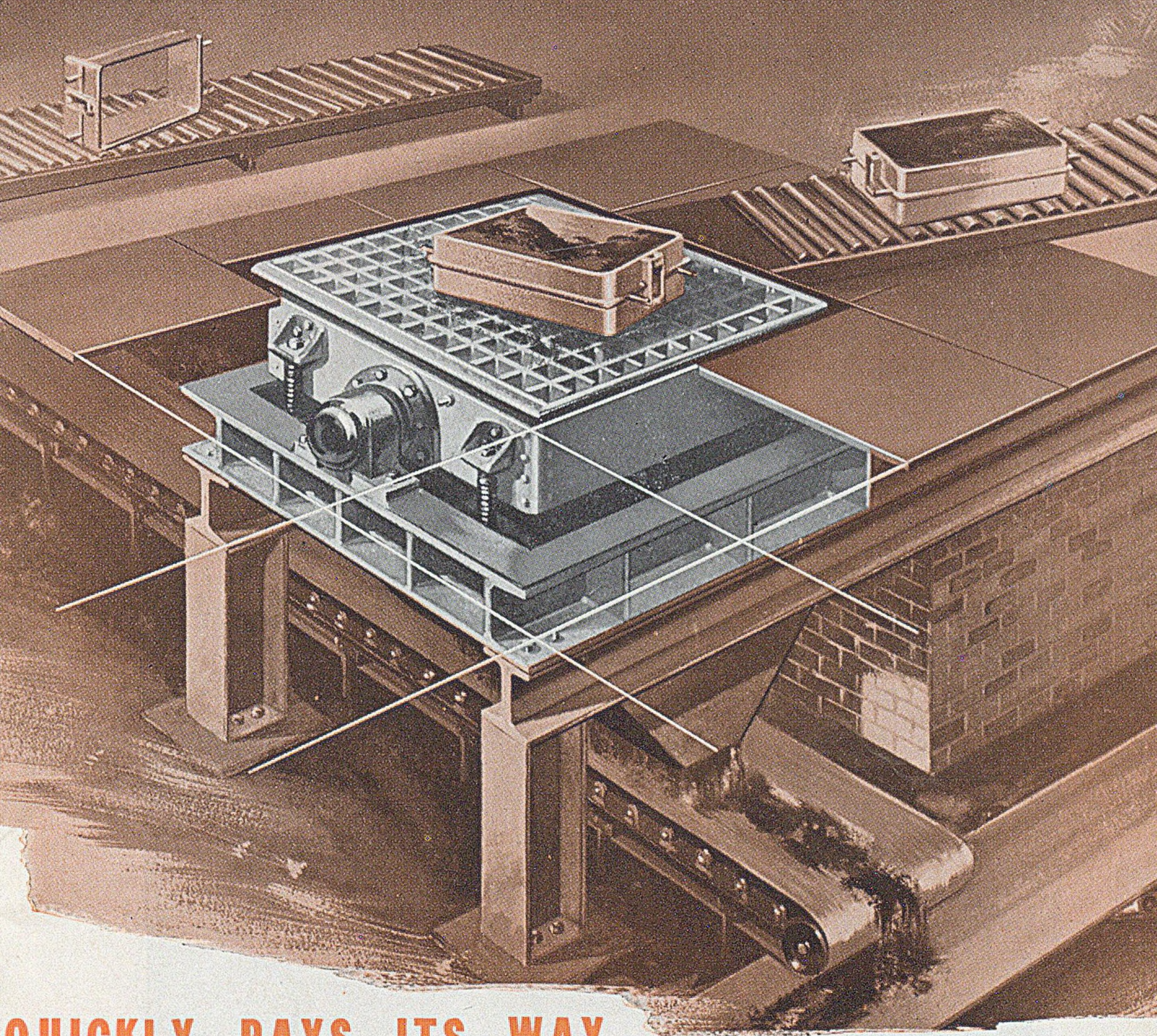

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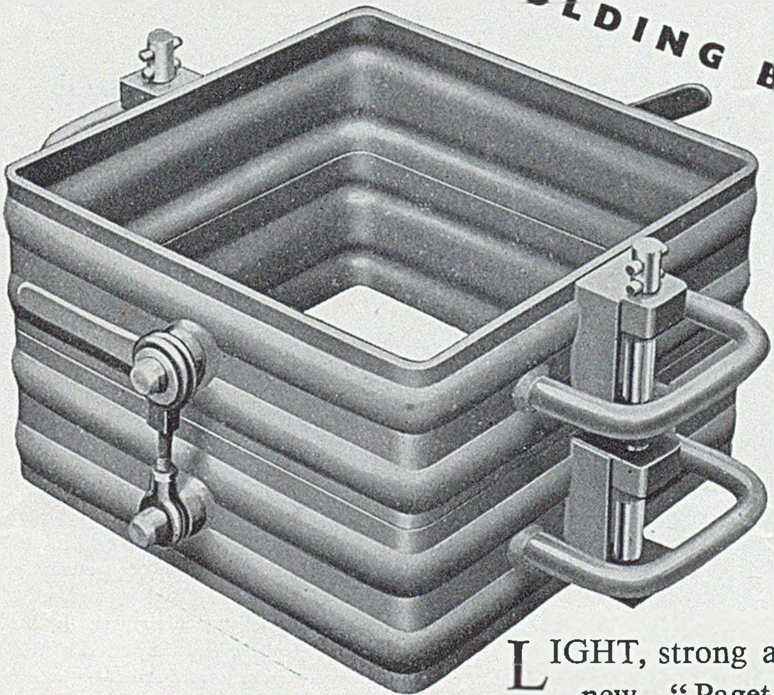

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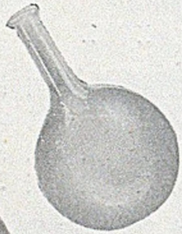

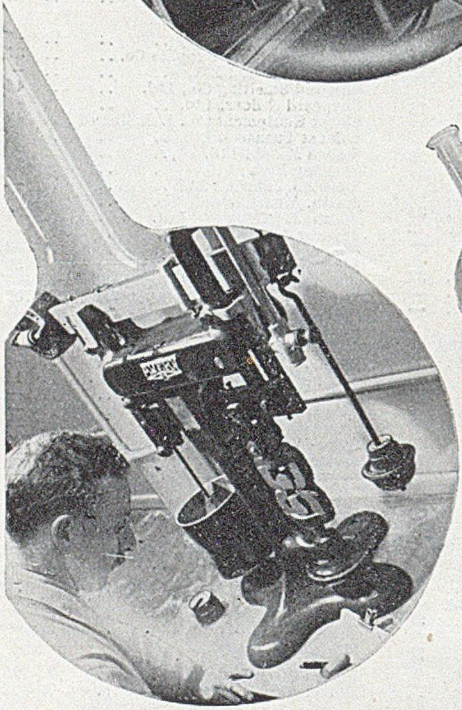

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Established 1902
WITH WHICH IS INCORPORATED THE IRON AND STEEL TRADES JOURNAL

Vol. 90 Thursday, June 28, 1951 No. 1817

CONTENTS

PUBLISHED WEEKLY: Single Copy, 9d. By Post 11d. Annual Subscription, Home 40s., Abroad 45s. (Prepaid).

49, Wellington Street, London, W.C.2. 'Phone: Temple Bar 3951 (Private Branch Exchange) Grams: "Zacatecas, Rand, London"

Resale Price Maintenance

The Government is proposing to enact legislation to eradicate the imposition of minimum retail price-maintenance agreements from British commercial life. They are doing so as they believe that such an action may tend to lower retail prices. It would appear that, during the hearing before the Lloyd Jacob Committee, most witnesses preferred a fixed price for the goods they bought. However, Sir Hartley Shawcross insists that had they been asked, supposing a line of branded goods were offered at one shop for 1s. and at another for 9d., they would have chosen the latter. He maintained this, forgetting that the value of a quarter of an hour in a queue would eliminate any gain! The mere taking of a short tram ride to a cut-price shop may well cancel out any potential saving. No wonder Sir Hartley expressed the notion that the measure would not " produce any dramatic reduction in prices."

So far as foundry owners are concerned, there is only the section making hardware that may be affected. In any case, as one does not buy a wringer, a mincing machine, or even a cast-iron saucepan or kettle every week, the influence on the cost of living would be negligible. The Report on the Light Iron Castings Industry indicated that everybody was quite happy about the various sales agreements, but there was the thought that the public might be paying too high a price. If, on the only occasion we bought a house, we paid too much for the builders' castings incorporated, we certainly did not notice it, nor has anybody else within our circle of friends had reason to complain.

The people who would be most affected, if this idea ever becomes law, are the retailers. There is a tacit assumption in the White Paper—" A Statement on Resale Price Maintenance "—that all retailers are thoroughly familiar with costing, and that when they cut prices they are fully cognisant of the whole of the implications. Foundry owners, whose true manufacturing expenses are obviously more difficult to obtain, well know that the smaller the concern, the greater the ignorance of costing. The enforcement of a fixed minimum sales price is often an insurance for the retailers against their own lack of fundamental business knowledge. A strange aspect of the Government's proposals is that the trade unions, their most loyal supporters, insist on a minimum price for the hire of their members. Again, the State monopolies just announce their charges, which must be paid for by, or passed on to, the general public; yet for the retailer a directly opposite policy is envisaged. It is our firm opinion that there is at the moment far too much theory, and far too little practice about the proposed legislation. We could detail much better measures for reducing the cost of living than the one proposed.

International Foundry Congress

The 1951 International Foundry Congress, organised by the *Association Technique de Fonderie de Belgique* under the auspices of the International Committee of Foundry Technical Associations, will be held in Brussels from September 10 to 14. The Technical sessions are to take place in the Fabrimétal Building, 21 rue des Drapiers.

The programme envisages for the opening day (Monday) the registration of the participants at 9 a.m., followed by the opening ceremony at 10.30. After luncheon, the first technical session is to be held at 2.30 p.m., then at 6 p.m. there is to be a cocktail party at the Brussels City Hall.

On Tuesday, there are technical sessions for both morning and afternoon, whilst in the evening there is to be an informal dinner, followed by dancing. The following day, Wednesday, is devoted to works visits in the Liége area, where the Espérance Longdoz, Ferblatil, and Ougrée Marihaye concerns will be receiving members. Technical sessions are scheduled for both morning and afternoon of Thursday, whilst in the evening there is to be the official closing banquet, for which evening dress is specified. The last day, Friday, is to be devoted to works visits in the Charleroi area. Post-congress tours are being arranged for visiting the Belgian Ardennes. During the Congress, there will be meetings of the main International Committee (5 p.m. on September 13); and the "Foundry Defects"; "Testing Cast Iron"; and "Dictionary"; committees on Tuesday, September 11 at 3 p.m.; 11 a.m.; and 4 p.m. respectively.

Ladies' Programme

On the Monday, the programme for the ladies is exactly the same as for the men, except that they have the afternoon free; on the Tuesday, at 11 a.m. they are to go sightseeing in Brussels, and at 3 p.m. there is a motor coach tour to Gasbeek and Beersel castles, and of course the informal dinner in the evening. Wednesday is to be spent in the delightful town of Bruges, with a call at Ghent, whilst on the Thursday, the morning is free and at 3.30 p.m. coaches leave to take them to Tervueren for tea, returning them in good time for the official banquet. On Friday at 10 a.m., coaches take the ladies to Antwerp, where they will visit Rubens' house and the docks; they will take luncheon on board a boat. Tea is to be served at the Antwerp Zoological Gardens.

The organising committee will in every case do their best to meet individual requirements, both as to works visits and sightseeing.

Congress Papers

At the technical sessions, the following Papers are to be presented:—Dr. W. T. Pell-Walpole on "Gases in Bronze"; Mr. N. Croft on "Quantity production of Spheroidal-graphite Cast Iron" (British exchange paper); Mr. Guy Henon on "Defining and Classifying Foundry Defects for Workshop Application"; Mr. J. S. Abcouwer on "Dimensioning Risers and Feeding Heads"; Mr. F. van Bergen on "Water-cooled Cupolas"; Mr. B. Schuil on "Use of X-ray Testing in Foundry Practice"; Mr. B. J. Hilders on "Co-operation between Foundry and Machine Shop"; Mr. E. O. Lissell, Mr. S. Forslund and Mr. S. Ryden on "Study of the Design and Performance of Mould- and Core-drying Stoves"; Mr. C. G. O. Burgess on "Surface Treating Grey Iron to Meet Specific Industrial Applications"; Mr. John B. Caine on

(*Continued at the foot of column 2*)

Conference Paper Author

Mr. D. C. G. Lees, M.A., A.I.M., Author of the Paper "Casting Characteristics of Some Aluminium Alloys" (printed on the opposite page), was born at Oldham in 1918, and educated at the Oldham Hulme Grammar School and Clare College, Cambridge (National Sciences Tripos Pt. II, Metallurgy, 1940). From 1940 to 1946, he held the gator at the British Non- position of research investi- Ferrous Metals Research Association, being mainly engaged in work on the melting and casting of aluminium alloys. From 1946 to 1948, Mr. Lees was on the staff of Industrial Newspapers, Limited, as editor of "Metal Treatment." He relinquished this appointment to take up the position of metallurgist to the Aluminium Development Association.

Mr. D. C. G. Lees.

Glasgow Foundry Explosion

Eight men were burned—four seriously—in Renfrew Foundries, Limited, at Hillington, Glasgow, on June 19, when a burst pipe shot a 45-ft. sheet of oil, which became ignited, through the pressure-die-casting section of the works. Four men were removed to hospital, where one died later; the others were allowed home after treatment. Men ran through the section with their clothing in flames.

A joint in a pipe—part of a high-pressure die-casting machine—suddenly slipped open and oil shot out with great force. Two lines of pots containing molten aluminium were standing in its path. The jet of oil ignited and sprayed the entire section with flames. Altogether about 30 of the foundry's staff were sent home after the accident. Renfrew Foundries, Limited, employ about 850 men and women in their Hillington factory, which is part-owned by Rolls-Royce, Limited.

Domestic Cooking and Heating Appliances

A conference took place in Paris on May 28, 1951, of representatives from Western European countries coming under the auspices of the Organisation for European Co-operation (O.E.E.C.) to explore the possibility of mutual co-operation and exchange of information on domestic cooking and heating appliances using solid fuel and gas. General agreement was expressed on the desirability of such co-operation, and a committee was appointed. The conference was arranged by the French association of makers of domestic cooking and heating appliances, and Great Britain was represented at the conference by nominees from the British Ironfounders' Association, the British Coal Utilisation Research Association and the Coal Utilisation Joint Council.

"Risering of Castings"; Mr. J. E. Rehder (Canada) on "Annealing and Heat-treatment of Nodular Cast Iron"; Mr. J. H. Lansing on "Important Attributes of Malleable Iron"; and Mr. Mathy on "Use of the Metallographic Microscope in the Heavy Non-ferrous Alloy Foundry."

Casting Characteristics of Some Aluminium Alloys*

By D. C. G. Lees, M.A., A.I.M.†

Designers have a wide choice from the many alloys to British Standard or Ministry of Supply D.T.D. *specifications when selecting light aluminium alloys for particular castings. The specification usually gives adequate guidance on strength, ductility and a number of other properties of sound castings, but little or no information on casting characteristics or behaviour in the foundry. The work described in the present Paper was undertaken to provide information, useful both to the designer and the manufacturer, on this class of properties, for a number of casting alloys in general use in this country. The great bulk of the work was carried out in sand moulds, as it is considered that the casting characteristics of an alloy are likely to be of the greatest significance in the large castings produced in the sand foundry rather than in the generally smaller pieces cast by gravity or pressure-diecasting.*

In the present Paper, the alloys used are referred to in terms either of B.S. 1490 "Aluminium and Aluminium Alloy Ingots and Castings" or the British Standard Series of "L" specifications. Where necessary, for the sake of clarity, reference is made to related Ministry of Supply D.T.D. specifications.

The principal casting characteristics of a foundry alloy are:—Founder's fluidity; susceptibility to hot-tearing; susceptibility to internal shrinkage defects and susceptibility to external shrinkage defects.

FOUNDER'S FLUIDITY

The ability of a liquid casting alloy to fill the mould completely is clearly of the first importance, but whether it is a measurable "property" is a question that has given rise to much experimental work, discussion and controversy. K. L. Clark[1] appends to his comprehensive review of methods of fluidity testing a bibliography of 105 published papers dealing with various aspects of the subject. He stated that "fluidity testing . . . is a method which can be used to evaluate the casting characteristics of alloys," and that, because of the variety of test-piece and testing procedure employed by numerous investigators, "an objective of the Committee on Fluidity Testing of the American Foundrymen's Association is to determine if a single, standard fluidity test which is reasonably suitable for all foundry alloys can be adopted by the industry so that data from many sources can be compared directly." Although Clark proceeds to specify design and operating details for a standard fluidity test, his review confirms the preponderating influence of the temperature of the alloy, when poured into the test-mould, on the results of all such tests. It may even be inferred from suggestions he makes, that routine fluidity testing in the foundry is mainly an indirect means of checking that the temperature of pouring is correct. Fluidity tests, in their application to steel, have been thoroughly considered by the Steel Castings Research Committee, Iron and Steel Institute[2].

In addition to the temperature of the liquid alloy as it enters the mould, a number of other factors such as specific heat, film formation on the advancing liquid surface and rate of loss of heat to the mould also influence founder's fluidity; the effect of true viscosity of the liquid alloy is probably almost completely masked by that of temperature and these other factors. Founder's fluidity must be sharply distinguished from fluidity regarded as the inverse of the true physical property, viscosity.

It is natural to assume that whether a given mould is completely filled depends primarily on whether the flow of the alloy is retarded or stopped by the onset of solidification, and that this must depend mainly on the superheat of the liquid, *i.e.*, the heat content available above the liquidus temperature. The hotter the alloy, the more heat is available to keep it liquid until it fills the mould, in this race between flow and solidification.

Experimental Work

Because of the attention given to fluidity tests and the importance attached to them in some quarters, a series of experiments was made with the main purpose of determining their value and significance. In the various tests described by previous investigators the liquid alloy flows under its own pressure along a channel of standard cross-section until flow is stopped by freezing. The distance thus travelled is taken as a measure of the fluidity of the alloy at the temperature of testing. The same general principle was employed in the method described below, but its details were devised to avoid certain sources of error. Much of the published work appears to have been vitiated by lack of control of factors which influence the results, such as turbulence of the molten alloy, pouring procedure, and the actual temperature of the melt as it enters the mould. In the tests now reported, turbulence is thought to have been eliminated and the design and procedure were such that the liquid alloy had negligible momentum in the direction of the length of the fluidity channel. The pouring procedure was

* Communication from the British Non-Ferrous Metals Research Association, presented at the Newcastle Conference of the Institute of British Foundrymen. The text comprises *B.N.F.M.R.A. Report* R.R.A. 907P. The work described in this Paper was made available to B.N.F.M.R.A. members in reports R.R.A. 564 and 629, issued 1941-43.

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Casting Characteristics of Aluminium Alloys

strictly standardised and the temperature of the flowing liquid was accurately measured in the mould. If, as has been common, the temperature is measured before pouring, the amount by which it falls during transfer to the mould is uncertain, and is increased irregularly by flowing over the cooler wall and lip of the crucible, causing the "cold lip" effect.

A straight channel as in the Ruff test[2, 3] was used, but circular in section and $\frac{3}{16}$ in. diameter. The small diameter gives a fairly high surface area per unit volume, resembling the conditions in a casting having thin sections and, therefore, sensitive to variations in founder's fluidity. The test casting, shown diagrammatically in Fig. 1, consists of a pouring gate A of one inch diameter, a horizontal channel B (shown dotted) of ½ in. width and ¼ in. depth, a sump C, 3½ in. square and 3½ in. deep, an uprun piece D, 5 in. high and 3 in. wide, and the five fluidity "runs" E, $\frac{3}{16}$ in. in diameter and open at the ends. The mould for this casting was rammed up in Mansfield sand, milled with 2 per cent. bentonite using a moisture content of 3.5 to 4 per cent. Initially the moulds were oven dried, but it was found that consistent and not markedly different results were obtained using green sand. The bare hot junction of the chromel-alumel thermocouple used was at position X in the casting and the couple was just above the entrance to the fluidity channels.

Tests were made on commercial purity aluminium, LM-6 alloy, 4L 11 alloy and three alloys containing 2 per cent. copper with different silicon contents, at three (in some cases four) different temperatures. The melt was degassed and allowed to cool to about

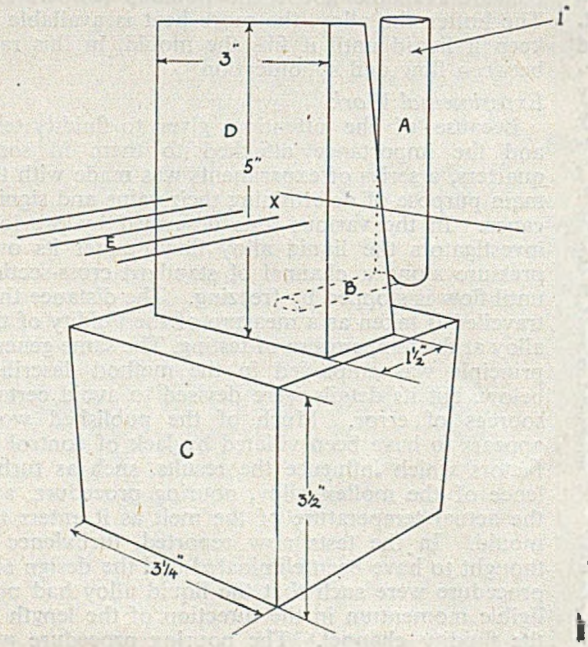


FIG. 1.—*General view of the Fluidity Test Casting.*

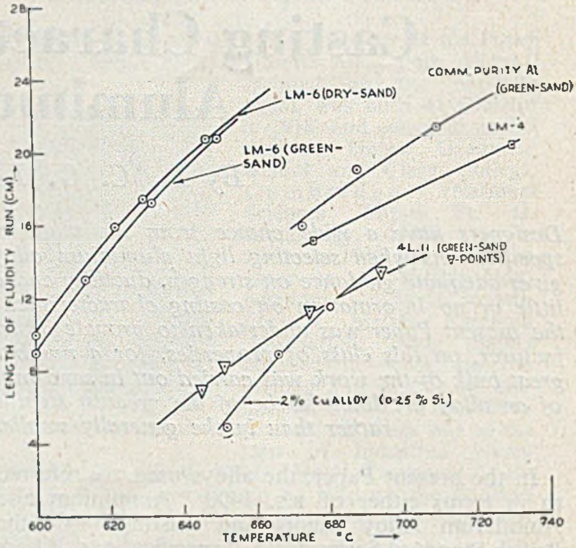


FIG. 2.—*Relation between Length of Fluidity Run and Temperature.*

60 deg. C. above the highest test temperature to be used. Pouring was then begun and the pouring gate A kept filled, maintaining a constant hydrostatic head and rate of flow. When the metal in the uprun piece rises smoothly to the level of the channels it flows along them. Almost simultaneously, the metal reaches the thermocouple and registers its temperature. The crucible was allowed to cool to a temperature about 60 deg. C. above the second test temperature and the procedure repeated, and similarly for the third temperature. The five rods were measured for each test and the average lengths plotted against the registered temperatures. The lengths of the five rods were never equal and for all the tests the average deviation from the mean was 8.2 per cent.; this is considered to be reasonably good consistency for a highly empirical test method such as the "fluidity test" described, and suggests that the results are likely to be reproducible.

The fall of temperature from crucible to mould varied considerably, between 40 and 100 deg. C., but the actual temperature of the metal when the fluidity channels were filled was registered in each test.

The length of fluidity run is plotted against temperature of liquid metal in Fig. 2 and against superheat (deg. C. above liquidus) in Fig. 3. Fig. 4 gives the results for three alloys, each containing 2 per cent. copper, 0.4 per cent. manganese, 0.25 per cent. iron, but with silicon 0.25, 2 and 5 per cent. respectively. The plots of fluidity runs against superheat for these three alloys are included in Fig. 3.

The chief conclusion to be drawn from the results obtained is that, as might be expected, temperature expressed as degrees of superheat is the main factor controlling founder's fluidity, and that the difference in this "property" between the alloys tested is much less significant than the differences in other casting characteristics such as susceptibility to hot-tearing and to the formation of shrinkage cavities. The

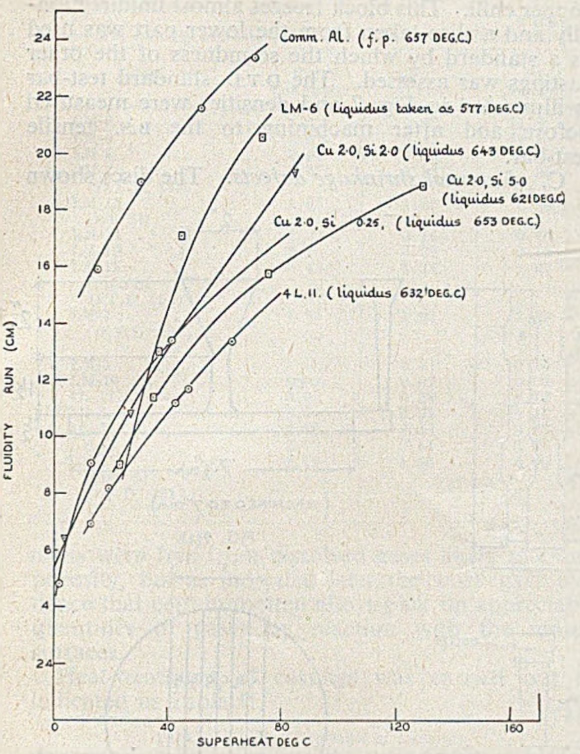


FIG. 3.—*Relation between Length of Fluidity Run and Superheat.*

value of "fluidity tests" does not appear to be established, but the results of the experimental work described emphasise the importance of control of casting temperature, particularly in the running of thin-sectioned castings.

SUSCEPTIBILITY TO HOT-TEARING AND TO SHRINKAGE DEFECTS

The experimental work on hot-tearing now reported preceded that described in the Author's previous Paper "The Hot-tearing Tendencies of Aluminium Casting Alloys" (*J. Inst. Metals*, (1946) *72*, 343-364) in which the literature of the subject was also reviewed. Susceptibility to hot-tearing was shown to depend mainly on (*a*) the constitution of the alloy and particularly the proportion of eutectic and also on (*b*) the grain size and (*c*) the gas content. The mechanism of hot-tearing was discussed.

Experimental Procedure

Test sand-castings were devised to reveal and accentuate the susceptibility of aluminium alloys to hot-tearing, to internal shrinkage defects (porosity, affecting mechanical properties and pressure tightness) and to external shrinkage defects (surface shrinks and draws). The same test castings and foundry technique were used for all the alloys tested, to give comparative results.

Alloys Tested

Most, though not all, of the alloys were the same as in the Author's previous Paper[6] but, for convenient reference, Table I gives the specifications and compositions of the alloys now tested. 3L 5, 4L 11, 3L 8, LM-15 (high silicon) and LM-14 were prepared in the B.N.F.M.R.A. laboratories from virgin metals and the remainder were kindly supplied (with chemical analyses) by manufacturers.

Description of Tests

A. *Hot-tearing.* Susceptibility to hot-tearing was determined by restraining the contraction of four horizontally cast bars 12 in. long and $\frac{5}{8}$ in. square in section (Fig. 5) by cast-in galvanised bolts carrying nuts which bear on the sides of the steel moulding box. The linear shrinkage of most aluminium casting alloys is of the order of 1.5 per cent. Four bars were cast from vertical runners connected to a horizontal gully and the degree of restraint of the several bars was varied by unscrewing the nuts on the bolts to different extents so that one bar freezes under full restraint, the second is free to contract one tenth of the natural shrinkage, the third one fifth, and the fourth three tenths. Two minutes after pouring (by which time the temperature of the bars had fallen to 200-300 deg. C.) the nuts were unscrewed so as to free them completely from the sides of the box. This was done to lessen the danger of a tear occurring due to the solid contraction of the bars below this temperature.

B. *Internal porosity.* Three castings were used to determine the effect of shrinkage porosity on mechanical properties. (i) *Uprun bars* (*equal bulges*) and (ii) *Uprun bar* (*unequal bulges*). These two castings, illustrated in Fig. 6(*a*) and (*b*), are bottom fed and bottom run; the bulges create heat centres which produce a concentration of shrinkage porosity. Preliminary tests showed that in the bars with equal bulges, the bulged sections nearest the horizontal runner were often much less sound, and correspondingly weaker, than the bulged sections farthest from the runner. This difference was largely

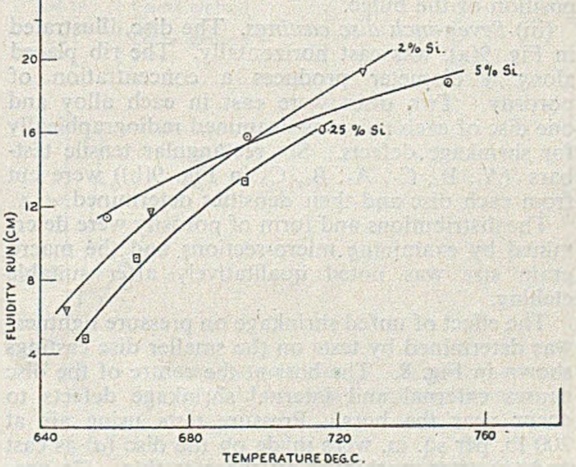
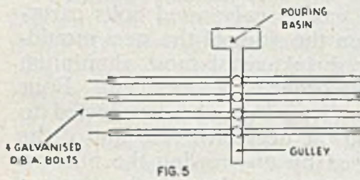
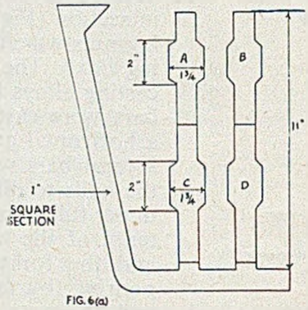


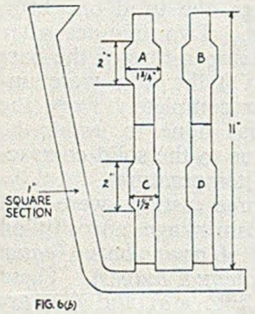
FIG. 4.—*Relation between Temperature and Length of Fluidity Run for an Aluminium Alloy Containing Cu. 2.0, Mn. 0.4, Fe 0.25 per cent. and Si as Indicated.*

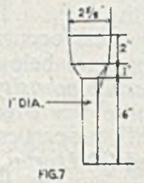
Casting Characteristics of Aluminium Alloys

eliminated by reducing the size of the bulges nearest the horizontal runner to produce the test casting with unequal bulges. Each casting was cut up to give four sections (A, B, C and D) as shown in Fig. 6 and density measurements were made on each section before and after machining to a B.S. tensile test-bar, the gauge length of which coincided with the position of the bulge.









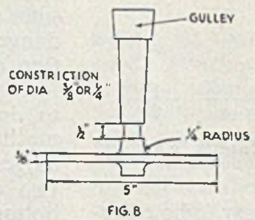


FIG. 5.—*Hot-tear Test Casting;* FIG. 6(a).—*Uprun Test-bars (Equal Bulges);* FIG. 6(b).—*Uprun Test-bars (Unequal Bulges);* FIG. 7.—*D.T.D. Standard Test-bar, and* FIG. 8.—*Pressure-tightness Test-piece.*

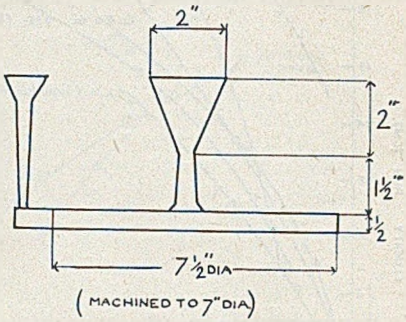


FIG. 9(a).

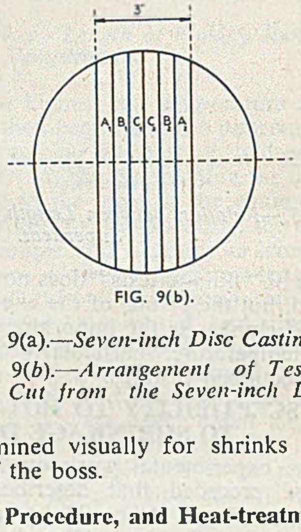


FIG. 9(b).

FIG. 9(a).—*Seven-inch Disc Casting.*
FIG. 9(b).—*Arrangement of Test-bars Cut from the Seven-inch Disc.*

(iii) *Seven-inch disc castings.* The disc, illustrated in Fig. 9(a), was cast horizontally. The rib placed along a diameter produces a concentration of porosity. Two discs were cast in each alloy and one disc of each pair was examined radiographically for shrinkage defects. Six rectangular tensile test-bars (A_1, B_1, C_1, A_2, B_2, C_2 in Fig. 9(b)) were cut from each disc and their densities determined.

The distributions and form of porosity were determined by examining micro-sections and the macro grain size was noted qualitatively after suitable etching.

The effect of unfed shrinkage on pressure tightness was determined by tests on the smaller disc castings shown in Fig. 8. The boss at the centre of the disc causes external and internal shrinkage defects to occur near the boss. Pressure tests using air at 200 lb. per sq. in. were made on the disc (*a*) as cast and (*b*) after machining off the cast skin. To provide standards of density and tensile strength, blocks and D.T.D. standard test-bars were used. A block of two-inch diameter and 3½ in. height was cast in a sand collar placed on a preheated copper chill. This block freezes almost unidirectionally and a slice taken from the lower part was used as a standard by which the soundness of the other castings was assessed. The D.T.D. standard test-bar is illustrated in Fig. 7 and densities were measured before and after machining to the B.S. tensile test-bar.

C. *External shrinkage defects.* The discs shown in Fig. 8 were examined visually for shrinks and cracks at the base of the boss.

Melting and Casting Procedure, and Heat-treatment

The test castings were made in a green synthetic sand bonded with 5 per cent. Fulbond No. 1 and containing 2 to 3 per cent. moisture, except that an inhibited sand containing from ½ to 2 per cent. boric acid was used for the castings in LM-10. 30-lb. melts were made in a gas-fired injector furnace and as a rule the temperature of the melt never exceeded 750 deg. C., or 740 deg. C. for LM-19. LM-6 and LM-9 were modified by covering with 2NaF/1NaCl flux for 5 minutes. LM-10 was degassed by passing a vigorous stream of chlorine for 5 minutes, and LM-5 by plunging aluminium chloride (¼ per cent. $AlCl_3$ into the melt. LM-11 had no fluxing or degassing treatment. The melts of all the other alloys were degassed by the "stirring plus flux" method (2NaCl/1NaF flux). LM-11 was poured at 690 deg. C. and all other alloys at 740 deg. C. All melts were tested for freedom from dissolved gases by allowing a small sample to freeze under reduced pressure[4]. It may be assumed, therefore, that *before pouring* all

TABLE I.—*Alloys Tested.*
(In the first column, material references to B.S. 1490 are indicated thus: LM-4; other alloys designated by reference to B.S. "L" standards.)

Alloy.	Cu, per cent.	Fe, per cent.	Si, per cent.	Mg, per cent.	Ni, per cent.	Mn, per cent.	Ti, per cent.	Others.
LM-6	—	0.22	11.9	—	—	—	—	Na as modifier
LM-9	0.02	0.43	11.7	0.44	—	0.45	—	Na as modifier
LM-4	2.94	0.66	5.30	0.04	0.05	0.31	0.04	
LM-7 .. .. .. (D.T.D. 133C)	1.67	1.13	2.35	0.11	0.97	—	0.17	
LM-15 .. .. (low Si)	1.55	1.29	0.60	0.77	1.45	—	0.15	
LM-11	4.32	0.14	0.10	—	—	0.03	0.14	
LM-19	3.1	0.30	0.15	1.14	—	0.22	0.009	Cd 1.46
LM-15 .. .. (high Si: D.T.D. 250)	2.40	1.24	1.94	0.76	1.53	0.10	—	Cb 0.10, Pb, Sn traces, Zn 0.06
LM-7 .. .. .. (D.T.D. 287)	1.25	1.07	2.29	0.08	1.33	0.65	—	Cb 0.08, Zn 0.05, Sn 0.02
LM-5	—	0.31	0.16	5.56	—	0.41	0.005	
LM-10	trace	0.07	0.06	10.9	—	0.03	trace	
4L 11	0.99	0.28	0.12	—	—	—	nil	
3L 8	13.7	0.63	0.16	—	—	—	0.15	
3L 5	2.72	0.43	0.27	—	—	—	0.13	Zn 13.8
LM-14	3.72	0.41	0.30	1.71	2.09	—	0.14	
LM-15 .. .. (high Si; D.T.D. 131A)	2.12	1.08	1.90	1.74	1.09	—	0.08	

melts were free from dissolved gases likely to cause porosity, but as indicated later the work gave evidence that certain molten alloys pick up appreciable quantities of gases by reaction with the mould surfaces.

Heat-treatment of castings was carried out as indicated in Table II.

TABLE II.—*Heat-treatment of Castings.*

Alloy.	Treatment.
LM-9-WP	4 hrs. at 528 deg. C.; quenched in water. 17 hrs. at 162 deg. C.; cooled in air.
LM-7-P	16 to 18 hrs. at 160 deg. C.; cooled in air.
LM-15-WP (low Si)	3 hrs. at 533 deg. C.; quenched in water. 20 hrs. at 161 deg. C.; quenched in water.
LM-15-WP (D.T.D. 131A)	4 hrs. at 530 deg. C.; quenched in water. 19 hrs. at 160 deg. C.; cooled in air.
LM-15-W	4 hrs. at 535 deg. C.; quenched in water.
LM-11-WP (D.T.D. 304)	15 hrs. at 542 deg. C.; quenched in water. 18 hrs. at 160 deg. C.; cooled in air.
LM-19-W	6 hrs. at 495 deg. C.; quenched in water.
LM-10-W	17 hrs. at 430 deg. C.; quenched in oil, bars removed after 10 minutes and allowed to cool in air. Maximum temperature reached by oil was 94 deg. C.
LM-14-WP	6 hrs. at 506 deg. C.; quenched in water at 95 deg. C.; bars aged 8 days before testing.

Discussion of Results

The results are given in Tables III (mechanical properties of D.T.D. bars), IV (percentage voids determined by density measurements of inadequately fed bars), V (mechanical properties of inadequately fed bars) and VI (hot-tear and pressure tightness tests and indications of external shrinkage defects). Table VII gives the strengths of the inadequately-fed bars as percentages of the strengths of D.T.D. bars cast from the same melt, the actual figures being those given in Table V.

Hot-tearing

Most of the high-strength heat-treatable aluminium casting alloys investigated were found, under the conditions of test used, to be free from tendency to hot-tearing with the notable exceptions of the low-silicon variety of LM-15, LM-19 and LM-11. The following examples illustrate the effect of large grain size in increasing tendency to hot-tearing.

The beneficial effect of the presence of eutectic was demonstrated and discussed in the Author's previous Paper,[8] and the method of calculating the "eutectic index" was described. The correspondence between eutectic index and hot-tearing resistance as determined by the present tests is almost exact (see Fig. 10).

When an alloy is cooling through the freezing range cracks may develop between the primaries, but if sufficient eutectic is present it may flow into these cracks and "heal" them. Consequently no hot-tear would be detectable when the casting is completely frozen. Fig. 11 shows that this "healing" has taken place in an uprun bulged bar in

		Hot-tearing resistance (symbols used as in Table VI).
3L 5	Coarse grained ..	C
	Fine ,, ..	B
LM-19	Coarse grained ..	D
	Fine ,, ..	B
4L 11	Coarse grained ..	B
	Fine ,, ..	A

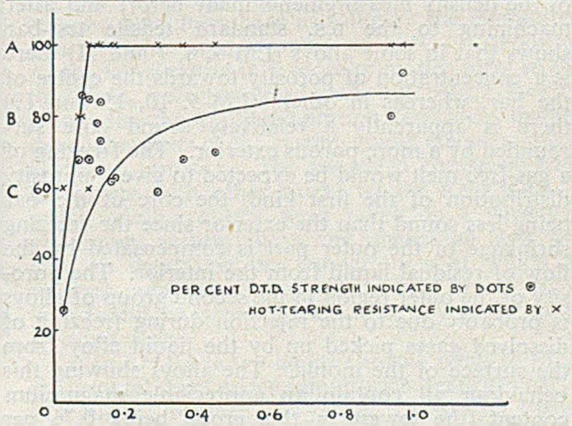


FIG. 10.—*Relations between Eutectic Index and Per Cent. D.T.D. Strength (Top Sections, Unequal Bulges) and Resistance to Hot-tearing.*

FIG. 11.—*Shrinkage Porosity in LM-9. Cavities of Rounded Outline, Isolated from Each Other.* (× 6.)

LM-9, the primaries having separated in the pre-eutectic solidification and the incipient crack being filled up by the flow of eutectic liquid into it. Vero[5] came to the conclusion that the eutectic content required to "heal" incipient cracks in this manner is about 12 per cent.

Internal Shrinkage Porosity: Its Distribution and Effect on Mechanical Properties

A. *Lateral distribution of porosity.* Comparison of the density measurements made before and after machining to the B.S. standard tensile test-bar shows that in some alloys (LM-4, 6, 7 and 11) there is a concentration of porosity towards the centre of the bar, whereas in others (LM-5, 10, 15 and 19) there is apparently a relatively sound core surrounded by a more porous exterior. The freezing of a gas-free melt would be expected to give a porosity distribution of the first kind, the core of the bar being less sound than the exterior since the freezing shrinkage of the outer part is compensated by the flow of residual liquid from the interior. The porosity of the outer region in the second group of alloys is probably due to the rejection during freezing of dissolved gases picked up by the liquid alloy from the surface of the mould. The alloys showing this behaviour all contain an appreciable magnesium content (the lowest in this group being 0.76 per cent. in LM-15) whereas the alloys of the first group contain at most 0.11 per cent Mg. In LM-9 containing 0.44 per cent. Mg the strong tendency shown by the otherwise similar alloy LM-6 to give a concentration of porosity towards the centre is substantially reduced.

To obtain more direct evidence of gas pick-up in alloys containing larger amounts of magnesium a 3-in. diameter block casting with a feeder head about 5 in. diameter and 2 in. deep was poured in various alloys. The same synthetic sand was used as in the rest of the work and at intervals after pouring a small sample of still-liquid alloy was removed and tested for dissolved gases by freezing under reduced pressure. It was possible to remove samples up to 6 minutes after pouring. In LM-15 (1.74 per cent. Mg) considerable quantities of gas were detected in the sample removed 5 minutes after pouring whereas in LM-7 (0.11 per cent. Mg) no such pick-up was found and the densities of the samples frozen in vacuo agreed to 0.001 gm. per cub. cm. with those taken from the degassed melt before pouring.

Further evidence of pick-up of gas by liquid alloys containing magnesium was obtained by fracturing the 1-in. square runner of a set of uprun bars cast in LM-10 (10 per cent. Mg). The fracture showed marked discoloration due to porosity in a region occupying about 60 per cent. of the whole cross-section, the centre and a narrow border being sound.

Similar gas pick-up has been found in certain copper alloys. Thus Baker, Child and Glaisher[6] showed that copper/tin alloys containing 0.3 per cent. phosphorus or more, and copper alloys con

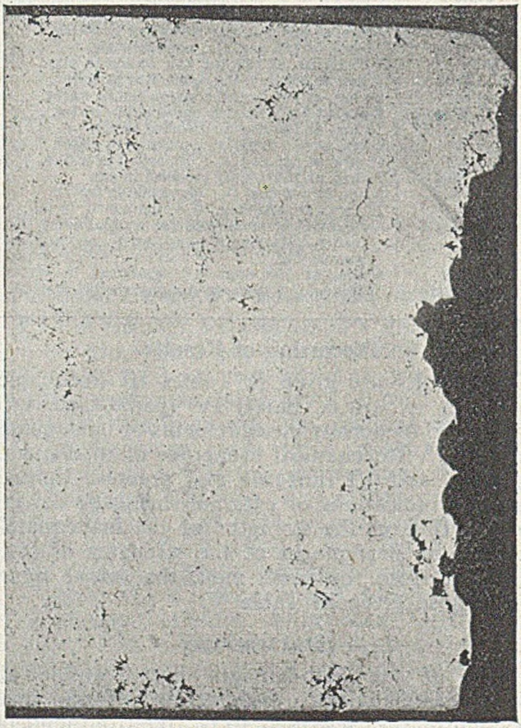


FIG. 12.—*Porosity in LM-10. Porosity of Fine Form due to Shrinkage near the Centre of the Bar and Coarser Porosity due to Metal-mould Gas Reaction nearer the Edges.* (× 6.)

taining lead and silicon together, absorb gases by reaction with the water vapour at the metal mould interface.

B. *The effect of internal shrinkage porosity on mechanical properties.* In the following discussion, attention is given to the reduction in mechanical properties due to uncompensated shrinkage porosity in the light of the tests made on castings in which feeding was intentionally restricted. In reading this section of the Paper, it should be borne in mind that some of the very large and complex aluminium alloy sand castings have been made by highly developed foundry techniques, giving adequate feeding to almost all sections. Thus, little reduction in mechanical properties occurred, and under these conditions, the inherent mechanical properties of the material became, once again, of paramount importance. The present discussion may be considered both as indicating the degree of feeding required for the attainment of such good conditions and, also, as indicating the extent to which the mechanical properties suffer when feeding cannot be complete.

(*a*) In LM-6 and LM-9 (alloys of almost eutectic composition) the porosity is in the form of rounded isolated cavities (Fig. 11). This form of porosity is evidently comparatively innocuous although LM-9 is more seriously affected than LM-6, probably because, as shown in Table IV, the bars contain far more shrinkage porosity.

(*b*) In a number of alloys (*e.g.*, LM-7, LM-14 and LM-15) the porosity, although fairly well isolated, is less regular in outline than in the alloys of higher eutectic content (Fig. 13). The effect is to lower the strength in the top section of uprun bars to about 75 to 85 per cent. D.T.D. strength. In LM-15 the bottom sections of uprun bars (equal bulges) gave strength properties as low as 20 per cent. D.T.D. Microscopical examination of one of these bars showed marked concentration of coarse porosity immediately behind the fracture (Fig. 14). After etching, aluminium-rich dendrites containing $NiAl_3$ in the familiar "brush" form were seen surrounding relatively large voids (Fig. 15). The course of freezing must have been as follows: the aluminium-rich primaries separate out and $NiAl_3$ is deposited. As the temperature falls more primaries form so that the $NiAl_3$ becomes enveloped, but before freezing is complete the still liquid portion flows away towards the cooler parts of the casting giving coarse and concentrated porosity. The suggested course of freezing agrees with other work[7] by the B.N.F.M.R.A. in which cooling curves were taken on a variety of aluminium casting alloys and quenching tests were used to determine the temperatures at which the various constituents separate. In LM-14, $NiAl_3$ was found to separate out relatively early in the freezing range.

(*c*) In LM-15 (low silicon) porosity tends to follow the general form of aluminium-rich dendrites enclosing $NiAl_3$ "brushes" as in the high-silicon variety, but is concentrated to a stronger degree (Fig. 16).

FIG. 14.—*Concentrated Shrinkage Porosity in LM-15 (High Silicon; D.T.D. 250) (Bottom Section, Up-run Bars, Equal Bulges).* (× 6.)

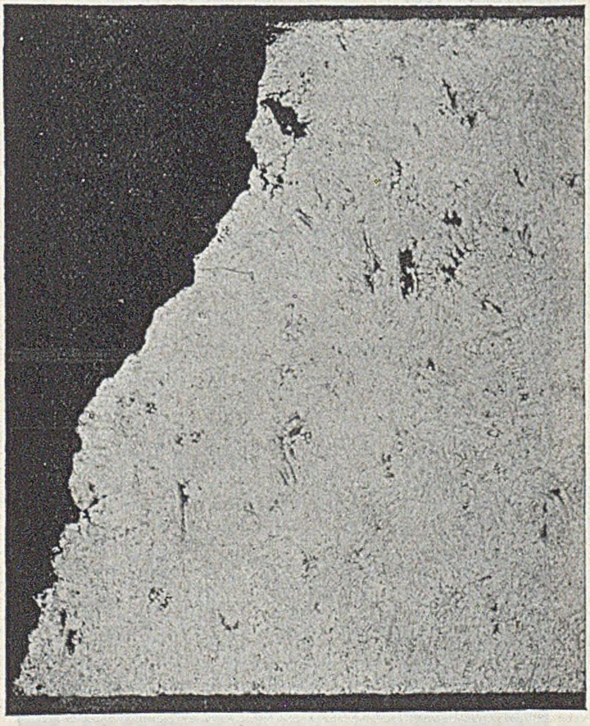


FIG. 13.—*Shrinkage Porosity in LM-15 (High Silicon; D.T.D. 250). Cavities fairly well Isolated but less Regular in Outline than in Alloys of Higher Eutectic Content.* (× 6.)

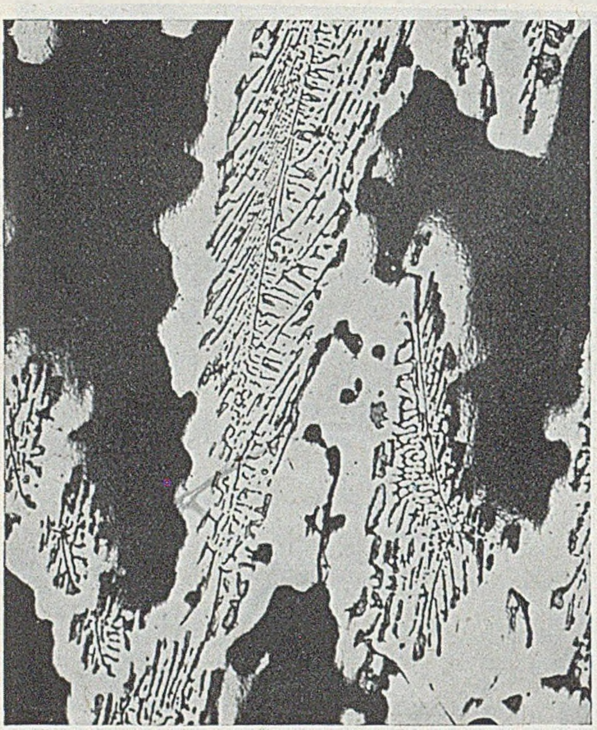


FIG. 15.—*Aluminium-rich Dendrites in LM-15 (High Silicon; D.T.D. 250) enclosing $NiAl_3$ "Brushes" and Surrounded by Shrinkage Voids.* (× 70.)

(*d*) Several alloys, notably LM-5, LM-10, LM-11 and 3L 5, tend to give patches of porosity, frequently on planes normal to the axis of the bars (Fig. 13), rather similar to that characteristic of magnesium-base alloys where it is sometimes referred to as "lake" porosity. It has a harmful effect on mechanical properties, bars containing it possessing 60 to 70 per cent. D.T.D. strength or less. LM-5 and LM-10 show this form of porosity but the effect is complicated by the metal/mould reaction resulting in gas absorption as discussed above. Fig. 12 shows both forms of porosity; fine patches due to shrinkage towards the centre of the bar and coarser porosity of irregular form due to gas pick-up nearer the edges.

(*e*) In LM-4 alloy much of the porosity is between the arms of dendrites forming the skeleton of the grains but some is at the boundaries of the macro grains. The former type is comparatively innocuous in its effect on mechanical properties especially in fine-grained material. The percentage D.T.D. strengths quoted in this Paper are lower than have been obtained on batches of this alloy with higher titanium contents giving finer grain size.

Generally speaking the tensile properties of the unsound castings can be satisfactorily explained by the form and distribution of the porosity as described above. However, as was noted above in the case of LM-4 alloys, the grain sizes of the cast alloys also affect their mechanical properties when the castings contain porosity and this factor was probably responsible for the fact that with the LM-11 alloy the mechanical properties of the relatively well fed D.T.D. type test-bars were below the specification limits when they were cast at 740 deg. C., the results quoted in Tables V and VII are for castings poured at 690 deg. C. Recent work in the British Non-Ferrous Metals Research Association laboratories[7] has shown that the mechanical properties of castings in alloys of this type which, in common with the LM-5 and LM-10 alloys, are substantially free from hard grain-boundary constituents, are markedly dependent on grain size because this factor affects the shape and hence the effect of the intergranular porosity. Such variation of mechanical properties with grain size is likely to be particularly important in those sections where solidification is slow and grain size coarsest.

The mechanical properties quoted in Tables III and V were no doubt affected to varying degrees by this factor, particularly those for the above-mentioned alloys. Nevertheless it is considered that the test results put the casting characteristics of the various alloys in an approximately correct order of merit. Furthermore the results show that the two most important casting characteristics of the alloys, *i.e.*, susceptibility to (i) hot-tearing and (ii) loss of strength when imperfectly fed, are both largely dependent on constitution and grain size, alloys with a high degree of immunity from hot-tearing suffering least damage to their mechanical properties when imperfectly fed.

FIG. 16.—*Concentrated Shrinkage Porosity in LM-15 (Low Silicon).* (× 6.)

TABLE III.—*Mechanical Properties of D.T.D. Bars.*

Alloy.	Specified values.			Values obtained.		
	0.1 per cent. P.S. (tons per sq. in.)	U.T.S. (tons per sq. in.)	Elongation, per cent.	0.1 per cent. P.S. (tons per sq. in.)	U.T.S. (tons per sq. in.)	Elongation, per cent.
LM-6	3.5	10.5	5	3.9	11.4	12
LM-9	13.0	15.5	—	13.1	18.1	2
LM-4	5.0	9.0	2	5.5	10.8	2
LM-7 .. .. (D.T.D. 133C)	7.5	10.0	2	9.9	13.3	2
LM-15 .. .. (low Si)	15.5	16.0	—	20.1	20.5	1
LM-15 .. .. (high Si; D.T.D. 131A)	15.5	16.0	—	15.2	15.7	0.5
LM-11	14.0	18.0	4	15.0	22.0	5.5
LM-19	11.0	14.0	3	12.2	15.2	2
LM-15 .. .. (high Si: D.T.D. 250)	11.5	14.0	—	11.7	15.4	1.5
LM-7 .. .. (D.T.D. 287)	7.5	10.0	2	9.3	12.8	2
LM-5	5.0	9.0	3	7.0	13.8	8
LM-10	11.0	16.0	7	11.4	20.8	11
4L 11	3.5	7.5	1.5	—	9.3	3
3L 8	4.5	7.0	—	6.2	10.8	1
3L 5	3.5	9.0	2	—	13.8	5
LM-14	13.0	14.0	—	14.1	17.2	1

Pressure Tightness of Castings with Restricted Feeding

The 5-in. disc with constrictions in the ingate is a severe test and only LM-4, LM-6 and LM-9 and 3L 8 gave a complete series of leak-proof discs; these may be regarded as being specially suitable for applications in which freedom from leakage under pressure is important and where the form of the casting makes feeding difficult. Alloys LM-14 and LM-15 gave very few leaky discs, but most of the other alloys proved to be prone to leakage. Where the shrinkage porosity is in the form of isolated cavities the discs may be expected to be leak-proof, but if the porosity is in the form of finer cavities a continuous channel may be formed in some discs whilst in others there may be no continuity. Assessment of the pressure tightness of such alloys would demand a much larger number of tests than were made in the trials now reported.

External Shrinkage

Many alloys showed considerable drawing, tearing, or sinking at the fillet. These defects occurred even in some alloys which are not prone to hot-tearing, but generally speaking the appearance of the discs appears to be worse in the alloys which tear.

TABLE IV.—*Percentage Voids in the Test Castings.*

Alloy.	Uprun bars (equal bulges).				Uprun bars (unequal bulges).				Bars cut from 7 in. disc castings.			D.T.D. bars.	
	T.		B.		T.		B.						
	UM.	M.	UM.	M.	UM.	M.	UM.	M.	A.	B.	C.	UM.	M.
LM-6	0.2	0.7	0.7	1.8 3.0	0.1	0.7	0.8	0.7	0.3	0.3	0.3	0.1	0.5
LM-9	2.0	1.9	2.9	2.9	2.0	2.3	3.1	2.7	0.7	0.7	0.7	0.2	0.2
LM-4	1.4	1.6	1.8	1.8	1.8	1.8	1.8	1.9	0.5	0.5	0.5	0.1	0.4
LM-7 (D.T.D. 133C)	2.1	2.0	2.1	2.1	2.7	2.6	2.3	2.4	0.8	0.7	0.7	0.2	0.8
LM-15 (low Si)	2.0	1.9	2.9	5.1 3.0	2.1	2.1	2.6	2.6	0.6	0.6	0.6	0.5	0.4
LM-11	0.9	1.1	1.1	1.6	1.1	1.4	1.0	1.4	—	0.1	0.2	0.1	0.2
LM-19	1.5	1.2	2.2	1.6	1.6	2.1	1.9	1.7	0.6	0.6	0.7	0.3	0.2
LM-15 (high Si; D.T.D. 250)	1.5	1.1	4.1	5.3 3.0	2.1	1.4	2.8	1.6	0.6	0.5	0.5	0.1	—
LM-7 (D.T.D. 287)	1.6	1.5	2.9	3.6 1.7	1.6	1.3	1.7	1.7	0.7	0.6	0.6	0.3	—
LM-5	2.8	2.3	5.2	0.8	2.7	2.4	4.6	3.3	1.4	1.5	1.2	1.3	0.2
LM-10	2.7	1.5	2.9	3.1	1.5	2.0	3.8	2.4	2.3	1.7	1.6	0.6	0.2

UM = unmachined. M = machined.

In the following five alloys only, uprun bars with unequal bulges were cast and densities determined after machining.

Alloy.	Voids, per cent.		
	Top.	Bottom.	D.T.D. bars.
4L 11	1.1	1.3	0.1
3L 8	1.4	2.1	0.1
3L 5	1.5	2.0	0.1
LM-14-WP	1.5	1.9	0.5
LM-15 (high Si; D.T.D. 131A)	1.4	1.4	0.6

TABLE V.—*Mechanical Properties of Inadequately-fed Bars.*

Except where otherwise shown, the results given in this table for tests on uprun bars are the mean of two determinations, while the results given for bars cut from disc castings are the mean of four individual tests.

Alloy, B.S. 1490 or other specification.	Uprun bars.		Equal bulges.		Uprun bars.		Unequal bulges.		Bars cut from 7in. disc casting.					
	T.		B.		T.		B.		A.		B.		C	
	U.T.S. tons per sq. in.	E. per cent. on $4\sqrt{A}$.	U.T.S. tons per sq. in.	E. per cent. on $4\sqrt{A}$.	U.T.S. tons per sq. in.	E. per cent. on $4\sqrt{A}$.	U.T.S. tons per sq. in.	E. per cent. on $4\sqrt{A}$.	U.T.S. tons per sq. in.	E. per cent. on 2 in.	U.T.S. tons per sq. in.	E. per cent. on 2 in.	U.T.S. tons per sq. in.	E. per cent. on 2 in.
LM-6	9.6	4	9.4	5	10.4	5½	10.7	7	10.4	6½	10.5	8	10.6	8
LM-9	14.6	1	14.0	1	12.7	1	14.6	1	13.6	1	14.4	1	13.9	1
LM-4	8.7	2	7.8	1	7.6	2	7.6	1½	9.3	2	9.2	2	9.2	2
LM-7	10.2	1½	7.6	1	8.6	1	7.8	1	11.3	2	11.2	2	10.8	2
LM-15 (low Si; D.T.D. 131A)	6.4	½	4.0	½	5.3	½	4.6	½	17.7	1	16.8	1	13.6	1
LM-11 poured at 690 deg. C.	15.0	2	13.0	2	14.8	2	13.5	2	19.0	3	17.7	2	16.0	1½
LM-19	12.4	2	12.2	2	13.0	2	11.7	2	13.2	1½	11.4	1	12.1	2
LM-15 (D.T.D. 250)	13.3	1½	3.05	1	12.9	1	12.2	1½	13.5	½	13.2	1	13.1	1
LM-7 (D.T.D. 287)	10.0	1	7.3	1	10.5	1	9.2	1	10.3	1½	10.0	2	10.5	2
LM-5	9.0	4	7.2	3	8.5	3½	8.2	3	10.8	4	10.6	4	10.5	4
LM-10	8.4	2	6.3	2	12.2	3	11.2	2½	14.2	4	13.8	4	13.5	3½
LM-14	—	—	—	—	14.6*	1	14.4*	1	—	—	—	—	—	—
LM-15 (D.T.D. 131A) ..	—	—	—	—	12.2*	½	12.1*	½	—	—	—	—	—	—
4L 11	—	—	—	—	5.8*	1½	5.4*	1½	—	—	—	—	—	—
3L 8	—	—	—	—	7.4*	1½	7.3*	1	—	—	—	—	—	—
3L 5	—	—	—	—	9.4*	3	7.2*	1½	—	—	—	—	—	—

T = Top sections. B = Bottom sections. * Mean of four results.

GENERAL CONCLUSIONS

Sixteen different alloys have been investigated and the results obtained make it possible to outline their casting properties and other factors influencing the ease with which the alloys are handled in the foundry.

The eutectic silicon alloy LM-6 has better all-round casting characteristics than any of the other alloys tested. LM-9 is similar, but the strength of inadequately fed sections is more strongly affected by internal shrinkage porosity. The high-strength heat-treatable casting alloys, of the Al-Cu-Ni-Mg type based on the original Y-alloy, have in general better casting properties than the older low-strength alloys such as 3L 5 and 4L 11. The two varieties of LM-7 distinguished by D.T.D. specifications 133C and 287 are very similar in composition and in their casting characteristics. Although the D.T.D. bar strength of the low-silicon variety of LM-15 is better than that of the more normal kind, its casting characteristics are not so good. Calculations based on the "eutectic index" indicated that an addition of about 0.5 per cent. silicon might substantially improve the casting properties. With an alloy otherwise of the same composition but having a silicon content of 1.27 per cent., hot-tearing was eliminated and the percentage D.T.D. strength in uprun bars (equal bulges) was raised from 31 and 20 per cent. to 81 and 59 per cent. in the top and bottom sections respectively. The silicon addition diminishes the D.T.D. bar strength from 20.5 tons per sq. in. to 18.5 tons per sq. in., but the increase in percentage strength of inadequately fed bars more than compensates for this in castings where feeding is restricted.

The main conclusions may be summarised as follows under the various properties that make up the casting characteristics of an alloy and influence its handling in the foundry:—

Susceptibility to Hot-tearing.—Alloys least resistant to hot-tearing: LM-11, LM-15 (low-silicon variety) and LM-19 and 3L 5.

Effect of Internal Shrinkage Porosity on Mechanical Properties.—Alloys most markedly weakened: LM-5, LM-10 and LM-15 (low-silicon), 3L 5, 3L 8 and 4L 11. When feeding is very poor, LM-15 is badly affected.

Pressure Tightness when Feeding is Restricted.—LM-4, LM-6, LM-9 and 3L 8 alloys are most suitable for use in making pressure-tight castings, while LM-14, LM-15 and LM-19 alloys need rather better feeding and the rest are much less suitable.

Ease of Handling Alloys in the Foundry.—(i) *Difficulties in degassing.* LM-5 and LM-10 cannot be treated with ordinary degassing fluxes containing sodium salts and treatment with chlorine or volatile chlorides releasing chlorine is necessary.

(ii) *Treatment of melts.*—LM-6 and LM-9 require "modification" to obtain the best mechanical and casting properties. Melts modified with flux should be covered with the modifying flux until the casting is poured. LM-19 suffers serious deterioration of casting properties if the melt is overheated,

TABLE VI.—*Results of Hot Tear and Pressure Tightness Tests.*

Alloy	Hot tearing resistance.	Pressure discs.					
		$\frac{3}{8}$-in. constriction.			$\frac{1}{4}$-in. constriction.		
		Appearance of discs.	Pressure tightness.		Appearance of discs.	Pressure tightness.	
			UM.	M.		UM.	M.
LM-6	A	Perfect	NL NL	NL NL	Perfect	NL NL	NL NL
LM-9	A	"	NL NL	NL NL	"	NL NL	NL NL
LM-4	A	"	NL NL	NL NL	"	NL NL	NL NL
LM-7 .. .. (D.T.D. 133C)	A	Discs badly cracked	RL	—	Discs very badly cracked. One not light tight	RL RL	—
LM-15 .. .. (low Si)	C	Very badly cracked	RL RL	— —	Very badly cracked. One not light tight	RL RL	— —
LM-11	C	Very bad cracking One not light tight	NL RL	RL —	Very bad cracking. One not light tight	RL NL	— RL
LM-19 .. .. Not heated beyond 740 deg C	B	Slight cracking only	NL NL	NL NL	Slight cracking only	SL NL	— NL
LM-19 .. .. Heated to 800 deg C	D	Very bad cracking	RL RL	— —	Very bad cracking	RL RL	— —
LM-15 .. .. (high Si; D.T.D. 250)	A	Bad cracking	RL RL	— —	Very bad cracking	RL RL	— —
LM-7 .. .. (D.T.D. 287)	A	Fairly bad cracking	RL NL	— NL	Severe cracking	RL NL	— —
LM-5	A	Bad cracking	RL RL	— —	Very bad cracking. Not light tight	VRL VRL	— —
LM-10	A	Perfect	RL RL	— —	Perfect	VSL SL	— —
3L 5	B	Bad cracking, some sinking	VRL	—	Bad cracking and drawing	VRL VRL	— —
4L 11 .. .. (coarse-grained)	B*	Slight cracking and sinking	NL NL	RL RL	Bad cracking	RL RL	— —
3L 8	A	Perfect	NL NL	NL NL	Very slight cracking	NL NL	NL NL
LM-15 .. .. (high Si; D.T.D. 131A)	A	Slight sinking	NL NL	NL NL	Bad cracking and sinking	NL VSL	NL —
LM-14	A	Deep sinking, slight tears	NL NL	NL NL	Deep sinking and drawing	NL L	NL —

UM = unmachined M = machined.

Hot tearing resistance:
A = no bars cracked.
B = fully restrained bar cracked.
B- = 1/10 „ „ very slightly cracked.
C = 1/10 „ „ cracked.
D = 2/10 „ „

Pressure tightness of discs:
NL = no leak.
VSL = very slight leak.
SL = slight leak.
RL = rapid leak.
VRL = very rapid leak.

* This alloy when grain refined by the addition of 0.15 per cent Ti is in category A.

e.g., to 800 deg. C., although chemical analysis failed to detect any loss of cadmium from a melt which had been overheated to 800 deg. C.

(iii) *Difficulties in obtaining maximum mechanical properties.*—LM-11 needs careful control of pouring temperature to meet the specification requirements when heat-treated to D.T.D.304. Pouring temperature should be about 700 deg. C. and certainly not as high at 740 deg. C. The strength of this alloy is badly affected by the impurities pre-

(*Continued on page* 708)

TABLE VII.—*Percentage D.T.D. Strength in Inadequately Fed Bars.*

Alloy, B.S. 1490 or other specification.	Uprun bars.				Bars cut from 7 in. discs.		
	Equal bulges.		Unequal bulges.				
	T.	B.	T.	B.	A.	B.	C.
LM-6	85	83	92	95	92	92	93
LM-9	81	77	70	81	78	80	77
LM-4	81	72	70	70	86	85	85
LM-7 .. .. (D.T.D. 133C)	75	57	65	59	85	84	81
LM-15 .. .. .. (low Si)	31	20	26	22	86	82	66
LM-11*	68	59	67	61	85	80	73
LM-19†	82	83	86	87	87	75	80
LM-15 .. .. .. (high Si; D.T.D. 250)	85	19	84	79	86	84	83
LM-7 .. .. (D.T.D. 287)	78	57	73	72	80	78	82
LM-5	65	52	62	59	78	77	76
LM-10	40	30	59	54	68	66	65
3L 5	—	—	68	52	—	—	—
4L 11	—	—	63	60	—	—	—
3L 8	—	—	68	65	—	—	—
LM-15 .. .. .. (high Si; D.T.D. 131A)	—	—	78	78	—	—	—
LM-14	—	—	85	84	—	—	—

T = Top sections. B = Bottom sections.
* Melt poured at 690 deg. C. † Melt not heated beyond 740 deg. C

Pattern Construction

By "Checker"

Occasions arise when existing pattern equipment can be used for new work with very little modification. Such conversion usually applies to work from which only a small number of castings is required, and where the making of a new pattern or corebox, or both, would entail considerable expense being added to the production price per casting. Another advantage is that any time taken in the patternshop on modifications, being considerably less than for producing a new job, allows castings to be obtained more quickly, which is a most important factor in many instances.

With straight pipes whose overall length is unaltered, their diameters can be increased by the addition of strips of wood sufficient to give the new diameter required. These strips should be of narrow width, and can be easily fitted between flanges and nailed in position, as shown in Fig. 1. The series of small flats which are formed round the diameter by these strips, can be easily removed by sandpapering. Flange thicknesses can, if necessary, be increased by having the required amount added at their inside face, while flange diameters can be made larger by nailing on a series of narrow pieces across their thickness, or with the addition of segments round the diameter, as shown in Fig. 2. With some patterns that may occasionally be used for different size flanges, it is an advantage to make flanges of various sizes which are interchangeable. The radius between body of pipe and flange can be restored if leather fillet of the desired size is added.

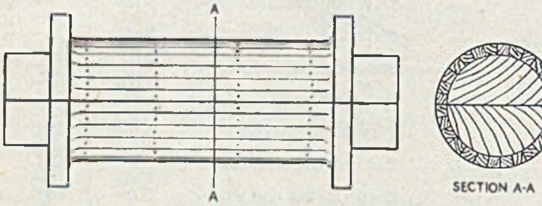


FIG. 1.—*Sections of Pipe Pattern enlarged by the Addition of Strips of Wood.*

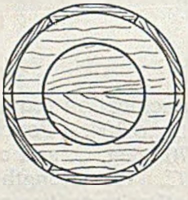


FIG. 2. — *Segments added to Enlarge the Flange Diameter of Pipe Pattern.*

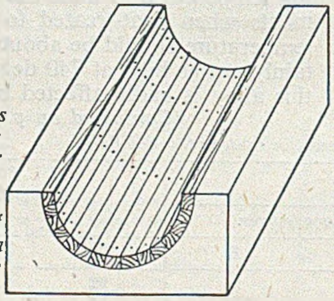


FIG. 3. — *Strips of Wood Nailed into a Core-box to Reduce Inside Diameter.*

Coreboxes can also be altered in many cases where a core of smaller diameter is required. This is achieved by the addition of narrow strips of wood which are nailed into position as shown in Fig. 3. In some instances where the only alteration is a reduction of their inside bore diameter, no modification is necessary to the pattern. Coreprints at each end which are too large, however, can be remedied without any pattern alteration, by adding wood strips inside the corebox to correspond with the overall length over both flanges, leaving only the core seating and prints at their old diameters, with the remaining portion in between being at the new and smaller diameter.

Dove-tail Construction for Loose Pieces

Various ways can be adopted for holding loose pieces in their temporary positions on patterns and core boxes, but possibly the best results are obtained by using dove-tail construction, which gives quick and accurate positioning of loose pieces, with the minimum of trouble. Dove-tails will vary in size and thickness according to the particular loose pieces with which they are to be incorporated, and their use is mainly confined to work of a standard character from which many castings are required.

Fig. 4 shows an ordinary dove-tail recess cut out, and with dove-tail piece fitted, prior to fixing on the boss which is indicated by dotted lines. Hidden dove-tails are also used at times; these show no part of the dove-tail when loose pieces are placed in position, the recess being cut away in the actual loose piece, as in Fig. 5, which shows the dove-tail section in broken line.

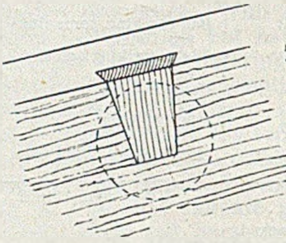


FIG. 4. — *Dove-tail Recess and Loose Piece for Producing a Boss.*

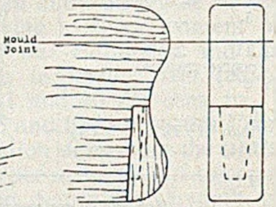


FIG. 5.—*Loose Piece held in Position by Hidden Dove-tailed Recesses.*

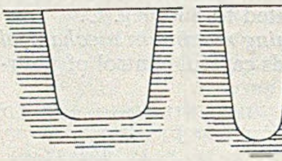


FIG. 6.—*Cutters used for Machine Forming of Dove-tails.*

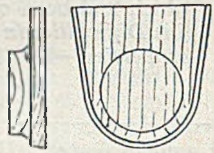


FIG. 7.—*One-piece Insert incorporating Boss, Fillet, and Dove-tailed Portion.*

When recesses for dove-tail pieces are cut by machine in either wooden or metal patterns and core boxes, it is usual for a radius to be formed at the bottom corners. This is unavoidable, and varies according to the diameter of cutter used, as shown in Fig. 6. Dove-tailed inserts should be made to fit this shape, and will be quite satisfactory without cutting the radius away to form square corners shown in Fig. 4. Another way is to extend the actual loose boss or facing shaped piece so that the loose portion, fillet, and dove-tailed portion, can all be worked from one piece, as shown in Fig. 7. In all cases dove-tailed inserts should be made an easy fit, to allow the pattern or core box to be withdrawn, without disturbing the loose pieces.

Thermal Considerations in Foundrywork*

By Dr. Victor Paschkis

(*Continued from page* 667)

First Comparison between Analyser and Casting Work

In 1944, the American Foundrymen's Association set up a Heat-transfer Committee which supervised the work reported hereafter from the foundry aspect. The Committee decided first to investigate prediction of solidification rates found from "bleeding tests" ("pour-out tests") made by K. L. Clark. On the Analyser an "infinite" slab was investigated, having no end or corner effects. Clark used slabs of 2 in. by 6 in. by 2 in., 4 in. by 8 in. by 8 in., and 6 in. by 12 in. by 12 in. to obtain data on different thicknesses, assuming that the size of the slabs was sufficient to preclude end effects. Castings were made partly in sand, and in part against a chill which was backed by sand. The properties of steel and sand which had to be used in the electric computation experiments were selected as carefully as possible. For details, reference is made to the original publication.[9] Here it is sufficient to deal with a few points:—

(*a*) All concerned expected to find correlation between the bleeding tests and the Analyser curve for the "solidus." To understand this remark it should be remembered that the Analyser produces merely curves, relating position, time and temperature, but has no way of indicating in what state the metal is at any given point or temperature. The latter information is determined by metallurgists.

Thus one curve may be taken showing for each position the time necessary to reach the liquidus and another curve showing the time to reach the solidus. Contrary to expectation the curve obtained from the bleeding test correlating solidification thickness with time after pouring checked well with the Analyser curve for the liquidus (see later paragraph under the caption "Solidus and Liquidus as Freezing Point").

(*b*) Because of the high thermal resistance of the sand, the additional resistance of the air-gap has relatively very small influence on the rate of solidification; thus, even if such gap is assumed to evist, the time when it is formed does not appear to be significant.

In the case of casting against a chill, however, the added thermal resistance of the gap is large compared with that of the chill. Hence, the estimated time when the air-gap forms is important. On the Analyser, this time can be selected arbitrarily; that is one can easily obtain results for different estimated times of "air-gap formation." It was found that if the time was assumed to vary with the square of the thickness of the cast slab, satisfactory check with Clark's work was obtained.

(*c*) The thermal resistance of the air-gap between outside surface of the casting and the inside surface of the mould depends on the difference of the fourth powers of the temperatures of these two surfaces. It was found that this difference was quite constant and therefore the thermal resistance of the air-gap does not change much during solidification.

Influence of Properties and Pouring Temperature

As the next step, computations on the Analyser were carried out in which all steel properties and the pouring temperature were varied arbitrarily over a wide range. For details, again reference is made to the original Paper.[10] The following observations may be of interest:—

(*a*) Times to reach both liquidus and solidus change markedly with pouring temperature (the latter being understood as the temperature at which the steel enters the mould, the filling time of the latter being assumed to be zero).

(*b*) As far as reaching the liquidus is concerned, heat of fusion has but little influence. Times change, very roughly, proportionally to specific heat and conductivity, for the latter slightly less than for the former. The solidification range has great influence.

(*c*) As far as reaching the solidus is concerned, solidification range is of only small influence; heat of fusion changes the time to reach the solidus very greatly. Conductivity has almost no influence, and specific heat has a very much smaller influence on the time to reach the solidus than on those to reach the liquidus.

What do these findings mean for the practical foundryman? Inasmuch as properties for different steels do not vary very greatly, he can transfer his experience from one composition to the other with reasonable accuracy. He must, however, pay very strict attention to the pouring temperature and in practice also to the pouring time. The latter influence the temperature with which the steel ultimately reaches the mould; and this temperature is the one which decides solidification time.

Freezing of Steel Spheres

Proceeding with experiments with steel (chronologically other experiments were taken first), a series of tests on steel spheres was run.[11] These tests served to compare Analyser work against a previous publication by Briggs and Gezelius.[12] Based on the recognition of the importance of the pouring temperature (see previous paragraph) experiments were run separately for different pouring temperatures.

* Official Exchange Paper from the American Foundrymen's Society, presented at the 48th Annual Meeting of the Institute of British Foundrymen at Newcastle-upon-Tyne earlier this month The Paper was read by Mr. J. F. B. Jackson on behalf of the Author.

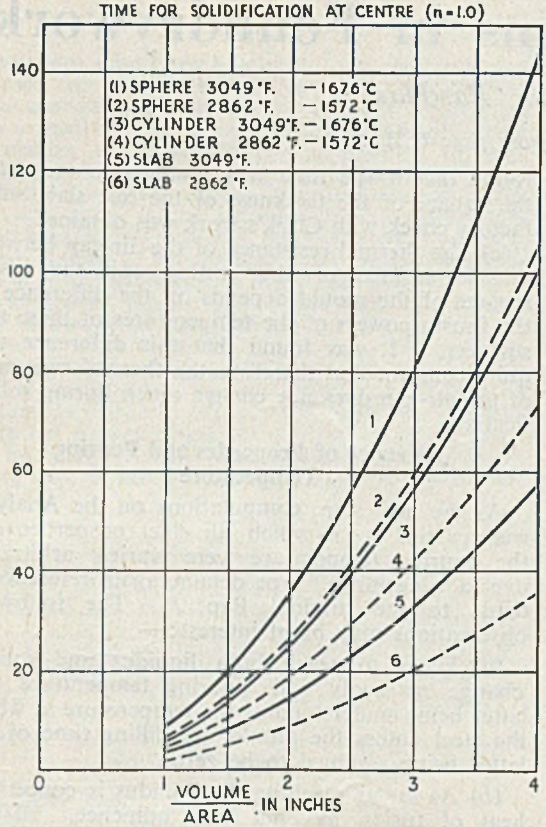


FIG. 9.—*Time to Reach the Liquidus for Different Shape Factors (Volume/Area).*

(*a*) The check with the values of Briggs is very good, except in case of a pouring temperature of 2,740 deg. F. (1,505 deg. C.). With so small a degree of superheat the minor changes in pouring temperature will result in great changes of solidification times. Hence, conceivably small errors in determining the "2740" by Briggs might account for the discrepancies between his and the Analyser's findings.

(*b*) By using the experiments described under the first heading of this Section for comparison, one can compare the time for the centre to reach the liquidus and the solidus in the case of a slab and in the case of a sphere. The original Paper contains the comparison of values for reaching the liquidus; the comparison of those for the solidus have been computed in the meantime. Both for slab and for sphere the solidification times increase with pouring temperatures. But the increase, percentage-wise, is less for the sphere than for the slab. The difference between slab and sphere is less marked for the solidus (9.6/6.5 = 1.48), than for the liquidus (3.27/1.47 = 2.22) (see Table I).

TABLE I.—*Relative Times for Spheres and Slabs to Reach the Liquidus and Solidus*

Pouring temp., deg. F.	Time to reach the liquidus (sec.).		Ratio of times, slab/sphere.	Time to reach the solidus (sec.).		Ratio of times, slab/sphere.
	Slab.	Sphere.		Slab.	Sphere.	
2,740	316	215	1.47	2,930	450	6.5
3,010	1,105	338	3.27	5,800	600	9.6

Comparative Solidification Studies

Having data on spheres and slabs, comparative studies including cylinders were made, particularly in view of the Paper by N. Chworinoff[13] which is finding considerable interest in America.

Chworinoff states the following:—

(*a*) Any two castings having the same ratio of volume/area (V/A) should solidify in the same time.

(*b*) The time for complete solidification of two castings varies proportional to the square of the ratio (V/A).

Accepting the liquidus as freezing point, as seemed obvious from the bleeding tests, it was found that Chworinoff's relationship does not hold.

Fig. 9 shows the summary of the experiments.

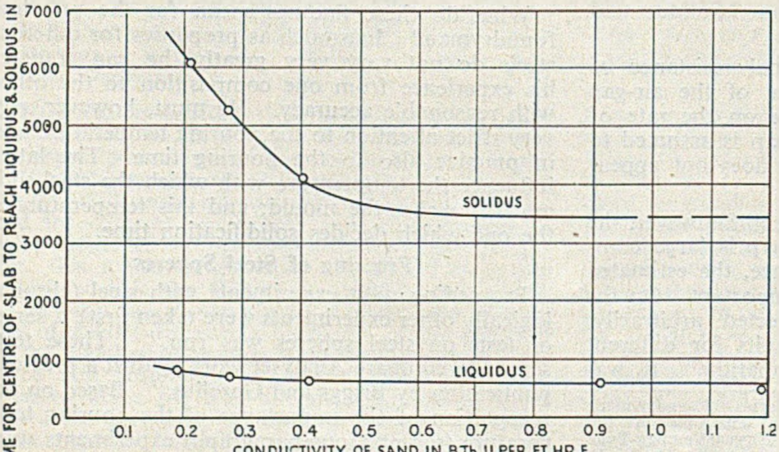


FIG. 10.—*Influence of Sand Conductivity (Dry-sand) on Solidification Times.*

Values of volume/area were plotted as abscissa, times to reach the liquidus were plotted as ordinates. Six curves are shown, three of which hold for a pouring temperature of 3,049 deg. F. (1,676 deg. C.) (curves 1, 3, 5), and the other three for a pouring temperature of 2,862 deg. F. (1,572 deg. C.) (curves 2, 4, 6). Two curves (1 and 2) hold for spheres, two for cylinders (curves 3 and 4), and the last two for slabs (curves 5 and 6).

No further discussion of this set of tests will be made here because of the recognition obtained since completion of the tests that bleeding tests are not reliable in determining solidification.

Influence of Sand Conductivity (Dry Sand)

In all investigations up to that time the conductivity of the sand was considered to be constant, namely, k=0.9 B.Th.U. per ft.-hr., deg. F. Investigations, mainly by Lucks and co-workers,[14] showed that conductivities of sand might be very much lower than this value and that conductivity changes substantially with temperature. Therefore one programme[13] was carried out to investigate the influence of sand conductivity on solidification rates of steel. The analysis was made for a steel slab 4 in. thick, covered on either side by a layer of sand 5 in. thick. The slab was considered to be so long that no end effects occurred. The results of the tests are summarised in Fig. 10. This illustration shows the times for the centre of the slab to reach the liquidus and the solidus (two curves) plotted against the average conductivity of the sand. Two points are of interest:—

(*a*) The influence of conductivity on the solidification time is greater for the solidus than for the liquidus: comparing the times for the centre to reach the solidus one finds a ratio of 6,050 sec. to 3,400 sec.=1.78 for the values of sand conductivities of k=0.9 and k=0.208 respectively; whereas for the times to reach the liquidus the ratio is only 780 sec. to 570 sec. = 1.36. Thus the sand properties are of considerable interest for complete solidification.

(*b*) The influence of the conductivity becomes more pronounced at conductivity values below 0.65. Above that the changes are much less marked.

(*c*) The conductivity of all sands increases markedly with temperature. This is understandable because the term "conductivity" for sand is an approximation: the figure actually represents an apparent conductivity including the phenomena of conduction between individual sand particles and radiation across the interstices between the sand particles; the radiation effect obviously increases at elevated temperatures.

Therefore in computations the change of sand conductivity with temperature should be taken into account; or, where this is too cumbersome, great care must be taken in selecting the average conductivity.

Influence of Moisture in the Sand on Conductivity

A later step in personal investigation deals with the influence of moisture on the solidification. When casting in moist sand, the moisture is driven towards the cold surface. This occurs by evaporating the moisture in layers very near the hot surface; the steam thus formed flows through the pores and condenses as soon as it reaches portions of the sand which are at temperatures below the boiling point of water. The heat of evaporation acts as a heat drain; more heat flows to a section of sand at the same temperature from which no evaporation takes place. The apparent conductivity of the sand is thus increased.

The representation of this process on the Analyser is quite complex; therefore in the computation carried out on the Analyser to date, a constant surface temperature on the casting/sand interface was assumed, whereas actually this temperature changes during solidification.

For this simplified condition (constant interface temperature) it is found that the influence of moisture disappears after relatively short time and that the influence is more marked at lower temperatures than at high ones. Fig. 11 expresses the ratio of heat extraction from the "ideal" casting ("ideal" because the interface between casting and mould is assumed to remain at constant temperature) in moist sand to that in dry sand of otherwise unchanged properties; this ratio is plotted against time.

It is obvious that moisture will exert an influence on the formation of a solidification skin, but will hardly influence freezing to great depth. Additional work on this problem is being carried out.

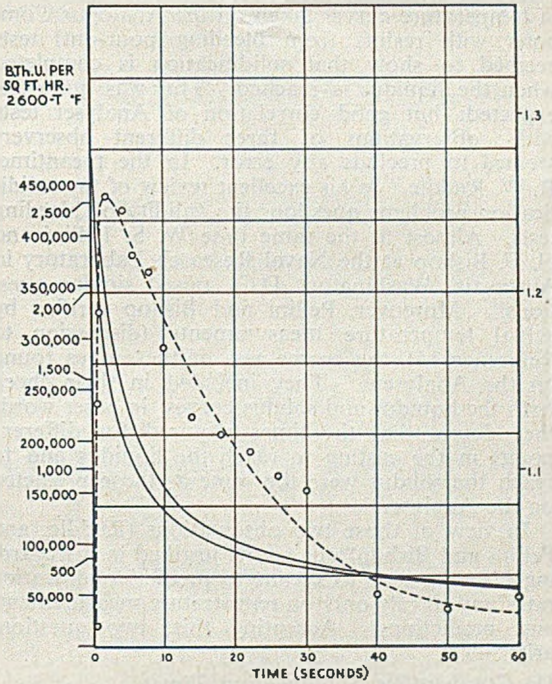


FIG. 11.—*Influence of Moist-sand Conductivity on Heat Extraction from a Face held at Constant temperature.*

Thermal Considerations in Foundrywork

Experiments on Materials other than Steel

For the sake of completeness it should be mentioned that work has also been carried out on the rate of solidification of white cast iron[17] and of aluminium.[18] In case of white cast iron, correlation with bleeding tests is poor.[17 18] It was, however, found that the bleeding tests themselves were very difficult to carry out, and in view of the later research and observations regarding bleeding tests, the validity of the bleeding tests themselves may be questioned.

The agreement in case of aluminium was very good. These tests are worth mentioning because aluminium, as the pure metal, freezes at one temperature rather than over a temperature range as steel and other alloys do. Freezing at constant temperature requires a different technique on the Computer; the fact that aluminium tests also match direct observations is an added proof for the correctness of the Analyser.

SOME OPEN PROBLEMS

Obviously the seven years work on the Analyser may be considered only as a beginning. Therefore the two problems which are discussed below are not meant as a complete list of unfinished business, but merely should point to regions of inquiry which seem at present particularly pertinent in view of the latest findings.

Solidus and Liquidus as Freezing Point

As stated in the previous Section, the comparison of temperature curves taken on the Analogue Computer with results from bleeding (pour-out) tests seemed to show that solidification is completed when the liquidus is reached. This was quite unexpected; but good correlation of Analyser tests with observations of three different observers seemed to preclude any error. In the meantime, R. W. Ruddle,[19] in his excellent review of the solidification problems questions the validity of bleeding tests. Almost at the same time W. S. Pellini and H. F. Bishop at the Naval Research Laboratory in Anacostia, Washington, D.C., raised similar questions. Moreover, Pellini and Bishop verified by actual temperature measurements (discussion to Reference 15), the correctness of the curves found on the Analyser. They included in their check both the liquidus and solidus curves; in other words they found that the times required for different points in the casting to reach the liquidus and to reach the solidus were the same as those predicted on the Analyser.

In view of those two observations (Ruddle, and Pellini and Bishop) one seems justified in disregarding bleeding tests as means to predict solidification rates and to rely only on temperature measurements and predictions. Accepting this, two questions arise:—

(1) *Comparative Solidification Times*

Chworinoff[13] makes two statements in this connection, both related to the ratio volume/area which may be called shape factor (S).

(*a*) Bodies having the same shape factor solidify in the same time independent of their size or individual shape.

(*b*) Solidification times vary proportionally to the square of the shape factor.

In previous publications from the Analyser laboratory, it was stated that his predictions do not agree with the findings on the computer. This statement needs re-examination since it was based on the assumption that the freezing point coincides with the liquidus. Accepting the solidus as freezing point may influence the statement.

Chworinoff in his illustrations* presents a graph in which solidification times are plotted against the shape factor; he uses a log-log scale and obtains for a large number of different castings a straight-line relationship between ordinate and abscissa, which in view of the scales used, indicates validity of his square law (*b*). The range of shape factors examined by Chworinoff is very wide; the lowest value is $S=0.19$ and the largest value which can be read on his graph definitely is $S=5$ near the upper end of the abscissa scale. There are a few points still beyond the $S=5$, but no dimensions are shown for these other readings. Based on his scale it should be $S=7.5$. The values given here (0.19, 5, and 7.5) are in inches, whereas the original graph is in millimetres.

The ratio of the largest to the smallest S value on Chworinoff's chart is $5/0.19=26$. Tests on the Analyser are available so far only for slab and sphere. The shape factor, S, has the dimension of length, and can conveniently be expressed as a multiple of the smallest dimension, D, of the shape. In case of a sphere or cylinder, D denotes the diameter; in case of a large slab (with no edge effects) it denotes the thickness and otherwise the smallest dimension.

In case of finite slabs, S approaches zero as D becomes smaller and smaller: the surface of a sheet may be quite large, but if the thickness is very small the volume becomes very small too.

For a large slab (no edge effects) one finds readily $S_P=D_P/2$. For a sphere the value of $S_S=D_S/6$. The subscripts P (plate) are used for the slab and S (sphere) for the sphere. Hence the ratio $S_S/S_S=3$.

Examining any pair of slabs or spheres of the same dimension D will result in a ratio for values S of 3:1.

For the same shape—whatever the shape may be, sphere, cylinder, slab, etc., the "square law" is correct provided that all dimensions including those of the mould are changed proportionally. That means that if a sphere of 3 in. diameter is compared with one of 6 in., the solidification time of the latter will be four times as long as that of the former; provided that the dimensions of the mould have changed in the same ratio and provided the same temperature and same metal is being used.

For different shapes, however, so far, only a comparison between slab and sphere is possible

* The illustration quoted is Fig. 19 contained in the work of Chworinoff listed under Reference 13.

having, as mentioned, a ratio of shape factors of 3. A comparison has been carried through of a slab of 4 in. thickness (no edge effects) with a sphere of 12 in. diameter. The two having the same shape factor should freeze in the same time. Their solidification times, taken as the times for the centre to reach the solidus, are shown in Table II; the first column contains the pouring temperature, the second the solidification time of the sphere, the third that of the slab, and the fourth the ratio of the two. As stated, according to Chworinoff the solidification times should be identical, or this ratio should be unity. It will be seen that at high pouring temperatures this ratio as postulated by Chworinoff is closely maintained, whereas at low temperatures the difference between the actual ratio and the postulated ratio is quite appreciable.

TABLE II.—*Comparison of Solidification Times of a Large Slab (No Edge Effects) with a Sphere, Both Having the Same Value of Volume/Area.*

Pouring temperature, deg. F.	Times to reach solidus.		Ratio slab/sphere.
	Slab (sec.).	Sphere (sec.).	
3,010	4,600	4,320	1.06
2,900	3,900	3,920	0.99
2,820	3,280	3,520	0.93
2,800	3,100	3,400	0.91
2,740	2,375	3,280	0.73

It must be remembered that the accuracy of tests at small degrees of superheat is reduced. But even discounting this possible source of error, and accepting also the ratio of 0.73 at 2,740 deg. F. (1,505 deg. C.) as correct, it is significant to compare this value with the one obtaining for the times to reach the liquidus. At a temperature of 2,740 (1,505 deg. C.) this ratio is only 0.16. Thus it is possible that Chworinoff postulated his rate based on observations at relatively large degrees of superheat only.

(2) *Air-gap*

The formation of an air-gap in the case of casting against a chill causes a considerable change in the rate of solidification. So far it has been next to impossible to determine the time when such an air-gap forms. Since the technique of temperature measurements in liquid steel have been developed and are practical, as Pellini and Bishop show, it may be possible to use the Analyser to determine the time for formation of the air-gap. This time has considerable influence on the rate of solidification, although percentage-wise it is less important than previously assumed. The air-gap time influences the time to reach the liquidus more than it does the time to reach the solidus.

For example, in case of a 2-in. casting backed by a 3-in. chill, which in turn is backed by 5 in. of sand, the time to reach the liquidus increases from 180 seconds to 270 seconds, if the air-gap time is reduced from 36 to 9 seconds. The increase is roughly 50 per cent. The same decrease of air-gap time changes however the time for complete solidification (time to reach the solidus) only from 420 to 540 seconds: a change of 28 per cent.

APPENDIX

In order to explain the working of the Heat and Mass Flow Analyser,[20] consider a rod (Fig. 12) which is completely insulated on the sides, so that heat flow can occur only parallel to the axis. Let the rod be initially at constant temperature throughout and at time zero a high temperature be impressed on one end while the other is maintained at its original temperature. Then the rod will slowly increase in temperature until, in steady-state, a straight-line temperature distribution occurs with the highest temperature at the hot surface and the lowest at the cold surface. The differential equations for the temperature rise with time at any point in the rod are the same as the differential equations for the increase in electric potential if an electric conductor with evenly-distributed resistivity and capacity is suddenly exposed to a voltage difference. Therefore one could study the time/temperature history by observing the potential increase in a suitable electric conductor.

Instead of attempting to find such a conductor with the appropriate properties, the "lumping technique" is used which has been mentioned in the text. This consists in considering the rod being divided into sections or lumps as indicated in Fig. 12. Within each section the resistance is considered to be concentrated at the axis, and the capacitance in the centre. Thus a simple electric network as shown by the solid lines in the "box" of Fig. 13 represents the rod shown in Fig. 12. Between the electric computing circuit and the heat-flow problems certain analogies exist, which are obvious from the identity of the equations.

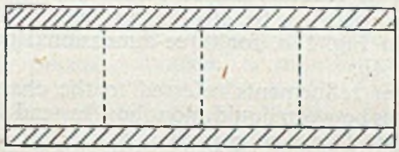


FIG. 12.—*Rod subjected to Heat Flow*

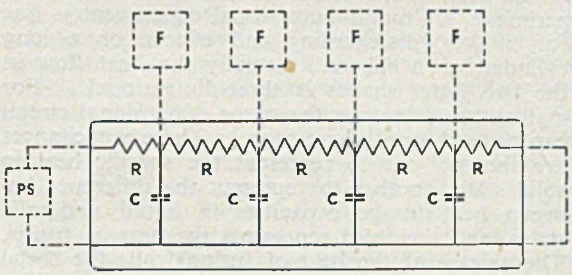
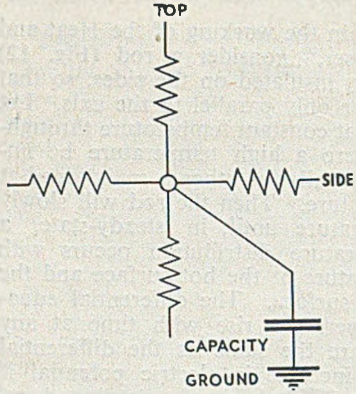


FIG. 13.—*Equivalent Electric Circuit to represent Rod shown in Fig 12.*

PS—Power Supplies.
R—Resistors representing resistance to heat flow.
C—Capacitance representing heat-storage capacitance.
F—Devices to feed current in. representing internal heat-sources.



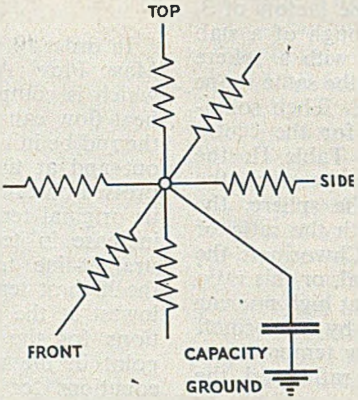


FIG. 14(*b*) (*right*).—*Element of Network to represent Three-dimensional Heat Flow.*

FIG. 14(*a*) (*left*).—*Element of Network to represent Two-dimensional Heat Flow.*

These analogies are as follows:—

Temperature: voltage (potential).

Rate of heat flow: current.

Thermal capacitance (volumetric specific heat × volume): electric capacitance (condenser).

Thermal resistivity (1/conductivity): electric resistivity.

To the circuit shown in the box of Fig. 13 various elements have to be added to represent different conditions. For example, if the rod is heated up as described above, connections are made as shown by dash-dot lines in Fig. 13. If, instead, the rod is heated by internal heat sources, such as di-electric heat and cooled to the outside, a circuit would be fed as shown by the broken lines in Fig. 13, and closed as shown by the dash-dot lines omitting the power supply PS.

If heat flow is in more than one direction, a network of resistors has to be used. One element of such a network for two-dimensional heat flow is shown in Fig. 14*a*, for three-dimensional heat flow in Fig. 14*b*.

Further refinements referred to the changing of properties between liquid and solid. Instead of having in each section one capacitance and two resistors (one on either side of the capacitor), each section has several resistors and capacitors. Fig. 15, for example, shows one section each of the steel and mould circuits for a mono-dimensional casting experiment. A mono-dimensional experiment is one for a slab, disregarding end effects, or a long cylinder, or a sphere. Actually the heat flow in the two latter shapes is three-dimensional. For mathematical reasons the mono-dimensional circuit can be used for all three cases.) Three capacitances are shown: one to represent the specific heat in solid state, another to represent the difference between heat-storage capacities in liquid and solid states, and the third represents the heat of fusion. The release of the heat of fusion while the metal temperature drops from the liquidus to the solidus temperature may be represented by an increase in apparent specific heat during that period. The resistances next to the capacitance represent the thermal resistance to solid state, and the outside resistors the difference between the thermal resistance in liquid and solid state.

As the temperature (voltage) of each section decreases from the initial "pouring temperature," the following changes have to be made:—

When the voltage (temperature) reaches the liquidus the "heat of fusion capacitance" is inserted into the circuit.

When the voltage has dropped to the mid-point between liquid and solid values, the properties (resistance and capacitance) are changed from their "liquid" values to their "solid" values. This implies shortening the two outer resistances, because the thermal conductivity of liquid metal is higher than that of solid metals; it also implies the disconnecting of the difference capacitances which represents the difference between liquid and solid specific heat.

When the voltage drops to the solidus point, the "heat of fusion capacitance" is taken out of the circuit.

In case of pure metal no "heat of fusion

(*Continued on page* 708)

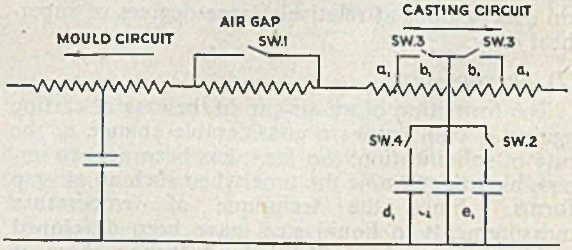


FIG. 15.—*End Sections of "Casting Circuit" and "Mould Circuit."*

Resistors *a* represent thermal resistance in the solid state, and resistors *b* represent difference in thermal resistance between liquid and solid state.

Capacitor *c* represents heat-storage capacity in the solid state, capacitor *d* represents the difference in heat-storage capacity between liquid and solid state, and capacitor *e* represents heat of fusion.

Switch (SW) 1 is closed initially and is opened as soon as the airgap forms; switch (SW) 2 is initially opened and is closed when the voltage (temperature) has dropped to the value of the liquidus.

At a voltage half-way between that representing liquidus and solidus, switches (SW) 3 are closed, thus representing an increase in conductivity upon solidification, and switch (SW) 4 is opened acording to a decrease in specific heat.

Capacitances *c* and *d* are pre-charged before the experiment to a voltage representing the pouring temperature. Capacitance *e* is pre-charged to a voltage corresponding to the liquidus; the capacitance in the mould circuit is either uncharged or, in case of a pre-heated mould, pre-charged to a voltage corresponding to the mould temperature.

Scrap Drive

FOUNDRY PRODUCTION in all spheres may at the present time " sink or swim " according to the failure or success of the drive for scrap. This seems to be true, whether it be for the steelworks to relieve the load on the blast furnaces, or to the foundries for direct melting to reduce the consumption of pig metal. What follows is an account of the efforts of the iron and steel industry shown against the general statistical background, including coke and ore supply.

Production of steel for May was at the rate of 15,864,000 tons per annum. The annual rate over the first five months of 1951 was 16,361,000 tons. The May figures reflect the effect of the difficulties over the winter period in the import of iron ore, with the limit this has set on the possible pig-iron production, and the results of an exceptionally low import of scrap. Only 26,000 tons of scrap were imported in May this year compared with an import of 196,000 tons in May last year.

According to the British Iron and Steel Federation, the immediate prospects for imported scrap are slightly better. For June and July it is hoped to obtain about 40,000 tons a month. The improvement in the raw-material position for steelmaking, however, depends on the full maintenance of the good start to the scrap drive and the expansion of pig-iron output. So far this year, pig-iron production has averaged 182,000 tons a week. In the second half of the year it is expected to increase to at least 190,000 tons a week and then to continue to rise into 1952. This increase is based in part on the expectation of better arrivals of imported ore. Shipping chartering has improved with the end of the coal-shipping season. Further, some help has recently been indicated from American shipping.

Complementary Materials

On the home ore side, consumption last year was 12¼ million tons. This year it is running at 14½ million tons—an increase of nearly 2 million tons a year.

Coke supplies have increased with the coming into operation in March of new ovens at Margam; these are now producing 5,000 tons a week. Another 8,000 tons a week should be available from the end of September, mainly as a result of further developments at Margam and Nantgarw also in South Wales. A further 5,750 tons per week will become available at the end of November with the doubling of the coke plant at Appleby Frodingham.

By next year, there should be capacity available for the production of about 10½ million tons of pig-iron compared with the 9¼ million being produced this year. This will involve increases in both home and imported ore supplies and every effort is being made to ensure the availability of the necessary material.

A steel scrap drive was launched in January this year with a letter from the Presidents of the Iron and Steel Federation, the Joint Iron Council and the Scrap Merchants Federation, to every consumer of iron and steel, pointing to the importance of scrap in the making of steel and urging the quick return of all process scrap and that, wherever possible, decisions should be taken to scrap obsolete plant and machinery, have it broken up and returned to the steel furnaces as rapidly as possible. This general letter was supported by the formation, in January, of nine district committees, representative of scrap merchants and steel makers.

Success of Drive depends on Merchants

It was recognised that for a scrap drive to be successful it must rest mainly on the individual efforts of the 3,000 scrap merchants in the country, working with the goodwill of the using industries which were bound to be the main source of scrap supply. Any highly-centralised method of collecting scrap would tend to prejudice the usefulness of the many scrap merchants which is vital in the processing and sorting of scrap, as well as in its collection.

It was also clear that the great volume of available scrap was in fact being collected and returned to the steelworks. What was needed was a supplementary effort to speed up wherever practical the rate of flow and to encourage the collection of smaller tonnages, over which there was hesitation in scrapping and returning.

Personal approaches have been made by chairmen and leading officials of user companies to their customers. These are designed to help the scrap merchants in obtaining the maximum co-operation of industrial scrap suppliers.

While the backbone of the scrap campaign is the encouragement of the normal collection of scrap through normal channels, a number of special approaches have also been made. Government departments have promised to give help. The campaign is planned to continue into 1952; it is quite clear that all the sources of supply will not be tapped in the initial stages; some will take a considerable period before they are organised.

The campaign so far has concentrated essentially on speeding up the collection of scrap within the steelworks themselves and in their associated works, and in obtaining the full support of the industrialists throughout the country. The amplification of the campaign to the farmer and then to the householder presents more difficult problems. Discussions have taken place with the National Farmers' Union and their help obtained, and measures are in hand to develop an increased flow of scrap from the farms. In the case of the householder, experimental arrangements are being tried out in a number of urban areas—of which a good example is Sheffield. Here, the local authority is distributing pamphlets to every householder, notifying its willingness to collect any scrap put out and proper arrangements have been made for handling the miscellaneous scrap arising and passing it on to the scrap merchant.

Scrap Drive

A similar approach is being followed on the North East Coast, where separate "scrap weeks" are being organised for various towns taken in turn. The experience gained in these initial measures will determine the policy to be adopted throughout the country at large.

Success to Date

The amount expected from home scrap in the absence of any scrap drive was 157,500 tons a week. This was almost exactly the weekly average of scrap obtained from inland sources last year. A number of favourable factors assisted in securing this figure last year, particularly, a rather better supply from shipbreaking. Higher freight rates, and therefore the increased use of shipping and the export of some ships abroad, have reduced the shipbreaking output this year. There are about 2,000 tons a week less from this source. The 157,500 tons a week for this year in the normal way is therefore initially a fairly optimistic assessment of the position. To this it was hoped to add, from the end of January onwards, 10,000 tons a week from the special drive. In fact, the average scrap deliveries in the period February to the end of May were exactly 167,500 tons, *i.e.*, 10,000 tons a week above the weekly average hoped for. So far, most has come from the steelworks and other sources of supply close to the steelworks. The approach over the wider field, and particularly from the farms and households, has not yet made a material contribution and it is hoped that this source will be progressively tapped, so keeping up and possibly improving on the start already made.

The British Iron and Steel Federation has recently produced a coloured sound film, "Speed the Scrap," which will be shown mainly to municipal authorities and executives of companies, as part of the scrap drive.

Iron-ore Imports

Imports of iron ore in May and the first five months of the year, with comparative figures for 1950, are shown below. There were no imports of manganiferous ore during the first five months of this year. In the first five months of 1950, 11,016 tons of manganiferous ore were imported, against 6,550 tons in the corresponding period of 1949.

Country of origin.	Month ended May 31.		Five months ended May 31.	
	1950.	1951.	1950.	1951.
	Tons.	Tons.	Tons.	Tons.
Sierra Leone	86,340	53,540	339,484	203,216
Canada	—	20,750	5,525	20,750
Other Commonwealth countries and the Irish Republic ..	9,935	2,873	13,267	10,878
Sweden	297,706	270,340	1,420,583	1,219,767
Netherlands	4,449	816	7,090	4,911
France	31,390	33,915	155,237	168,635
Spain	94,533	76,183	343,490	339,005
Algeria	87,241	135,146	593,428	512,609
Tunis	43,040	39,850	199,493	198,270
Spanish ports in North Africa	55,340	28,345	226,356	150,607
Morocco	16,850	22,207	134,573	100,275
Other foreign countries	35,139	12,480	55,784	39,805
TOTAL	761,963	696,445	3,494,310	2,968,728

Reorganisation of G.K.N. Cwmbran Works

As from July 1, the Cwmbran works of Guest, Keen & Nettlefolds (Cwmbran), Limited, a subsidiary company of Guest, Keen & Nettlefolds, Limited, which comprises a railway fastenings division, ironfoundries, clay mines, and refractories works, will be separated into two distinct works. The railway-fastenings division will be sold to, and managed by, Guest, Keen & Nettlefolds (Midlands), Limited, bolt and nut division, Atlas Works, Darlaston (Staffs), which company is also a subsidiary of Guest, Keen & Nettlefolds, Limited.

The bolt and nut section of the railway fastenings division is to be completely reorganised and the most modern machinery and equipment will be installed to take care of the ever-increasing demand for this type of product. The output will shortly be increased by 40 per cent. and employment will be found for at least an additional 70 persons.

The ironfoundries, clay mines, and refractories works will remain under the ownership and management of Guest, Keen & Nettlefolds (Cwmbran), Limited.

Guest, Keen & Nettlefolds (Cwmbran), Ltd., are said to be the largest individual producer of cast-iron railway chairs, baseplates, and wagon castings in Great Britain. In addition, this company has begun work on the building of a large cast-iron cylinder block foundry which will be capable of a weekly production of 2,500 cylinder blocks and cylinder heads for the motor industry. This new foundry will give employment to approximately an additional 100 men and 150 women.

Further reorganisation is taking place at the company's refractories works, where fireclay products are produced by the most modern methods. To keep the refractories works adequately supplied with raw material an additional clay level has been opened at Blaendare (Mon).

Canadian Steel Expansion

Predicting an addition of 1,000,000 tons in the annual output, Mr. Howe, Minister of Defence Production, told the Canadian House of Commons that every steel plant in Canada has a substantial expansion programme under way. Even with this expansion he doubted whether Canada would ever become self-sufficient in steel owing to the country's rapid growth and the necessity of importing products that could not be manufactured economically.

Remarking that Canada had been heavily dependent on the United States for iron ore since the first steel plant was installed, Mr. Howe said: "This situation will change in a year or two."

The steel supply situation in Canada at the present time is critical and Mr. Howe has instructed mills to defer deliveries of less-important products.

Tungsten and Molybdenum

The Tungsten and Molybdenum Committee of the International Materials Conference announces that on June 8 it unanimously recommended to governments that an international system of equitable distribution for ores and concentrates of these two metals be established.

The Copper-Zinc-Lead Committee has reached tentative agreement to recommend an allocation scheme, beginning next October, to ensure equitable distribution of copper and zinc.

Thermal Considerations in Foundrywork

(*Continued from page* 704)

capacitance " is inserted. Instead, when the voltage (temperature) of any section has dropped from the pouring value (temperature) to the solidification point it is connected to a constant-voltage supply which feeds current into the circuit at that point. The current represents the rate of heat generation by the latent heat of fusion. This power supply is held in contact until enough current has drained into the circuit to represent the entire heat of fusion.

An air-gap between casting and mould is represented by a resistance between the end of the casting circuit and the beginning of the mould circuit. As mentioned in the text, a time scale can be introduced when using the Analyser. This is done by appropriate choices of electric resistances and capacitances to represent given values of thermal properties.

Physically, the laboratory consists of a large number of resistors and capacitors so arranged that an unlimited number of different connections can be made conveniently and in short time. In addition, of course, the necessary power supply and measuring devices are provided.

Acknowledgments

The Author is indebted to the members of the Heat-transfer Committee, and particularly to Dr. H. A. Schwartz, chairman of this committee since its inception, who introduced the Author to the field of foundrywork and who showed continued interest and support. He and Mr. E. C. Troy also were kind enough to read the manuscript.

Thanks are also due to the American Foundrymen's Society, which was the first organisation in this country to take up a systematic study of heat transfer in its field of operation by means of the Analogue Computer. The items 9, 10, 11, 15, 16 and 18 in the references represent parts of reports issued by the Heat-transfer Committee as results of work sponsored co-operatively by the American Foundrymen's Society and Columbia University.

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*16 V. Paschkis, "Heat Flow in Moist Sand," to be presented at the annual meeting of the A.F.S. in 1951 in Buffalo.
17 V. Paschkis, "Studies of Solidification of White Iron Castings," *Trans. A. F. S.*, vol. 56, pp. 371-373 (1948).
*18 V. Paschkis, "Studies on the Solidification of Aluminium Castings," *ibid.*, pp. 366-371.
19 R. W. Ruddle, "The Solidification of Castings," Institute of Metals, 1950.
20 V. Paschkis and H. D. Baker, "A Method for Determining Unsteady State Heat Transfer by Means of Electrical Analogy," *Trans. A.S.M.E.*, vol. 64, p. 105 (1942).

* See acknowledgments.

Casting Characteristics of some Aluminium Alloys

(*Continued from page* 697)

sent and it is normally made from aluminium of purity such that the total iron and silicon content does not exceed 0.25 per cent. More-recent B.N.F.M.R.A. work has shown that the mechanical properties of this alloy are markedly affected by grain size variations.[7]

(iv) *Fluidity attainable.*—A carefully controlled preliminary series of tests, on six typical alloys, led to the conclusion that "founder's fluidity" or flowing power of aluminium casting alloys, as determined by fluidity tests, depends primarily on the degree of superheat of the liquid alloy as it enters the mould, although it may be influenced to a minor extent by other factors. The differences between different alloys are much less significant in "fluidity" than in the other casting characteristics considered. Control of temperature in relation to the design of the mould, is the main requirement for the complete filling of moulds in the manufacture of sand castings of aluminium alloys.

Alloys with a low liquidus temperature and not adversely affected by a high pouring temperature can be given sufficient superheat to impart high founder's fluidity. LM-6 and LM-9* are therefore the most suitable alloys where difficulty is likely to be experienced in filling a complicated mould. LM-4 is good in this respect whereas LM-11 and LM-19 are likely to be poor. In some cases it may be necessary to apply a greater pressure head by changing the gating system to obtain complete running of the casting.

Acknowledgments

The Author is indebted to the director and council of the British Non-Ferrous Metals Research Association for permission to publish this Paper. Thanks are also due to Dr. H. Moore, who kindly prepared the text for publication.

* LM-20, which is similar to LM-6 apart from having a higher upper limit on the copper content, may be regarded as generally similar as regards casting characteristics.

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Export Licensing Regulations

The Export of Goods (Control) Order, 1951 (S.I. 1951, No. 1053. price 1s. 3d.). which came into operation on June 21 and brings up to date the Consolidation Order, 1950, with all subsequent amendments, was published on June 19. In addition, one formal change is made—goods for which a licence to export has already been given under the recent Control of Goods (Import Certificates) Order, 1951, are no longer controlled under this Export Goods Order.

News in Brief

WINGET CONCRETE MIXERS are to be made in the Union of South Africa by James Brown, Limited, of Durban.

PARIS POLICE are to use British Triumph "Thunderbird" motor cycles for patrol work and escort duties in the capital.

THE NORTH LONDON BRANCH of the Institute of Welding will visit Vauxhall Motor Works, Luton, on Monday, July 2.

THE ANNUAL GENERAL MEETING of the British Ceramic Society will be held at the North Staffordshire Technical College on July 16, at 7.0 p.m.

THE ROLLS ROYCE WELFARE SOCIETY have opened a new sports ground at St. Mary-le-Gill to cater for the employees in the Barnoldswick area.

THE MAY MEETING of the Victorian Division of the Institute of Australian Foundrymen was devoted to a lecture "Overseas Impressions" by Mr. J. Ritchie, past-president.

AN IMPORTANT SECTION of the British Standards Institution exhibition at the South Kensington Science Museum will be taken to Scotland and housed at the Engineering Centre, Glasgow, from July 9 to 14.

A CHANGING ROOM, equipped with shower-baths, and a messroom are to be provided at a cost of about £8,000 at the works of David King & Sons, Limited, ironfounders, Carleton Road, Skipton.

AT THE ROYAL HIGHLAND SHOW at Aberdeen last week, Cruikshank & Company, Limited, Denny Iron Works, were awarded a silver medal for their D.C.M. spinner, digger, collecting machine for the uplifting of potatoes.

THE NINTH International Management Congress will be held at Brussels from July 5 to 11, under the auspices of the International Committee of Scientific Management. A special 30-day tour of the Belgian Congo will follow the Congress.

AT AN EIGHT-DAY EXHIBITION of local industries organised recently by the Wednesbury, Darlaston and District Manufacturers' Association, the iron and steel industries were represented by the majority of the stand holders and ten per cent. of the total were founders.

THE IRON AND STEEL CORPORATION OF GREAT BRITAIN have announced their intention to exercise their option to acquire the three Sheffield steel firms of William Jessop & Sons, Limited, J. J. Saville & Company, Limited, and Bromley, Fisher & Turton, Limited, owned by the Birmingham Small Arms group; negotiations on price and date of transfer are proceeding.

THE JOINT COMMITTEE on Materials and their Testing, in association with the Institute of Welding, announces a symposium on recent developments in notch-bar testing of materials and its relation to welded construction, to be held in London on December 5. Papers are being invited from a number of British and foreign authorities and will be pre-printed and only introduced at the meeting with a view to discussion, which will occupy two sessions, one in the morning and one in the afternoon.

THE BRITISH CAST IRON RESEARCH ASSOCIATION have issued a preliminary notification of a conference at Ashorne Hill from September 26 to 28. This conference will be concerned with problems of foundry ventilation, lighting, dust hazards and dust extraction, foundry heating and foundry amenities, and it is hoped to obtain the services of a number of lecturers who are recognised authorities in these fields. The conference will be of particular interest to those foundries anxious to carry out the recommendations and suggestions embodied in the Report of the Joint Advisory Committee on Conditions in Ironfoundries, the so-called Garrett Report.

Personal

MR. DANIEL SHARPE, past-president of the Institute of British Foundrymen, attended the annual general meeting of the Melbourne Section of the Institute of Australian Foundrymen.

MR. I. G. BUCHAN, C.A., has been appointed chief accountant and local director of Samuel Osborn & Company, Limited, steel manufacturers, of Clyde Steel Works, Sheffield. Mr. Buchan took up his appointment in May after five years on the staff of Thomson McLintock & Company, Limited, of London.

RETURNING HOME next month is Lieut.-General Sir JOHN EVETTS, who is retiring from the position of head of the British Ministry of Supply staff in Australia which he has held since 1946. He will be succeeded by Mr. IVOR BOWEN, formerly superintendent of the aircraft and armament experimental station at Boscombe Down, who went to Australia last year. Mr. W. A. S. BUTEMENT, chief scientist in the Australian Department of Supply, will become controller of the Woomera rocket range.

DR. EGON OROWAN has been appointed as George Westinghouse Professor of mechanical engineering at the Massachusetts Institute of Technology. Dr. Orowan joined the faculty of the Institute last June, and now succeeds Professor William R. Hawthorne, who has held the Westinghouse chair since 1948. Professor Hawthorne is resigning to accept the post of the Hopkinson and Imperial Chemical Industries Professorship of applied thermodynamics at Cambridge University. He will sail for England late this month.

At a special meeting on June 14 of the general committee Sir RONALD GARRETT, a director of Anderson, Green & Company, Limited, and London director of Mount Lyell Mining & Railway Company, Limited, was re-elected chairman of Lloyd's Register of Shipping, an office which he has held since 1946. Sir GUY ROPNER, a director of the Consett Iron Company, Limited, the Consett Spanish Ore Company, Limited, and other companies, was elected deputy-chairman of the register and chairman of the sub-committees of classification.

In 1937, Dr. Orowan was engaged upon research work on the mechanical properties of metals in the physics department of the University of Birmingham in England. In 1939 he was associated with the Cavendish Laboratory under Sir Lawrence Bragg, where he was head of the metal-physics group and Reader in the physics of metals in the University of Cambridge. He has received many honours, of which the most important are the Thomas Hawksley Gold Medal of the Institution of Mechanical Engineers in 1945 and election as a Fellow of the Royal Society in 1947.

MR. GEORGE LEVY on June 17 celebrated the 50th anniversary of his joining, as an apprentice, George Cohen Sons & Company, Limited—the parent concern of the "600" group of companies. In 1908 he became partner and twenty years later was elected to the board of the Limited Company into which the firm was then converted. To-day he is vice-chairman of George Cohen Sons & Company Limited; chairman of T. C. Jones & Company, Limited; chairman of Browett Lindley Limited; a director of the Selson Machine Tool Company, Limited; and chairman of K. & L. Steelfounders & Engineers Limited. Whilst active in the general affairs of the group, he has of recent years given much of his time to the last-named Company, whose works are at Letchworth. They are among the largest steelfounders in Great Britain and their range of engineering products includes the well-known Jones KL mobile cranes.

Raw Material Markets

Iron and Steel

Supplies of pig-iron and scrap to the foundries continue to cause much anxiety. Output of hematite has been reduced considerably due to shortage of ore, and not until imports of foreign ore are increased will producers be able to provide a much larger tonnage. Increased supplies of high-phosphorus pig-iron should be available from the Derbyshire area when the new furnace is working normally. The refined-iron makers will also be able to step up production when they can secure additional supplies of pig-iron and scrap, and a more regular flow of raw materials would enable makers of low- and medium-phosphorus iron to obtain maximum outputs.

The raw materials position at the steelworks remains acute, particularly the shortage of scrap, and the need for larger quantities of basic-steel making pig-iron cannot be ignored in assessing the future supply position of the foundries.

The engineering, motor, and textile foundries have plenty of work on hand and potential business is good. The light and jobbing foundries have sufficient work on hand to warrant larger tonnages of high-phosphorus pig-iron than are at present forthcoming. Foundry coke is coming forward generally to schedule, while ganister, limestone, and firebricks are forthcoming to requirements, but some grades of ferro-alloys present some difficulty.

No relief is, as yet, forthcoming for the re-rollers, whose supplies of steel semis are at a very low level. Substantial orders are on hand for their products of sections, bars, and strip, and fresh orders are not difficult to obtain. Deliveries of steel semis from home steelworks are far below requirements and only small tonnages of Continental material are coming to hand. Many mills are on short time. Sheet re-rollers are also in need of greater quantities of sheet bars. The mills are taking up all available supplies of defective material and crops.

Non-ferrous Metals

Although further discussions on the vexed question of fixing upper limits for brass and copper ingots are believed to have taken place, no announcement has been made to give effect to maximum prices. However, the plan has not been abandoned, and it is believed that in a matter of a few weeks the scheme will be put into force, at any rate for brass ingots and billets. It seems likely, however, that a decision about copper may be delayed. Business in secondary metals is decidedly slow and purchases very difficult to arrange. On every hand there is talk of evasion of the Order, in spirit if not in letter, but these reports seem to lack substance, inasmuch as it is apparently impossible to obtain chapter and verse for such incidents. Only a modest tonnage of Government scrap is now coming out, and here, again, it seems to be difficult to find anyone who has been fortunate enough to secure a parcel. It has been suggested that the authorities are working on some kind of a rota system, which ensures that everyone gets something in turn, but, if this is so, it would seem that the allocations are well spaced out, for there is not much heard nowadays of Ministry material. This should not really occasion surprise, for it is well known that the wartime surplus of Government stock is pretty well exhausted.

Tin has been an erratic market, with some reaction following the rally which followed the big drop caused by the severe cutback in the U.S. price. Some pessimism seems to have been engendered by a report that the U.S. Government had sent word to the Belgian Congo producers recalling a clause in the American purchase contract which provided for suspension of purchases if the price exceeded 103 cents. Confirmation of this is lacking, but the idea that the price would in fact decline to $1.03 per lb. has been fairly prevalent. At the end of last week the New York figure was 106 cents. In view of the fall of some 23 cents that has now occurred in the New York price, and the heavy decline in the quotation on the London Metal Exchange and in the Far East, it would seem that the time is fast approaching, if it has not already arrived, when the United States will once again appear as a buyer on the world market.

Official tin quotations on the London Metal Exchange were as follow:—

Cash—Thursday, £960 to £970; Friday, £930 to £932 10s.; Monday, £910 to £915; Tuesday, £910 to £915; Wednesday, £950 to £960.

Three Months—Thursday, £932 to £932 10s.; Friday, £895 to £900; Monday, 872 10s. to £875; Tuesday, £875 to £880; Wednesday, £900 to £905.

Claim for Damages Dismissed

At the Derbyshire Assizes last week William Albert Craig (44), of Derby, brought a claim for damages for the loss of his right leg, following an accident at the Qualcast, Limited, foundry, Derby, by whom he was employed at the time as a moulder.

When casting moulds with a man named Griffiths in the late afternoon of April 8, 1949, Craig claimed that, as he was carrying a ladle of molten metal, Griffiths, who was subject to serious stuttering, collided with him. Griffiths, as many people who stutter frequently do, had closed his eyes in a paroxysm of stuttering, while trying to say something. Although it was only a touch, it was sufficient to cause the molten metal to spill over Craig's right ankle and into his boot. The burning was so serious that the leg was amputated, first just above the ankle, and later just below the knee.

Mr. A. J. Flint, who appeared for Craig, said, although his employers had given him another job, that because he was not able to continue as a moulder, Craig had lost earning power and now wore an artificial leg.

The company denied that Griffiths had caused the accident, said Mr. I. Sutherland for the firm. It was alleged that Craig had been negligent himself, in that he had bumped into one of the machines.

In the witness box, Griffiths denied that he had bumped into Craig. The first he knew of the accident was when he heard Craig call out that he had "stopped one." At that time he (Griffiths) was standing close to the bogey having his own ladle filled with molten metal. The works manager, Mr. H. Clarke, said he had visited Craig in hospital on several occasions, but Craig had not mentioned then that he had collided with Griffiths. Two more witnesses who were stated to be in the same shop at the time gave evidence that Griffiths did not cause the accident.

Mr. Justice Pilcher said that, although he felt the greatest sympathy for Craig in his unfortunate accident, he was bound to find the case had not been proved, and would therefore be dismissed.

Luncheon

MOND NICKEL COMPANY, LIMITED

Mr. L. K. Brindley, chairman of the company, who presided over a luncheon held at Grosvenor House, London, W.1, yesterday (Wednesday), had as his guests editors of the technical Press.

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

(Delivered, unless otherwise stated)

June 27, 1951

PIG-IRON

Foundry Iron.—No. 3 IRON, CLASS 2:—Middlesbrough, £10 17s. 9d.; Birmingham, £10 13s.

Low-phosphorus Iron.—Over 0.10 to 0.75 per cent. P, £12 9s., delivered Birmingham. Staffordshire blast-furnace low-phosphorus foundry iron (0.10 to 0.50 per cent. P, up to 3 per cent. Si)—North Zone, £12 16s. 6d.; South Zone, £12 19s.

Scotch Iron.—No. 3 foundry, £12 7s. 9d., d/d Grangemouth.

Cylinder and Refined Irons.—North Zone, £13 7s. 6d.; South Zone, £13 10s.

Refined Malleable.—P, 0.10 per cent. max.—North Zone, £13 17s. 6d.; South Zone, £14.

Cold Blast.—South Staffs, £16 10s. 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 7s. 6d.; Scotland, £12 14s.; Sheffield, £13 2s. 6d.; Birmingham, £13 9s.; Wales (Welsh iron), £12 7s. 6d.

Spiegeleisen.—20 per cent. Mn, £18 3s.

Basic Pig-iron.—£10 19s. all districts.

FERRO-ALLOYS

(Per ton unless otherwise stated, delivered.)

Ferro-silicon (6-ton lots).—40/55 per cent., £37 15s., basis 45% Si, scale 14s. per unit; 70/84 per cent., £52, basis 75% Si, scale 14s. 6d. per unit.

Silicon Briquettes (5-ton lots and over).—2lb. Si, £44 2s.; 1lb. Si, £45 2s.

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., 35s. 6d. per lb. of W.

Tungsten Metal Powder.—98/99 per cent., 37s. 6d. per lb. of W.

Ferro-chrome (6-ton lots).—4/6 per cent C, £66, basis 60% Cr, scale 22s. per unit; 6/8 per cent. C, £61, basis 60% Cr, scale 21s. per unit; max. 2 per cent. C, 1s. 6¾d. per lb. Cr; max. 1 per cent. C, 1s. 7¼d. per lb. Cr; max. 0.15 per cent. C 1s. 8d. per lb. Cr.; max. 0.10 per cent. C, 1s. 8¼d. per lb. Cr.

Chromium Briquettes (5-ton lots and over).—1lb. Cr, £69 4s.

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., £37 19s. 10d.

Manganese Briquettes (5-ton lots and over).—2lb. Mn, £46 18s.

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

SEMI-FINISHED STEEL

Re-rolling Billets, Blooms, and Slabs.—BASIC: Soft, u.t., £17 4s.; tested, up to 0.25 per cent. C (100-ton lots), £17 9s.; hard (0.42 to 0.60 per cent. C), £19 4s.; silico-manganese, £24 6s. 6d.; free-cutting, £20 9s. SIEMENS MARTIN ACID: Up to 0.25 per cent. C, £22 11s. 6d.; case-hardening, £23 9s.; silico-manganese, £26 14s.

Billets, Blooms, and Slabs for Forging and Stamping.—Basic, soft, up to 0.25 per cent. C, £20 4s.; basic, hard, over 0.41 up to 0.60 per cent. C, £21 9s.; acid, up to 0.25 per cent. C, £23 9s.

Sheet and Tinplate Bars.—£17 6s. 6d.

FINISHED STEEL

Heavy Plates and Sections.—Ship plates (N.-E. Coast), £21 3s.; boiler plates (N.-E. Coast), £22 10s. 6d.; chequer plates (N.-E. Coast), £23 8s.; heavy joists, sections, and bars (angle basis), N.-E. Coast, £20 1s. 6d.

Small Bars, Sheets, etc.—Rounds and squares, under 3 in., untested, £22 15s.; flats, 5 in. wide and under, £22 15s.; hoop and strip, £23 10s.; black sheets, 17/20 g., £29 13s.; galvanised corrugated sheets, 17/20 g., £43 6s.

Alloy Steel Bars.—1-in. dia. and up: Nickel, £37 19s. 3d.; nickel-chrome, £56 6s.; nickel-chrome-molybdenum, £63 1s.

Tinplates.—48s. 3½d. 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, £950 to £960; three months, £900 to £905; settlement, £955.

Zinc.—G.O.B. (foreign) (duty paid), £160; ditto (domestic), £160; "Prime Western," £160; electrolytic, £164; not less than 99.99 per cent., £166.

Lead.—Good soft pig-lead (foreign) (duty paid), £160; ditto (Empire and domestic), £160; "English," £161 10s.

Zinc Sheets, etc.—Sheets, 15g. and thicker, all English destinations, £180; rolled zinc (boiler plates), all English destinations, £178; zinc oxide (Red Seal), d/d buyers' premises, £178.

Other Metals.—Aluminium, ingots, £124; antimony, English, 99 per cent., £390; quicksilver, ex warehouse, £73 10s. to £74; nickel, £454.

Brass.—Solid-drawn tubes, 24¼d. per lb.; rods, drawn, 27d.; sheets to 10 w.g., 28⅞d.; wire, 30½d.; rolled metal, 27⅝d.

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

Gunmetal.—Ingots to BS. 1400—LG2—1 (85/5/5/5), £285; BS. 1400—LG3—1 (86/7/5/2), £302; BS. 1400—G1—1 (88/10/2), £369; Admiralty GM (88/10/2), virgin quality, — , per ton, delivered.

Phosphor-bronze Ingots.—P.B1, £379; L.P.B1, £322 per ton.

Phosphor Bronze.—Strip, 39d. per lb.; sheets to 10 w.g., 41⅛d.; wire, 43¼d.; rods, 39d.; tubes, 44d.; chill cast bars: solids —, cored, —. (C. CLIFFORD & SON, LIMITED.)

Nickel Silver, etc.—Ingots for raising, 2s. 6½d. per lb. (7%) to 3s. 6¾d. (30%); rolled metal, 3 in. to 9 in. wide × .056, 3s. 0½d. (7%) to 4s. 0¾d. (30%); to 12 in. wide × .056, 3s. 0¾d. to 4s. 1d.; to 25 in. wide × .056, 3s. 2¾d. to 4s. 3d. Spoon and fork metal, unsheared, 2s. 9½d. to 3s. 9¾d. Wire, 10g., in coils, 3s. 6¼d. (10%) to 4s. 6½d. (30%). Special quality turning rod, 10%, 3s. 5¼d.; 15%, 3s. 10¼d.; 18%, 4s. 2¾d. All prices are net.

Obituary

MR. E. A. GUTHRIE, manager of the American division of the Metropolitan-Vickers Electrical Export Company, Limited, since January 1, 1948, died on June 12. He joined the British Westinghouse Company as a school apprentice in 1910. After periods with Switchgear & Cowans, Limited, and Ferguson Pailin, Limited, he returned to Metropolitan-Vickers in 1920. In 1935 Mr. Guthrie joined the M-V Export Company as a sales engineer at the London office, and at the beginning of 1947 he transferred to the South American division, later being appointed manager of the division.

MR. F. S. HOLDER, a member of the London office staff of the Metropolitan-Vickers Electrical Export Company, Limited, from 1923 to 1949, when he retired, died on June 6. Born in 1882, Mr. Holder was the eldest son of Sir Frederick Holder, the first speaker of the Australian Federal Parliament. He joined the old British Westinghouse Company in 1906 and in 1907 sailed for South America as one of the company's first overseas representatives. He remained in the Argentine until the outbreak of the 1914-18 war. In 1919 he joined the newly-formed Metropolitan-Vickers Electrical Export Company.

Contracts Open

The dates given are the latest on which tenders will be accepted. The addresses are those from which forms of tender may be obtained. Details of tenders with the reference E.P.D. or C.R.E. can be obtained from the Commercial Relations and Exports Department, Board of Trade, Thames House North, Millbank, London, S.W.1.

JOHANNESBURG, July 12—Flat-bottom rails and fishplates, the Rural District Council. Mr. O. M. Farrell, engineer and surveyor, 34, Green Bat, Alnwick.

ALNWICK, July 16—Supplying and laying 1,140 yds. of 2 in. and 3 in. or 5 in. and 3 in. dia. cast-iron mains, for for the South African Railways. Room 1086 (CRE (IB) 63628/51).

Recent Wills

BUNE, C. H. P., a retired metallurgist, of Knutsford (Ches) £12,482

KEATLEY, JOHN, a director of John Keatley (Birmingham), Limited, metal merchants £21,194

POULTON, FRANCIS, late senior partner of Poulton & Son, boiler setting engineers, of Reading £45,988

SCULLARD, HARRY, a principal of H. Scullard & Son, consulting marine engineers, of Newcastle-upon-Tyne £4,125

SAUTTER, J. J., late managing director of Philip & Son, Limited, engineers and shipbuilders, of Dartmouth £28,274

FROST, J. C., for 52 years employed in the heat-treatment department of Thos. Firth & John Brown, Limited £9,414

COWAP, J. E., joint managing director of Fodens, Limited, motor vehicle manufacturers, of Sandbach (Cheshire) £13,806

MEREDITH, H. D., a director of Rownson, Drew & Clydesdale, Limited, manufacturers of elevators and conveyors, and hardware and machinery exporters, of London £12,598

GLENN, GEORGE, chief metallurgist and chemist of Tinsley Wire Industries, Limited, Sheffield, and a founder member and president of the Sheffield Metallurgical Association £786

SMITHIES, R. H., governing director of John James Smithies, Limited, iron and steel stockholders, etc., of Rochdale, and of John Petrie (The Baum), Limited, iron and metal merchants, of Rochdale £54,208

FAIRHOLME, F. C., a former managing director of Cammell Laird & Company, Limited, and of Thomas Firth & Sons, Limited, from 1908 to 1929, and who, as chairman of the Firth-Brearley Stainless Syndicate, Limited, was closely connected with the development of stainless steel in this country £36,020

MALEK, E. M., who had had considerable experience with railway electrification schemes, and at one time was assistant chief engineer of the Central London Railway Company, and who had also served with the British Thomson-Houston Company, Limited, the English Electric Company, Limited, and British Insulated Callender's Cables, Limited £29,623

CLASSIFIED ADVERTISEMENTS

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

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

SITUATIONS WANTED

FOUNDRY MANAGER, desiring change, seeks post in Birmingham, Wolverhampton area. Experienced in all respects of foundry work. Sound practical and technical qualifications. M.I.B.F. and A.M.I.P.E.—Box 1066, FOUNDRY TRADE JOURNAL.

FOREMAN PATTERNMAKER (47), married, now employed with large non-ferrous London founders, sand and die, seeks position of trust where ability and general foundry knowledge, including die design and technical sales experience, are an asset.—Box 1003, FOUNDRY TRADE JOURNAL.

SITUATIONS VACANT

IRON MOULDER required for Jobbing Foundry in South-East London. This is an opening for an experienced man who requires a permanent job and a good wage. Accommodation can be arranged for a single man.—Box 1071, FOUNDRY TRADE JOURNAL.

WELL-KNOWN Firm of Core Binder Manufacturers require man with energy and initiative as REPRESENTATIVE for Lancs. and Yorks. area. Foundry experience essential. Car an advantage. Good salary and expenses paid.—Write, stating age, experience, etc., to Box 1070, FOUNDRY TRADE JOURNAL.

TWO able and keen FOUNDRY TECHNICIANS required for servicing well-known bonding material. Practical experience essential. One about 28-32 years of age, the other 24-25. Salaries not less than £550 and £450 per annum respectively. Able to drive car. Will work half time in laboratory and half time on servicing.—Good prospects for right men. —Box 1031, FOUNDRY TRADE JOURNAL.

LARGE Founders in S.E. London have the following posts vacant:—
(a) METALLURGIST for work in connection with the production of cast iron and copper base materials.
(b) METALLURGIST for work on light alloys. Applicant with knowledge of aluminium and magnesium base alloys used for castings will be preferred.
(c) METALLURGIST for investigations on non-ferrous alloys in Research Laboratory. Applicant should have a good degree in metallurgy or equivalent qualification, or alternatively a degree in physics or chemistry with metallurgical experience.
(d) RADIOLOGISTS for X-ray inspection of castings. Applicant, with experience in the interpretation of radiographs of light alloy castings will be preferred.
Salaries according to qualifications and experience.—Write PERSONNEL MANAGER, Messrs. J. Stone & Co. (Charlton). Ltd., Woolwich Road, Charlton, London, S.E.7.

SITUATIONS VACANT—Contd.

VITREOUS ENAMELLING.—Experienced Man required to take charge of Mill-room. Knowledge of sheet and cast iron enamels, also colour matching.—Box 1065, FOUNDRY TRADE JOURNAL.

ASSISTANT FOREMAN wanted for small Iron Foundry, East Anglia. State salary wanted and give full details of training and experience.—Box 1030, FOUNDRY TRADE JOURNAL.

FOUNDRY MANAGER.—Wanted Manager to take full charge of medium sized Iron Foundry in Sunderland area. Must be thoroughly conversant with modern iron foundry practice and have had some commercial experience.—Write, giving full particulars of training, stating age, salary required, etc., to Box 1046, FOUNDRY TRADE JOURNAL.

ASSISTANT (18/20) required for investigation work on Foundry Bonding Agents at Laboratory in Liverpool. Experience in Foundry Sand Testing an advantage. Facilities granted for part-time education. Pension Fund. Good prospects.—Write full details age, experience, and salary required, to STAFF MANAGER (Ref. A/L), F. W. Berk & Co., Ltd., 1-19, New Oxford Street, London, W.C.1.

QUALIFIED METALLURGIST required for the control of whiteheart malleable iron production. A person who has experience of gas annealing preferred. —Write, giving details of age, training, experience, etc., to Box 1049, FOUNDRY TRADE JOURNAL.

FOUNDRY FOREMAN required for Malleable Iron Foundry. To control foundry and ancillary departments. Must have sound experience of jobbing and repetition moulding, coremaking, core-blowing, sand and production control, and payment by results methods. Good disciplinarian. Excellent future prospects.—Write, with full details of training, experience, and present salary, to Box 1041, FOUNDRY TRADE JOURNAL.

FOUNDRY SUPERINTENDENT (aged 35/45) required for Grey Iron Foundry handling also high tensile iron, in West Riding of Yorkshire, producing 50 to 60 tons of high quality precision machine castings per month. Applicants must have proved themselves in a similar capacity and should be capable of taking full responsibility to the Works Manager for both the pattern making department and complete foundry covering core-making, machine and floor moulding, fettling, cupolas and metal and sand control. Also to have knowledge to facilitate instituting and operating foundry loading system. Starting salary commensurate with responsibility.—Replies, which will be treated as strictly confidential, should state age, full details of practical and technical training, positions held and present salary, Box 1050, FOUNDRY TRADE JOURNAL.

SITUATIONS VACANT—Contd.

ASSISTANT METALLURGICAL ANALYST required for modern iron-foundry laboratory. Experience in the analysis of plain and alloy irons essential. Position offers scope for advancement.—Replies in confidence to C. AKRILL, LTD., Golds Green Foundry, West Bromwich.

FOUNDRY SHIFT FOREMAN required by Non-ferrous Refiners, Billet and Ingot Manufacturers in Birmingham area. Commencing salary £550. Applicants should be capable of supervising all labour and controlling Electric, Coal and Oil Fired Furnaces. Full particulars in confidence.—Box 1068, FOUNDRY TRADE JOURNAL.

THE ANDERSTON FOUNDRY CO., LTD., Railway Permanent Way Engineers and Ironfounders, require the services of an ASSISTANT WORKS MANAGER. Applicants should have sound training in mechanical engineering, with practical foundry experience. Administrative experience an advantage. Good prospects for the right man.—Apply, stating age, experience, and salary required, to the SECRETARY, at Port Clarence, Middlesbrough.

SKILLED MOULDERS, PLATERS, TURNERS, BORERS, etc., required by Distington Engineering Co., Ltd., Workington, Cumberland.—For further details apply to the LABOUR MANAGER.

FOUNDRY FOREMAN required, to take charge Iron Foundry in North-West on jobbing work up to 8 cwts., but changing part to repetition light castings. Must be capable of training labour, etc. Excellent prospects to right man.—Box 1074, FOUNDRY TRADE JOURNAL.

FOUNDRY MANAGER, accustomed to mechanised mass production, for Iron Foundry in Midlands.
The equipment is modern, serviced by well equipped sand, chemical and physical test laboratories, adequately maintained by well trained engineering staff.
A Leader is required, having sound practical foundry knowledge and a capacity to make the best use of all facilities available. Keen but practical interest in costs, output, quality and maintenance of good relationship required. Salary in keeping with responsibility involved.
Applicants are invited to send details in confidence, training experience, present production, and salary level, to Box 1072, FOUNDRY TRADE JOURNAL.

PATENT

THE Proprietor of British Patent No. 601968, entitled "Improvements in the extraction of alumina from its ores," offers same for license or otherwise to ensure practical working in Great Britain.—Inquiries to SINGER, STERN & CARLBERG, 14, East Jackson Boulevard, Chicago, 4, Illinois, U.S.A.

PARTNERSHIP

PATTERNMAKER, with small staff, est. 2 years, needs a PARTNER, with capital. Working preferred. E. London area.—Box 1064, FOUNDRY TRADE JOURNAL.

FINANCIAL

OLD-ESTABLISHED Midland Firm, with extensive connections, interested in purchasing part Share Capital, with seat on Board, of Grey Iron Foundry. Can place long term contracts of upwards of 30 tons weekly, repetition and jobbing casting work. Small foundry desirous of expanding not objected to.—Box 1069, FOUNDRY TRADE JOURNAL.

WANTED an interest in a small Iron Foundry in the London area, who either specialises or can be adapted to small soft grey iron castings.—Apply Box 1073, FOUNDRY TRADE JOURNAL.

AGENCY WANTED

LONDON AREA.—Engineers' Agents, with good offices in Westminster, require AGENCY for Malleable or Steel Castings. If principals have established connections amongst users in the area, remuneration required would be correspondingly moderate.—Box 1061, FOUNDRY TRADE JOURNAL.

MATERIALS FOR SALE

LARGE and Small Rollers. Solid and Laminated Woods. Also turnery in all hardwoods, including Lignum.—MUSTILL, Clifton Road East, Liverpool, 6.

ROLLER Conveyor Track, 12 in. wide, 1¼ in. dia., roller 4 in. centres. 12s. 6d. per ft.

FRANK SALT & CO., LTD.,
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BOGIE LADLE, secondhand, in good condition, required. 6-8 cwts. capacity. Vaughans, Ltd., or similar make. Box 1062.

REQUIRED, urgently, 30-cwt. Geared Crane Ladle. New or secondhand.—NEWCAST FOUNDRIES, LTD., Silverdale, Staffs.

OFFER YOUR SURPLUS PLANT TO

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WANTED. — Aluminium Bale - Out Furnace, 100-lb. capacity, gas fired. —H. B. BARNARD & SONS, LTD., Dudley Port, Tipton, Staffs.

REQUIRED, urgently, one "Mulbaro," suitable for 400 volts, 3-phase supply, and two barrows.—NEWCAST FOUNDRIES, LTD., Silverdale, Staffs.

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FOR SALE.—1-5 Ton Gas Fired Blower, fitted Zinc Tilting Furnace. 3-ton capacity, with pyrometer equipment and two spare parts. Manufactured by British Furnaces, Chesterfield. In good condition. Price on application.—Box 1067, FOUNDRY TRADE JOURNAL.

TILGHMAN Shot Blast Plant. Chambers 15 ft. by 8 ft. by 8 ft. 3 in., with filters, regulators, couplers and exhaust fan. Complete with air compressor giving 100 lbs. per sq. in., 16 h.p. motor starter for 400/3/50 supply.—F. J. EDWARDS, LTD., Lansdowne House, 41, Water Street, Birmingham, 3. CENtral 7606.

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75,000-c.f.m. encased type Fan, by BRITISH AIR CONDITIONERS. 2½ in. w.g., 320 r.p.m., inlet 66 in. dia., horiz. bottom discharge 43 in. by 47 in., shrouded multivane impeller.

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15,000-c.f.m. sheet metal encased Fan, by CHAPMAN ENGINEERING CO. 1½ in. w.g., 585 r.p.m., 30 in. dia. inlet, vert. upwards discharge 22 in. by 28 in., multivane impeller, arranged to drive from 5-h.p. T.E. motor 400/3/50.

SEVEN 13,900-c.f.m. sheet metal encased Fans, by R. K. WEBSTER. 3 in. w.g., 802 r.p.m., 27 in. dia. inlet, top horiz. discharge 27 in. by 18 in., multivane impeller, arranged belt drive, will give 6,000-c.f.m. 1 in. w.g., 434 r.p.m.

Eleven 10,000-c.f.m. sheet metal encased type Fans, by MATTHEWS & YATES. 3 in. w.g., 980 r.p.m., inlet 22 in. dia., horiz. bottom discharge 23 in. by 16½ in., paddle blade impeller, arranged for belt drive, will also give 5,000-c.f.m. 1 in. w.g., 500 r.p.m.

Seven 10,000-c.f.m. casing type Fans, by KEITH BLACKMAN. 1½ in. w.g., two bottom inlets 15 in. by 29¾ in., bottom discharge 24 in. by 26½ in. 4-h.p. at 645 r.p.m. required.

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FOR SALE.—One Coleman No. 24A Davenport Type Machine Jarr, Roll-over. Pattern draw 12 in.; 1,100 lbs. working capacity. Suitable for boxes up to 40 in. by 24 in. Price £350.—Box 288, FOUNDRY TRADE JOURNAL.

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ALL THE ABOVE WOUND FOR 400 volts, 3-phase, 50 cycles.
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MOULDING BOXES fabricated from Aluminium Alloy or Steel; for all types of welded fabrication we can give a first-class job and good delivery.—THE GLENMOOR ENG. Co., LTD., Eyre's Avenue, Stanningley Road, Leeds, 12.

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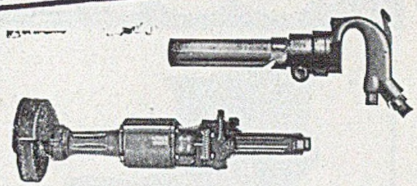

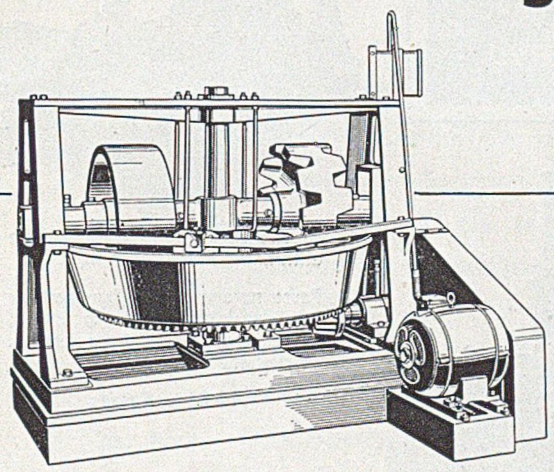

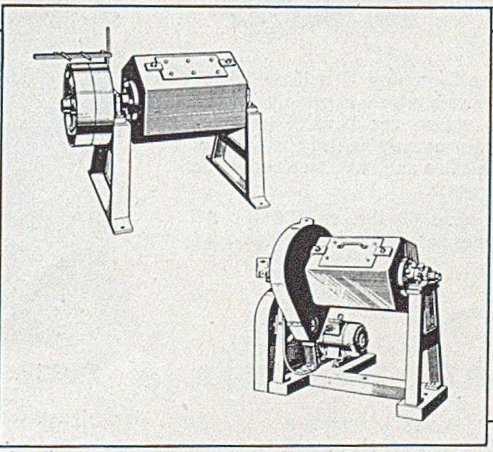

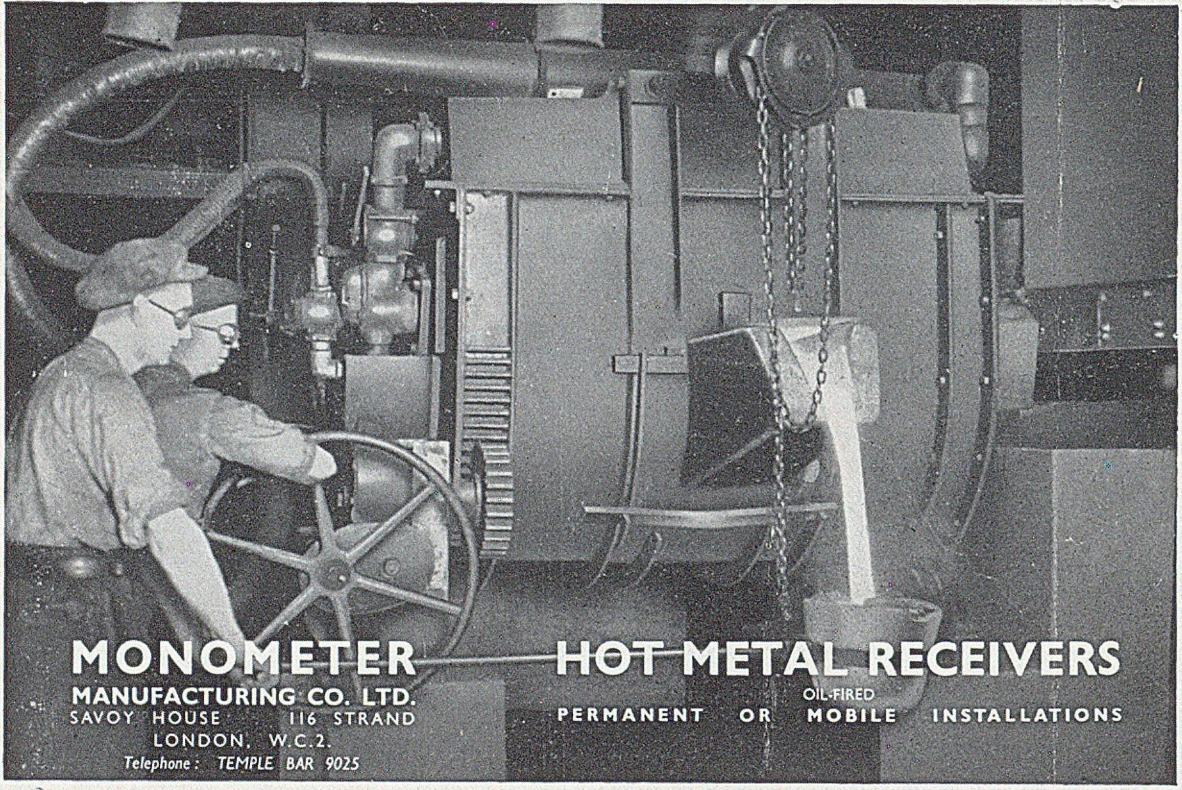

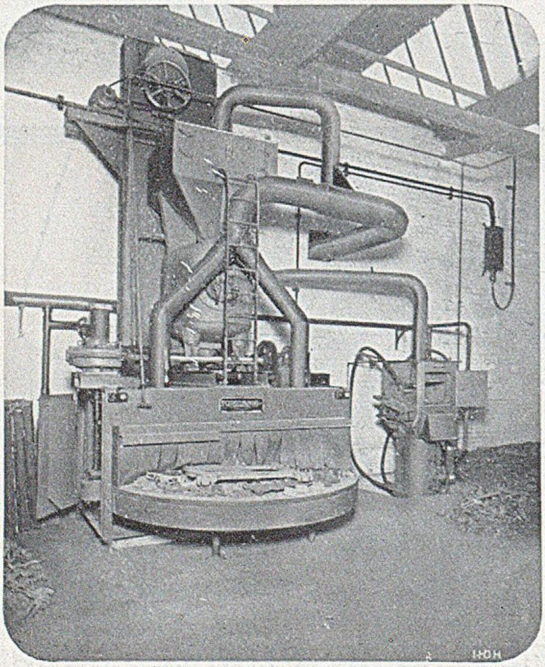

Published by the Proprietors, Industrial Newspapers, Limited, 49, Wellington Street, Strand, London, W.C.2, and Printed in Great Britain by Harrison & Sons, Ltd., Printers to His Majesty The King, London, Hayes (Middx) and High Wycombe.

FOUN
TRADE JOURNAL
EST. 1902.
VOL. 90
No. 1817
Registered at the G.P.O. as a Newspaper
WITH WHICH IS INCORPORATED THE IRON AND STEEL TRADES JOURNAL
JUNE 28, 1951
Offices: 49, Wellington Street, Strand, London, W.C.2
Single Copy, 9d. By Po
11d. Annual Subscrip
tion, Home 40/-, Abroa
45/- (Prepaid)