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OF CANADA

OFFICIAL PROCEEDINGS

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PROCEEDINGS OF THE CENTRAL RAILWAY AND ENGINEERING CLUB OF CANADA MEETING.

PRINCE GEORGE HOTEL, TORONTO, March 21, 1911.

The President, Mr. G. Baldwin, occupied the chair.

Chairman,—

The first order of business is the reading of the minutes of the previous meeting, and as you have all had a copy of the Proceedings it will be in order for some one to move their adoption as read.

Moved by Mr. Herriott, seconded by Mr. Jefferis that the minutes of the previous meeting be adopted as read. Carried.

Chairman,—

The second order of business is the remarks of the President.

There are one or two things that I have to say to you to-night, and which is more with the object of it appearing in the minutes, than with the idea of it referring to the members present.

I have a note here from the Secretary in reference to members paying their dues. This does not refer to the present company as I feel satisfied that all who are present have paid their dues, but we have been carrying a number for two and three years, in fact we have quite a number of members who have not paid for 1908, during this time they have been receiving the regular monthly Journal and have been notified of all meetings. This is quite an expense from which we get no benefit, and I purpose taking the matter up at the next Executive Meeting.

Another matter is the attendance. While it might appear that we have a good attendance at most of our meetings we do not have the attendance we have on our Social Nights. As I said before, I am not blaming anyone here, it is more to appear in the minutes so that the delinquent members will come to the meetings a little more regularly.

The next paper will be on "Improvements of Modern Locomotives," by Mr. G. Black. Mr. Black is one of our old executive members, and an old railroad engineer, who is at present a Road Foreman on the Grand Trunk. I have no doubt we will have a big crowd of railroad men here next meeting.

There is another matter which I have to bring before you in reference to Mr. Hacket's paper given on "Railroad Signalling," some time ago. We have been in communication with Mr. Hacket, and his reply is a little too lengthy for me to take up to-night, but it will appear in this month's Journal.

MONTREAL, March 16, 1911.

MR. C. L. WORTH, SEC.-TREAS.

THE CENTRAL RAILWAY AND ENGINEERING CLUB OF CANADA,

Room 409 Union Station, Toronto, Ont.

DEAR SIR,—

Replying to yours of Feb. 16th, which I find on my return from abroad, and relating to a statement in the "*Canadian Engineer*" to the effect that the Whyte crossing signal obtained the energy for operating the bell and light, which they use, from different sources, would say that this must be an entirely new departure in this signal, as at the time my article was written one battery or source of energy was used, and the failure of this would give both a negative audible and visual indication.

I should be greatly interested to hear what new development the Whyte Railway Signal Co. have made, as apart from the objectional feature I mentioned and which is common to almost all crossing bells, their signal possessed considerable merit.

There seems also to be a misunderstanding as to what I intended to convey in my paper which was not so much that the failure of the bell would mean the failure of the light or *vice versa*, but that the failure of the energy would effect both as they relied on the effectiveness of this to give their danger signal and which is entirely against the fundamental principles of railway signalling.

Yours very truly,

(Sgd.) C. L. HACKET.

The Secretary is all right for papers up to the end of September. If there are any of the members who would care to get up a paper for October, November or December, I shall be very pleased if they will drop a card to the Secretary, advising him to that effect.

I also wish to state that some members of the Executive and Reception Committees are not attending to their business as they should. We do not have as many present at the meetings as we should, and you will readily understand that it is impossible to run an institution of this kind unless the gentlemen who have been elected on these committees attend to their duties. There are several of them who have never been to a meeting, which I do not think is fair.

I feel safe in saying that had it not been for the Executive Committee in the past, neither Mr. Jefferis or Mr. McRae would have met with the success they did during their year of office, and I sincerely hope the Executive and Reception Committees, when called upon to attend meetings will endeavor to do so in future,

The next order of business is the announcement of new members.

NEW MEMBERS.

J. Shields, Machinist, Christie Brown Co., Toronto.
G. Ward, Merchant Tailor, Toronto.
W. Demett, Engineer, Toronto.
J. Milne, Machinist, Consumers' Gas Co., Toronto.
F. W. Prentice, Wireless Engineer, Canadian Train Control, Limited, Toronto.
F. Burnett, Gas Engineer, Economical Gas Apparatus Co., Toronto.
F. H. Squibb, Draughtsman, Toronto.
J. Fleck, Insurance Engineer, Toronto.
W. S. Davis, Foreman, G.T.R. Shops, Stratford.
W. C. McGhie, Chairman, Ontario Engineers License Board, Toronto.
J. Kelley, Chief Engineer, Mercer Reformatory, Toronto.
M. LeC. Atkinson, Marshall Coal Co., Toronto.
H. Pedelty, Foreman Loom Moulder, Canada Foundry Co., Toronto.
John Wright, Machinist, Gurney Foundry Co., Toronto.
A. J. Ross, Manager, Dominion Foundry Supply Co., Limited, Toronto.

MEMBERS PRESENT.

C. Schadel
V. Baker
E. Blackstone
R. M. Carmichael
B. Clarke
F. D. Dewar
H. G. Fletcher
J. G. Holfelder
J. Jackson
J. Adam
G. S. Browne
J. Barker
D. Cairns
D. Campbell
J. Douglas
C. G. Herring
H. O. R. Horwood
T. H. Jefferis
J. Bannon
P. Bain
J. F. Campbell
T. B. Cole
E. E. Cummings
J. T. Fellows
J. Herriot
P. Jerreat
J. Kelly

T. McKenzie
R. E. Layfield
J. W. McLintock
J. Nicholson
W. Smith
H. E. Rowell
E. G. Southam
W. A. Grocock
A. Taylor
J. Wright
G. Black
F. R. Wickson
S. Best
J. Kennedy
J. H. Morrison
N. D. McIntyre
W. Newman
P. Robinson
F. J. Ross
G. Service
A. E. Till
A. Woodly
G. Baldwin
R. H. Fish
H. Eddrup
L. S. Hyde
E. Logan
W. Malott
W. McGrath
J. McKee
H. Pedelty
A. Stewart
F. H. Squibb
E. T. Spidy
L. M. Watts
A. M. Wickens
W. C. Sealey
F. Scott
C. L. Worth

Chairman,—

This is a fairly good list, but we have got lots of room for more members. I may state that these gentlemen have been approved of by the Executive and are elected as members of the Club.

The next order of business is—"Reading of Papers or Reports and Discussion Thereof."

The paper to-night by Mr. Grocock treats on the device for using steam in a cupola known as the "Doherty" process of iron founding.

I notice we have quite a number of "Foundry" men here, and I feel sure that this paper will be listened to with the greatest of interest by them. I have much pleasure in introducing Mr. Grocock.

THE DOHERTY PROCESS OF IRON FOUNDING.

By W. A. GROCOCK, Engineers' Representative, Toronto.

As probably the only Englishman who has successfully applied the Doherty system of Iron Founding both in England and the Far East of Burmah, I hope I may be able to place before you some interesting points to justify the selection of subject I have chosen, even at the risk of exemplifying the old saying of carrying coals back to Newcastle; for I understand Mr. Thos. Doherty is one of Canada's illustrious countrymen, hailing from Sarnia, Ont., and my loss is, that I have never had the pleasure of meeting him and comparing notes, or learning further from him of this interesting process.

It is said "fair play is a jewel," and I think you will all agree with me, that in discussing Mr. Doherty's invention or system, it will be fair on our part to let the gentleman have the first say, and I, therefore, propose to read you some excerpts from a paper read by him before the American Association of Iron Founders at Philadelphia, and following with some observations from my own experience. He said in part:

Much has been said and written the past year or two about science in the foundry. Some writers claiming one theory and some another, as to the actions and reactions taking place in an ordinary foundry cupola while melting is in progress. Chemical action, unlike many other actions, cannot be described as it is only known by its effects, and the nearest approach that man can come to a description of chemical action is by regarding it as a molecular attraction or motion of the masses in action. The Dalton law of fixed and definite proportions which so beautifully serves to relate chemistry to Voltaic electricity, though adopted in its entirety by a large number of chemists, presents great difficulties when applied to all chemical combinations, and among the number, iron. Twenty-seven grains of iron will combine with eight grains of oxygen or with twenty-four, or with three proportionals of oxygen, yet no compound is known which twenty-seven grains of iron will combine with two proportionals or sixteen grains of oxygen; although such a compound may yet be discovered, and therefore, we should not on this account condemn the atomic theory. But now comes the difficulty, twenty-seven parts by weight of iron will combine with twelve of oxygen, and twenty-seven parts of iron will also combine with ten and two-thirds of oxygen, or if we retain the unit of oxygen we must subdivide the unit of iron, or we must subdivide both by a different divisor—this being so, what becomes of the notion of an atom or molecule physically indivisible. It is true that in the case of solution different proportions can be united up to the point of saturation without any difference in the character of the compound. For example, one class of pig iron may contain a certain amount of silicon, carbon, phosphorus, manganese and sulphur; and another class contain exactly the same proportions of these substances, yet the two irons will not give the same resultant casting, although melted in the same cupola and under the same conditions. Then we must arrive at the conclusion that there must be a variation in the metallic iron, and in this respect to the chemist, metallic iron is metallic iron, and in our present state of knowledge and education chemistry cannot give the character of it, and the consequence is that we are never sure of the same results, even on the same analysis and there may be a variation of ten per cent. in strength in the castings made from the two irons. Then the question arises, what is the best plan to adopt under the circumstances to overcome the difficulty? Some months ago, while carrying out some experiments, I found that by combining a steam jet in the tuyere in certain proportions it produced a molecular change in the casting; that the casting was finer in the grain, softer and stronger than ordinary, that in melting old rusty scrap which under ordinary practice would result in great waste, in this case the loss was under two per cent. This should be conclusive evidence that Hydrogen gas is a powerful reducing agent, that its influence in reduction of the oxide of iron in an ordinary cupola plays a very important part, and aside from this most valuable feature it has other valuable functions, namely, softening and strengthening the casting. These are the plainest terms that can be used, and every foundryman will readily understand their meaning. It makes little difference to him whether the action is chemical or allotropical, *i. e.*, the capacity to undergo without change of chemical composition, a change of chemical and physical condition, or plainer still, a rearrangement of the molecules. To the man of science the chemical reactions produced by the H_2O. is most marvelous, which is best observed by the aid of a spectroscope, that most marvellous little instrument. When examining the gases as they pass up by the charge door of the cupola and by the simple turning of a small steam valve having a $\frac{1}{4}''$ opening, these gasses can be changed and the changes analysed just as readily as if we had them bottled up on the shelves of our laboratories. There can be seen the yellow sodium line, the blue hydrogen, the red carbon and other lines well known to all those who have studied the colors of these gasses through this wonderful little machine. This simultaneous production of several different forces changed by the simple operation of a small valve may seem at first sight to be irreconcilable with their mutual and necessary dependence, and it certainly presents a formidable experimental difficulty in the way of establishing their equivalent relations. But when examined closely it is not at all inconsistent with the claims I have made both in my patents all over the world and my claims to the public, but is indeed a strong argument in their favor.

Difficult as it may seem to the scientific mind to restrict the action of any one force to the production of any other force and of one only—yet if the whole of one force in chemical action be supposed to be employed in producing its full equivalent of another force, say heat, then as this heat is capable in its turn of producing chemical action and in the limit a quantity equal or at least only indefinitely short of the initial force, if this could at the same time produce independently, say magnetism, we could by adding it to the total heat get more than the original chemical action and thus produce perpetual motion. But this rule does not prove a correct deduction in this case any more than in the case of that of nitro glycerine, where the force produced is so much greater than that exhausted in its production. And thus in evaporating the small quantity of water into steam and the small percentage of heat required in the tuyeres of the cupola to decompose the steam into its elements, hydrogen and oxygen, we have obtained heat 4.28 times greater than that of carbon, and therefore the heat so utilized in production is far more than compensated by the hydrogen. I am quite willing to admit that a man cannot lift himself up by his boot straps and that motion cannot be conceived on general principles without parallax change of position, for we must admit that the evolution of one force or mode of force into another has induced many to regard all the different natural agencies as reducible to unity, and as resulting from one force which is the efficient cause of all others; and one theory tries to prove that electricity is the cause of every change in matter, while another theory says chemical action is the supreme cause, and still another that heat alone is the universal order, and so on. But these questions we will, for the present leave to the philosophical mind to discuss and theorize upon and return to the point and state only what we know to be true, believing it to be so, because we have proved it.

Reference has already been made to the many difficulties in accepting in its entirety the atomic law of fixed and definite proportions, and the application to iron, and while the law does not hold good in this respect it does in many respects. In the average cupola it takes from twenty-eight to thirty thousand square feet of air to melt a ton of iron, four-fifths of which is nitrogen and one-fifth oxygen, and both these elements when in the nascent state do obey the law of combination, for if we endeavor to burn 30 parts of carbon in 60 parts of oxygen the elements will assert themselves of their own accord and refuse to unite in these proportions, and the 30 of carbon will only take up with 40 of oxygen and form 70 of carbon monoxide, and this gas, had it the opportunity, would combine with 40 more of oxygen and form 70 of carbon dioxide, but finding only half that amount, 20 of oxygen contents itself by one-half, that is 35 of carbon monoxide. And again if 30 parts of carbon (coke) be burnt in more than, say 85 of oxygen, only 80 will be used, the other 5 remaining as oxygen merely mixed with the resulting dioxide. Or if an attempt to burn say 30 of carbon in less than 40 of oxygen, the oxygen will take up three-fourths its weight of carbon and form carbon monoxide and the excess of carbon will remain as carbon. Thus we see how important it is from a scientific standpoint to use the proper quantity of fuel and the right amount of air in the foundry when melting iron, if we wish to get the best results and the best castings. Then following on this line of reasoning by adding hydrogen, 2 parts will combine with every 1 part of oxygen, or it will go on and combine with the nitrogen and form $N.H.^3$. ammonia gas, this element then combining with sulphur becomes ammonia sulphydrate which, having a greater affinity for sulphur than what iron has, is carried off by the heat instead of being absorbed by the iron and retained in the casting. And much the same result is secured in the case of phosphorus, only not to the same extent, as has been proved by analyses both in England and America.

That this process will admit of a lower and cheaper grade of iron and coke being used has been demonstrated both in this country and Europe, beyond a question of doubt. It will also admit of a very inferior grade of badly oxidised scrap being used and at the same time produce a very fine resultant casting which excels in strength and texture that made from the very best brands of pig iron melted in the old way, and in this respect alone, can be of immense value to every foundryman in the world who adopts it.

I am quite aware that new facts and the mode of regarding them are most favorably received by the public when in strict accordance with old and recognized views. The new fact may be very far removed from those to which it is referred and belongs to an entirely different order of analogies, but this cannot then be known because its co-ordinates are wanting and it is quite possible for the public mind to be so moulded by past events that it is very difficult to convince the world of a new view, and very many new and valuable discoveries have been lost because the public mind has proved antagonistic to their reception. We can only receive the new discovery just in proportion as our minds are educated and our knowledge broadened in that particular sphere to which they belong. Thus the founder should, if he desires to become a master of his avocation, study the principles that promulgate thought and investigation in the science of metallurgy and chemistry of iron, because it cannot be discussed along any other line. The average founder up to the present time is not as well posted in the chemistry of iron as he might be. He knows when his castings are soft and workable or hard and unworkable, as the case may be, but he does not know the cause and effect of the different compounds that go to produce such undesirable conditions in the metal, and to him the mere mention of chemistry is a mystery, and the result is he has to rely upon the iron broker to furnish him with an iron which in his opinion is suitable for his product, and in many cases the selection at best is mere guess work. I am quite aware that there is a crude notion in many minds that it is the business of science to occupy itself merely with the study of matter, but science must not be confined to such narrow conceptions. Its office is to investigate all the universal order and explain all the developments in dynamical and intellectual progress of which the world at the present time is so full. It is true that many doubt the advisability of intellectual advancement and scientific progress and claim that the world is moving at too rapid a pace. Some men do not believe in any progress and even go so far as to doubt the existence of a Supreme Being, and it was, no doubt, this class that Goethe had in mind when he said, "If there be not a God now, there will be some day." For every principle of causality and code of scientific law which we take as axiomatic in life is valued, not because of our experience of disconnected sequences, but because we take for granted a uniformity in nature, which means that behind the day and the things that pass there is something determinate and final. The progress that we see in creation is that of the growth of a principle, not that of the working out of a plan, not that of an adaptation of parts, but of the development of a life, for creation is indeed not a machine made by God with a balancing of good and evil analagous to a system of cylinders and piston rods, but a manifestation of a living will become more and more perfect as it adapts itself, not to its own parts, but to its own purpose. I am quite ready to admit that my knowledge of the sciences is very remote; that after nearly a lifetime spent in the study of iron I know little or nothing and can only repeat the words of the great Newton, "I am only a little boy playing on the sea shore of knowledge, diverting myself by now and then finding a smoother pebble or prettier shell than ordinary, while the great ocean of truth lies spread out before me." And in the language of Graham Travers say "I want to learn all that it is possible for one human mind to know, because it is awful to contemplate being buried alive in the coffin of one's own ignorance and selfishness." Or, like Lytton, say "I hold that the greatest friend to man is labor; that knowledge without toil, if possible, were worthless; that toil in pursuit of knowledge is the best knowledge we can attain; that it is not wealth suddenly acquired that is deserving of homage, but the virtues a man exercises in the slow pursuit of wealth, the abilities so called forth, the self-denials so imposed—in a word, that labor and patience are the true school masters on earth."

THOS. DOHERTY,
Sarnia, Canada.

In corroborating Mr. Doherty's claims as fulfilled to a very large extent from my own practical experience, I might here state a strange coincidence, and that is, when Mr. Doherty was making his first test in England at the Hamilton Bridge Works, Garston, N. Liverpool, I was making similar tests at the Rangoon Foundry in Burmah from his drawings and details supplied at the time, and subsequently some years afterwards I happened to be selected out of 1,187 applicants to the management of the very works at Garston where he had been carrying out his tests. I regret to say I found his process, in the intervening years, had for some reason or other, been abandoned and I found also the foundry department of those works in a deplorable condition, which, although only an auxiliary department of fairly large works employing 600 men, had been a loss to the firm of £1,000 during the year previous to my taking over charge, and the directors pressed upon me the advisability of closing up this department and purchasing the castings required for the works from outside firms. It was with some misgivings on their part that I obtained their reluctant consent to try for one year more, and the result was that without spending a penny on new plant or tackle, on capital account, I converted the £1,000 loss into a £1,500 profit in the first twelve months and received the directors' thanks with permission to lay out in necessary plant and improvements all that I desired.

The relative figures were for the month before taking over charge, and the 12th month after taking over:

Before.	*After.*
Output (1 month) 72 tons	187 tons
Wasters, 18 %	0.9% (less than 1%)
Backscrap, 40%	8%
Cost per ton, £7–5–0 (labour and material)	£5–13–0

I have only heard of one other works in Great Britain adopting this process, that of the firm of R. Hornsby & Sons, Limited, Grantham, well known large agricultural and general engineers, who with true British reticence or conservatism, I have only heard that they were satisfied as to the economy of the process and the quality of the castings produced, giving no details or statistics.

DESCRIPTION OF THE PROCESS AND OBJECTS AIMED AT.

The process consists of injecting dry steam into the cupola along with the blast, with the several objects of:—

1. Increasing the value of the gases of combustion present in the zone of fusion by the high specific heat of the hydrogen

introduced in the decomposition of steam (the heat of combustion of hydrogen being 4.28 times that of carbon).

2. Carrying off a proportion of the sulphur primarily in combustion with the hydrogen, and so making practicable the use of materials having that element in excess.

3. Effecting a saving of the loss of iron—especially apparent where a high proportion of oxide of iron is present by

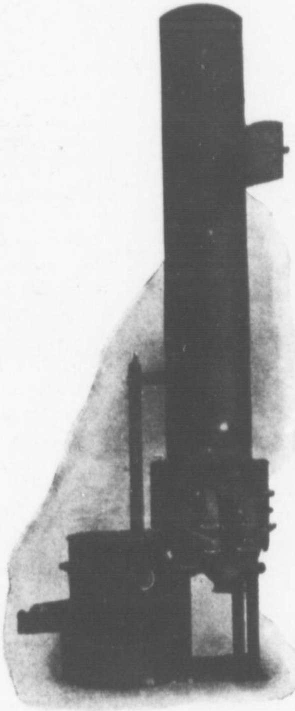

FIG. 1

the increased volume of actively reducing gases produced by the decomposition of steam.

4. Securing by more perfect combustion, high liquification and corresponding homogenity of iron melted.

Assuming these objects to be attained by the process, it is obvious that the advantages incidental to it are:—

(1) A saving of fuel.

(2) A possible economy in the value of the iron and fuel employed.

(3) A decrease in the loss of iron carried off in the slag.

(4) Cleaner castings and stronger metal.

APPARATUS. SEE FIG. 1. (This is the kind of cupola I used in all cases).

Underneath the air belt of the cupola a steam pipe is fixed, having connections opposite each tuyere from which small

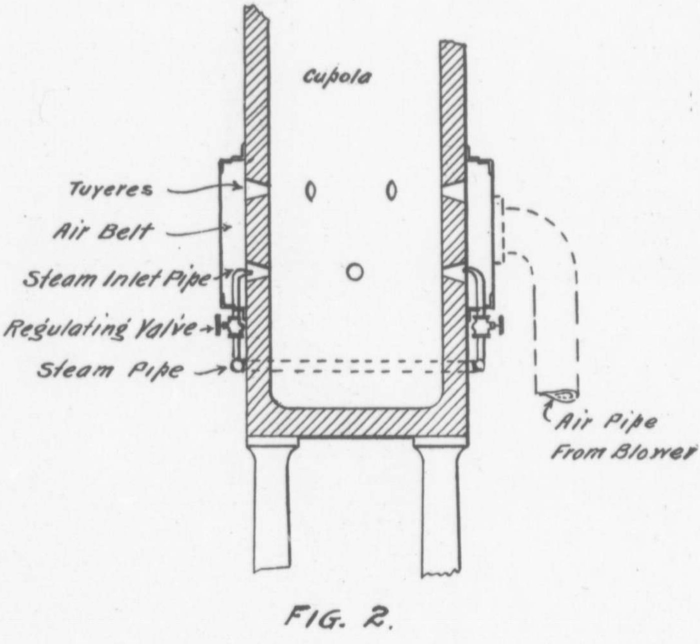

FIG. 2.

branch pipes of $\frac{1}{4}''$ bore are led into each tuyere, each branch having a wheel regulating valve to regulate the amount of steam introduced with the blast. (See Fig. 2). All exposed portions of steam pipe are covered with asbestos or other non-conducting material to prevent condensation; and as near to the cupola as possible, the steam passed through a simple superheated coil, the steam pressure being 80-90 lbs. and air pressure not exceeding $\frac{3}{4}$ lbs. per sq. in., *i. e.*, $1\frac{1}{2}''$ of mercury or $21''$ of water.

RESULTS.

Whilst Mr. Doherty was tabulating results at Garston, I was arriving at similar (but not exactly identical) results in Rangoon as follows:—

	Garston.		*Rangoon.*	
	Ordinary.	*D. Process.*	*Ordinary.*	*D. Process.*
Average loss on iron melted.....	6%	2.7%	10%	5%
Average rate of melting per hr..	4 tons	5 tons	2 tons	2½ tons
Average consumption of coke per hour...........	3.35cwts	2.74 cwts	3 cwts.	2.15 cwts

I obtained much better coke consumption results in Rangoon than I found possible later on in Garston, the extreme heat and dry climate of the former being, no doubt, accountable for the difference and not the excellence or the smaller capacity of the cupola in Rangoon. One pound of carbon burning to carbonic acid develops 12,906 units of heat, and one pound of cast iron requires 511.2 units of heat to melt it at 2,190° Fah., and allowing coke value to be .82 of carbon; we would, therefore, require to melt one ton (2,240 lbs.) of iron $\frac{2240\times 511.2}{12906\times .82}=108.2$ lbs. of coke or nearly 1 cwt. Since the best results obtainable are a little over 2 cwts. in actual practice, we arrive at some idea of the actual waste of heat incidental to the operation of melting iron in a cupola and if any apology were needed for the endeavor to economize the gifts of nature in the useful arts and manufactures, we have it right here, apart from the superiority of the resultant product claimed by this process. The brands of cast iron used in foundries for ordinary castings are Nos. 1, 2, 3, and 4, which are grey cast irons. The quality of the iron can be judged by inspecting the fracture. When the color of the fracture is a uniform dark grey, mottled and without lustre, it is very weak; when the color is lightish grey with high metallic lustre, the iron is tough and hard; but when the color is light grey without metallic lustre, it is hard and brittle. No. 1 has a dark grey fracture with high metallic lustre; it is more fusible and more fluid than the others, but being deficient in hardness and strength, it is only suitable for very light castings.

Nos. 2 and 3 are used for ordinary castings, the color being a lighter grey, with less degree of lustre than No. 1.

When melting in the cupola without the Doherty process, I used for ordinary castings

Scotch mixed brands, No. 3	5 cwt. per ton.
Cleveland mixed brands, No. 3.........	6 cwt. per ton.
Good clean scrap	9 cwt. per ton.

For light castings I used—

Scotch mixed brands, No. 3	5 cwt. per ton.
Glengarnock, No. 1	6 cwt. per ton.
Good clean scrap	9 cwt. per ton.

With the Doherty process I used:—

Scotch mixed brands, No. 3	3 cwt. per ton.
Cleveland mixed brands, No. 3	4 cwt. per ton.
Scrap (unselected and rusty)	10 cwt. per ton.
Wrought iron punchings	3 cwt. per ton.

By the introduction of steam (H_2O) in combination with the air blast, a new element is secured in combustion. The excess of oxide of iron in the large amount of scrap used, gives sulphydrate of ammonia, and when reduced to the ferrous state, is ferrous sulphide, and sets sulphur free.

The oxygen is removed from the oxide by the hydrogen and produces a much more strict form of metallic iron.

The oxide or rust visible on the iron is simply the metal going back to its original form—the ore—and in order to recover it, the oxide must be re-smelted; and to do this the same elements or their equivalent must be brought into action, as were at work in the smelting furnace in the first place; the only difference in the original ore and the oxide, being that the ore contains about 50 per cent of pure metallic iron, while the oxide contains about 90 per cent. Thus the practical foundry-man can at once see wherein the great waste takes place when the oxide is carried off with the slag and lost. It is a well known fact, that in melting cast scrap (the more rusty the more waste) there is a loss of 30 per cent in ordinary foundry practice, while it has been verified by me that the charges weighed into the cupola and the castings weighed out therefrom, the loss did not exceed 5 per cent. Here is a saving of 25 per cent., aside from the superiority in quality of the metal produced, which of itself was a finer, softer structure, and possessed fully 20 per cent. more physical strength. It might be of interest here to explain the cause and process of oxidation of iron. Iron does not oxidize in dry air, nor even in dry oxygen, at common temperatures, but in moist air, it becomes coated with a scaly covering of black oxide or rust. The presence of carbonic acid in the air greatly assists the operation, for the iron becoming changed into the carbonate of the protoxide, absorbs a new portion of oxygen, and is thus transformed into the hydrate of the peroxide of iron. The carbonic acid disengaged, facilitates the oxidation of a new portion of metallic iron. When once iron has begun to rust at one point of its surface, the rust spreads rapidly round this point in consequence of galvanic action, which accelerates the oxidation. The small spot of rust forms the two elements of a voltaic pile in which the iron is positive, and thus acquires for oxygen an affinity sufficiently strong to decompose the moisture of the air, and thus hydrogen is set free. Rust also contains portions of ammonia, the odor of which becomes evident by heating it with potash. Ammonia consists of hydrogen and nitrogen and when these two elements come in contact in what is called the nascent state, *i. e.*, in the very act of separating from a body under decomposition, the moisture of the air, containing a portion of the air, and consequently a portion of nitrogen, coming in contact with the rust of iron, is decomposed, and the nitrogen and hydrogen which are set free at the same time, combine to form ammonia and the ammonia is retained by the peroxide of iron, which acts towards it as a weak acid would do. It will be readily seen from the above reaction, which is both analytical and synthetical, how marvellous are the results that may be obtained in an ordinary foundry cupola, when natural laws are carried out by the introduction of a certain new element, acting in combination with other elements, thereby forming new elements and new combinations in the very act of separation by heat. It is very difficult to describe the chemical reactions at work in a cupola, because chemical action is only known by its effects. It requires very little technical skill to operate this process—no more than is within the reach of the ordinary foundryman, in order to secure the best results claimed.

These claims are:—

1. Effects a saving in quantity of fuel used.
2. An inferior grade of fuel may be used.
3. An inferior iron may be used.
4. There is less loss in iron.
5. It requires less time and power to operate the blast.
6. Castings are more perfect, being very smooth and even.
7. Castings are more easily worked in the lathe.
8. Castings are very strong, resembling malleable and steel.
9. A cleaner furnace and very much less slag, great saving in preparing furnace and longer life of lining.

Satisfactory as these results undoubtedly were, the reduction of the quantity of iron lost in the slag resulting from the Doherty process as compared with the ordinary, appears to me the most remarkable feature; in fact, I have on some occasions had almost a clean furnace after a day's "blow," and a few minutes only sufficed to get ready and make up the furnace for the next "blow." And the quality and quantity of scrap iron possible to use was also most pronounced in favor of the Doherty system and these without any deleterious effect upon the castings produced, and there is no doubt that when oxide of iron is present, it is thoroughly reduced by this process instead of passing into the slag as in the ordinary process.

COKE YIELDS.

I never attempted to reduce the quality of the coke and always obtained for foundry purposes, both in England and in India, the best possible, but I understand that Mr. Doherty, in his tests at Garston, used an admixture of 50 per cent. inferior quality, this being too soft and too full of sulphur to use in ordinary practice; saving thereby 4 shillings per ton on this item alone. He would probably have saved quite as much in quantity had he used the best, but no doubt was anxious to make good his claims in every respect, including that of using a commoner quality of coke.

SPEED OF MELTING.

The new process increased the power of the cupola 25 per cent. in each case over the normal output and moreover, Mr. Doherty reduced the air pressure from 14 ozs. at the tuyeres to 10 ozs., reducing the speed of the blower by 50 per cent., although the melting speed of the cupola was improved by 25 per cent. In all cases I kept at 12 ozs. pressure, preferring to take no risks of getting the metal down too stiff, at the same time there is great danger in having it too hot, as I have known good castings, to all appearances, utterly fail on the test bar, through melting at too high a temperature.

CHEMICAL EXAMINATION.

Mr. Doherty, I understand, submitted samples to Messrs. Pattenion & Stead, of Middlesborough, for examination, from which it would appear that most of the elements contributed to the combustion in a greater degree than obtains in ordinary practice. From a 30 per cent. mixture of Middlesborough pig (high in phosphorus, about 1.60) and 70 per cent. scrap (also high in this element) he obtained a very useful soft malleable product of the following analysis:—

Combined carbon	.58
Graphite carbon	2.47
Manganese	.44
Silicon	2.25
Sulphur	Trace
Phosphorus	1.34

From another analysis which Mr. Doherty was demonstrating at Garston in England, the figures were as follows:—

Charge.	*Containing 150 p.c. phosphorus.*
Cleveland pig	$12\frac{1}{2}$ per cent.
Hematite	$12\frac{1}{2}$ per cent.
Scrap	75 per cent.

The castings contained:—

Combined carbon	0.24
Graphite carbon	2.37
Silicon	1.93
Sulphur	0.19
Phosphorus	0.64

Thus emphasizing Mr. Doherty's claim of reducing the sulphur and phosphorus, uniting the molecules of the metal in a closer relation, thereby giving tougher, stronger and more ductile castings than otherwise could be obtained at so low a cost.

Physical Qualities.

The metal produced by the process possesses some remarkable features. In appearance the fracture is close grained, uniform and of silvery grey color, and does not present that crystallization in the centre, shading off to a finer grain at the edges, such as may be observed in ordinary castings. In fact, the homogenity of the metal is most marked. Tests for strength by means of test bars have been numerous, and always well above the average of ordinary cast iron tests. Bars resting on bearings 3 feet apart and 2″x1″ on edge seldom failed below a gradually applied weight of 30 cwts. in the centre, and frequently stood up to as high as 34 cwts. I have also known these bars frequently leave the testing machine unbroken at 30 cwts. with a permanent set of 1″ to $1\frac{1}{2}$″ off the straight at the centre; and of a ductility approaching that of malleable cast iron, evidenced by a short bar $\frac{1}{2}$″ square when placed in a vice and hammered at one end, being upset to the extent of 25 per cent. increase of its section, and when heated to a cherry red, roughly forged and expanded to a chisel point. Its strength and ductility also is particularly instanced in very thin castings being readily punched in an ordinary press without fracture. The grain and ductility also renders it of great value in machining where it may be cut like very soft malleable cast iron at a quicker speed than ordinary castings could be treated, and it is capable of high polish and finish.

Cost of Process.

Apart from the initial outlay of pipes and connections to the nearest steam supply which, of course, is variable, costs were taken out at under ¼d per ton for the supply of steam used, but the process *does* require an increase of limestone to the extent of from ½ to 1 cwt. for every 7 tons charged into the furnace, which taken at 6 shillings per ton, will add to the cost of the metal melted, about ½d per ton.

I will now conclude with the testimony of two firms on this side:—

Messrs. J. D. Smead & Co., of Toledo, after working the process some months wrote:—

"The writer has been in the foundry business for more than a quarter of a century and could hardly credit the statements made concerning the process, but after its use I have to say that Mr. Doherty makes no claims that are not verified

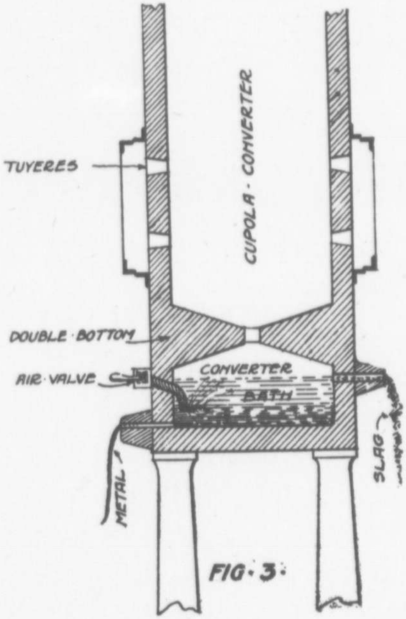

FIG. 3.

in practice. A saving at the cupola and in the machine shop aggregate about $4 per ton; and our castings are better than we have ever before made, notwithstanding the fact that it has been generally understood that better castings were made at the Smead Foundry than anywhere in this city."

Also the Goldie McCulloch Co., Limited, of Galt, Ont., wrote as follows:—

"We have had the process in operation four months and the results are satisfactory to us. In charging our cupola we use a larger proportion of scrap iron and a smaller proportion of pig than formerly, thus effecting a saving in the cost of the charge. The iron is softer, tougher, and stronger than we had by the old process of melting and we find less waste. As a result of the experiments we have decided to permanently adopt the process."

And now I am nearly through, but since first starting on my task of preparation of this paper, I have received a communication from Mr. Doherty describing his latest invention in the foundry, which I roughly show in Fig. 3.

This invention consists essentially of a cupola and pneumatic converter combined in one. An ordinary cupola is divided by refractory fire bricks so arranged as to form a double bottom or partition above where the pig and scrap iron and coke are when charged as shown. The metal, as it becomes melted, falls down through an opening into the converter chamber, where it accumulates and forms what is known as a bath, upon which compressed air is applied and converts the molten metal into any quality of steel desired, by operating a valve in the blast pipe. The reaction produced is similar to that of all the other pneumatic processes and produces intense heat, burning out the carbon and silicon and carries off the slag automatically through the opening at the side as shown. In other words the raw material is charged above, melted, converted into steel of any desired grade and tapped out below by one operation. This process is more especially adapted to making steel machinery castings at a very low price which eventually will take the place of cast iron, as the tendency of the times would indicate, because they are not only lighter and stronger but much more easily worked and reliable. The difficulty heretofore has been the extra cost. This has been a hindrance to their general use, but now with that objection removed by this simple process, it is fairly safe to predict that steel will replace iron castings at no distant period of the world's march of progress. The process, I understand, is being patented in most countries.

Chairman,—

From the very close attention you appear to have given to this eloquent address by Mr. Grocock, I am led to believe that you have been very much interested and I feel sure that some of you will wish to ask Mr. Grocock some questions, and I have no doubt that Mr. Grocock is prepared to answer them.

It is almost impossible for a man to follow a lecture of this description and be able at the end of it to ask questions he would like to ask, but, as Mr. Grocock is a member of our

Club, we are likely to have him amongst us very frequently, therefore, if there are any questions which you would like to ask Mr. Grocock at a later date, I have no doubt he will be pleased to answer them.

Before calling on anyone in particular is there anyone who would like to ask Mr. Grocock any questions?

I might state, gentlemen, that Mr. Grocock has no axe to grind, he is not now in the foundry business, and I think it is very creditable of him, as he has only been a member of this Club a matter of three months, to devote his time to giving us this paper.

As no one seems disposed to say anything, I will ask Mr. Clarke to make some comment.

Mr. Clarke,—

I would like to ask Mr. Grocock how long this system has been in use as near as he can tell?

Mr. Grocock,—

Since between 1901 and 1904. I used it at Garston and previously at Rangoon. I first used it in 1897.

Mr. Clarke,—

It seems to me that I saw steam used in a cupola thirty years ago. The J. F. Roberts Co., Swan Village, England, followed this plan but I do not think they have been following it up.

Mr. Grocock,—

Mr. Doherty, I understand, has taken out patents all over the world for this process. He has had a good deal of litigation in defending his patents, especially in the United States, but, I understand he has always been successful.

Mr. Clarke,—

But this process has been in use for thirty years.

Mr. Grocock,—

I have no doubt that this is an old process, but it has apparently not been followed up.

Mr. Clarke,—

I understood you to say that it was cheaper on account of being able to use small scrap?

Mr. Grocock,—

Yes.

Mr. Clarke,—

But that would not be much good here when scrap costs us about $1.00 a ton more than pig iron.

Mr. Grocock,—

That is in places where you can get lots of scrap.

This process reduces the amount of slag which ordinarily comes from the cupola, this is due to more perfect combustion. I can only compare it to the imperfect combustion of an ordinary oil lamp, which, through its imperfect combustion deposits a black residue on the glass, if the combustion is perfect there is no residue. This cupola will convert rust, *i.e.*, oxide of iron into metal without any slag resulting from it. I have always had very little slag coming from the cupola when using steam in conjunction with the air.

Mr. Herring,—

There is one thing I would like to know. You mentioned in your paper that it was necessary to use more limestone for fluxing.

Mr. Grocock,—

You know in introducing hydrogen there is always a liability of the tuyeres getting covered over, and the introduction of more limestone obviates that.

Of course, in using this system we had to make trials, and mistakes were made in introducing too much or too little steam into the cupola, and by putting the limestone in we kept the tuyeres clean.

Mr. Herring,—

All you were doing then was to use more fluxing? Why was this?

Mr. Grocock,—

I think the excessive amount of hydrogen made this necessary.

Mr. Herring,—

What about using a cheaper quality of coke?

Mr. Grocock,—

I was always dead against using anything but the best, therefore, I have had no experience in using common coke. Mr. Doherty did, but I think he simply did this to substantiate the statements he made that a saving in coke could be made.

Mr. Herring,—

Would it not be possible to use good dense gas coke?

Mr. Grocock,—

This is not satisfactory. Gas coke always carries with it a lot of sulphur, and the elimination of sulphur from the cupola is important.

Mr. Woodley,—

I should like to know if Mr. Grocock could tell us why two bars of iron taken from the same cupola are different under test? I have seen two test bars, one cast the day before the other, from the same class of iron, show up differently, they were both the same size 1″ x 14″ long, one went up to 2,200, and the other to 2,760.

Mr. Grocock,—

That is just the difficulty. In the first part of the paper I explained, as well as I could, the uncertainty of the test coming out the same with the same process. This is one of the things we have all to learn a great deal more about. Why is it so?

My own opinion is that iron is treated by chemists as iron, although, whether it is what they call the ions or the molecular arrangement, but there is a further sub-division of iron yet to be discovered.

As I pointed out in the first part of the paper, there are always variations, although you cast two bars at the same time you seldom get identical results.

Mr. Woodley,—

In these bars the silicon in the 2,760 was 2.3, sulphur 1.19, combined carbon .56, and in the 2,200, silicon 2.49, sulphur 1.80, combined carbon .48.

Mr. Grocock,—

I would almost venture to say that the bar which contained the larger proportion of sulphur was the weaker bar of the two?

Mr. Woodley,—

Yes.

Mr. Grocock,—

I am very glad to have your corroboration in this as the elimination of the sulphur is what we try for.

Chairman,—

I would like to hear from Mr. Nicholson.

Mr. Nicholson,—

Not at present.

Mr. Layfield,—

The very interesting paper we have heard from Mr. Grocock tends to bind us together—that is the foundry men. We have these things happening every day in our foundries, the uncertain qualities which are between 90 and 94 per cent. of our melt. We know from chemical analysis what happens to 6 or 7 per cent. but the rest of it is uncertain.

I think we can promise Mr. Grocock that every moulder in this audience will watch this matter very closely this month, and will read and re-read his lecture. Probably we may get some little points that will help us out of our difficulties. It does not matter what company we are with, the same difficulties arise to all those engaged in the moulding business.

I am sure the members of this Club owe a great debt of gratitude to Mr. Grocock for this paper and while we may not all agree to what he has said, he will probably give us a few little pointers to help us in our daily troubles.

I have much pleasure in moving a hearty vote of thanks to Mr. Grocock.

Mr. Herring,—

I second that.

Chairman,—

It has been moved by Mr. Layfield, and seconded by Mr. Herring that a hearty vote of thanks be tendered to Mr. Grocock for his paper. I will ask you to signify by standing. Carried.

Mr. Grocock,—

I am very much obliged to the members for their vote of thanks for the paper I have just read. It has been quite a pleasure to prepare it, and to anyone who is going to make further investigations as to the variations I would just like to give one pointer. The variations of temperature at which the iron is melted, I believe, has a great deal to do with it, and they also affect the strength of the iron when it comes to the test.

Moved by Mr. Bannon, seconded by Mr. Taylor, that the meeting be adjourned. Carried.

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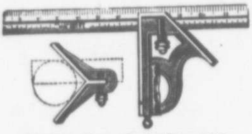

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