ART. XXIV.—*New Zealand Ironsands: an Historical Account of an Attempt to Smelt Ironsands at Onehunga in 1883.*

By J. M. CHAMBERS.

Communicated by Mr. Evan Parry.

[*Read before the Technological Section of the Wellington Philosophical Society, 13th June, 1917; received by Editors, 31st December, 1917; issued separately, 17th June, 1918.*]

IT is extremely difficult after a lapse of nearly thirty-five years to obtain a complete history of this undertaking, as the directors of the New Zealand Iron and Steel Company (Limited) are all dead—in fact, almost everybody who had any connection with it. Its records have been lost or destroyed, and the only data I have have been obtained from a private letter-book and a few odd documents which I found amongst my father's papers.

In 1866 Mr. John Chambers arrived in New Zealand, and soon afterwards saw the ironsand on the beaches of Taranaki. He was much impressed with it as a valuable asset, if the material could be converted into marketable iron. From some early settlers he learnt that 100 tons of sand had been sent to Staffordshire, where it was manufactured into iron by David Hipkins, who wrote that he smelted and puddled the sand into bars, sheets, hoops, boiler-plates, and fencing-rods, afterwards making it into horse-shoes, chain, &c. All were tested and pronounced equal to any of the Staffordshire irons; but owing to cost of manipulation he would not recommend his principals to obtain further supplies or establish a works in New Zealand.

Later, in 1876, Mr. Chambers took a parcel of ironsand to England and the United States. He interviewed many ironmasters, but could get none sufficiently interested to experiment seriously with the samples, excepting in laboratories, where a few pounds of iron and steel were produced in crucibles.

In 1886 I attended the Indian and Colonial Exhibition, where there were exhibited a parcel of sand and some iron manufactured by the above company. While in London I was introduced to W. T. Jeans, Price Williams, and Sir Henry Bessemer, all of whom were interested in the sands of New Zealand and Canada. Arrangements were made with Sir Henry Bessemer to carry out a series of experiments. His report was unsatisfactory, for, although he claimed that the best-quality iron and steel could be produced, it would require a great deal of research work, and he was too old to go on with it.

Just before Sir William Siemens died, in 1883, he stated that his attention had been called to the ironsand in New Zealand and Canada, containing about 50 per cent. of metallic iron, and he demonstrated with a patent rotating furnace that he could manufacture iron from the ironsand of Canada, producing iron balls in four hours, which were then treated in the open-hearth furnace and converted into mild steel. At that time his process was tried in Pittsburgh, but unfortunately it did not prove a commercial success, on account of cost.

Mr. John Chambers visited the Philadelphia Exhibition in 1876, and there tried to induce men in the iron and steel trade to test the ironsand; but nothing could be arranged, as all the ironmasters of America were fully occupied in building additional works to handle the trade which they could easily get in America for all the iron that could be produced from ordinary iron-ore at a cheap rate. But before leaving New York Mr. Chambers heard that Mr. Joel Wilson, of Dover, New Jersey, had in 1873 patented a furnace which he claimed would treat ironsand and convert it directly into wrought iron; but everything was in an embryo state, and it was arranged for an agent to watch the work of Mr. Wilson, who claimed in 1882 to be able to manufacture successfully from sand. Mr. Guy H. Gardner, of New York, obtained an option on the New Zealand patents, purchasing them jointly with Mr. Chambers; and so sanguine was the inventor that he agreed to send out his best man, Mr. W. H. Jones, to demonstrate the working of his patent in New Zealand.

A full-size furnace was erected in 1882 to manufacture 3 tons of iron per day. The furnace was built from a drawing accompanying patent specifications granted to R. L. Malcolm (J. Wilson)* and G. H. Gardner,† except that the reducing-furnace contained eight retorts, instead of sixteen as shown on the drawing accompanying Malcolm's patent. The drawing of the furnace as built has been reconstructed and shown in the figure accompanying this paper. It consisted of a deoxidizer, A, and of an ordinary reverberatory or open-hearth furnace, about 17 ft. long, divided into three compartments—B, the balling-furnace; C, the puddling-furnace; D, the fire-grate. The coal used for firing on the ordinary furnace-bars was from Westport and Newcastle. The hot gases from the furnace played direct on the floor of the puddling-furnace C, passed on to the balling-furnace B, then passed through the roof into a central flue F, about 2 ft. in diameter, and were carried up the full length of the deoxidizer, a height of 21 ft.; the gases struck the crown at the top of the furnace, and passed in a downward direction between the retorts R, there being radial spaces F between the retorts for the gases to pass through; on reaching the bottom they were deflected so as to pass upwards (F) on the periphery or outside of the surface of retorts, and between that and a firebrick lining against the shell of furnace. On the gases reaching somewhere near the top they passed out into an annular flue and by way of an iron chimney into the atmosphere.

The deoxidizer held 10 tons of carbon and ironsand. After the silica had been extracted by a magnetic separator it was thoroughly mixed with 20 per cent. to 25 per cent. of coal or charcoal, Taupiri coal being used. The material was hoisted to a platform above the deoxidizer, from which each retort was filled from filling-boxes. It required twenty hours to deoxidize or carbonize the iron by driving out the oxygen. The sand was red-hot, but not so sticky that it would not run through the chutes leading to the balling-furnace, which were controlled by heavy gate-valves.

The deoxidized sand dropped on to the floor of the balling-furnace, where it lay for some thirty minutes, there being a door at the side of the furnace to permit the puddlers to test the condition of the material before balling it. It would work up exactly as cream works into butter, having very much the same appearance. On a ball of about 18 in. diameter being made it was rolled or passed over to the puddling-furnace C, when it was again attacked by a fresh set of puddlers, who vigorously worked it up

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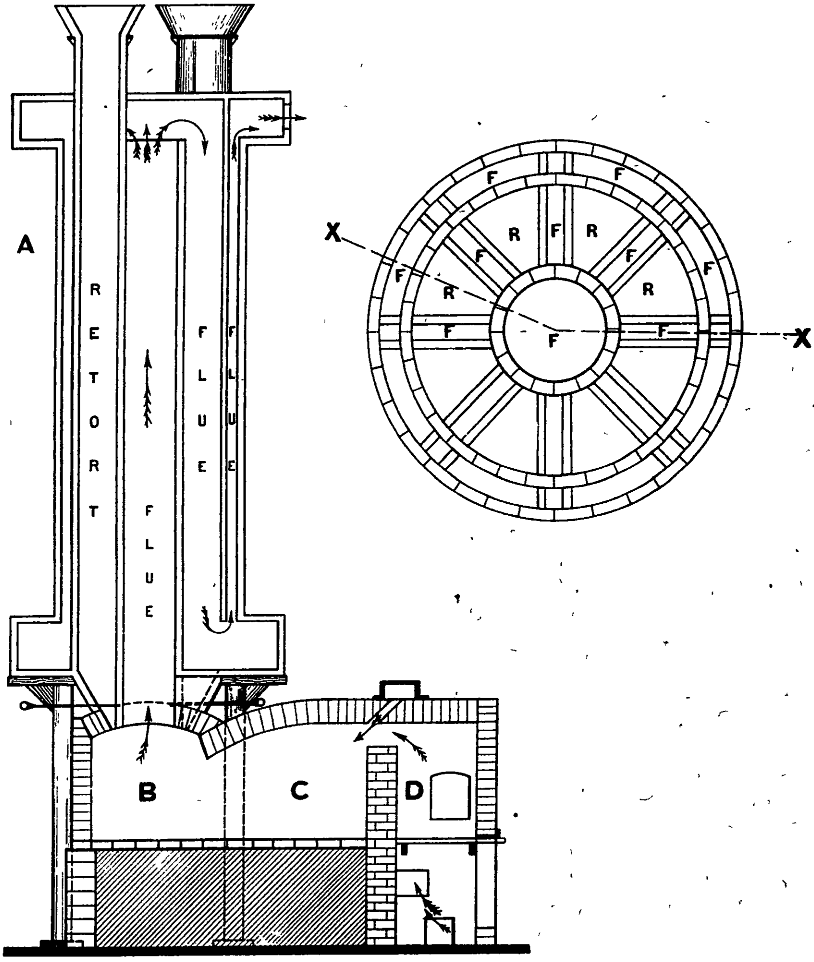
* "Malcolm, R. L.—8th January, 1883—Improvements in furnaces for reducing iron-ores," *N.Z. Pat. Reg.* No. 762.

† "Gardner, G. H.—23rd April, 1883—Improvements in furnaces for the manufacture of bar iron and blooms," *N.Z. Pat. Reg.* No. 818.

until it was ready for the squeezer; or, in the case of the first trials, the ball was placed on the anvil of a steam-hammer and gently squeezed into a square form, after which it could be hammered with the full force of the hammer and drawn into the shape of a billet or bloom.

The cost of the first furnace was £500. It was completed early in February, 1883, and on the 27th the first iron by the new process was



Design of Furnace.

A, deoxidizer; B, balling-furnace; C, puddling-furnace; D, fire-grate; F, flues; R, retorts.

made into billets, and it was shown that the quality exceeded all expectations. On the 5th March George Fraser and Sons, Auckland, made three bars, 8 ft. long, 2 in. square, of perfect quality. The furnace, under the charge of W. H. Jones, was kept working for about ten days, and at that time good blooms were produced, which were worked up into bars and thoroughly tested by several leading blacksmiths in Auckland, Mr. George

Leahy making a large double pair of ornamental gates of beautiful design to demonstrate the quality of the iron, which was equal to Netherton Crown.

After a stoppage for some necessary repairs the fires were lit for a second time. The best results obtained from one charge in the deoxidizer was the manufacture of 6,751 lb. of iron from 14,625 lb. of sand; the slag or cinder amounted to 7,215 lb., the loss of cinder and waste in furnace being reckoned at 659 lb., resulting in 46¼ per cent. of iron being produced from the separated sand. The operations were carefully watched by Messrs. James Stewart and Edmund W. Otway, of Auckland, who on the 29th March made the following report:—

"We have the honour to state that, as requested by you, we have attended at your works erected at Onehunga for the reduction of the ironsand, for the purpose of examining in detail the whole process and obtaining data for reporting on the cost of production. We are as yet unable to make a complete report, but hasten to give you a few of the more important results, and the deductions which may fairly be drawn from them. We hope shortly to report in a more exhaustive manner.

"On Monday, the 19th instant, four retorts were filled with a mixture of ironsand and charcoal, in the proportions of one measure of sand to two of charcoal. Other four retorts were filled with a mixture of ironsand and ground Waikato coal, in the proportions of two measures of coal to three of sand, the intention being to put in 20 per cent. by weight of both charcoal and coal in proportion to the sand. The above mixtures give that percentage of coal, but more than that of charcoal, and in subsequent operations in filling up the exact ratio of 20 per cent. was adhered to.

"The fires were lighted on Monday night, and on Wednesday a small charge was tried, but found not sufficiently carbonized or deoxidized—either term appears correct. Puddling was therefore deferred until Thursday, the 22nd, and was then commenced with the coal mixture principally. But it soon became apparent that the coal was not in sufficient proportion to carbonize the ore, and after working all day with a very poor result it was determined to discharge all the coal mixture remaining in the retorts and recharge with charcoal and ore.

"On Friday work was resumed with better success, but, as coal mixture had been used to fill up the shrinkage in the retorts remaining to be worked, its presence still caused trouble, principally by the great amount of slag produced, and iron dry and difficult to work to nature, causing the blooms to be returned to the furnace once, and sometimes twice.

"On Saturday the work went on very well, and if the draught of the furnace had been perfect little could have been desired in the result.

"We have worked out the result in two ways: (1) total sand ore worked by both mixtures, against total yield of iron; (2) discarding the yield of iron on Thursday, when the iron-ore was mixed with the coal, as obviously the fairest view to take. The first result is 38 cwt. of iron from 149 cwt. of sand, equal to 25·5 per cent. (very nearly) of puddled blooms. The second view gives 33·25 cwt. from 98 cwt. of ore, equal to 34 per cent. (nearly) of puddled blooms.

"From the somewhat extemporized nature of the works, we feel confident that the above percentage at least can be maintained by carbonizing with charcoal. And by increasing the coal mixture to an amount equivalent to 20 per cent. of carbon we have reason to believe a like result will be obtained.

"Discarding Thursday's run, the coal used in puddling and keeping up the heat at night on Friday, Saturday, and Monday, including the coal necessary to keep the furnace hot over Sunday, was 3·21 tons, which works out to 38·6 cwt. per ton of blooms. We feel quite safe in saying that with continuous working the conversion of the ore can be effected at under 30 cwt. of coal per ton of iron, and that all the heat and firing required by the whole process can be supplied by the waste heat from the furnace and retorts in the use of that weight of coal. This is even with the direct use of coal; but with the most improved gas regenerative furnace not only will the amount of coal be very largely reduced, but much inferior fuel may be used.

"Keeping in view all the above points, we have no hesitation in saying that the process has been shown to be profitable, but to what extent we are yet unable to say. We trust, however, that this interim report will be of service to you."

It was estimated the cost of manufacture would be as follows:—

	£	s.	d.
Cost of 3 tons of ironsand at works, at 6s. 8d. per ton	1	0	0
30 cwt. coal at works	1	10	0
Carbon for retorts	0	10	0
Puddling, per ton	1	0	0
Shingling, rolling into puddle-bars, weighing, shearing, piling, reheating, and rolling into 1 in. bars	0	10	0
Engine-driver's time, millwright, bricklayers, &c., and incidental expenses	0	10	0
	£5	0	0
Add 25 per cent. for establishment charges, depreciation on plant	1	5	0
Cost per ton	£6	5	0

When the furnace was working during April the works were visited by Mr. Pearson, of Pearson, Knowles, and Co., of Warrington, who took a great interest in the work, and said the process represented the greatest advance of the present age. At the same time they had another distinguished visitor—Mr. Sydney Gilchrist Thomas, of London, inventor of the basic process which did so much to cheapen the cost of manufacturing steel. He declared that for the first time he had seen wrought iron made direct from ore, and it was what all ironmasters had been trying to do for a century. He was prepared and wished to enter into a contract for the purchase of 5,000 tons of blooms per annum.

As a result of the visits of these two men and the favourable reports obtained from all quarters it was resolved to form a company with a capital of £200,000, made up of 40,000 £5 shares: of these, 9,103 were subscribed by the public, leaving a balance of 30,897; the paid-up capital being £45,515. The total expenditure was about £58,000, the plant and buildings costing £34,329.

The company proposed to order sufficient material and plant for the erection of ten deoxidizers and furnaces. A rolling plant was ordered from Messrs. Walker, Eaton, and Co., of Sheffield, who supplied an 18 in. forge-train with squeezer, pendulum shears, and engines, a 14 in. and 10 in. merchant mill, hot-saw, two shingling-hammers (each of 50 cwt.), and all necessary gear for a complete works to turn out 30 cwt. of bar iron or rolls per day. Four Lancashire boilers and four Wilson gas-producers were ordered from Tangyes Limited, to provide gas for heating furnaces, firing boilers, &c., it not being proposed to use coal in any furnace or place.

The site on which the experimental furnace was erected was purchased, consisting of about 5 acres on the south-east side of the Onehunga railway-station, from which a siding was run into the works. It had a water frontage, which became valuable by a canal being cut to deep water to enable vessels of light draught to come right into the works, so that Westport or Newcastle coal could be delivered direct. It was a fine site, having many advantages, several springs providing a good supply of fresh water. It was admirably situated for cheap and economical working, for it was intended that the ironsand should be brought from the North Head of Manukau Heads, where a Government lease, of sixty-six years, was obtained for 6¼ miles of beach and 1,000 acres of land, on which there were millions of tons of iron. There was good shelter and deep water at the Heads for loading, it being proved from actual experience that the sand could be raised, trucked, delivered to vessel, and conveyed to works at a cost not exceeding 6s. 8d. per ton. The average sample of ironsand obtained from the Manukau Heads would analyse as follows:—

Iron-oxide	88·88
Titanium	0·30
Lime	Trace
Magnesia	"
Silica	9·98
Loss	0·84
	100·00

Equal to 66·36 per cent. iron.

The patience of the shareholders was somewhat tried by the long wait for machinery to come from Great Britain. Contracts were let for a furnace-house to contain the forge-train, which measured 106 ft. by 100 ft. The roof of this building had a single span. There was also a similar building, 100 ft. square, for the merchant mills and reheating furnaces. Offices, laboratory, carpenters' and engineers' workshops, foundry complete with cupola, set of furnaces for making crucible steel, storage, drying and mixing shed for coal and sand, were all got under way, and, in addition, a brick-kiln, which turned out 200,000 firebricks before the machinery arrived.

The prospects were bright and every one was sanguine of success; but on the 23rd December the company suffered a great blow by Mr. W. H. Jones quarrelling with a bricklayer, whom an hour or two afterwards he shot in the main street of Onehunga, for which he got ten years' hard labour. No suitable man could be obtained from America, and it was thought that Mr. Edmund Otway, an old ironmaster, would fill the position, which he did for some months. He was a very capable man, but unfortunately he broke down and died in June, 1884. This was looked upon as a serious loss, but fortunately the position was filled by Mr. John Heskett, at one time manager of one of Bolckow Vaughan's works at Middlesborough, who proved to be thoroughly capable, and manfully carried on the work. He, unfortunately, had to fight against great difficulties through ill health, and finally broke down at a critical time, when the works were completed and ready to commence operations.

On the 7th November, 1884, the first machinery arrived from England; it was quickly erected, for by the 1st May, 1885, the fires were lit in two furnaces, when it was shown that 1 ton of bars could be made from 3 tons of 75 per cent. oxide—that is, the sand as found on the beaches. The new furnaces were supplied by gas under forced draught generated by the four Wilson gas-producers, and all worked well for a few days, when it was found that the coal contained too much moisture, which destroyed the heating properties of the gases. Again and again endeavours were made to overcome this difficulty. The fires would be lit in the gas-producers, and the quality of gas for the first few hours would be perfect; but as the furnaces became hot and just about ready for men to work the sand and deoxidizers the heat gradually fell away, or a series of explosions took place, which showed it was time to stop. This was one of the first difficulties met with, and one that was never overcome in spite of many experiments.

By this time the shareholders were becoming impatient, for they wanted to see returns. The loss of two managers, followed by the enforced retirement of Mr. John Heskett, had a good deal to do with the company breaking up.

Mr. James McAndrew, an ironmaster, who had been on the Clyde, accepted the position of manager, and did his best to produce iron from sand, but none of Mr. W. H. Jones's successors could produce iron of the same quality as he did. There were difficulties with the deoxidizers: air seemed to leak through or get into the retorts, resulting in a portion of the sand not being deoxidized, and, although it would work up into a bloom which had the appearance of being good, when passed through the forge-rolls the bars would fracture through the sand not being properly deoxidized or cemented together.

The directors got a rude awakening by receiving a report from Mr. John Coom, which showed that the iron was brittle and could not be sold as a first-class commercial article. The report reads as follows:—

"The iron was tested for tensile strength and by bending; the steel was made into tools and used in wheel-turning and general work.

"Three pieces of the iron (marked 'A' in the schedule) were drawn down to a sectional area of ¼ in.; the two pieces marked 'B' were tested as sent from the works, the section of these being about 1 square inch.

"The apparatus used in testing is not one specially designed for the purpose: the results cannot, therefore, be looked upon as strictly accurate.

"For your information I have shown results of some of Kirkaldy's tests of Bowling and Lowmoor iron, and the specification of the iron supplied for the Ohio (America) railroad bridge.

No. of Piece.	Brand.	Mean Breaking-weight per Square Inch of Original Section.	Contraction of Area at Fracture.	Mean Elongation.
		Tons.	Per Cent.	Per Cent.
1	A	26·00	23·4	7·3
2	A	26·46	25·1	4·1
3	A	31·93	27·6	10·9
4	B	16·26	20·6	8·5
5	B	16·26	4·5	2·7
..	Bowling ..	27·86	45·3	29·4
..	Lowmoor ..	27·59	53·1	26·5
..	Ohio River Bridge specification	26·75	25·0	15·0

"The pieces 1, 2, and 3, which were drawn down from a large section, are superior to the pieces 4 and 5, which were tested in same section as received.

"The results show the iron to be of a hard and unyielding character, but it evidently is improved by working; it would require this before it could be safely used in engineering-works. The mean breaking-weight is high, but the contraction at the fractured area and the elongation are low, showing the iron to be as I state.

"A further test of the iron was made by bending cold, and the results were fairly good: two pieces were bent double and showed but few cracks.

"The steel was made into tools for use in the wheel and other lathes; these were given to the turners with instructions to use them for a week and then report. Their report was very favourable: they say the tools stood as well as most of those made from the imported article."

The company then resorted to manufacturing wrought iron from scrap, but this was not profitable. First-class chemists were engaged in the laboratory, Mr. D. S. Galbraith working very hard in the hope of overcoming difficulties, but this was never done.

The company struggled on until November, 1886, when, with its capital spent and a liability of £20,000, an attempt was made to reconstruct; but the shareholders would not find money, and the assets of the company were taken over by the mortgagee. For a short time it was worked under tribute in the manufacture of bar iron from scrap, but this was never profitable, and finally the plant was broken up and shipped to China, to be used there in new ironworks.

So ended the most serious attempt at manufacturing iron from the sands of New Zealand, and one wonders now why it was not a success. Everything was done that could be thought of at the time by all concerned, for they were sanguine to the last, and hoped to retrieve the fortune spent in endeavouring to create a great industry for the Dominion.

Art. XXV.—*Notes on the Autecology of certain Plants of the Peridotite Belt, Nelson: Part I—Structure of some of the Plants (No. 1).*

By M. Winifred Betts, M.Sc.

Communicated by Professor Benham, F.R.S.

[*Read before the Otago Institute, 9th October, 1917; received by Editors, 29th December, 1917; issued separately, 24th June, 1918.*]

Introduction.

At a short distance from the city of Nelson there is an area known as the "Mineral Belt." This is a zone of boulder-strewn land-surface, often dun-coloured in appearance, underlain by peridotite and serpentine rocks, which extends from D'Urville Island, in Cook Strait, south-west for a distance of sixty miles. It is an almost continuous band, but it disappears for about a mile between the valleys of the Lee and Serpentine Rivers. At its narrowest part the Mineral Belt is 100 yards wide, and it reaches its maximum width of 3 miles 50 chains in the vicinity of the Dun Mountain. The area occupied by the Mineral Belt is about $29\frac{1}{4}$ square miles.*

* J. M. Bell, E. de C. Clarke, and P. Marshall, The Dun Mountain Subdivision, *N.Z. Geol. Surv. Bull. No. 12*, 1911.