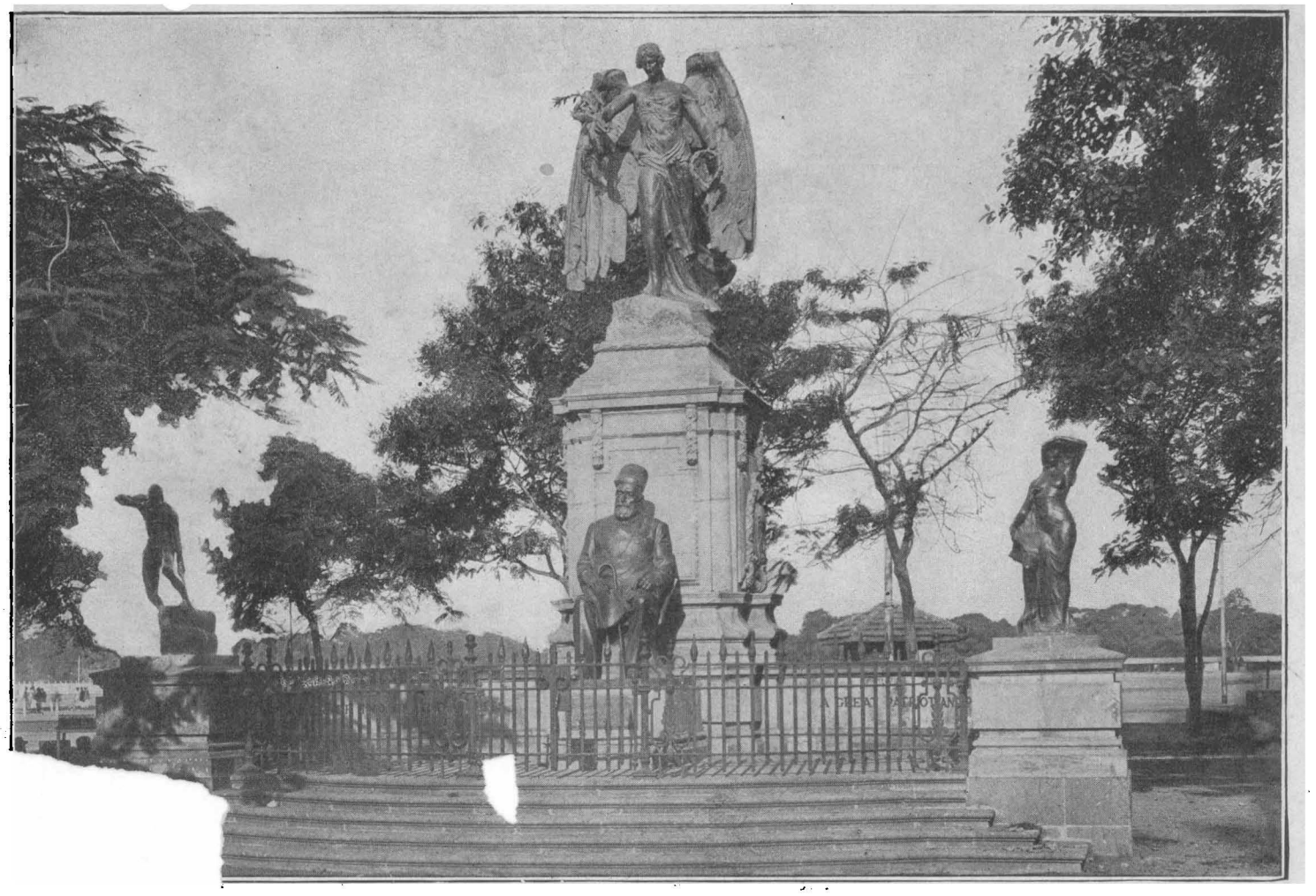

...RIAL TO THE LATE MR. J. N. TATA, BOMBAY.

IRON AND STEEL IN INDIA

A CHAPTER FROM THE LIFE OF
JAMSHEDJI N. TATA

BY
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FOREWORD

It is necessary only briefly to explain the circumstances which have led to the publication of this chapter from the life of Mr. Jamshedji Tata. Immediately on the death of Mr. Tata arrangements were made to prepare an adequate account of his life and work. The task was undertaken by Mr. Lovat Fraser; but various circumstances have delayed the completion of the biography. Meantime the war brought to the forefront the greatest of Mr. Tata's enterprises. The armies in Mesopotamia, East Africa and Palestine were largely equipped and maintained from India. Cut off from supplies from the East and the West, the resources of India could not have been mobilised for this service if the Tata Iron and Steel Works at Jamshedpur had not furnished a continuous supply of rails for the Indian railways and for the strategic lines which allowed our troops to push forward to decisive victory in Palestine and Mesopotamia. Now the war is over the works are destined to form the trunk from which will spring a variety of vigorous industrial branch industries with iron and steel as the bases of manufacture.

It has therefore been thought desirable not further to delay the publication of the remarkable story of patient achievement in the face of immense difficulties which induced the firm establishment of these works in the jungles of Chota Nagpur—works which have assumed a national, nay, an Imperial importance. With the approval of Sir Dorab Tata and the consent of the author, this chapter is separately issued with appendices describing the growth of the works and their subsidiaries. The chapter will be incorporated in the complete biography when it is published.

STANLEY REED.

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IRON AND STEEL IN INDIA

THE art of smelting and fashioning iron is believed to have been known in Asia, the oldest home of civilisation, long before it reached Europe. The Chinese, who did most things earlier than the other races of the world, are sometimes said to have been the first workers in iron. Through them, India is thought to have learned how to smelt and to forge. From India came the first supplies of those weapons which figure in the earliest recorded and half-mythological history of the peoples of the Mediterranean. The views of experts on this subject are curiously conflicting. On the one hand, we are told that it is a proof of the lack of mechanical inventive genius in India that, in spite of the early familiarity of her people with the iron industry, they never developed it beyond certain primitive stages. On the other hand, we are sometimes assured that India did, in early times, reach a very high stage of proficiency in metal manufactures. The truth probably lies midway between these two opposing forms of statement. If, as the late Mr. Syed Ali Bilgrami stated, the steel from which Damascus blades were made came from Hyderabad, it is reasonable to assume that Indian workers in metal were at least highly competent in the Middle Ages. An earlier example of Indian skill in casting metals is found in the famous iron column at the Kutab Minar, near Delhi. The column is estimated to be three thousand years old, and it represents a forging which weighs between seven and eight tons. To this day, the method by which it was produced is a mystery greater than the building of the Pyramids. That the steel known as

"wootz" produced in Hyderabad was not solely used for the purposes of export is sufficiently proved by the wonderful collections of ancient arms still found in India. Many of the weapons are of very great antiquity, and show remarkable qualities of workmanship. The art of damascening upon soft steel was widely practised in India, chiefly in connection with arms. It was only after the downfall of Sikh independence in the last century that it almost ceased to be associated with the manufacture of swords and armour, and was thereafter employed only in the adornment of more peaceful products.

Of the antiquity of the iron and steel industry in India there is, therefore, no doubt. The high degree of skill attained in certain directions has also been abundantly proved. Yet it is equally true that the Indian metal manufacturers never overcame certain definite limitations, and showed little tendency to progress. The vast heaps of slag found at Wai in the Western Ghauts and in several other places indicate the extent of the industry. The pitiful and laborious methods adopted may still be seen in use in India to-day. The village worker in iron smelts his ore with the aid of a wooden bellows, handled by his assistants exactly as his forefathers did in the days when Alexander the Great raided the Punjab. He knows no better method, nor does he seek to know one. The failure to progress need not fill us with surprise. Even in Europe the use of iron upon a widespread scale has been comparatively modern. The extensive production of iron in England really only dates from the seventeenth century, and the methods of manufacture remained crude until the eighteenth century was well advanced. The basic process of eliminating phosphorus from iron, out of which the largest steel industries of Europe and America have grown, was only discovered so recently as 1878. That Indian metal workers in iron got no further than the export of large quantities of "wootz" steel and the fashioning of splendid weapons was due to the fact

that the scientific age in Europe left them untouched. When British rule was being established throughout India, the newcomers depended for their supplies of metals chiefly upon imports. The introduction of railways dealt a death-blow to the indigenous industry, because cheap imported iron and steel was carried everywhere, and the Indian craftsmen soon found their occupation gone. The primitive smelting industry still lingers in some districts, and is even said to have shown slight signs of revival, but it must unquestionably disappear. The modern encouragement of technical education and the influence of schools of art should, however, help very much to revive the more artistic side of metal working.

The first attempt to establish an iron and steel industry in India upon Western lines was made by Mr. Josiah Marshall Heath early last century. Mr. Heath was a very remarkable man, and his unfortunate experiences form a sorrowful page in the annals of Indian industrial development. He spent his own means, and those of some of his friends, in his efforts to create great iron works in India. Sir Lowthian Bell said of him in 1899, "a more amiable, indefatigable and modest man I have never met. It has been my good fortune during a long series of years to have made many friends. Among all those, none occupied a warmer place than Josiah Marshall Heath, nor have I ever met a man who behaved, under very adverse and dangerous circumstances, with so much fortitude and resignation as he did." The pathos of his story is not associated solely with his long and vain struggle in India. He claimed to be the inventor of the use of manganese in the manufacture of steel, but the priority of his patent was only established after fifteen years of litigation. Before the interminable procedure of the Courts was over, he had died of a broken heart, and the memory of his misfortunes was preserved by Charles Dickens in a characteristic article published in *Household Words* in 1853.

Mr. Heath was originally a civil servant in the Madras Presidency. He was attracted by the specimens of steel manufactured at Salem, a town two hundred miles south-west of Madras. With the approval of Sir Thomas Munro, the famous Governor who did so much to establish the British administration of Madras upon a sound basis, he decided to give up his appointment in the Civil Service and to devote himself to creating iron and steel works in the province. Sir Thomas Munro obtained for him a grant from the Court of Directors in 1824, and in the following year Mr. Heath went to England where he remained four years, gaining information about the iron industry and procuring machinery and workmen. The quality of the ore with which he proposed to work has been the subject of very varying reports, extending over a long number of years, but the general conclusion to be derived from these reports is that the ore was of sufficiently good quality for his object, and that the ultimate failure of the enterprise was due to other reasons. Mr. Heath returned to India in 1830 and proceeded to establish his works at Porto Novo, on the Madras coast. At the end of a year, he had built his works and made various experiments, but had exhausted all his funds. The next three years appear to have been principally devoted to unsuccessful attempts to obtain more money, and at last Mr. Heath was compelled to appeal to the Government for further help.

A Commission was appointed to examine the conditions of the undertaking. It was found that the works were mortgaged for a sum of Rs. 2,50,000 (£16,666). Experiments made at the instance of the Commissioners resulted in the successful manufacture of cast iron. Mr. Heath's smelting furnaces were then capable of yielding about forty tons of pig iron per week. The blowing machine was, however, driven by bullocks because the four-horse power steam engine had been rendered useless by the bursting of a boiler. The real causes of the lack

of success were undoubtedly that Mr. Heath and his colleagues had insufficient experience, that the capital provided was far too small, and that mistakes had been made regarding the machinery brought out from England. The Commission was, however, very greatly impressed by the quality of the iron ore used at Porto Novo, and by the quantity of iron which it seemed possible to manufacture. On the recommendation of the Commissioners, the Government of Madras resolved to lend more money to Mr. Heath, while he, on his part, decided to turn his undertaking into a company, which he styled, "The Indian Iron and Steel Company." Except to experts, the prospects of the enterprise still seemed satisfactory. Mr. Heath proposed to manufacture bar iron in India and to export it to England, where he believed he could compete on highly favourable terms with Swedish iron. The total sum advanced by the Government of Madras amounted in the end to Rs. 5,71,000 (£38,000) which cleared the debts on the works and provided one lakh of rupees (£6,666) for their continuance.

Within three years, the works were once more in difficulties. The causes given are failure of machinery and miscalculation of its powers, the varying qualities of different ores and the difficulty of arranging for a supply of ores and of fuel. In these admissions, the real reason for the ultimate hopeless failure of the Salem enterprise began to become visible. Like all iron manufacturies in India up to that date the Salem works used charcoal for the reduction of the ore. In India, a square mile of forest has been estimated to produce about 64 tons of charcoal annually. Many years later, it was found at Salem that not more than 1,560 tons of charcoal could be procured annually for each blast furnace from the surrounding district accessible to it. All over the world, the use of charcoal is steadily diminishing, and in India it would not have been possible to establish iron works upon a large scale if restricted to charcoal as fuel. In 1837, however, these now familiar

truths were not so obvious. Another Commission was in that year sent by the Government to Porto Novo and gave it as its opinion that the embarrassed state of the Company's affairs was principally due to the lack of "an engineer of education, capacity and experience." The statement of the Commission was no doubt true, but it was not the main truth. The cost of manufacture was at that time given at Rs. 45 (£3) per ton for smelting, and Rs. 53 (£3 10s. 8d.) per ton for making malleable iron or blooms.

The report of the second Commission appears to have deterred the Madras Government from making any further advance, and the directors of the Company were compelled to raise more money by private endeavours. Mr. Heath went home in 1857 to manage the Company's affairs in England and very soon became involved in the long course of litigation about his manganese patent, during which he died. The Porto Novo Works languished but were never entirely closed, although no profit was made and no interest was paid on the loans made by the Madras Government. In 1847, and again in 1850, steps were taken for the formation of a new and stronger company. At this time a new obstacle was obtruded. The Government of India had become more than ever imbued with that spirit of unfriendliness to commercial undertakings which, for so long a period, helped to paralyse the industrial development of India. They expressed grave doubts about the expediency of renewing the concession, which amounted to a monopoly, and would therefore shut off Southern India "from the mining enterprise of other adventurers and capitalists." They therefore urged that the promoters of the Salem Works had no claim to special consideration, for "they had failed in the fulfilment of their engagements, and had involved the Government of India in a loss of not less than one hundred thousand pounds, unfortunately without any profit to themselves." The Court of Directors took the shrewder view that hard

treatment of the Salem enterprise would deter British capital from starting other enterprises in India, and the concession was therefore renewed. A new company called "The East India Iron Company" was formed in 1853, with a capital of £400,000 and the Madras Government agreed to cancel the debts due to it from the old Company in return for a payment of £10,000. The Directors of the New Company soon saw that the difficulty of obtaining charcoal fuel was the chief weakness of the undertaking. They therefore established three new works, one on the Cauvery River, another at Trinomalai in Arcot, and the third on the west coast. It was hoped that by thus drawing on widely separated forest areas, the requisite amount of charcoal would be obtained. The end was renewed failure. It was not possible to obtain more than 1,500 tons of charcoal annually for each of the four works. As $3\frac{3}{4}$ tons of charcoal were then required to make each ton of iron, the smallness of the output of iron may be readily calculated. The works on the Cauvery River were soon closed, but those at Porto Novo and on the west coast were kept working for several years longer. Some of the iron manufactured was sent to England, and is said to have been used in the construction of the Menai and Britannia tubular bridges. Some time in the sixties, manufacture was stopped altogether, and in 1874 the Company was dissolved, and the ill-fated experiment inaugurated by Mr. Heath, exactly fifty years before, came to an end. General Mahon, R.A., from whose history of the Porto Novo Works this narrative has been drawn, points out that, in the last stages of the Company's history, even the charcoal difficulty ceased to be the principal cause of failure. What finally shattered for ever the high hopes originally formed was that the rapid growth of the iron industry in England, the more scientific methods adopted, and the greatly reduced cost of production, rendered Mr. Heath's original calculations about the possibility of competition entirely obsolete. The

great lesson of the Porto Novo Works is that an extensive iron industry can never be established in India upon a charcoal basis. The other notable fact is that throughout Mr. Heath appeared to have looked for success to the export of bar iron to England as a chief source of profit and never contemplated the establishment in India of a completely self-contained iron industry. Though he failed, the history of the Porto Novo Works has proved a valuable guide to those who came afterwards. His mistakes were due to lack of practical experience and to an ardent disregard of the highly technical character of the scheme he propounded. He was in advance of his time. His broad ideas were sound enough, but he could not foresee that only the discovery of the basic process, long after his death, rendered possible the creation of a great iron and steel industry in India.

Attempts were afterwards made to smelt iron in Chota Nagpore, which now forms part of the province of Behar, and at Kaladunghi, near Naini Tal, in the United Provinces. Little information now remains about these enterprises, but Sir Thomas Holland, formerly Director of the Geological Survey of India, says that "the ruins of furnaces and workshops stand as silent witnesses to misguided effort." The first iron and steel works in India which ever attained even a moderate measure of success were established near Barakar, on the Jherria coal-field, about 130 miles north-west of Calcutta, in 1875. The undertaking suffered many reverses at the outset, but in 1889 it passed into the hands of the Bengal Iron and Steel Co., who entrusted the management to Messrs. Martin and Co. The works, which were entirely remodelled, include four blast furnaces, which can each produce eighty tons of pig-iron a day. The endeavours originally made to manufacture basic steel at Barakar were not pursued largely because the buildings constructed were unsuitable, owing to their intense heat. The Company possesses, however, pipe

foundries and sleepers and chair foundries, and manufactures miscellaneous castings. It is now flourishing, and though its range is limited, its controllers deserve recognition because they were the true pioneers of the modern iron industry in India. They have never accomplished great things, but they have laboured arduously and successfully to overcome adverse conditions.

In the year 1899 General (then Major) R. H. Mahon, an artillery officer who had been Superintendent of the Government Ordnance Factories at Cossipore, issued a memorable report upon the manufacture of iron and steel in India. In the previous year, there had been a great revival in the iron trade throughout the world, and Major Mahon declared that the time had arrived for India to establish iron and steel works "on a considerable scale." He began by insisting that it was useless to attempt to produce charcoal iron in large quantities. Coal, the production of which was just beginning to increase greatly in India, must be the fuel used; and it says much for his foresight that he not only indicated Bengal coal as the only source of supply capable of being efficiently transformed into coke for blast furnaces, but suggested that the Jherria coal-field would furnish the largest supply of coal of the requisite quality. When Major Mahon turned to discuss the sources of supply of iron ore and limestone, he was on less sure ground, because at that time the available information was extremely incomplete. He thought that limestone would probably have to be brought from Burma, where, on the Arakan coast, there are inexhaustible supplies; but he was cautious enough to add that there was "little doubt that the creation of a demand for pure limestone will be followed by the discovery of fresh supplies of this not uncommon rock." As to iron ore, he selected three areas as probably suitable for his purpose—the Salem mines in Madras, the Chanda mines in Central India, and the mines in the Bengal area. Of the Bengal

mines he said, however, that "it is open to the gravest question whether any brand of pig-iron suitable for subsequent working into steel of high quality could be made on a large scale from Bengal ore alone." He further observed that "although the ores of Bengal are spread over a wide area examinations of these have not so far shown that any one site or even any one neighbourhood would yield a sufficient output to supply the needs of a large works." On both these points Major Mahon was wrong, but he cannot therefore be criticised. He was not a prospector, but was writing upon such data as were then accessible, and his conclusions were in accord with the scanty facts then known. The genius and stubborn perseverance of Jamsetjee Tata and his successors were to prove in a few years that within the boundaries of the old province of Bengal, iron ore of the finest quality existed in unlimited quantities; and they were further destined to discover a huge supply of excellent flux for blast furnaces without going overseas to Burma.

In other respects General Mahon's report was almost prophetic. He contended that Calcutta or its neighbourhood would be the best site for iron and steel works, and he laid down three principles which should guide the promoters of such an enterprise. The first was that the plant of the works must be thoroughly modern in every detail; the second that the management should consist of persons "combining expert knowledge with local experience;" and the third that economy in collecting and assembling the raw material would have to be insisted upon in order to secure a return upon initial outlay. All these conditions were duly fulfilled when General Mahon's dream of a great iron and steel works for India was realised.

For another, and an even more practical dreamer, was already shaping in his mind the great scheme which was to provide India with a huge iron and steel works of the most

modern kind. The idea of utilising upon the largest possible scale the iron deposits of India had simmered in the mind of Mr. Tata for very many years. In 1882, when he was still spending much of his time at Nagpur and supervising the Empress Mills, he chanced to see a document which had just been issued by the Government. It was a "Report on the financial prospects of iron working in the Chanda district," by Ritter von Schwarz, a German expert, who then and for many years afterwards, was frequently employed by the authorities in investigating the iron and coal deposits of India. Von Schwarz was not the first inquirer who had examined the Chanda district. Mr. Bauerman had visited the field in 1873, and others had followed him. Von Schwarz stated that the most important and the best situated deposits of iron ore in the Chanda district were the specular ore at Lohara and the magnetite at Peepulgaon. "Each of these deposits," he said, "forms a continuous accumulation of compact iron ore." He was apparently the first to announce the existence of the afterwards famous "hill of iron" at Lohara, and he gave its dimensions as three-eighths of a mile long, 200 yards broad, and 100 to 120 feet high. He further said that the coal of the adjacent Warora district was only good enough for the "refining process, namely, the conversion of the pig-iron into finished iron and steel." Von Schwarz seems never to have contemplated the smelting of the ore otherwise than by charcoal. He pointed out that fuel could only be obtained from the forests within a 20-mile radius, that the utmost yield of charcoal would be 32,000 tons yearly, and that the output of iron would therefore be approximately limited to that quantity, allowing one ton of charcoal for each ton of pig.

Mr. Tata's active mind was fired by his perusal of the report of Von Schwarz. It is believed that he visited Lohara, a name which may be freely translated as meaning "the place where iron is found." There are five or six Loharas in

the Central Provinces. He was not satisfied with the conclusion of Von Schwarz that the Warora coal would not coke sufficiently well to smelt iron ore. He had the coal analysed—the Warora mine is now closed, but was worked by the State until 1906,—and at a later date he took specimens to England where coking trials were made with no very satisfactory result. He thereupon advertised in various technical journals, offering a reward to any one who could devise a method of smelting the Lohara ore with Warora coke. Although no completely suitable method was found, some of the answers contained suggestions which Mr. Tata considered useful, and eventually he divided the reward between several persons. On his return to India, he went to Sir John Henry Morris, the able administrator, who had then for fifteen years been Chief Commissioner of the Central Provinces. He asked for a concession to work the Lohara ore deposits with the Warora coal. His intention was, he said, to form a company, and he further requested that the branch railway from Wardha Junction to Warora might be placed under the control of the proposed Company. One can imagine that Sir John Morris was a little breathless when confronted with this sweeping proposal. He and Mr. Tata had always been good friends, and he had deeply appreciated Mr. Tata's services in developing a great industry at Nagpur; but in those days the Government still looked suspiciously upon mining projects and all that pertained thereto. The unfortunate exclamation of Lord Lawrence: "I know what private enterprise means! It means robbing the Government!" still defined the spirit in which the authorities contemplated schemes for tapping the country's unutilised resources. Sir John Morris was not unfavourable, but he was helpless. The Warora line was worked as a branch of the Great Indian Peninsula Railway, and was 45 miles long. The Government thought a great deal about the strategic value of railways and very little of their commercial uses. They could

not contemplate handing over their coal mine, and the railway line leading to it, to private control. Mr. Tata, on his part, was unwilling to pursue his scheme unless he had control of the means of transportation to the trunk line. It was therefore dropped, and for many years nothing more was heard of the Chanda iron deposits. The time was to come, long afterwards, when the Government of India were to spend over a quarter of a million sterling in building forty miles of new railway to assist Mr. Tata in his scheme for iron and steel works; but he had to wait twenty years to see the birth of a new spirit.

One obstacle which for a long time cooled the active interest of Mr. Tata in iron and steel projects was the absurdity of the Indian regulations for mining and prospecting, which seemed carefully devised to obstruct and prevent development. It was not until 1899 that investigators were released from the antiquated chains in which they were bound. I have dealt with this question in another work,* wherein I said:—

> "In his first year in India (1899), Lord Curzon issued revised rules for mining and prospecting; I believe the question had been under consideration before his advent. The extraordinarily obstructive and unjust rules previously in force are scarcely conceivable to-day, but they illustrate very forcibly what I have already said about the former attitude of the Government of India towards private enterprise. One ridiculous rule was that no prospecting license could be granted to a company or syndicate, although mining enterprises are usually entered upon by associations rather than by individuals. The framers of the original rules seem to have been inflamed by an almost inexplicable intolerance of companies and syndicates. Again, even a prospector for coal was limited to an area of four square miles, and it was further directed

* "India under Curzon and After."

that at least eight miles must intervene between any two prospecting grants to the same person! Prospecting for coal is sometimes an elaborate business, involving heavy initial outlay, and such a rule was almost prohibitive. A disgracefully unjust rule was that "when any area has been explored and its value as a field for mining is sufficiently ascertained," provincial Governments were empowered to refuse to grant prospecting licenses, and to put up the whole of the mining rights for sale by auction. It is hardly possible to estimate all the mischief that single enactment did in retarding the development of the mineral resources of India. By its provisions the Government, after permitting an individual to undertake the arduous work of exploration, were enabled to step in, regardless of the preferential claim established by the explorer's industry and enterprise, and sell to any competitor all the mineral wealth he had revealed. A Chinese mandarin of the old school would hardly have been capable of more shameless injustice. A ludicrous regulation was that when premises and mines were abandoned, the workings had to be handed over to the Government "in a workmanlike state." Even an exhausted coal seam had to be delivered up "in a proper state for working" if the rules were insisted on.

The old mining rules were by no means a case apart; they were simply a fair illustration of the normal demeanour of the Government of India towards business men for a period of half a century. The changes made in them by Lord Curzon were the first fruits of the new policy by which he instilled confidence into every branch of commercial life. All the regulations I have quoted were ruthlessly destroyed: royalties on precious stones and gold and silver were based on net profits

instead of on output, and thus an iniquitous provision which had cost the Burma Ruby Mines Company £150,000 while it was working at a loss was abolished; the royalty on coal was reduced from 2*d.* to a 1*d.* per ton; an absurd prohibition controlling the assignment of interests was excised from the rules, and in many other ways the whole of the conditions were revised.

The reform gave a great impetus to mining enterprise in India. Sir Thomas Holland, in a lecture to the Royal Society of Arts in April 1911, pointed out that the year 1899 was memorable in regard to mineral questions, in two ways. In that year not only were the new mining rules promulgated, but a gold standard of currency with a fixed rate of exchange was adopted. English investors knew for the first time the exact nominal value of their outlay and the worth of their dividends . . . . Certain flaws in the new rules have now been rectified; but after ten years' working Sir Thomas Holland was able to testify to "the generous nature of the rules as a whole."

Mr. Tata had never abandoned his hopes of developing the mineral resources of India. The copious cutting books which he kept show that for years nothing published about Indian minerals had escaped his watchful eye. He was a great reader of newspapers, but always with special regard to the questions in which he was deeply interested. He saw General Mahon's report as soon as it appeared in 1899; and when in the same year the mining and prospecting regulations were revised, his mind turned with revived activity to his schemes of long ago.

In the Summer of 1900, Mr. Tata, while in England, saw Lord George Hamilton on the question of a family settlement in connection with the Institute of Science, which he proposed to endow. The conversation passed to the question

of the cotton excise duties. In illustration of his contention that industrial enterprise in India was often thwarted by official opposition, Mr. Tata related to Lord George the story of his attempts to found an iron and steel industry twenty years earlier.

The services of Lord George Hamilton to India have never been sufficiently realised. He was for four years Under-Secretary for India, and for seven years Secretary of State. No other English Statesman except Sir Charles Wood (afterwards Viscount Halifax) has been associated with the administration of India for so long a period. Lord George Hamilton was always ready to give a sympathetic ear to schemes for the advancement of India, as many Indian visitors to England have had occasion to know; and he instantly urged Mr. Tata to revert once more to his scheme for an iron and steel industry. His great desire, he said, was to see Indian industries developed with Indian capital; and he added that from what he had heard he felt assured that in Mr. Tata the Government of India had found the man they had been looking for. Lord George expressed surprise, and a little incredulity, at Mr. Tata's roseate accounts of the rich deposits of iron in India. Even if he had seen General Mahon's report, he had not fully realised that the prospects of establishing a successful iron and steel industry on an extensive scale were as hopeful as Mr. Tata seemed to think. Mr. Tata explained that there were other confirmatory reports, and at the request of Lord George he telegraphed to Bombay for these documents. Even the forgotten report of von Schwarz was rescued from some dusty pigeon-hole for the Secretary of State's perusal. Mr. Tata was moved by the cordiality of his reception to explain to the Secretary of State not only his hopes, but his fears, for the success of his scheme. He was twenty years older, he said, than he was in the days when he first turned his attention to the Chanda deposits.

At that time he was ambitious, he had his way to make in the world. Now God had given him enough and to spare, and there was no reason why he should go on, save only his deep concern for the better welfare of India. He was afraid that if he persevered in his enterprise, he might meet with rebuffs from officials. Lord George replied that Lord Curzon would assuredly help him. What better backing could he desire than the support of the Viceroy? Mr. Tata's answer was that Viceroys come and go, and that before his scheme took final shape he might find himself dealing with strangers who would treat him with indifference. He knew his India. The Secretary of State reassured him, strongly urged him to proceed with his task as a duty he owed to his country, and promised to authorise the Government of India to give him all possible help. The promise was faithfully fulfilled. Lord George wrote to India expressing the warmest interest in the project, and signifying that any steps the Government of India might take to assist it would receive his ready endorsement. From that time onward, Mr. Tata and his successors never had much reason to complain of any lack of official support.

Those unfamiliar with the British system of controlling India may wonder why it was imperatively necessary to interest the Secretary of State in the scheme. India had a Viceroy and an Executive Government on the spot. Why, it may be asked, should London be consulted? The answer is that the India Office exercises a constant supervision over the executive acts of the Government of India. The scrutiny is especially close in cases of expenditure of an unusual character. Help to Mr. Tata meant, in the long run, expenditure in unusual directions. Unless the interest of the Secretary of State and his advisers had been urgently solicited, the proposed outlay might have been disallowed.

On his return to India, Mr. Tata applied for prospecting licenses for the Lohara and Peepulgaon areas in the Chanda

district. His applications were favourably received by Sir Andrew Fraser, who had become Chief Commissioner of the Central Provinces. Sir Benjamin Robertson, then Chief Secretary to the Central Provinces Government, also gave him much encouragement. Through these applications Lord Curzon and Sir Edward Law, then Minister of Finance, became aware of Mr. Tata's schemes. The mistake he made at this stage was that the work of prospecting was placed in the hands of agents with insufficient experience, and for a long time there were no very definite results. By letters to the late Sir Richmond Ritchie, he kept Lord George Hamilton acquainted with what he was doing, in fulfilment of a promise made when in London. His methods were leisurely, and he had no intention of rushing with insufficient inquiry into a great scheme. At Nagpur and Simla it was thought that he was too leisurely, but he would not be hurried.

Mr. Tata left India once more at the beginning of May, 1902, on the Austrian Lloyd Steamer *Imperatrix*, and reached Trieste on May 17th. He stopped for a couple of days in Paris, and on reaching London saw Sir Richmond Ritchie at the India Office. He sought another interview with the Secretary of State, partly regarding the Research Institute, though he was also anxious to discuss his iron scheme once more. In a letter dated June 20th he says that he found Sir Richmond Ritchie "very sympathetic;" but much to his disappointment, he was told that there would be "no chance of a good long talk with Lord George Hamilton" until the Coronation festivities were over. On July 4th, in a postscript to a letter to Sir Dorab Tata, he says:—

> As regards our iron and coal business, I am sorry nothing has been and can be done yet. Everybody seems to be absorbed in something of his own. But from next week the Secretary of State has promised to attend to the matter.

• The promise does not seem to have been immediately fulfilled, for Secretaries of State are very busy Ministers. When Mr. Tata wrote again from London on August 1st, the promised interview had not been given. Repeating his action a couple of decades earlier, he had once more brought to England various samples of Central Provinces coal. Regarding these, he says, in a letter to Sir Bezonji Dadabhai :—

> As regards the coking of coal I am having experiments made in Germany and America. I am going to Germany next week, and will see to the matter. In America I have been promised every assistance by Sir Clinton Dawkins, through his firm of Pierpont Morgan in New York. So far the results of the trials are fairly satisfactory.

Sir Clinton Dawkins had been Finance Minister in India, and must have been well acquainted with Mr. Tata and his work. Mr. Tata spent the greater part of August at Carlsbad, and at the beginning of September went to Dusseldorf, where he saw the Exhibition and attended the Congress of the British Iron and Steel Institute. He then returned to London, and on September 18th, wrote thus to Sir Dorab :—

> I am sorry I have not been able to see either the Secretary of State or Lord Reay, they both being in the country for the vacation. But I have written to Lord George to give me a few minutes interview should he come down for a Cabinet meeting, or let me go and see him at his place, before I leave for America on the 24th. I must try to do this, as on my return from America I may not have more than three or four days to spare here.

Fortunately Mr. Tata was eventually able to see Lord George Hamilton before he crossed the Atlantic, and among other things the iron and steel scheme was once more discussed.

Mr. Tata sailed for the United States on September 24th, and stayed in America for some weeks. He quickly attracted the insatiable curiosity of the American newspaper reporters,

and many cuttings are preserved of the amusing and not always very veracious articles which were published about him during his visit. When possible, he evaded the interviewers, or managed to pass them on to his New York Agent, Mr. A. P. Cochrane, who accompanied him to various cities. At times, however, he was cornered, and then he submitted to the ordeal good-humouredly enough, and talked freely about his projects. Afterwards he was annoyed to find that one of the leading Anglo-Indian newspapers had reprinted extracts from the most fulsome of the American articles, with some rather wounding comments. He was by no means insensitive to ridicule, and when I saw him in the following year he complained that he had been unfairly blamed for the reckless statements of American journalists.

That they drew extensively upon their exuberant imaginations is clear from the records which remain. One Cleveland writer, after describing him as "a jolly good fellow," declared that he was "the J. P. Morgan of the East Indies," and that his partner was "the Nizam of Hyderabad." When he went to Grand Rapids, a local newspaper announced that he was "the richest man in all India and one of the wealthiest men in the entire world." It went on to say that he was "so rich that he has little idea of his own wealth, his possessions even exceeding those of the late Li Hung Chang, who was reckoned the richest man in the world." It mildly complained, however, that "he was not inclined to be communicative." The *Birmingham Ledger* said that "he enjoys the distinction of having refused to be knighted by Queen Victoria at the sacrifice of his religion," and asserted that he "wore a large diamond in his shirt." The *Birmingham News* was much more sedate, and on the whole extremely accurate, but insisted on christening him "John N. Tata." It would be unfair to suggest that all the articles and interviews were wildly written. Some were admirably done, and one of the Cleveland journals printed a

very long and careful account of Mr. Tata and his schemes.

Mr. Tata seems to have stayed some days in New York, and then went to Washington, where he was entertained by ex-Secretary of State John W. Foster, with whom he had some previous acquaintance. The news of his scheme for working the iron deposits of the Central Provinces had already been published in the New York papers. The *Washington Post* wrote of him that he was "merchant prince, manufacturer, and importer, and likewise philanthropist, scholar, and philosopher." From Washington he went to Pelzer, in South Carolina, where he inspected a large cotton factory. He never lost any opportunity of enlarging his knowledge of the industry which had laid the foundation of his fortunes. Thence he proceeded to Atlanta, the capital of Georgia, and examined more cotton mills. On October 20th he reached Birmingham, in Alabama. Birmingham stands in the midst of "an immensely rich iron, coal and limestone region," and is "the most important centre for the production of iron and steel in the southern states." The city also does a large trade in cotton. At Birmingham he saw Mr. Erskine Ramsey and other prominent manufacturers of iron and steel, and made special inquiries into the various coking processes used in the district. The difficulties likely to be experienced with Indian coal were ever present in his mind. He told one interviewer at Birmingham about the primitive and wasteful methods of Indian smelters in the Chanda district, and said they required eight tons of ore and fourteen tons of charcoal to produce one ton of wrought iron. To another interviewer he mentioned the possibility of smelting by electricity. There was, he said, abundant water power ready to hand; but he added that he regarded the making of coke as the key to the problem, and "did not despair of ultimate success." While at Birmingham, he also studied with characteristic zeal the gins and other devices for handling cotton made by the Continental Company.

Birmingham happens to manufacture large quantities of cotton-seed oil, and he was eagerly questioned about the possibility of Indian competition in this product. He replied that India had only made cotton-seed oil "in an experimental way," and he pointed out that cotton-seed was an important food-stuff for Indian cattle. To deprive them of it, even for the manufacture of oil, would be in his opinion "a very serious thing." His statement still holds good, though developments were even then taking place which he evidently did not foresee, as after his death his own firm carried out an experiment in pressing cotton-seed oil, which was not successful. In the first years of the new century India began to export cotton-seed in large quantities. More recently there has been some decline, and the bulk of the seed is still reserved for home consumption. In 1912-13 India exported 130,564 tons of cotton-seed, out of a total available supply of 1,306,000 tons. The exports represented a decline of 35 per cent. due chiefly to a temporary shortage of supply.

From Birmingham Mr. Tata went to Chattanooga, in Tennessee, where he was again in the centre of an important iron-district. Into the next twenty days he crowded a great deal of rapid travelling, for by November 19th he was back again at the Holland House in New York. On October 26th he wrote from the Auditorium Annexe, Chicago, to his son Dorab, who was then in charge of the prospecting and other preliminary work in connection with the investigation of the scheme:—

> "I am glad to see that the Chief Commissioner has been good enough to sanction the further extension of two years to our prospecting license for iron in both the Lohara and the Peepulgaon blocks. Also that in addition to iron we are to be allowed to prospect for copper, coal, and manganese, and that we are also to be allowed a license for the additional area for which you have applied,

as it was near to Peepulgaon and was reported to contain a coal bed at a place called Bandur, and limestone at Minjaree. . . .

I am glad that our Nagpur people are busy exploring things there, and have got to discover two old borings made by Government some years ago. I am sorry you have not heard anything yet about the concession for Bellarpur coal. I hope the surveys of the P. W. Department have been completed. They may enable the Chief Commissioner to define the boundaries of his grant. . .

I am glad that the matter of the Pisgaon coal bed is also cleared up. I do not think we shall have much difficulty in obtaining the concession to work this in native territory on the other side of the river. . . .

It is quite necessary for all experiments as regards the coking of our coal, that some of the Bellarpur coal should arrive here in time, as we are not quite sure about the coking of the Warora coal which we have had. Even if that should coke, and though the Bellarpur coal be richer in carbon by nearly 50 per cent., still it does not always happen that a richer carbonaceous coal is more cokeable than a poor one. So it is necessary that we have about five or ten tons of this Bellarpur coal to carry on our trials. Even if this should fail, of course we have the other coal at Umaria, which has been proved to be of a coking quality, and though nearly 250 miles from our ore, yet can still be made available for working it. . .

As regards the rich iron ore field in the Indore Territory, about which the Resident spoke to you, it is a place I know. The Government of Indore spent many lakhs of rupees on it, and about three years ago advertised for sale the mines at Burwai. Nobody replied, and I believe they are still in possession of that Government and unworked; but our hands being already full in the Chanda

District, I do not think that we should at all try to get these mines at Burwai, as I do not think they will be taken up by anybody within any reasonable time."

The Resident referred to above was Sir David Barr at Hyderabad whom Sir Dorab saw in connection with concessions in Berar, then under his jurisdiction.

From Chicago, which he knew quite well owing to his visit to the World's Fair in 1893, Mr. Tata went to Grand Rapids, in Michigan, a city which is said to have "a world-wide reputation as a furniture centre." The local papers remarked that he "attracted much attention about the streets and in the Pantlind Hotel," and were ingenuously surprised at his fair complexion. He inspected several of the large furniture factories, and made extensive purchases. All his life he was an ardent shopper, and a joy to zealous salesmen. Some of his friends were wont to say that he bought recklessly and without discretion; but it was noticeable that he always bought with a purpose. His habit of shopping largely wherever he went was really due to the promptings of his curious and inquiring mind. He wanted to test new things, and to try the products of other countries. At Grand Rapids, for instance, it is recorded that he flatly refused to look at articles made of mahogany, with which he was familiar, and only bought goods made of bird's eye maple and other typical American woods. Even in the midst of his absorption in his great schemes, he also found time at Grand Rapids to drive out and inspect the black bass hatchery at Mill Creek.

His next important stop was at Cleveland, in Ohio, on the shores of Lake Erie, where he was at last approaching the ultimate object of his journey to America. Cleveland is "the largest ore market in the world," and manufactures enormous quantities of iron and steel products. Mr. Tata was welcomed to the city by Senator Mark Hanna, famous as the campaign manager of the Republican party, the apostle

of the "full dinner pail," and the devoted ally of President McKinley. Senator Hanna summoned to his office more than a score of local authorities on iron and steel, including some of the officials of the American Steel and Wire Company. The conference about the Indian project lasted several hours, and the papers afterwards noted that those who talked with Mr. Tata said that he was "remarkably quick in grasping things, and that he gained considerable valuable information." Senator Hanna also entertained Mr. Tata at a dinner party, whereupon the newspapers flared forth with the headlines:— "Hash for Tata. Hanna Invites the Indian Merchant Prince to Dinner." Another of his hosts at Cleveland was Colonel Myron T. Herrick, the President of the American Bankers' Association. While in Cleveland, too, he saw a good deal of Mr. A. E. Brown, the head of the Brown Hoisting Machinery Company, and examined the company's mechanism at work in the Cleveland docks. He said afterwards:—

> "We need just such an improvement as that in Bombay. There are usually at least thirty big vessels there receiving or discharging cargo, and the methods used are slow and unsatisfactory. Till I saw the Brown mechanism working I had supposed that the best and quickest work of loading vessels was accomplished at Nagasaki, where I have seen the natives load 2,000 tons in 10 hours."

It should be added that the Bombay Docks, which have since been much enlarged, are now amply equipped with hydraulic cranes and other contrivances of the most modern type.

Commissioner Booth Tucker, of the Salvation Army, writes respecting Mr. Tata's visit to Cleveland:—

> "One of the most pleasant associations I had with Mr. Tata was during the time when I was in charge of the work of the Salvation Army in America. He had written to tell me of the many difficulties he had encountered

in launching his great steel enterprise. I suggested that he should come over and visit the principal steel centres in America, and get in touch with the leading magnates connected with the Steel Trust and other great Corporations. Amongst these were some warm friends and admirers of the Salvation Army, and these would, we felt sure, give all desired information and assistance.

In this we were not disappointed. America is keenly interested in India, and there was a touch of romance which appealed strongly to the American mind in the landing of the great magnate and philanthropist.

Judge Cory, the President of the Steel Trust, invited us to luncheon to discuss matters, and the door was thrown wide open to their Indian guest to visit the very arcana of the Steel World, and to help himself to all the information and advice that the greatest steel leaders of the world could supply. A banquet was arranged at Cleveland by Senator Hanna and Colonel Herrick, and nothing could have exceeded the cordiality of Mr. Tata's reception.

It was interesting to see Mr. Tata in close touch with such geniuses as Senator Hanna, who was then in the zenith of his power, and who, as Chairman of the Republican Party, might well have been termed the uncrowned king of the United States. I was proud of our Indian representative. Amidst such a constellation of suns and moons, stars of even exceptional brilliance would have disappeared from view, or at least been dimmed. But our Indian luminary lost nothing of its brilliance in this company. It was a great gratification to me to learn afterwards from these leaders that a profound impression had been made upon them by their guest, and that it had given them a new idea of Indian possibilities."

It was at Pittsburgh in Pennsylvania, however, that

Mr. Tata at last attained his purpose, and found precisely the advice and help he sought. Pittsburgh ranks first among the cities of the United States in the manufacture of iron and steel products, of which it sends forth more than 50 per cent. of the output of the whole country. It stands in the midst of productive coalfields, and absorbs a large proportion of the iron ore produced in the Lake Superior region. Its neighbourhood contains the chief plants of the immense United States Steel Corporation. It is also the home of the Westinghouse Company, the famous organization which manufactures electrical apparatus, air brakes, and railway signals and other devices. Curiously enough, Mr. Tata appears to have seen Mr. George Westinghouse, the inventor of the air brake, almost as soon as he reached Pittsburgh. Despite his preoccupation with the iron scheme, he was thinking constantly of the proposal for creating and harnessing water power in the Western Ghats. Mr. Westinghouse had played a large part in the utilisation of the Niagara Falls, and it was under his guidance that Mr. Tata, while at Pittsburgh, made a special journey to Niagara to inspect the machinery used there. He was also entertained at Solitude, the residence of Mr. Westinghouse at Homewood. Iron soon reclaimed him, however. He went over the Homestead and Duquesne mills of the Carnegie Steel Company, and met many leaders of the industry; but the great result of his Pittsburgh visit was that he encountered at last the man for whom he had been searching.

This was Mr. Julian Kennedy, the head of the firm of Julian Kennedy, Sahlin & Co., Ltd., Engineers, whose headquarters are at Pittsburgh, with a branch at Brussels. Mr. Kennedy is one of the foremost metallurgical engineers in the world, and has a reputation which may well be described as international. His partner, Mr. Axel Sahlin, who in normal times is stationed in Brussels, is an equally remarkable man, of varied knowledge and wide experience. Mr. Tata unfolded

his scheme to Mr. Kennedy and received the practical counsel he required. Mr. Kennedy's acquaintance with the iron and steel business is encyclopædic, but his firm now specializes in the designing of metallurgical plants. He told Mr. Tata that he must first institute a far more thorough and scientific investigation of the local conditions, the raw materials, and the markets of India, than he had hitherto done. He also warned him that the preliminary inquiries would probably cost large sums of money; but he pointed out that it would be unwise to embark upon an enterprise which in the end would cost millions, without first conducting an exhaustive examination of the possibilities. If, he said, Mr. Tata was prepared to face the cost, then he knew no one better qualified to undertake the geological work, which must be the initial step, than Mr. Charles Page Perin, an eminent mining engineer of New York.

Mr. Tata was not dismayed. He believed in his scheme, and was determined to go through with it. His search was over, for he resolved to follow Mr. Kennedy's advice implicitly, and did so to the end. He returned at once to New York and saw Mr. Perin, whose services he engaged. Mr. Perin could not go to India at that time, and advised Mr. Tata to employ his associate, Mr. C. M. Weld, another man of remarkable energy and capacity. Mr. Weld agreed to begin the work, and started for Bombay almost immediately. Mr. Tata stayed in New York a few days longer, and reached London on November 25th. He was only four days in England, after which he hurried to Germany and settled the contract for the electric lighting plant for the Taj Mahal Hotel. He sailed from Trieste for Bombay on an Austrian Lloyd Steamer at the beginning of December, being accompanied by his relative and partner, Mr. R. D. Tata, and Mrs. Tata. Mr. R. D. Tata had gone with him to the United States, but did not accompany him on his journey to the south and to the iron districts. He says it was remarkable to notice how closely Mr. Tata concen-

trated upon his schemes during the American visit. He declined to go anywhere sight-seeing, except to mills and other enterprises in which he was specially interested. The story of his diamond studs was constantly printed, although as a matter of fact his sleeve links and studs were of the plainest silver. No man was less ostentatious in his apparel. In New York an interviewer one day followed him into a shop while he was buying some boots. Mr. Tata declined to be interviewed, but next day a New York newspaper gravely announced that "the Pierpont Morgan of the East" was trying to acquire a monopoly of the American boot trade.

Two days after he reached Bombay, he went to Delhi, to attend the Imperial Coronation Durbar held by Lord Curzon to mark the accession of King Edward VII. I remember meeting him in the arena of the amphitheatre before the Durbar on New Year's morning. He was clad in the simple white dress of his race, which he usually wore when in India. Mr. Tata attended the Durbar as a private visitor, and his name does not even appear in the official Directory of the Assemblage. There was something lacking in a method of selection which omitted one of India's most prominent men from the list of official guests.

As soon as he saw his son Dorab, on his return to India, Mr. Tata urged him to concentrate upon the iron scheme. Sir Dorab agreed to do so, and from that time onward the enterprise was largely in his charge. Mr. Tata, whose health was already beginning to fail, did little more active work upon it. During the remainder of his life, he kept in close touch with the undertaking, gave constant advice, and saw the various persons employed upon it when they passed through Bombay; but henceforward the story deals with the labours of others. Mr. Tata conceived the broad idea; he got the scheme moving; he found the large sums required to keep it going; but he was no longer able to face physical strain

as he was when he personally superintended the building of the Empress Mills in the 'seventies. His mind moved as vigorously and spaciously as ever. There were moments in the last two years when to those around him his schemes and dreams seemed more illimitable than they had ever been before. Had he had another twenty years of robust health he might have done wonderful things; but in the twilight of his career he had to stand aside, and he did so with calmness and without vain regret. No one ever heard him complain of his diminishing energies. It was, indeed, difficult even for his own family to realise that his strength was slowly ebbing. His interest in affairs remained fresh and keen almost to the end; but he could not undergo the intense and laborious toil which the iron scheme was now to involve.

The prospecting work in the Chanda District was at that time being conducted under the supervision of Mr. Shapurji Saklatwala, a nephew of Mr. Tata. Mr. Saklatwala was not an expert, and it was through no fault of his that the enterprise had languished. He had established camps in various places in the blocks for which Mr. Tata held prospecting licenses. He was also boring for coal in a new coalfield beyond Bellarpur, a place 38 miles south-east of Warora. The Bellarpur coal measures are mentioned in Mr. Tata's letter from Chicago. A concession had been sought for the Bellarpur coal. The Government refused to grant it, because it had decided to open up the Bellarpur field itself. Permission was given to try farther on, but it was feared that at the allotted point the seam dipped.

In April, 1903, Mr. Weld and Sir Dorab Tata joined Mr. Saklatwala, and entered upon a period of adventurous wanderings which was often marked by much privation. The heat in the Central Provinces in April, May and June is intense. The prospectors were generally moving far from the railway, and sometimes had difficulty in obtaining food. Water was

frequently scarce and bad, and they were often compelled to make their tea with the soda-water they carried on their carts. There were times when they could make hardly any progress at all. The district includes large forest areas, which are the joy of the hunter because tigers are numerous; but prospectors for iron and coal regard a multiplicity of tigers with more apprehension than delight. Roads were few and indifferent. Sometimes the party found shelter in a village house, but there were many nights when they had to sleep in their carts. At first they lived very roughly indeed. At a later date, when the magnitude of their task dawned upon them, they procured tents and pitched camp in orthodox fashion. Wherever they went, Mr. Weld made a careful geological examination of the locality, conducting his researches with much minuteness and patience. He had many curious experiences during the four years he spent in India at the instance of the Tatas; and should he ever commit them to paper, they will form a prose epic of prospecting.

There were simultaneous difficulties of another kind. Lord Curzon, who was eager to see iron and steel works established in India, grew impatient at the delay. He wanted to know what Mr. Tata was doing with his prospecting licenses, expected to see tangible results, and had small sympathy with the slow and cautious methods adopted on the advice of Mr. Kennedy and Mr. Perin. Sir Thomas Holland, the Director-General of the Geological Survey, was more appreciative, but at that early stage could give little help. He too had to await results. Then rival prospectors appeared in the Central Provinces. Sir Ernest Cassel, the great capitalist, who has done so much for the development of Egypt, had visited India during the cold season of 1902-03, and the Viceroy had aroused his interest in the iron question. He was advised to investigate iron deposits which were reported to exist in the neighbourhood of Jabalpur, in the most northerly portion of

the Central Provinces. He sent out two experts, Mr. E. P. Martin and Professor Henry Louis, who examined the Jabalpur District with considerable care. Mr. Tata regarded their advent with calmness. He had made private inquiries, and was advised that he had nothing to fear from Jabalpur. The advice he received was accurate. Messrs. Martin and Louis have recorded their researches in the *Agricultural Ledger*, in a report upon "Native Methods of Smelting and Manufacturing Iron in Jabalpur." The conclusion they came to was that "the entire district undoubtedly contains considerable quantities of ferruginous material, but the latter is nowhere concentrated into what may be called a workable ore deposit showing the essential characters of steadiness and persistence which are indispensable in a deposit that is to form the basis of an important industry." There was no prospect of a successful iron and steel works in the Jabalpur area. Messrs. Martin and Louis further stated that most of the Jabalpur ore, being in the form of soft micaceous hematite, was physically unfit in its natural condition for use in a blast furnace. Moreover, the ore contained a proportion of phosphorus too high for acid Bessemer steel.

That was the end of Sir Ernest Cassel's endeavours, but other competitors were less seemly. For some time Mr. Weld and Sir Dorab were shadowed wherever they went. Prospecting licenses were granted to people who worked in close proximity to themselves, occasionally almost within sight of them. They were taken up by people who hoped to dispose of them at a profit later on to the Steel Company when formed. These annoyances ceased in the end so far as the Chanda District was concerned, for the speculators whose imagination had been fired by a perusal of General Mahon's report did not possess the requisite patience and persistence; but the day came at length when even Mr. Tata and his agents began to despair of attaining success. Mr. Weld had quartered the

whole area covered by the prospecting licenses, and had travelled far and wide in search of suitable coal and a water supply. Iron he had found in Chanda in considerable quantities. Limestone was there in abundance, but with the Bellarpur seam barred, the coal difficulty seemed insuperable. The Warora coal mine, on which Mr. Tata had originally built such strong hopes, was getting worked out, and the Government was already preparing to shift its local operations from Warora to Bellarpur. In the matter of water and freight facilities, the outlook was more promising. A large reservoir was projected in the district, and the authorities were willing to furnish water therefrom. Sir Reginald Craddock, then Commissioner of the Nagpur District, who later became Chief Commissioner of the Central Provinces, was pressing forward a plan for the construction of a new railway—since built—from Chanda to Gondia, which would pass close to the iron deposits at Lohara. He expressed himself ready to advocate the addition of such branch lines to the ore-fields as were necessary. By this time, indeed, the Central Provinces Administration had become so thoroughly convinced that Mr. Tata and his representatives were in earnest, that they gave them the warmest help and encouragement. But coal was the obstacle, and through lack of it the whole scheme was imperilled.

At this critical stage it happened that Mr. Martin and Professor Louis passed through Bombay on their way home after their investigations in the Jabalpur districts. They saw Mr. Tata and inquired about the progress of his prospecting work in Chanda, probably with some idea of an amalgamation with Sir E. Cassels. At their instance Mr. Tata sent a wire to Sir Dorab who was then in Chanda with Mr. Weld to ascertain how much ore was in sight there, as they advised him that unless there was enough for at least 15 years working it was not worth anyone's while to go further with the scheme.

Major Mahon had suggested that Lohara hill was probably an outcrop and that the deposits in Peepulgaon and other places were part and parcel of the same ore-field. Mr. Weld had some trenching work carried out all round the hill to find out if the ore extended any distance beyond the hill. The result of the inquiry proved that the various deposits situated at some distance from each other were not continuous but mere " pockets," and that there was not enough ore in Lohara hill to justify starting iron works. So reluctantly they had to come to the conclusion that the Chanda project must be given up, and they asked Mr. Tata to inform Government that it was not possible to start an iron and steel industry in India. Mr. Weld then went alone on a final tour, inspecting various new coal-fields which had been found, and examining all the rivers in the Central Provinces in the hope of finding a place where, by damming, a cheap water supply could be provided. He came back unsuccessful, and in the ensuing despondency all the prospecting licenses held by Mr. Tata were subsequently surrendered, except the one relating to Lohara.

At this stage one of those chance incidents which make or mar all great enterprises stirred their energies afresh. Sir Dorab Tata went to Nagpur to see Sir Benjamin Robertson, then the Chief Secretary of the Central Provinces Administration, to inform him about the conclusion they had arrived at. The Chief Secretary happened to be out, so he drifted rather aimlessly into the museum opposite the Secretariat to await his return. There he came across a geological map of the Central Provinces, printed in colours. He noticed that the Drug District, near Raipur, about 140 miles from the Chanda area, was coloured very darkly, in a hue which was meant to indicate large deposits of iron. He called Mr. Weld, who had accompanied him, to look at the map. Mr. Weld recollected that he had seen some mention of the district in the reports of the Geological Survey. In a case in the museum

they found a specimen of very good iron ore from the Drug area. Let no one say after this that museums in India serve no useful purpose.

When Sir Benjamin Robertson reached his office, Sir Dorab reluctantly told him that it would be impossible to work the Chanda ore unless cokeable coal could be obtained near at hand. He went on to ask about Drug, and told him what he had seen in the museum. Sir Benjamin produced the records of the Geological Survey, and it was found that fifteen years earlier Mr. P. N. Bose, a Bengali, employed as a survey officer, had gone through the district looking for iron. In a report published in 1887, he had mentioned that the neighbourhood was rich in iron ore, but his investigations seemed to have been cursory, and his report had long been forgotten. Had Mr. Bose pushed his inquiries a little farther, he would have stumbled upon one of the richest deposits of iron ore in the world. One wonders, after the revelation which was about to be unfolded to the Tatas, how many other stores of minerals still lie hidden in India, awaiting chance discovery.

The prospectors lost no time. They did not know what lay before them, but they thought the Drug district was worth looking at. Mr. Weld, accompanied by Mr. Saklatwala, went at once to the spot indicated, and put up at a dak bungalow at another Lohara, called Dondi-Lohara. Again they found themselves shadowed by other prospectors whose agents were there on behalf of mining syndicates, searching for more manganese mines. That was the period when manganese production in India underwent enormous expansion, and when relatively impecunious people in Bombay and elsewhere rapidly grew rich beyond their wildest dreams. The country was pervaded by agents looking for fresh manganese "propositions," and it was remarkable how many of them prospered. The manganese industry in India is now firmly estab-

lished, and the latest returns show that it continues to expand. Sir Dorab Tata has since stated that he could have obtained several promising manganese concessions during his journeys through the Central Provinces; but he was looking for iron, and would touch nothing but iron.

The occupants of the bungalow were not the only other prospectors in the neighbourhood. It was hard, indeed, to go anywhere in the metalliferous regions of India at that juncture without striking the trail of a prospector; but though most of them were trying to find more manganese with as much ardour as the knights of old displayed in hunting for the Holy Grail, Mr. Weld and his associates soon realised that they included pertinacious folk who did not disdain common iron ore. Finding Mr. Weld at work with a hammer on the outcrop there, they concluded that he was after that body of ore, and wired to their principals who put in an application for a prospecting license before Mr. Weld had quite realised what had happened. But this was of no consequence as he had come to the conclusion that the Dondi-Lohara ore was only a "pocket," and he had no intention of applying for it as he had come to inspect the Dhalli and Rajhara hills a few miles further on. The whole district seemed full of promising indications, and he felt convinced that he had only to proceed farther in order to succeed. So he started early one morning in a country cart, and by a lucky chance took his gun with him in the hope of picking up some game for the cooking pot. Those who were shadowing him, not having heard of any other deposits in those parts, believing that he was going out on a shooting expedition only, did not think of following him and were thus thrown off the scent. He reached the village he was looking for and found some iron smelters who worked with primitive furnaces. He asked them where they got their ore, and they took him to a hill about 300 feet high. "We get it from this hill," they said. Mr. Weld climbed the height, and was as-

tonished to find that his footsteps rang beneath his feet as though he was walking upon metal. That was precisely what he was doing. He had found a veritable hill of almost solid iron! No more striking and remarkable discovery has ever been made in the whole history of the iron industry; and there was another hill not far away which was chiefly composed of iron also.

Hurrying back to Nagpur at once, he applied for a prospecting license for the Dhalli and Rajhara hills, the license was granted, in due course, after some official delay.

The next step after obtaining the license was to make borings in the hills with diamond drills, and this was done on an extensive scale in the Rajhara hill under Mr. Weld's supervision. The cores of the borings were analysed, as were also average samples picked up at random. The result of the first rough analyses showed that the ore carried about 65½ per cent. of iron; and more careful tests afterwards proved it to be even richer. It may be mentioned that the record maximum yield of iron ore on being smelted is 70 per cent. Specimens were forwarded to the Geological Survey, and Sir Dorab Tata took the earliest opportunity of seeing Sir Thomas Holland. The Director-General was frankly incredulous, and could not believe that ore had been found in India which yielded 65½ per cent. of pure iron. He said that iron was not found in such solid masses, to his own knowledge; that the deposits usually lay in streaks like streaky bacon; and that he felt the stories told him must be exaggerated. Sir Dorab invited him to come and see for himself.

He did so. On his next tour in the Central Provinces, Sir Thomas made a special journey to Dhalli and Rajhara. He had to do the journey on an elephant for 45 miles to the Tata camp at the foot of the Rajhara hill, and he arrived there one very hot morning shortly before noon. He refused a tub and breakfast, and said he would like to make his in-

spection at once. He went up the hill with Mr. Weld, Sir Dorab Tata remaining at the camp. His footsteps rang as they climbed the slope together. Even an inexperienced man would have soon perceived the nature of the substance on which they were walking. To the expert it was quickly obvious. Half-way up the hill Sir Thomas stopped and said: "I need go no farther. I have seen enough. I only wanted to satisfy myself that at the rate you propose to work, you have enough ore to last you for fifteen years, with an output of 250 tons a day. I am satisfied that you have. All I wish to test now is your analysis. I will pick my own specimens." He returned to the camp, and the samples of ore he had gathered were afterwards proved on analysis to contain 67½ per cent. of iron. Thenceforward Sir Thomas Holland was a most cordial ally and helper of the Tata enterprise, and gave it all the encouragement he could.

In the "Quinquennial Review of the Mineral Production of India during the years 1904 to 1908," by Sir Thomas Holland and Dr. L. Leigh Fermor, the iron-ores in the Dondi-Lohara district covered by the Tata license are thus described:—

> The iron-ores, on account of their resistance to weathering agents, stand up as conspicuous hillocks in the general peneplain. The most striking of these is the ridge which includes the Dhullee (Dhalli) and Rajhara hills, extending for some 20 miles in a zigzag, almost continuous line and rising to heights of sometimes 400 feet above the general level of the flat country around. The iron-ores are associated with phyllites and are often of the usual type of banded quartz-iron-ore schists characteristic of the Dharwar system. But in places thick masses, apparently lenticular in shape, are formed of comparatively pure hematite, and one of these in the Rajhara hills has been subjected to very careful examination by diamond drilling. The Rajhara mass was carefully sampled across the surface

at each point selected for a drill hole and the cores obtained were also analysed in lengths representing successive depths of 10 feet each from the surface, giving altogether 64 samples which were assayed for iron, phosphorus, sulphur, silica and manganese. The average results obtained for the surface samples were as follows:—Fe, 66·35; P, 0·058; S, 0·108; Si 0^2, 1·44; Mn, 0·151 per cent.; while for the cores the averages were:—Fe, 68·56; P, 0·064, S, 0·071; Si 0^2, 0·71; Mn, 0·175 per cent.

In this mass the prospecting operations thus proved the existence of 2½ million tons of ore carrying about 67·5 per cent. of iron and phosphorus content only slightly below the Bessemer limit. The quantity estimated is that which may be regarded as ore in sight, while almost certainly much larger quantities may be obtained by continuation of the ore-bodies beyond their proved depth. There are other large bodies of ore in this area which have not been examined in the same detail. These masses of hematite include small quantities of magnetite, but separate determinations of the iron in the ferric state have not been made in order to determine the relative proportions of the two minerals.

Here, then, was iron in extraordinary abundance at last, and of the highest quality. Mr. C. P. Perin, when he afterwards visited Dhalli and Rajhara, declared that they were one of the mineral wonders of the world. But the coal difficulty was as insistent as ever, and Mr. Weld carried out a long and careful survey of the Jherria and Ranygunge coal fields and on Mr. Perin's advice eventually came to the conclusion, as General Mahon had tentatively done at an earlier period, that the only suitable coal in India for coking could be obtained from the Jherria coal-field in Bengal. About eight or ten tons of Jherria coal were therefore sent to Germany and America, together with a quantity of Dhalli and Rajhara

ore. The coal was tested, and its cokeable quality ascertained; and the ore was smelted with the coke thus produced. The reports were highly satisfactory.

The water question next received further attention. A large and constant supply of water was required to cool the great furnaces which were to be built. It was essential to find a river which was not materially affected during the dry season. Once more the rivers of the Central Provinces were surveyed during the period of drought, as well as in the rains. Mr. Weld considered in the end that the works must be established outside the Central Provinces altogether. He selected the River Mahanadi, which enters the Bay of Bengal below Cuttack; and he chose a suitable site near Sambalpur, at Padampur, in the district of that name, which then formed part of the old province of Bengal. Apart from the water supply, the great advantage of Sambalpur was that it lay almost midway between the Dhalli and Rajhara deposits and the Jherria coalfield. The haulage necessitated would be considerable, but by no means in excess of the conditions sometimes found in other iron-producing countries. Both Sambalpur and Jherria, it may be noted, are now included in the new province of Behar; but Eastern India has been so much chopped about in recent years that it is often difficult to remember the provincial differences. All the modern atlases of India are now rendered obsolete.

To Padampur, therefore, the Tata camp was moved, and the tents were pitched on the banks of the River Mahanadi. The great stream was studied in order to find a point at which it could be effectually dammed. Mr. Perin arrived from America to test the investigations already made, and to give his advice in the final shaping of the scheme. The time had arrived to submit more definite plans to the Government of India, and to apply for a formal concession. By the time the camp was shifted to Padampur, the sum spent upon preli-

minary work considerably exceeded £30,000. Mr. Tata had breathed his last at Nauheim, but his successors were steadfastly determined to carry his great idea to fulfilment. Although he had done little for the scheme in the closing months of his life, his Bombay offices had kept closely in touch with it. His chosen lieutenant, Mr. B. J. Padshah, sat untiringly in Bombay, watching and checking all the reports with the utmost vigilance. He conducted most of the voluminous correspondence, supervised the accounts, framed innumerable and intricate bodies of statistics and estimates, and in conjunction with Sir Dorab Tata, exercised a general control over the whole investigation. But it was by his enthusiasm, still more than by his actual labours, that Mr. Padshah rendered inestimable service to the undertaking during these years of patient research. His faith never flagged, and he infused his own confidence into his colleagues.

But the Padampur project was never destined to be begun in real earnest. Although no one realised it, in crossing the boundary into Bengal the Tatas had at last drawn near to the final goal of their endeavours.

One morning the Tata firm received a letter from Mr. P. N. Bose, whose name was already familiar to them by reason of his report upon the iron deposits in the Drug district. Mr. Bose explained that he had retired from his post in the Geological Survey, and was now in the employment of the Maharajah of Mourbhanj. The state of Mourbhanj is one of the tributary states of Orissa, and was then included in the province of Bengal, but is now under the control of Behar. The Maharajah is subject to British suzerainty, but exercises larger independent powers than any of the other independent chiefs in Orissa. He wanted to develop his territories, and had engaged Mr. Bose to report upon the mineral resources they contained. Mr. Bose, with the concurrence of the Maharajah, informed Messrs. Tata, Sons and Co., that he had found very rich deposits of

iron, and invited them to send representatives to inspect the ore-fields. His statements were on the whole below the mark. In the story of the industrial development of India, Mr. Bose is assured of permanent mention. His inquiries were the prelude to the discoveries of Mr. Weld in the Drug area, and he now pointed the way to still more promising results. His work is one more refutation of the current criticism of Bengalis on the supposed ground that they are not practical men.

The Tata partners were perplexed by the letter of Mr. Bose. They thought no deposits of iron in India could equal those they had discovered at Dhalli and Rajhara. At the same time, the statements of Mr. Bose were disturbing. It was clear that he had found important ore-fields. They were also well aware that more iron was being traced in the adjacent British districts of Manbhum, Singbhum, and Dhalbum. All these districts were far closer to the Bengal coal-fields than Sambalpur, and even the state of Mourbhanj was not more than 150 miles eastward of their projected works. Supposing some rival firm stepped in, and reaped all the advantage of the shorter railway haulage? The Tatas hoped eventually to make pig iron for export far more cheaply than anyone had ever yet done in India, but where would they be if others were able to make it cheaper still? The success of their scheme depended on the cost of transport of their products to the coast, and still more upon the cost of assemblage of iron ore, coal, and limestone at their works. After some hasty statistical investigations regarding the relative cost of production, they realised that they must look at Mourbhanj without delay. In their wanderings they continually drifted farther east.

The state of Mourbhanj was at that time controlled by an unusually enlightened ruler, who died in 1912. It remains to-day an exceedingly picturesque territory, one of many

such areas which the transient visitor to India never sees, and of whose character he has little conception. Mourbhanj is over 4,200 square miles in extent, and in its centre lies a tract of richly-wooded hills covering 1,000 square miles. The hills are almost uninhabited, and though this hilly region is within 150 miles of Calcutta, the greater part of it has never been explored. Those who have looked across the plain at the hills of Mourbhanj are astonished at their wildness. One peak in the south reaches a height of nearly 4,000 feet. Herds of elephants wander amid the Mourbhanj jungles, and other big game abounds. The ruling family is said to be of Rajput origin, and has held the principality for 1,300 years; but like all the Orissa chieftains, the Maharajahs paid tribute to the Mahrattas until the British broke the power of that race of plundering conquerors. Most of the people are of aboriginal descent, and they include nearly 200,000 Santals. Mourbhanj is one of those Indian backwaters which the successive tides of conquest touched but lightly. Even British influence has not penetrated very deeply, and such advancement as has been accomplished is mainly due to the efforts of the later chiefs themselves. Agriculture is the principal industry, and in the plains there is ample room for its expansion. Contact with states like Mourbhanj and many similar districts in British India makes one marvel at the persistence of the legend that India is overcrowded. When some writers lightly talk of transporting millions of Indians to the Northern Territory of Australia, or to East Africa, or to the Sudan, they seem to be unaware that the peninsula could support far more than its present population. The problem of over-pressure on the soil must be solved by redistribution of the people rather than by emigration. But Mourbhanj is not rich in fertile lands alone. It has magnificent mineral deposits, the true extent of which was only understood when the experts employed by the Tata firm responded to the Maharajah's invitation.

More than one appeal was received from the Maharajah before the first actual visit; but at last Sir Dorab Tata, Mr. Perin, Mr. Weld, and Mr. Saklatwala went to the Mourbhanj territory. They had to journey to Midnapur and thence down the East Coast to Rupsa junction, whence a little narrow-gauge line took them to Baripada, the capital of the State, 32 miles away. Baripada is a quiet place with 6,000 inhabitants, and the usual high school, courts, public offices, and dispensary invariably found nowadays in the chief town of a well-conducted protected State. The party was met by Mr. Bose, and afterwards received by the Maharajah, who welcomed them very cordially. Mr. Bose, expounded the promising results of his survey of the State's resources, and Mr. Weld, began afresh his interminable inquiries.

After the preliminary discussions with the Maharajah, Sir Dorab Tata left for Calcutta. Mr. Perin and Mr. Weld, accompanied by Mr. Bose, plunged into the trackless hills in the direction of the ore-fields, which are situated in the north-west districts of the State. They were carried in dhoolies, and had numerous exciting and uncomfortable experiences. At length, in the Bamanghati sub-division, their frequent meetings with native iron smelters working with crude apparatus showed them that they were reaching the end of their long quest. In the lofty Gurumaishini Hill, which rises to a height of 3,000 feet, they found enormous deposits of iron ore, nearly as extensive as those at Dhalli and Rajhara, not so compact and not quite so rich, but more favourably situated. They further found hundreds of acres of rich " ore-float,"—ore lying loose on the surface, which required no mining, and simply had to be picked up by unskilled labour. The explorers were in the presence of a treasure-house far more potentially valuable than most gold mines. The merest superficial examination indicated that the supply of ore was very extensive. Mr. William Selkirk, mining engineer, of London, reported at a

later date that when fifteen million tons of ore had been won the property would still be far from exhausted. For many years the "Float" ore alone would be sufficient to supply the furnaces. Mr. A. Sahlin afterwards said that the ore-beds consist of "intensely metamorphosed ancient surface flows. The ore, here as in Brazil, forms a solid cap on the tops of the mountains, and covers the slopes in the form of larger and smaller stones and float. The cost of mining is therefore very low indeed."

The party was told by the local smelters of other ranges farther away, almost equally rich in ore. They made perfunctory explorations, and saw enough to convince them that the statement was true; but the weather was exhausting, the district malarious, and they had obtained all the proof they required. Mr. Weld was stricken with high fever, and marched thirty miles to a railway station while his temperature was much above normal. Mr. Perin and Mr. Bose found their way back, and a long and careful consideration of the new facts followed. It was clear that Mourbhanj offered advantages superior to those of Dhalli and Rajhara. It was far nearer the sea, and nearer the coal-fields. If, as the firm hoped, they would in time develop a large export trade in cheap pig iron, the shorter railway haulage was of inestimable importance. The Sambalpur scheme was therefore abandoned, and the Dhalli and Rajhara ore-beds were retained as a reserve source of supply. The firm came to terms with the Maharajah of Mourbhanj, who treated them with great consideration. He agreed to allow them to take ore for the first three or four years without any royalty, and then to charge a royalty beginning at half an anna ($\frac{1}{2}d.$) per ton, and gradually rising to eight annas ($8d.$) per ton. The average royalty works out over a term of fifty years at three and a half annas ($3\frac{1}{2}d.$) per ton. The lease which was ultimately granted by the Maharajah covers an area of twenty square miles.

Sir Thomas Holland was asked if he would like to inspect the new mine. His reply was characteristic. "If the Tatas," he said, "are prepared to forsake Dhalli and Rajhara, that is, all the proof I require of the value of their new discovery." In the *Quinquennial Review*, by Sir Thomas Holland and Dr. Fermor, from which quotation has already been made, the following account of the principal Mourbhanj iron deposits, summarized from the later observations of Mr. Weld, appears:—

> Recent prospecting operations have determined the existence of over a dozen considerable deposits of high-grade ore in the more accessible parts of the Mourbhanj State. Of these deposits three, namely, Gurumaishini, Okampad (Sulaipat), and Badampahar, so far overshadow the others that reference will be made in detail to them alone. The chief point of interest in connection with the smaller deposits is that in every case the nature or type of occurrence is practically identical with the great deposits, they being miniature reproductions as it were of the latter. As the main work of the prospectors has been devoted to the first necessary problem of determining the superficial disposition of the richer ore-bodies, very little has been done so far in the way of studying the geological relations and genesis of the ores.
>
> The ore-deposits have all been found to take the form of roughly enticular leads or bodies of hematite, with small proportions of magnetite, in close association with granite on the one hand and granulitic rocks on the other. These latter have been noted in the field as charnockites, the term being employed, rather loosely no doubt, but probably in the main correctly, to cover types of pretty widely varying acidity. In still more intimate association with the ores than either of the foregoing were found masses

of dense quartz rocks, frequently banded, and banded quartz-iron-ore rocks. These last are of the types so commonly associated with Indian iron-ores, but are here not so prominent as is usually the case. Lastly, there exists a net-work of basic dykes certainly cutting the granite and apparently cutting the iron-ores and charnockite.

In a very broad general way the impression so far received has been that the ore-bodies occur at or near the contacts between the granite masses and the charnockites. This impression is pregnant with suggestion, but needs a great deal of verification. The relative age of the granite and charnockite has not as yet been determined.

The Gurumaishini hill-mass, with its three prominent peaks, the highest rising to an elevation of 3,000 feet above the sea-level, and its numerous flanks and spurs, forms a conspicuous feature in the topography of the northern part of the State. The enormous bodies of iron-ore offered at this point and their accessible position have combined to make it the first point of attack. The ore deposits of Gurumaishini occur in three parallel and separate leads, which are 7,000, 5,500, and 3,000 feet respectively in length, and vary in width from 300 up to 700 or more feet. Further, there are three large, isolated, irregularly-shaped masses, the 3,000-foot peak itself being one of these. The vertical difference in level between the lowest and highest crops of ore is practically 2,000 feet.

The quantity of ore is certainly very great, the superficial area occupied by it amounting roughly to ten million square feet. It is too early to put forward any formal estimate of tonnage, however, as we are able to judge of the depth of the ore only from the vertical differences in elevation of the various outcrops. In addition to this

ore in place there are large blankets of rich ore 'float' extending over some 750 to 800 acres.

The quality of the ore is best indicated by quoting the following analyses of samples taken in the course of the several examinations to which the deposits have been subjected :—

———	Iron.	Phos-phorus.	Sulphur.	Silica.
	Per cent.	Per cent.	Per cent.	Per cent.
Average of eleven samples, both solid and 'Float' ore	61·85	0·135	0·036	4·08
Average of twenty samples of 'Float' ore	61·46	0·048	0·036	3·34
Average of ten samples of solid ore	64·33	0·075	0·021	1·64

A number of these samples was put through a complete analysis, thereby proving the absence of titanium, chromium, zinc, nickel and cobalt (except in one case where 0·090 per cent. was found), copper, lead, and baryta; and the presence of arsenic in traces only (in one case up to 0·008 per cent.).

The Gurumaishini ore will be mined by open cuts, the breasts advancing along the ridges in terraces or benches, with gravity inclines to lower the product to the bottom of the hill, where it will meet the broad-gauge railway. A large proportion of the first few years' despatches will be 'float'-ore, gathered up at a very minimum of expense. The day when ore below drainage will have to be drawn upon is very far distant.

The Okampad ore deposit is situated just west of the

Khorkai river, where the latter breaks through the Sulaipat-Badampahar range. Okampad is a conspicuous peak, only slightly lower than the Sulaipat peak (2,535 feet elevation) which lies one mile to the south-west of the former. Gurumaishini lies 12 miles to the north-north-east. A representative sample of the ore gave on partial analysis :—Fe, 63·11 ; P, 0·029 ; S, nil ; Ti, nil, per cent.

A 13 to 15-mile extension of the Gurumaishini Railway will tap the Okampad deposit when the time comes for its development.

The ore-body occurs as a single great lens, exhibiting at one point a scarp about 300 feet high, and covering a superficial area of some 300,000 or more square feet in plan. There are, besides, two smaller outliers, and about 165 acres of ' rich float '-ore. The immediate associates of the ore are banded quartz-iron-ore rock and a dense blackish quartzite, the latter especially abundant ; all these are completely enclosed in what has been referred to in the field notes as trap. The low-lying country to the north-west is occupied by granite.

Four samples of Okampad ore, taken at two different times and by two different observers, gave the following average analysis :—Fe, 67·65 ; SiO^2, 1·58 ; P, 0·043 ; S, 0·012 per cent.

The last of the three major deposits occupies the Badampahar peak (2,706 feet elevation), in the Sulaipat-Badampahar range, $8\frac{1}{2}$ miles south-west from Okampad. Here again, as at Okampad, a single great lens of ore, roughly figured to be 3,000 feet long by 500 feet broad, with many smaller outliers, occupies the crest of the range, masses of rich float extending for many hundreds of feet downwards. Six hundred vertical feet were measured from the lowest observed massive outcrop to the highest.

The immediate associates of the ore were seen to be banded quartzites and quartz-iron-ore rocks, with abundant rather basic holocrystalline rocks, this time recorded in the field notes as a variety of charnockite. The lower ground to the north-west was again seen to be completely occupied by granite.

Here, then, was the supply of iron finally selected; but it was in the hills, far from coal and water, and a search had to be made elsewhere for a site for the works. Mr. Perin and Mr. Weld at first chose Sini, a junction on the Bengal-Nagpur Railway, about sixty miles north-west of the Gurumaishini hill. It was considered that the iron-ore, coal, and limestone could be assembled there at low transit charges. Sir John Hewett, who was at that time at the head of the newly-formed Department of Commerce and Industry, gave the project every reasonable encouragement. On behalf of the Government of India, he undertook to build a railway from a point on the Bengal-Nagpur Railway to Gurumaishini. His original desire was to carry the line right through to the East Coast Railway, through Chaibassa-Chakardapur, and this proposal was warmly supported by the Maharajah of Mourbhanj, the whole of whose State would be thus traversed. The survey of the route was begun, and the Tata firm very soon pointed out that the alignment chosen would add ten unnecessary miles to their haulage. The Government agreed not to charge haulage for the ten extra miles. Then came the question of gauge. The Government wanted to build a narrow-gauge line, and to this Sir Dorab Tata agreed, but later he went to Calcutta and was fortunate enough to persuade the authorities to construct the line on the broad gauge. Reduced rates of freight on the line were promised, and the Government further undertook, subject to certain precautionary conditions, to purchase from the proposed works, at import prices, 20,000 tons of steel rails annually for ten years. The idea of carrying

the line right through the State of Mourbhanj was ultimately deferred; but the survey was completed to Gurumaishini and the Government announced that it would begin building the line as soon as Messrs. Tata Sons and Co. had formed the undertaking into a Company, and when the share capital had been subscribed, and sixty lakhs of rupees (£ 400,000) had been paid up. Meanwhile the firm, through Sir Dorab who was then in London, had entered into communication with various persons prominent in the iron and steel industry in England. The idea was that most of the capital should be raised in London, and it was felt that as a preliminary some English opinions upon the character of the iron deposits and the prospects of the scheme should be obtained. On behalf of a group of London financiers interested in the scheme Mr. Charles J. Stoddart, Chairman of the Parkgate Iron and Steel Company, Limited, accordingly visited India, taking with him Mr. William Selkirk, an eminent mining engineer of London. Both these experts reported very favourably upon the quality of the ore, satisfied themselves about the immense quantity available, and expressed the view that it could be cheaply converted into pig-iron and made into high-grade steel.

At this stage, which was reached in the spring and summer of 1906, the project flagged again. A preliminary prospectus was prepared and submitted to various financial interests in London, but unforeseen difficulties were encountered. There were differences about the degree of control which was to be entrusted to the representatives of English investors. A disposition seemed to be manifested to sweep the Tata firm aside. Far more disconcerting was the lack of interest shown by the London Money Market, which is always ready to pour capital into China, or Patagonia, or Timbuctoo, but shows a traditional unwillingness to invest in new enterprises in India. Sir Dorab and Mr. Padshah, acting for the Tatas, had, moreover, come into touch with London during one of its periodical

phases of depression. Money was very "tight" and all fresh projects were looked at askance. The sum asked for was very large. It would have met with a doubtful reception at that moment had the works been projected for England; being for India, people buttoned up their pockets. Eventually there was one exciting period when about four-fifths of the required capital was actually promised; but the Syndicate fell through, and the enterprise again seemed doomed, and Sir Dorab returned to India.

For more than a year the negotiations were continued in England, but never with more than partial success. By the summer of 1907, however, a new situation had been created in India. The "Swadeshi" movement, which on its more praiseworthy side meant the cultivation of the doctrine that the resources and the industries of India ought to be developed by the Indians themselves, had reached its height. All India was talking "Swadeshi," and was eager to invest in "Swadeshi" enterprises. Sir Dorab and Mr. Padshah, who had spent weary months in the City of London without avail, after their return, conceived in conjunction with Mr. Bilimoria the bold idea of appealing to the people of India for the capital needed. The decision was a risky one, and many predicted failure, but it was amply justified by the result. They issued a circular, which was practically an appeal to Indians. It was followed by the publication of a prospectus, which bears the date August 27th, 1907. Mr. Axel Sahlin, in a lecture delivered to the Staffordshire Iron and Steel Institute in 1912, has described the instant response. He says:—

> From early morning till late at night, the Tata Offices in Bombay were besieged by an eager crowd of native investors. Old and young, rich and poor, men and women they came, offering their mites; and, at the end of three weeks, the entire capital required for the construction requirements, £1,630,000, was secured, every penny contri-

buted by some 8,000 native Indians. And when, later, an issue of Debentures was decided upon to provide working capital, the entire issue, £400,000, was subscribed for by one Indian magnate, the Maharaja Scindia of Gwalior.

The prospectus contained the following statement :—

> The Import of Iron and Steel into India of the classes intended to be produced by the Company has averaged during the past twelve years, 409,000 tons annually, (the imports in 1905-6 amounting to 615,000 tons) and is therefore largely in excess of the capacity of the plant which it is now proposed to erect for an output of 120,000 tons of pig iron and the conversion of 85,000 tons thereof into 72,000 tons of finished steel; there is thus every probability of a ready market on the spot for the whole production.

It was further stated that the ore-fields, railway, and freight concessions, together with all the other privileges conceded by the Government of India, would be handed over to the Company by Messrs. Tata Sons and Co., in consideration of the allotment to them of Rs. 15,00,000 (£100,000) in Ordinary shares issued as fully paid up, and Rs. 5,25,000 (£35,000) in cash to reimburse them for their preliminary out of pocket outlay upon the scheme. The latter amount, together with an additional Rs. 4,75,000 (£31,666) of their own the firm undertook to invest in shares of the Company and not to sell any of these shares for five years. By an agreement entered into between Messrs. Tata Sons and Co. and the Company, the firm was to receive a royalty of 4 annas (4*d.*) per ton of ore "sold as ore in this country or exported." The firm was also to act as agents for the Company for a period of 18 years, their remuneration being a commission of 5 per cent. on annual net profits, after deducting interest on debentures and amount set aside for depreciation, with a minimum of Rs. 50,000 (£3,333)

per year. The directors named were Sir Dorab Tata, Sir Sassoon David, Sir Cowasji Jehangir, Sir Vithaldas Thackersey, Mr. Gordhandas Khattau, Sir Fazulbhoy Currimbhoy Ebrahim, Mr. Narottam Morarjee Goculdas, and Mr. A. J. Bilimoria.

The capital having been obtained, Messrs. Julian Kennedy, Sahlin and Co. were formally appointed construction engineers to the Company. Mr. Sahlin had left Brussels for America on October 19th, 1907, and he spent seven weeks in planning and discussing the plant with Mr. Julian Kennedy and Mr. Perin. The plans and specifications of the plant having been prepared Mr. Sahlin sailed for India, and landed at Bombay on January 31st, 1908. On his arrival, he found that the site for the works had been changed from Sini Junction to a village called * Sakchi, 20 miles away, and about 2½ miles from the wayside station of † Kalimati on the Bengal-Nagpur Railway.

The reasons for the change were numerous. It was difficult to secure at Sini the very large tract of land required for the works. The grading of the site and the sinking of foundations would have been very costly. To obtain a sufficient water supply it would have been necessary to construct a reservoir by damming a stream near Sini. As the stream had an ample flow only for four months in the year, storage would have been required. To provide against the risk of a year of drought, it was considered imperative to construct a reservoir sufficient to supply the works and the community for 600 days. In an early report, Messrs. Perin and Weld, estimated the probable cost of the reservoir at 4 lakhs (£26,666). Mr. Sahlin afterwards stated the probable cost at 14 lakhs (£93,333). The conclusive cause of the change was, however, that sufficient land was not obtainable at Sini.

Sakchi was accidentally discovered during the surveys for the railway. Its first advantage was that it shortened

* Now Jamshedpur. † Now Tatanagar.

the distance to Calcutta. Kalimati Station was 152 miles from Calcutta, Sini was 171 miles. Then the new site was considerably nearer the ore-fields at Gurumaishini, though this benefit was partly counterbalanced by the longer haulage necessary for the coal from Jherria. Ample land of a suitable character was obtainable. The crowning gain of the change to Sakchi was that an unfailing water supply was furnished by the Khorkai and Subarnarekha River, which has never been known to run dry. The name Subarnarekha means "gold-streaked," and at one time gold was found in the river bed. The river is the largest stream in the district of Chota Nagpur.

Some difficulty was experienced in obtaining the consent of the Government to the change, but the obstacles were soon smoothed away. The chief trouble was the question of the railway to Gurumaishini. The earlier proposal had involved hauling the ore for nearly 20 miles over the main line of the Bengal-Nagpur Railway to Sini. Sir Dorab Tata now asked for the construction of a direct line from Gurumaishini to Kalimati, with a short connection from Sakchi to the main line at Kalimati. The length of new line thus proposed was shorter by ten miles, being 40 miles instead of 50. To this proposal the Government agreed, with the odd proviso that the haulage of 40 miles from Gurumaishini to Kalimati was to be charged as 50 miles. Notwithstanding this stipulation, it was found that the total cost of assembling the materials at Sakchi would be appreciably lower than at Sini. The Government further acquired five square miles of land in perpetuity at Sakchi, which area was handed over for the site of the works. The Company leased in addition about 18½ square miles from the Dhalbhum Syndicate, the owners of an adjacent *zamindari* property, the lease being for 23 years. The reason for the acquisition of so much extra land was that it was considered necessary to have the power to prevent undesirable characters from settling within easy reach of the works. All the land

thus dealt with was of undulating character, mostly covered with thin jungle, and possessing few inhabitants. Most of the dwellers in the neighbourhood were Santals, a still primitive tribe. The original village of Sakchi still stands on the road from the works to the pumping-station at the edge of the river, and is a small settlement of the type usually found in Bengal.

Mr. Sahlin, having seen and approved of the new site, lost no time. The first stake was driven on a plateau at Sakchi, 535 feet above the sea, in the midst of jungle, on February 27th, 1908. It was found that the plateau was everywhere underlain by mica schist, affording cheap and good foundations for the new works. The locality is extremely picturesque. From the works as they stand to-day one looks across the Subarnarekha at the lofty hills of the Manbhum district, and marvels that such forest-clad heights should be so little known to the tourist. The highest peak in Manbhum is over 3,400 feet high, and several lesser eminences are within an easy distance of Sakchi.

From February until April Mr. Sahlin remained at Sakchi, and then he handed over the task of supervising the preliminary preparations for construction to Mr. Renken who acted as Resident Engineer on behalf of the firm of Kennedy and Sahlin. All that summer the earlier stages of the undertaking were pressed forward. The site of the works was graded, brickworks were established, large quantities of lime were prepared, railway sleepers, sand, and building stones were collected. Rough bungalows were built for the construction staff. The town was laid out, roads constructed and linked up with the railway station at Kalimati. The branch railway to Kalimati was begun. Above all, the waterworks were laid out and were in steady progress by the autumn. A good deal of this work was done by Mr. Godbole, a retired Engineer from the Bombay P. W. D., but it was completed by Mr. Renken, who took over the charge from him later.

Though the water supply was derived from the Subarnarekha River alone, the Sakchi works lie in an angle formed by the junction of that stream with the River Khorkai. The first necessity was to throw across the Subarnarekha a low dam about 1,200 feet long, in order to bank up the river water to get suction for the pumps. On the edge of the river near the dam a powerful pumping-station was built, containing two pumps driven by an electrical current supplied by the power-house at Sakchi. The level of the river is about 140 feet below that of the works, and the intervening distance is nearly two miles. The water is pumped through a 30-inch pipe-line into a reservoir which adjoins the works. The reservoir was formed in a small natural valley on the site, across which a dam about half a mile long was constructed. The area of the reservoir is about 64 acres, it has a depth which at one point reaches 67 feet, and it holds about 256 million gallons of water. The water is taken by other pumps into the works, returned along shallow cooling ditches into the reservoir, and used again and again. Even if the river temporarily ran dry there would thus be ample water available.

The actual construction of the plant was begun in the autumn of 1908, and the foundations were started in May 1909, though not much was visible above ground until after October, 1909. The first iron was made on December 2nd, 1911. To include in this chapter a long technical description of the work done during the years of construction would be both wearisome and out of place. I have set forth at great length the romantic story of the steps which led to the establishment of these huge iron and steel works at Sakchi. Those steps were initiated and guided by Mr. Jamsetjee Tata until the whole project began to take definite form. He it was who selected the experts to whom the technical decisions were entrusted. He it was who handed over to his sons and their associates the task of direction. From the fortune he had amassed came the

funds upon which the undertaking in its earlier stages depended. The whole organization was due to his vision and insight, and bears to-day the stamp he placed upon it. But it only came to fruition years after his death, and the remainder of the story must be more briefly told.

After Mr. Renken had made considerable progress with the preliminary work, Mr. R. G. Wells arrived early in 1909 and took over charge as General Manager. Mr. Wells was an American, who specialized in the construction of iron works. His experience included prolonged periods of work at Mariopols, in Russia, and at the Dominion Iron and Steel Company's works in Sydney, Nova Scotia. When he reached India, the new centre of industry was still only slowly emerging from the surrounding jungle. It was largely owing to his and Mr. Sahlin's energy and driving power, that the works were actually built in considerably less than three years.

The Tata Iron and Steel Works were originally constructed for the following capacity :—Coke, 180,000 tons; pig-iron 160,000 tons; steel, 100,000 tons; rails, beams, and shapes, 70,000 tons; bars, hoops and rods, 20,000 tons. Well-equipped foundries and machine-shops were provided, capable of dealing with all ordinary repairs and maintenance of the plant. The coal delivered at the works is so cheap that it would have been extravagant to employ gas engines or even condensers for the rolling mill engines. The plant is therefore operated by steam and electric power generated by steam turbines. The boilers are fired with blast furnace gas and coal. Electricity is generated in three turbine-driven units. All the pumps are rotary. For the blast furnaces turbo-blowers are employed.

The following compressed technical description of the works was prepared for me at the time of my visit in December 1911, the first month in which iron was made :—

The Coke Oven Plant :—Consists of 180 non-bye-product coke ovens fitted with two coal-breaking and crushing

plants for a combined capacity of 1,400 tons per 10 hours, coal storage bins, electric charging larries and electrically driven coke pushers and levellers. The coke is carried on steel trucks from the coke ovens to the blast furnace charging pockets.

Blast Furnaces:—Consist of two blast furnaces 77 feet by 19 feet each equipped with inclined double skip hoist, automatic stock pockets served by electric charging larries; four 22 feet by 90 feet central combustion chamber Cowper-Kennedy hot blast stoves, dust catchers and centrifugal gas cleaners. The iron can either be run liquid into ladles, or cast into pigs. The slag is removed in self-emptying slag cars.

Boilers:—The available gas from the blast furnaces, supplemented by hand coal firing, is used in a central boiler plant, consisting of 8,000 H. P. Babcock and Wilcox boilers.

Blowing Engines:—Each blast furnace is blown by one out of three Zoelly Type Turbo-Blowers, having a capacity of 30,000 atmospheric cub. feet of blast per minute against a pressure of 18 lbs. per square inch. The turbo-blowers are equipped with separate surface condensers.

Electric Power Plant:—This consists of three 1,000 kilowatt Turbo-Generators direct-coupled to Zoelly type turbines with surface condensers. The dynamos generate 3-phase current, 3,000 volts, 50 periods. Part of this energy is transformed by two-motor-generators into 250 volts direct current to be used for cranes and in the Rolling Mill plant. Another part is cut down by stationary transformers to a tension of 440 volts, and distributed throughout the works. Still another part is carried at high tension to the River Pumping Station about two miles from the works.

Pumping Plant:—This plant consists throughout of Sulzer centrifugal type pumps for the distribution of water throughout the works, for hydraulic pressure, boiler feed, filters and town service. The whole of the blowing, generating and pumping machinery is concentrated in one central power plant located alongside the boiler plant.

Steel Plant:—This is located in a building 650 feet by 135 feet containing one 300-ton gas-fired mixer resting in cradles; four 40-ton Basic Open Hearth Furnaces and three 5-hole gas fired Soaking Pits. All the furnaces are equipped with Dyblie water-cooled reversing valves. The metal is brought in ladles from the blast furnace plant and is poured into the mixer by one of the two 75-ton casting cranes. The ingots are cast in moulds standing on trucks. At the east end of the steel plant is located a stock yard covered by a 10-ton travelling crane running on trestles. All cold stock is charged into the furnace by a charging machine running on over-head runway. The ingot moulds are stripped and charged into the soaking pits by special charging and drawing machines suspended from crane bridges.

Gas Producers:—On a line parallel with the furnace building is located a plant of 16 Morgan mechanical gas producers with revolving bottom, hearth and tuyere. The producers are equipped with George's patent automatic revolving feeds. Each furnace is fired independently by the necessary number of producers.

Rolling Mill Plant:—The heated ingots are carried from the soaking pits in an electrically-driven tilting chair, which conveys them to the rolling-mill building, measuring 216 feet by 150 feet. In this building is placed an Ehrhardt and Sehmer three-cylinder reversing engine non-condensing with cylinders $51\frac{3}{8}'' \times 51\frac{3}{8}''$. On one side of this engine and connected to it by a hydraulic coupling

is a Blooming Mill, which is a duplicate of the blooming mill of the Youngstown Sheet and Tube Company, Youngstown, Ohio. The pinions, which have a diameter of 40 inches, are made of forged steel, and run in oil in hermetically closed housings. The steel blooming rolls have a length of 80 inches with a diameter of 33 inches; they are served by tables with 18 inch diameter steel rollers and by hydraulic manipulators. The shear is of the steam hydraulic type, with both knives moveable. The upper knife is dropped by gravity upon the bloom and held in position while the lower knife does the cutting. The blooms are transported directly by an overhead charger from the shear table to the rail mill table, or to the heating furnace, placed in the mill building, and fired with gas from the general producer plant.

At the opposite side of the engine and connected with one another by a hydraulic coupling similar to the one for the blooming mill is a 28-inch two high reversing rail mill, with three stands of rolls; the pinions are of forged steel running in oil in hermetically closed housings. The rail mill is served by two travelling transfer tables, equipped with steel rollers and mechanism for tilting the bloom as required. From the finishing stand, the bar is delivered upon a long line of rollers leading to the hot saw, which is placed in a separate building at a distance of 255 feet from the centre of the rail mill.

Behind the saw the cut bars pass over a section of rollers, equipped with tilting mechanism, by which they are placed on their flanges before they are delivered upon the double cooling bed, measuring 72′ × 80′, and placed in a separate building provided with large ventilators.

From the cooling bed the bars are passed through a roll-straightening machine and delivered into the finishing department which contains the usual machinery for

finishing rails and beams, and which is commanded by a 10-ton travelling crane. The bars are finally placed on the inspection beds, located alongside the finishing shed.

Bloom Storage Yard :—Between the mill building and the hot shear building, crossing all the railway tracks in the works, is an elevated crane runaway 1,073 feet long, with a span of 83 feet, forming an ample and accessible yard for stock and materials of every description. This yard is commanded by a 10-ton travelling crane. At one end of the yard is placed an electrically-driven skull cracker.

Machine Shop :—Alongside of the stock yard is placed a machine shop building, 216′ × 72′, commanded by a 30-ton travelling crane, with a 5-ton auxiliary hoist and containing the equipment of tools usual for iron and steel works, roll turning lathes, large and small machine lathes, horizontal and vertical boring mills, planers and shapers, radial and fixed drill-presses, wheel presses, erecting plates and tool room machinery.

Foundry :—Contiguous to the machine shop is placed a foundry building, 192′ × 72′, equipped with two cupolas, driven by electric rotary blowers, core-ovens, brass furnaces and the usual equipment.

Store House and Pattern Shop:—Conveniently located to the foundry and machine shop is placed a three-storey fire-proof brick and steel building. The two lower floors are used for stores, and top floor for pattern shop and storage.

Blacksmith's and General Shop :—At the rear end of this building is located a steel building containing a blacksmith's shop providing space for steam hammer with heating furnace, blacksmith's fires, and the necessary equipment; also boiler-shop equipment, consisting of punches, shears, drills and plate bending machine. At one end of the building is provided shed room for four

locomotives.

Buildings :—The mill buildings throughout are placed due east and west with protected gables and open north and south elevations. This will, in the latitude of Kalimati, where the declination of the sun from its zenith is 0°-30 feet north at midsummer and 42° south in midwinter, procure continuous shade in the interior, at the same time as free circulation of air. The building frames are of steel and of heavy design so as to withstand the occasional tropical storms. The columns are not less than 34 feet high. The roofs are of corrugated puddled iron sheets.

Railway Equipment :—The railway system in the works consists of about 8 miles of 5 ft. 6 in. gauge tracks laid with 75 lbs. per yard standard Indian flanged rails resting on sal wood ties. The rolling stock consists of five six-wheeled yard locomotives, weighing 45-tons, with separate low back-shifting tenders; also the trucks necessary for handling hot metal, slag, waste material, ingots, blooms and pig iron. There are also two travelling steam cranes of 6-ton capacity, capable of being used for light-shunting.

Laboratories :—Adjacent to the shops and steel plant is a brick building, containing testing machines, physical and chemical laboratories.

It did not suffice to build an iron and steel works. The Tata Company had also to build a town in the midst of the wilderness, and to me the new town of Sakchi seemed a model for all great industrial enterprises, not only in India, but in any part of the world where land is easily obtained. I walked through street after street of commodious one-storey brick houses, all well ventilated, all supplied with running water and lit by the electric light. Many of the houses possessed electric fans. The larger bungalows, built for the use of the European staff, stood in the midst of garden plots. The streets

were wide and well-made, and were planted with trees. In the centre of the town was a spacious recreation ground, and it fell to my lot to witness the Christmas athletic sports. There was a bazaar containing both European and Indian shops. Institutes had been provided for both European and Indian workmen. A court-house, a post and telegraph office, and a police station were among the adjuncts of this extremely modern town. I saw the hospital and the schools, both well-equipped.

The principle laid down for manning the works was that labour-saving machinery should be used wherever possible, and that in any case there should be no repetition of the excessive demands upon the strength and endurance of Indian workmen which have marred the early history of some other industrial enterprises in the Dependency. The original scheme provided for a normal operating crew of about 2,000, of whom about 175 were to be Europeans. At the time of my visit, Sakchi was an extremely cosmopolitan place. Mr. Wells was General Manager, and his chief assistants in the management, as well as the Blast Furnace Superintendent and his staff, were all Americans. The crew of the steel-works and their superintendent were Germans. The Superintendent and crew of the rolling-mills were English. The clerical staff was chiefly composed of Bengalis and Parsis, and there were a few extremely efficient Parsis in the various mechanical departments. There were a certain number of Austrians, Italians, and Swiss, while Chinese were working as carpenters and in the pattern-shops. This medley of nationalities did not always work very well together. I recall that at the athletic sports I witnessed there was a fierce quarrel about a tug-of-war between German and American teams. The Americans complained that just when they were winning, the Germans, taking advantage of the darkness which had suddenly come on, slipped extra men upon their rope, in order to obtain a victory by unfair means.

The squabble was ultimately settled by Sir Dorab, who was acting as Referee, deciding that the event should be settled the next morning by daylight, when the Americans won easily. Eventually the crews of European workmen were somewhat reduced. The American crew worked with conspicuous vigour while they remained. They were mostly from the Southern States, and were accustomed to a 12-hour day. At Sakchi they worked an 8-hour day, and seemed to stand it very well, despite a temperature of 115 degrees in the shade in the hot weather and a very humid atmosphere, with an average rainfall of 50 inches, from mid-June to mid-September. The buildings are, of course, especially designed for hot weather work. Nevertheless, I doubt whether the American crew could have kept up their energy for several years.

Both Mr. Julian Kennedy and Mr. Sahlin happened to be at Sakchi during my visit. Mr. Kennedy informed me that there had been fewer labour difficulties there than in any plant with which he had ever dealt. Sakchi is on the edge of the district from which the tea planters of Assam obtain much of their labour. The supply of unskilled labour has therefore always been ample. The unskilled Indians are mostly Santals and Khols, who represent the best coolie labour in India. Even before 1911, the Company sometimes had as many as 8,500 people working at Sakchi, and another 10,000 gathering float ore at Gurumaishini. Mr. Wells added to these statements the comment that "coolie labour is not cheap," which was my own experience in certain other branches of Indian industry. The true test is not the rate of wages, but the amount of work done in a given time. The daily average of people employed at Sakchi during 1912 was 6,300.

Mr. Julian Kennedy had only just completed his inspection of the works when I met him, and this was the first time he had paid a personal visit. Mr. Sahlin, who accompanied him, had not been out since 1908, but both partners had been constantly

consulted. Mr. Kennedy was very favourably impressed with the site, and was still more impressed by the cheapness of production. He said: "To make the ore for a ton of pig iron costs 75 cents here, as against 8 dollars in Pittsburgh—that makes a tremendous handicap in favour of this place. No other place is so cheap. Moreover, we can make in 2½ minutes from ingot to rail." The coal from the Jherria field, 120 miles away, was, he said, brought to Adra, and then down to Sini Junction and Kalimati, and thence by the branch line to Sakchi. The coal was of excellent quality and was low in sulphur, but it was higher in ash than the best American and English coal. With their high-grade ore and high-grade flux they might have had to put into the furnaces some impurity in order to get enough slag to run them, so it was just as well to have a high ash in the coal. The flux for the blast furnaces was dolomite, obtained from Pamposh in the Gangpur State, about 100 miles west of Kalimati. The price paid for flux was 6 annas (6*d.*) per hundred cubic feet. The Company had a limestone quarry at Jukehi, a station on the East Indian Railway near Katni, about 500 miles away, and from this source they obtained the limestone (technically known as calcite) used as the flux for the steel furnaces. At a later date the Jukehi quarry was temporarily closed and limestone was purchased at Katni. The Dhullee and Lohara deposits of ore, in the Drug area, were being kept in reserve. This ore was somewhat richer than the Gurumaishini ore, and was much lower in phosphorus, a great advantage for the European market, particularly England, where the acid process of making steel is used. Limestone in the furnace forms a slag which removes the phosphorus. In Mr. Kennedy's opinion the Jherriah fields furnished the only coal suitable for metallurgical coke. It takes 1½ tons of coal for a ton of coke, and 1¼ tons of coke for a ton of pig. Roughly, about 1⅞ tons of coal are required for a ton of pig. Mr. Kennedy expressed

the view that the manganese mine which the Company possessed at Balaghat, close to the Bengal-Nagpur Railway line, would be able to produce ore very cheaply when the railway was carried to the mine. Only about 6,000 tons of manganese were required annually at Sakchi, and the rest of the production would be available for export. The railway connection to Balaghat, a length of 32 miles, has since been completed, and Mr. Kennedy's prediction about cheapness of production has been amply realised.

The Sakchi works soon became a recognised place of pilgrimage for prominent officials, and for distinguished visitors to India who sought proof of the country's capacity for progress. Perhaps the first important visit was that paid in July 1911, by the members of the Indian Mining and Geological Institute. At that time no iron had been made, but the visitors were much struck by the labour-saving devices already installed. One glowing record of the visit notes the following:—

> Of labour-saving devices the coke ovens and the coal crushing plant furnish a fine example. The coal is carried mechanically into the crushers and having been so pulverised that the proportion which will equal the size of a pea will be less than one per cent. it is shot up into an elevator from which it is discharged into wagons for conveyance to the coke ovens. Seventy tons of coal can thus be handled and crushed in an hour. The ovens can turn out 500 tons of coke in 24 hours. The rams which drive the coal into the ovens, the levellers by which the coal is spread inside the ovens, and the pushers by which the coke is ejected from the ovens are all electrically driven, and the coal is scarcely touched by human hands from the moment of its arrival from the Jherria coal-fields to the time when it is shunted to the blast furnaces yard.

The speech delivered on this occasion by Sir R. P. Ashton, the President, is worth preserving. He said:

Midday in the rains in Chota Nagpur is not the place to make a long speech, but it will be your wish that I should express the hearty thanks of the Institute to Messrs. Tata & Sons, the Iron and Steel Company, and to Mr. Wells, for the hospitality, the instruction, and the inspection of their titanic enterprise, that we have enjoyed to-day. Surely there has been seldom in history so interesting an enterprise as that which we have seen. It had its origin in the great brain of one who, alas is no longer alive to see its fruition—the brain of the late Mr. Jamsetjee Tata. The Parsees, as you know, are a remnant of a once mighty empire, a remnant which had maintained its individuality through dark centuries of adversity and persecution under alien Oriental government, till having escaped into the freedom of British rule and thought, the community, like a plant or seed long kept in the dark, has put forth mental leaf, flower, and fruit, with surprising vigour. I may be permitted to think that the vigour and originality of thought that conceived this enterprise is the lineal descendant of the thought and enterprise which long days ago conquered Asia and Egypt, and was only driven back from Europe at Salamis. Is not this revival a testimony of the effect of the British rule which it is just now the fashion in some quarters to decry? Then we have the torch lighted by Mr. Jamsetjee Tata at this ancient fire carried forward by the filial piety of Mr. Tata's sons and cousin, and by the indomitable perseverance of Mr. Padshah, who refused to be beaten or disappointed. It has been my privilege to have watched this great game played from the start, therefore I may be excused speaking with enthusiasm. Like Darius and Xerxes, only with more success, these Persians of to-day have gone beyond their own border and ransacked the world, not for gold and

silver, but for its greater riches—for its brains and knowledge.

In the gentlemen that we have met here and the plant that we have seen, men and material are represented sent by the greatest Engineers of England, Scotland, Wales, America, Canada, Germany, Belgium, Switzerland, and France, and the men and material are worthy of their senders. Not a rivet nor a bolt or sheet in that group of immense structures which have so impressed us with their latent energy but is the embodiment of work and thought which is focussed in this wild valley, to melt for man's use a great hill of ironstone that has been waiting for ages some 40 miles from here. Then this enterprise is planted in what a few years ago was one of the wildest spots of India, and where even at this moment the naked hunter with his bow and arrow, the tiger and the bear may be looking from the surrounding hills at the latest outcome of engineering genius. In a few months it is expected that a fire will be lighted which will not be extinguished till the Gurumaishini hill has been melted into railway materials, beams, sheets, which will be so much material to open up this country, to traverse its rivers, house the people, and to bring India forward into line with the most advanced of countries. May the fires soon to be lighted here not only turn stone into rails, but help as all sound industry does to develop the people among whom it is planted into props and girders of civilization, as useful as the British, American and German nations, who have given them the Tata Iron and Steel Works, and sent Mr. Wells to erect and start them.

It had been hoped that His Majesty the King-Emperor during his progress through India in the cold weather of 1911-12, on the occasion of the Imperial Coronation Durbar at Delhi, would have been able to visit the Sakchi works. The great

programme of festivities arranged at Calcutta rendered these hopes vain, but in His Majesty's stead Lord Crewe, the Secretary of State for India, visited Sakchi on January 6th, 1912. The following record of an occasion which will always be memorable in the history of the Tata enterprises was afterwards published in the *Times of India*:—

> Since his arrival in India, Lord Crewe, Secretary of State and Minister in attendance on the King, has received no deputations and made no speeches, yet he has been assiduous in his efforts to ascertain the real trend of affairs in this country and to come into contact with people of every shade of opinion. If the first visit of a Secretary of State for India to this country has not bulked large in the public eye because of the simultaneous presence of the King, still Lord Crewe will leave Bombay with a varied store of valuable impressions of the land for whose good government he is responsible to Parliament. On Saturday, however, he made a slight departure from his practice. He accepted an invitation from Messrs. Tata and Sons to visit their iron and steel works at Sakchi, and advantage was taken of this occasion to invite a number of officials and others to the blast furnaces and steel house set up in the jungle. Sir Dorab Tata, Chairman of the Company, arranged for a special train to leave Howrah at 8 o'clock. Amongst those who accepted his invitation to be present were Lord Crewe, the Hon. Mr. Clarke, Member for Commerce and Industry, and the Secretary of the Department, Mr. R. E. Enthoven, Sir James Meston, Secretary of the Finance Department, H. E. Rear-Admiral Sir Edmond Warre Slade, Sir Thomas Holland who greatly assisted the Company in its early days, the Hon. Mr. Gokhale, Mr. Harold Cox, Sir Frederick Dumayne, Deputy Chairman of the Calcutta Port Commissioners, and Sir R. N. Mukerji of Messrs. Martin & Co.

Mr. Ratan Tata, Sir Shapurji Broacha and Sir Vithaldas Thackersey, of the Directing Board, were also of the party. It was a journey of a little more than four hours from Howrah to Kalimati and as breakfast was served *en route* the short run was pleasantly performed. The route lay through the rice fields of Bengal, now bare even of stubble for the grain has long been harvested, then into the hills and jungles of Chota Nagpur, giving, as Kalmati was approached, a glimpse of Gurumaishini, whence the Company draws an unlimited supply of the highest grade iron ore. At Kalimati the Company's engine was attached to the special and hauled it over the short branch which leads from the main line to the works and drew it up just outside the blast furnaces where there were present, amongst others, the Hon. Sir Fazalbhoy Currimbhoy and Sir Cowasji Jehangir, and Mr. R. G. Wells, the General Manager of the works, who acted as cicerone.

As soon as the guests were assembled the cast timed for their arrival was begun. There are two blast furnaces at the works, one of which has been in operation for the past month. Their bases, so far as they are visible above ground, rest on a raised platform, the floor of which is a bed of sand. Down the centre of this floor ran a broad channel with high banks and on the right side stood the serried rows of moulds ready to receive the liquid metal and shape it into pigs. The foreman of the blast furnace gang, an American of splendid physique, seized a long steel rod and vigorously attacked the clay stopping which sealed the exit from the furnace. The baked clay soon gave way before his vigorous strokes and first a feeble trickle, then a rushing stream of molten iron gushed out, throwing up a cloud of starry sparks which at night produce a pretty pyrotechnic display. Just outside the

furnace the molten iron was dammed up, so that the ash might be led away if necessary, then it flowed down the blast house till it turned right-handed by the bottom row of pig moulds. As these were filled one workman tore down the inner bank of the sandy channel, another arrested the flow of iron by thrusting a broad bladed shovel in the current and so the second row filled. This process went continuously forward until the flow of iron weakened, then ceased, and between forty-five and fifty tons of smoking incandescent pig iron lay on the floor. Immediately, the mud gun was swung round to the front of the furnace—a steel cylinder with a ram worked by steam terminating in a nozzle. The nozzle was thrust into the furnace hole, the gun was charged with balls of fireclay; and plunk, plunk, to a hissing accompaniment the plugs were rammed home till the sealing was completed. Then the blast which had been partly shut off was let loose; you could hear the rattle of the skips as they carried the ore and coal and flux to the furnace top and plunged them into the raging cauldron within and all was relative peace. The furnace had renewed its unending task—to receive its charge of raw material and convert it into liquid form, until in another six hours or so it would be ripe for another tapping, by which time the pigs on the floor would have been carried off to the store and the floor prepared with another series of moulds.

This was as far as the guests were able to witness the actual process of manufacture, as the steel works are not quite ready. When they are in operation, which will probably be next month, very little iron will be converted into pig and the molten metal will be carried direct in great ladles to the steel house where it will be poured into a three-hundred-ton mixer and thence diverted into one or another of the open hearth steel furnaces when, with

the cycle of manufacture complete, the iron will never cool from the time it leaves the blast furnace until it is carried, a finished rail or shape, to the store yard. These other processes for the moment have to be taken on trust. A fascinating hour was, however, spent in inspecting the processes subsidiary to the making of iron and the works which will ultimately convert it into steel. They saw the bins where the ore from Gurumaishini and the flux from the Central Provinces are stored, and the coke ovens which take the coal from Jherria and turn out a coke of excellent quality. They saw the bins automatically drop the charges into skips running up an inclined way and tip their contents into the furnace, which is so tightly sealed that none of the gases escape, but are harnessed to utilitarian purposes. Some of them are carried off to the four stoves which heat the blast and so effect the great economy in fuel which makes the production of cheap iron possible. Others are carried away to the water-tube boilers which generate the steam driving the turbo-blowers for the blast and the turbo-generators for the electric power, which is the maid of all work. Indeed, a modern blast furnace recalls Max Adeler's ideal of every pig his own sausage maker, for the gases from the furnace produce the power which creates the blast and heats the blast, so that it can do its work cheaply and well.

Then they passed into the steel house, the largest building of its kind in Asia, where the "mixer" acts as a balancing reservoir between the blast furnaces and the steel works, where four furnaces are almost ready to begin the process of steel making, where the gas-fired soaking pits are to heat the steel ingots to a uniform temperature in readiness for the "blooming" mill. And so to the rolling mill where the twelve thousand horse-power engine was running the rolls which on one side will reduce the

ingot to the short lengths which are technically termed blooms, and on the other will roll the blooms into rails or whatever structural shapes may be demanded by the market. Lord Crewe who was specially interested in these processes, for he is an iron-master himself, was driven off to the model township where the European and Indian staffs are housed and the others passed through the fine machine shops and foundries which make the works self-contained.

The visit made a deep impression on all who were present. They admired the courage which has planted a steel city in the jungle and raised a crore and a half of rupees* in order that India may possess the iron and steel manufacture which is the life blood of modern industry. They were able to appreciate the careful scientific investigation which preceded the stage of construction and the skill and forethought which have erected in India a plant which embodies the very best modern practice. With this recognition came the earnest and confident hope that those who pioneered and carried to completion this great enterprise may be rewarded by an adequate financial return.

* Since raised to 10½ crores. Debentures 2½ crores.

The foregoing chapter describes the history and development of the Tata Iron Steel Works up to the time of the blowing-in of the first blast furnace. The progress made since that time, and the plans for the future, are set out in the following appendices.

APPENDIX A.

FLOTATION AND FINANCE.

The Tata Iron and Steel Company, Limited, with an authorized capital of Rs. 2,31,75,000 (£1,545,000), was formed in 1907, and was registered in Bombay on the 26th August 1907. The Capital of the Company was divided into 50,000 6% Preference Shares of Rs. 150 each, 2,00,000 Ordinary Shares of Rs. 75 each, and 22,500 Deferred Shares of Rs. 30 each, making a total Capital of Rs. 2,31,75,000. The objects of the Company were stated in the prospectus to be the establishment "in India of Blast Furnaces, Open Hearth Steel Furnaces, Rolling Mills, Coke Ovens, and other plant necessary for the manufacture of pig iron, steel rails, bars, plates, etc., and for these purposes to acquire mining rights over very valuable and large deposits of iron ore." The total Capital of the new Company was subscribed by the Indian public in the remarkably short space of a few weeks, the number of shareholders being about 7,000.

The properties, prospecting license and other rights acquired by Messrs. Tata, Sons & Co., together with the freight concessions and other privileges granted by the Government of India were then taken over from them by the newly formed Company. Messrs. Tata, Sons & Co., were appointed the Company's Agents, and Sir Dorabji Tata was appointed Chairman of the Board of Directors, which, besides himself included seven other Indian gentlemen well-known in the Indian business-world.

The original Capital of the Company of Rs. 2,31,75,000 was increased to Rs. 3,52,12,500 by a Special Resolution of the Company passed on the 12th day of December 1916 and confirmed on the 11th day of January 1917 and again increased to Rs. 10,52,12,500 by a Special Resolution of the Company passed and confirmed on the 7th and 22nd days of November 1918, respectively.

The Debenture Capital of the Company, all of which has not yet been issued, is Rs. 2,25,00,000. The total capital of the Company, including debentures, therefore, amounts to Rs. 12,77,12,500.

It would be interesting at this stage to state the present financial position of the Company up to the year ending 31st March 1919. The total net profits made by the Company up to 31st March 1919 came to about Rs. 3,85,23,753. Out of this the Company has paid up to now the following dividends :—

	Rs.
Preference Shares	32,78,758
Ordinary Shares	1,11,43,359
Deferred Shares	53,25,000
Total Rs. ..	1,97,47,117

Besides the payment of dividends amounting to Rs. 1,97,47,117 the Company has wiped off all the preliminary expenses which amounted to Rs. 5,33,000 and has carried the following amounts to the Depreciation, Reserve, and Repairs and Renewal accounts:—

	Rs.
Depreciation..	1,28,91,037
Reserve	15,35,440
Repairs and Renewal	15,59,258
Total Rs. ..	1,59,85,735

APPENDIX B.

OPERATION PROGRESS.

The present plant comprises the following Departments besides the usual Boiler and Power House, Machine shop, Foundry, Pattern shop, etc.

COKE OVENS.

A battery of 180 Coppee Non-Recovery Bye-Product Coke Ovens, with the necessary equipment for the crushing and handling of coal, and 50 Kopper's Bye-product Coke Ovens together with the Bye-Product and Sulphuric acid Plants.

BLAST FURNACES.

Two Blast Furnaces each of 350 tons capacity per day, with brick-lined hot blast stoves, chimneys, dust-catchers, slag ladles, 30-ton brick-lined ladles for transporting the iron to the Steel Works, travelling cranes, and electric lorries and automatic skip-hoists for charging material. An addtional furnace, known as the Batelle furnace, with a capacity of 300-tons a day has recently been installed and lighted.

STEEL WORKS.

One 300-ton hot metal mixer and six Open Hearth Furnaces, four of which are of 50-ton capacity and two of 60-ton capacity.

BLOOMING MILL.

One 40-inch reversing Blooming Mill.

One 28-inch Reversing Combination Rail and Structural Mill with roller-table, re-heating furnaces, hot saw, cooling beds, rail beds, cranes, and all necessary machinery for finishing.

BAR MILLS.

One 16-inch and two 10-inch Rolling Mills.

The Coke Ovens were the first to start work, the Blast Furnaces next, then the Steel Works and Rolling Mills. This is also the natural order in which the coal, iron ore, and other materials of production pass from their raw stage into the finished product. The Coke Ovens must produce coke before the iron ore can be smelted in the Blast Furnaces and converted into pig iron. The iron in turn becomes the raw material for steel and is sent to the Open Hearth Furnaces which convert it into steel. The liquid steel is then cast in the form of large rectangular pieces called "ingots." The ingots are then made to pass through the Blooming or Cogging Mill which reduces their size and converts them into blooms and billets. The work of rolling the blooms and billets into rails, beams, bars, angles, channels, fish-plates, etc., is performed by the 28-inch Mill and the Bar Mills, and the finishing department which is attached to the Rolling Mills puts the finishing touches to the various products. The Company's steel has to pass a strict test in the Government Laboratory before it is despatched from the Yard to its respective destinations.

A brief review may now be given of the progress of the production departments, commencing with the coke ovens.

THE COKE OVENS.

The plant in this department originally consisted of a battery of 180 Coppee Ovens of the Non-recovery type; and it came into operation in September 1911. In order to make permanent provision for a greatly increased output of coke and to obtain and utilize the valuable bye-products resulting from its manufacture, it was decided to make an addition to the plant of a fresh battery of ovens of the bye-product recovery type. In 1914, the Company entered into a contract for the installation and construction of 50 Koppers Coke Ovens and Bye-Product Plant for the recovery of coal tar and gas, and the manufacture of sulphate of ammonia. In connection with this

a Simon Carve Sulphuric Acid Plant with a daily capacity of 5 tons of acid has been installed. The work of constructing the Bye-Product Ovens was commenced in July of that year. The Coke Ovens proper were completed in the beginning of 1916 and the Bye-Product Plant a few months later.

The Plant has been so arranged that an additional battery of 50 Ovens can be subsequently erected continuous to the new ovens, and the Bye-Product Plant has been constructed to provide for its subsequent duplication without interfering with the existing arrangements.

With the installation of the new ovens which came into operation in August 1916, the 60 Drag Ovens were discarded. It has not been found feasible to discard the other battery of Coppee Non-recovery Ovens, but the waste gases from 45 of the ovens are at present utilised to operate a power plant and thus economise coal. In course of time the non-recovery ovens will be either altered or discarded in favour of bye-product recovery ovens. The valuable bye-products which are at present recovered from the Koppers Ovens are coal gas, coal tar, and sulphate of ammonia.

THE BLAST FURNACE PLANT.

The Blast Furnace Plant consists of two Blast Furnaces 77 feet by 19 feet and 12 ft. diameter hearth, equipped with up-to-date charging and weighing apparatus and four Cowper-Kennedy Stoves.

When the works were started, only one furnace was in operation and as the entire Blast Furnace crew had been engaged at the end of 1911 it was found practicable to run it almost entirely on American labour. The second furnace was blown in on 22nd September 1912. There were some initial difficulties which are usual with this kind of work, but after these were put right, both the furnaces worked without a hitch, producing a record tonnage.

The maximum output has been a little over 15,000 tons per month.

The great increase in price of Ferro-Manganese due to the War, led the Management to consider the advisability of manufacturing it from the Company's own Manganese Ore. Accordingly, in the month of October 1915, one of the Blast Furnaces was put on Ferro-Manganese.

The Pig Iron produced by the Works has been of uniformly excellent quality and equal in quality to the best imported brands. During the first three years of operation the production was in excess of the demand. Throughout 1913, the pig iron market suffered from heavy depression, prices sagged very low, and large stocks were left on hand unsold. Towards the end of 1914, the market improved and prices continued to advance, so that the demand now keeps abreast of the production of pig iron.

In 1915 a new foundry for the manufacture of cast iron pot sleepers was added to the Works, and it has been making pot sleepers for the Indian Railways since September 1915. Thus a new product has been added to the list of manufactured articles, and an increased proportion of the production of pig iron produced is profitably utilized. Before the prohibition of pig iron export from India came into force, shipments varying in size were made to Burma, the Straits Settlements, Ceylon, Java, Manchuria, Japan, Australia, New Zealand, United States, etc.

The slag which is formed in the manufacture of pig iron is now made use of in making granulated slag bricks for local use. The bricks thus made are found to be more durable than ordinary red bricks.

THE STEEL WORKS.

The steel works plant originally consisted of one 300 ton furnace, known as the "Mixer," and four stationary Open Hearth Furnaces, each with a capacity of 50 tons per "heat." They

were designed for a capacity of 40 tons per "heat," but in January 1914 the designs were altered and the capacity of each furnace was enlarged to 50 tons per "heat."

The liquid pig iron is conveyed from the Blast Furnace to the Steel Works in 30 ton brick lined ladles and poured into the Mixer, which receives all the hot metal from the Blast Furnaces, preparatory to its conversion into steel. From the Mixer the iron is tapped out into ladles and charged into the Open Hearth Furnaces for conversion into steel. When the process of conversion is over, which takes on an average about 8 to 10 hours, the liquid steel is tapped and cast into "ingots," which are then sent on to Soaking Pits to be ready for the Blooming Mill.

There are at present three Soaking Pits which are placed in the Steel Works building. This is a great advantage in a country like India from the point of view of temperature. The Soaking Pits are equipped with mechanically operated lids and an electric overhead charging and drawing crane. The ingots measure in section 21" × 19" and weigh about 2 to 3 tons each. They are taken by a self-tipping electric trolley to the mill tables.

The first heat from the Open Hearth Furnaces was tapped on 16th February 1912. Two additional Open Hearth Furnaces with a capacity of 60 tons per heat were completed and put in operation in 1917.

Until the outbreak of the war, the Open Hearth Furnaces were worked by German labour. There were 40 covenanted hands in 1912. At the outbreak of the war they were allowed to continue at the Works by the kind permission of Government; but half of them were removed to Ahmednagar in October 1914, and the rest in December. Their places were taken by men recruited in England.

The Kumardhubi Fireclay and Silica Works of Messrs. Bird & Co., and the Potteries, Raneegunge, of Messrs. Burn & Co., have now commenced to supply the Company with silica bricks

which promise to compete with the foreign bricks hitherto imported.

As regards Magnesite bricks, this Company is now quite independent of the foreign supply, as magnesite bricks made from the Company's Mysore Magnesite Ore by the Kumardhubi Fireclay and Silica Works are as good as the Austrian Magnesite bricks formerly imported.

ROLLING MILLS.

The Company have a 40" Blooming Mill, a 28" Rolling Mill, a 16" Mill and two 10" Bar Mills (one of the 10" Bar Mills came into operation only in September 1915).

In the Blooming Mill the hot ingot from the Soaking Pits is reduced to the required size of blooms and billets for the 28" mill and bar mills respectively.

28" FINISHING MILLS.

The 28" finishing mill can turn out rails from 100 lbs. to 30 lbs., beams from 15×6 inches down to 5×3 inches, angles from 6×6 inches to 3×3 inches, channels from 12×4 inches to 6×3 inches.

Blooms from the Blooming Mill are reheated in reheating furnaces before they are rolled. Sections of rails or structural material after being rolled to required dimensions are cut by circular saws into required lengths and are mechanically conveyed by rollers to cooling bed which is of the moving type. From the cooling beds, all bars including rails are passed through a roller straightening machine in the Finishing Department which is equipped with three straightening machines and the usual drilling and planing machines, and an overhead electric crane which runs over the full length of the Finishing Department.

BAR MILLS.

At first there was one 16" mill and one 10"mill. In September 1915, one more 10" mill was added so that now there are two 10"

mills. The 16" mill makes light rails weighing 30 lbs. to 14 lbs. to the yard, angles of all sizes from 3" to 1½" and channels from 4" down to 1½", 4"×1¾" beams, and fishplates for rails. The 10" mills are devoted to the production of lighter sizes of flats, squares, rounds, etc.

A roll turner's shop is attached to the mills and most of the rolls required by the mills are turned here. But for the foresight of the Company in having a roll-turner's shop manned by trained European operatives, the Company would have been considerably handicapped by its inability to obtain rolls from abroad during the war time.

There is a well equipped Chemical and Physical Laboratory attached to the Works for testing raw material and finished products. There is also a Government Laboratory in charge of the Metallurgical Inspector of the Railway Board who supervises the Company's manufacture on behalf of the State Railways. The position of the Metallurgical Inspector was filled by Dr. Mac William (late of the Sheffield University) till last year, when his services were borrowed from Government by the Tata Iron and Steel Company for the improvement of the Open Hearth practice and other research work.

There are also well fitted machine shops together with shops for pattern makers and carpenters, blacksmiths, repairs to locomotives, electrical repairs and for structural work.

POWER HOUSE.

The Power House contains three Turbo-Blowers for supplying air to the furnaces in the blast house. A volume of 32,000 cubic feet of air, under pressure of 15·5 lbs. to the square inch, is blown into those receptacles in the course of a minute, and the power absorbed is for a full load 2,250 H. P., for a three-quarter load 1,920 H. P., and for a half load 1,700 H. P.

The plant consists of three 1,000 Kilowatt, 3,000 volt Turbo-Alternators running at a speed of 3,000 revolutions per minute,

and three Transformers of 1,250 K. V. A., 3,000 to 440 volts and two Motor Generator sets of 500 Kilowatts each.

These machines supply power for lights and fans throughout the entire works, including the bungalows in the Northern Town, for driving all machinery in the Machine Shop and Foundries, and for cranes and pumps.

The supply of water not only for the Works but also for the large number of persons living in the adjoining township which has come into existence since the commencement of the Works was at the outset a question of supreme importance to the Directors, but ample provision has been made for all purposes by pumping from the Subarnarekha River—a distance of 2 miles. The water is pumped electrically through pipes 36″ in diameter from the river to a very large storage tank at the Works.

APPENDIX C.

EXTENSIONS AND SUBSIDIARIES.

Extensions of the Company's Works on a large scale are under construction, whereby the Works will be equipped to produce about 350 to 400 thousand tons of Finished Steel per annum. The following additions will be made to the present plant :—

200 Wilputte Coke Ovens.
3 Blast Furnaces including the "Batelle."
2 Duplex Furnaces and an Open Hearth.
A Blooming Mill.
A Continuous Sheet Bar & Billet Mill.
A Rail Mill.
A Sheet Mill.
A Continuous Merchant Mill.
A Plate Mill.
A Sleeper Press.
A Pipe Foundry.
An Electric Furnace.

Thus there will be an increase in the output of Coke Ovens, Blast Furnaces, Open Hearth Furnaces and the Finished Steel will be more diversified. Over and above the rail and structural sections, Works for the manufacture of Bolts and Nuts and Rivets Plate, Sheet, Galvanized Sheets, Wire and Wire Shapes, Steel Sleepers, Cast Iron Pipes, Steel Tubes, manufacture of Wheel Axles, Tyres, Springs and other accessories of Wagons and Railway Wagons themselves will be established. Some of these products will not be made directly by the Steel Company, but by subsidiary industries established in the vicinity of its Works.

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Arrangements have almost been completed for the establish ment of Subsidiary Industries to undertake the manufacture of:—

1. Enamelled Ware,
2. Tin Plate,
3. Sulphuric Acid and Zinc,
4. Jute Mill Machinery,
5. Steel Tubes.

In addition to the above, the Company is considering proposals for the establishment of the following industries.

1. General Engineering,
2. Electrical Machinery,
3. Chemicals,
4. Agricultural Implements,
5. Galvanized Buckets, &c.,
6. Wire Shapes and Steel Shelving,
7. Structural Work.

In order to enable the Company to locate these Subsidiary industries, and for other purposes of the Company, Government have been pleased to acquire for the Company 11¼ square miles of land at Jamshedpur; this with the area already acquired and a further area which is likely to be granted by Government, will bring the total area of land owned by the Company to about 25 square miles.

The Extensions of the Works of the Company will also include all the works necessary for the welfare of labour such as schools, Hospitals, Agricultural Farms, Dairy Farms, Co-operative Societies, Libraries, Gymkhanas, Technical Schools and all other Institutions solely devoted to the benefit of labour.

The proposed Extensions will ultimately increase the population of Jamshedpur to about 200,000 souls, which will necessitate the Extensions of the Town and amenities such as water, drainage, habitation for the work people, staff, &c.

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The main principles underlying the Extensions are to effect economy of operation and to promote efficiency, and to put the Company in a position successfully to meet competition by the manufacture of a larger variety of products, by low costs attending on large scale production, and by securing fixedcustom for a portion of its products through the establishment of Subsidiary Industries at Jamshedpur.

APPENDIX D.

MUNICIPAL AND WELFARE WORK.

Before the establishment of the Tata Iron and Steel Company, Ltd., the present site of the Works and the town was covered with jungle with a few aborigines living in the villages near by. When the Company started its manufacturing work, it had therefore to assume municipal functions for the protection of the health and for the welfare of the employees. The present population of Jamshedpur numbers about 50,000 souls, out of whom 18,000 are directly or indirectly employed by the Company. The following is a short account of the welfare and municipal work done by this Company :—

Jamshedpur Town.—Up to the middle of 1918 the Tata Iron and Steel Company had spent about 25 lacs of rupees for Town Buildings including Hospital and Roads. The cost of Town and Road lighting came to about Rs. 1,32,000. The Company is now considering the question of building more houses for the accommodation of the employees. For the convenience of the public, the Company has built Rice and Vegetable sheds in the vicinity of the Bazaar, at a total expenditure of about Rs. 36,000.

Sanitation.—On Town Sanitary Works which includes the septic tanks for the Northern and Southern towns and drains, the Company has up to the middle of 1918 spent about Rs. 3,31,000 and under the Greater Extensions scheme the Company will incur an additional expenditure on this account.

For the water supply for the works and the town a capital expenditure of about Rs. 10,53,000 has been incurred, and the Company proposes to spend a further sum of about Rs. 31,50,000 for the improvement of the present water system to cope with the larger population that would grow during the next ten years.

Public Latrines.—The Company is maintaining 23 Latrines in Jamshedpur Town for the convenience of the general public.

Abattoir.—As there is no slaughter house at Jamshedpur at present, the Company proposes to build an abattoir on modern lines.

The Company has recently employed a qualified Public Health Officer to look after the sanitation of the Town, water supply, drains, roads, septic tanks, lavatories, fish and meat, vegetables and fruits sold at the Jamshedpur Bazaar, &c.

The Company has also engaged the service of Dr. Gilbert Fowler, the drainage expert at the Indian Institute of Science, Bangalore, at great expense to study the problems of applying the Activated Sludge process to the disposal of sewage at Jamshedpur and thus convert the sewage into a valuable fertiliser. At present experiments are being carried out at Jamshedpur by Dr. Gilbert Fowler's assistants which point to the successful application of this process to Jamshedpur sewage. The Tata Iron and Steel Company is the first corporation of its kind in India to experiment at their own expense in the Activated Sludge Process which, if successful, will be of benefit not only to this Company but also to the whole country.

Hospital.—There is no Government Hospital or Government Aided Hospital at Jamshedpur or in the neighbourhood. The Tata Iron and Steel Company has a hospital where the Company's employees and outsiders are treated free of charge. The number of patients treated in our Hospital from the year 1911 to 30th April, 1918, comes to about 8,27,462, out of whom 40 per cent. were outsiders from Jamshedpur and neighbouring villages, who were supplied with medical aid entirely free of charge. Thus this Hospital is not only taken advantage of by the employees of the Company, but also by the inhabitants of some 12 to 15 villages situated within the radius of 10 to 15 miles of the town of Jamshedpur.

APPENDICES

In connection with the present Hospital, there is a segregation shed situated at a considerable distance from the residential quarters where patients suffering from infectious diseases are kept.

As the accommodation at the existing Hospital is not sufficient to take care of the increasing number of patients, arrangements have been made for building a new well equipped hospital on modern lines at an expenditure of six lacs of rupees.

Dalma Hills.—A scheme is under discussion for the establishment of a Hill station at Dalma in co-operation with the Government of Bihar and Orissa for the benefit of the Company's employees.

Education.—The Company have at present four schools at Jamshedpur :—

(*a*) The Mrs. Perin Memorial School.
(*b*) A Night School.
(*c*) A Mechanic School.
(*d*) A Girls' School.

The Mrs. Perin Memorial School has been up to now a middle English School. But it is now proposed to raise it to the High School Standard. The number of boys at present on the roll is about 204, daily attendance being about 150.

In the Night School, Office *Chokras* and other employees of the Company who are desirous of learning English and Mathematics, get free tuition every evening for two hours. The number of students attending this Night School is about 70 at present.

A School for the children of better classes of Indian and European employees is being considered; while six Primary Schools teaching Hindi and Bengali are about to be started in different parts of the Town.

In the Mechanic School, promising young boys of the Mistri class employed at the Works, are taught elementary mathematics and Drawing with a view to make them more efficient in their work. About 25 students attend this School at present.

The total Capital Expenditure incurred on school account by the Company up to the middle of 1918 came to about Rs. 30,400. Since then, the Directors have sanctioned the building of a Girls' school at Jamshedpur. This building is now complete ; and is capable of accommodating 200 to 300 pupils.

It has been proposed by the Government of Bihar and Orissa to start a Technological Institute at Jamshedpur with the help of this Company, which would specialise in Metallurgy and Electrical and Mechanical Engineering ; and this proposal is at present under discussion between the Company and the Local Government. The building and equipment for this Institute are expected to cost about Rupees Two Lacs about half of which will be shared by this Company. A part of the running expenses, not exceeding Rs. 35,000 per year, will also be borne by this Company.

Clubs and Public Amusement.—The Company has built a fine Institute for the employees containing a Concert Hall, Billiard Hall, and Reading Rooms, Tennis Court, Cricket and foot ball ground and a Bowling Alley. Any employee of the Company can become a member of this Institute without distinction of pay, colour or creed. For the convenience of the employees living in "G" Town, the Company has recently built a Branch Institute in that quarter. These two Institutes have cost the Company Rs. 98,300. For the amusement of the public a band has been organised from amongst the Company's employees and the cost incurred up to now of equipping it with necessary musical instruments comes to about Rs. 2,000.

Public Safety Department.—The Company has a public and town safety department employing about 100 Chowkidars and Sepoys under a Police Officer lent by the Bihar and Orissa Government. This Department works in co-operation with the Local Government Police for the safety of the Public and detection of crime. From 1st of July 1911 to 30th April, 1918, the operation expenses incurred in connection with this Department amount to Rs. 1,29,000.

Public Conveyance.—As there were no suitable means of conveyance of public passenger traffic from the station to the Jamshedpur Town, the Company bought two Motor 'buses in 1916, at a cost of Rs. 21,400. These 'buses meet every train at Tatanagar and are available for the public. This facility is provided to the public at a loss. A picnic or holiday 'bus is also about to be provided for the recreation of the employees of the Company.

Jamshedpur Hotel.—As there is no Government Dak Bungalow at Jamshedpur or near about, the Company had to start a Hotel last year to provide accommodation for the Public, though in running it the Company suffer a considerable loss.

Consumption of Country Liquor.—In order to minimise the effect of drunkenness among the workmen, and in order to help the Government in their policy of "Minimum consumption and Maximum Revenue" this Company, last year, arranged with the Government to have shops of their own in Jamshedpur and neighbouring villages on the contract supply system.

Supply of Milk.—As it was found difficult to procure good-milk and bread for the Northern Town, the Company gives facilities to a private concern for a dairy and bakery.

When the low lying land at the junction of the Khorkai and Subernareka River is acquired, they propose to devote about 4,000 acres of this land to large-scale farming on modern lines. Mr. Milne, the Government Agricultural Officer of this Province, has reported favourably on this scheme. The object is to start a model Farm on a large scale, worked by up-to-date methods. As the Works produce ammonium sulphate and basic slag as by-products, these fertilisers will be advantageously used in this farm to which a plentiful supply of water can be secured from the water which now runs to waste after serving the Works. This will be a model Farm of its kind in the Province. Not only will it supply the necessary Dairy Farm produce to the growing population of Jamshedpur and the neighbouring villages,

but it will be an example to the neighbouring farmers of modern up-to-date methods of farming. This scheme is expected to cost the Company nearly Rs. 2 lacs.

Town Hall and Bank.—To add to the amenities of the Town, it has been proposed to build a Town Hall at Jamshedpur.

For the convenience of the Company, the subsidiary industries and the general public, it has been arranged to have a branch of the Tata Industrial Bank established at Jamshedpur.

Insurance against Accidents.—To give facilities to the employees for insurance against accidents, etc., the Company has a scheme whereby any employee of the Company can insure himself against accidents met on the premises of the Works at half the cost of what he would have to pay as premium to any Accident Insurance Company.

Social Welfare Work on Scientific Lines.—In order to carry on the Social Welfare Work on modern scientific lines, a Committee of distinguished Sociologists consisting of Professor Urwick of the London University, Professor Hobhouse and Mr. and Mrs. Sydney Webb has been formed in London to help in drawing out a scheme for scientific welfare work to be done at Jamshedpur. This Committee recommended that Dr. Mann, Principal of Poona Agricultural College, should be asked to make a preliminary report about Social Welfare Work at Jamshedpur. Dr. Marn accordingly visited Jamshedpur and has now submitted his report which is being considered by the Directors.

A Rest House for Coke Ovens Coolie Women.—In 1915 the Company provided a Rest House for the women working at the Coke Ovens where they might sleep. "Creche" is also provided in the Rest House for their children, who are taken care of by an Indian Nurse.

Grain Distribution and Co-operative Societies.—Owing to the recent rise in the prices of foodstuffs the Company has arranged for the wholesale purchase of grain and other necessities, and their

distribution to its employees at cost price. The Servants of India Society have lent the services of Mr. A. V. Thakkar and two other members for the purpose. A number of Co-operative Societies are also being organised.

Hours of Work.—Realising the harmful effects of long hours on workmen, the Company has introduced in all its operative departments, coke ovens, blast furnaces, steel works, rolling mills, etc., a shift of eight hours instead of twelve, which is the usual practice in Indian factories.

APPENDIX E.

WAR SERVICES.

The Tata Iron and Steel Company has rendered valuable services to the Government during the war by their ready supply of rails and other materials required for India and for the Campaigns in Mesopotamia, Egypt, Salonica and East Africa. These services have been publicly acknowledged by the Viceroy. From the beginning of the War in August 1914, the Company has supplied to the Government about 291,562 tons of steel material in the shape of rails, shell steel and structural material at an average base price of less than Rs. 150 per ton. If this pioneer Steel Works had not existed, this supply would have had to be obtained from the United States as the English Works were busy with urgent Munition work of their own. The average price at which the Government could have secured their requirements from the States would have been at least Rs. 200 per ton more than what they have paid to this Company, considering the high level of prices obtaining in the States and the exorbitant freight and insurance rates. In other words, by supplying, 291,562 tons of steel materials to the Government at an average base price of less than Rs. 150 per ton, this Company has made a saving of about six crores of Rupees to the Government. We give below the figures showing the total percentage of the Company's steel output supplied to the Government since the beginning of 1st April 1917:—

	Per cent.
April 1917	77·88
May	76
June	69
July	71·19
August	77·36
September	77·84
October	79·97

	Per cent.
November	77·59
December	83·31
January 1918	74·94
February	81·85
March	79
April	89·7
May	89·2
June	92·6
July	91·19
August	92·04
September	97·72
October	96·42
November	93·75
December	86·10

To give an idea of the sacrifice made by the Steel Company it may be mentioned that for the Bar Mill material sold to Government, the Company could have easily realised in the market four to five times the price paid to it by Government, as the price of steel bars in the Calcutta Market went up as high as Rs. 1,000 per ton.

In addition to these supplies, about four thousand tons of Pig Iron were supplied against orders from Government for Military requirements and for the requirements of public bodies at very low rates compared with the price of Pig Iron in England. Thus, for instance, when the f. o. b. price of Cleveland Pig in England was about 122 shillings per ton (Rs. 91-8-0) supplies were made by the Tata Steel Company to the Government Gun and Shell Factory at Cossipore at Rs. 80 per ton only, which would mean that the Tata price was cheaper by over Rs. 11 per ton even without taking into account the sea freight, insurance and handling charges, etc.,

which Government would have had to incur to get their supplies from England.

In the beginning of the War the Company had two Blast Furnaces for Pig Iron and four Open Hearth Steel Furnaces, and as the output of the Blast Furnaces was very much more than what the Steel Furnaces could convert into steel, a very large tonnage of Pig Iron was available for sale in the market at very profitable rates. But during the War, the Company, realising the urgent need of Government for additional steel, voluntarily added two more Open Hearth Furnaces to its Steel Plant and thus converted practically the whole of its output of iron into steel, though to do that meant heavy sacrifice because the rate of profit on Pig Iron was ever so much higher than that of steel at its controlled price.

In 1916, Ferro-Manganese, which is one of the essential alloys required in steel making, was made at Jamshedpur for the first time in India and a few thousand tons were sold in the American Market at very profitable prices. For Ferro-Manganese fancy prices were obtainable during the years 1917 and 1918 in America and Japan. The Steel Company, with a loyal determination to help the Government, agreed not to manufacture this much needed alloy and utilized the Blast Furnaces, for the manufacture of Pig Iron which again, as stated above, instead of being placed on the market yielding better returns, was practically converted into steel to help Government during the period of the War. If one of the Blast Furnaces of the Steel Company had been placed on the manufacture of Ferro-Manganese for nine months during the year 1918 and the whole of this Ferro Manganese exported to America, the Steel Company would have made a net profit of not less than about a crore and ten lakhs of Rupees from the output of this one Furnace alone. But it had to forego this advantage in order that both the Blast Furnaces may be put on Pig Iron for conversion into steel so urgently required by Government.

APPENDICES

Tata Steel was furnished at controlled prices not only for the Military requirements in Mesopotamia, Egypt, East Africa, Salonica and other theatres of War, but was supplied also at the same rate to the Indian Railways and Military and Civil Departments of the Government in India. Even the Port Trusts of Bombay and Karachi, which have their own separate organisations, were allowed the benefit of controlled prices for the supplies they received, and were able to obtain practically all their requirements of steel at the low controlled price fixed by Government. The Steel Company, during the period of the War, has thus done services not only directly for the conduct of the War, but have indirectly helped all the Railways in India and all public bodies in India to obtain considerable quantities of steel at very low prices.

It would not be out of place here to refer to the Steel Company's contribution to the War Loans, and figures showing the amounts contributed by the Steel Company and its Employees are given below:—

	Rs.
Contribution by the Steel Company to the *First* Indian War Loan (Bombay Office)	40,00,000
Contribution by the Steel Company to the *First* Indian War Loan (Jamshedpur Office) ..	2,75,000
Contribution by the Steel Company to the *Second* Indian War Loan (Bombay Office)	10,00,000
Contribution by the Steel Company to the *Second* Indian War Loan (Jamshedpur Office) ..	5,00,000
Total contributed by the Steel Company ..	57,75,000

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	Rs.
Contribution by the Employés of the Steel Company to the *First* Indian War Loan (Jamshedpur Office)	2,75,000
Contribution by the Employés of the Steel Company to the *First* Indian War Loan (Bombay Office)	10,000
Contribution by the Employés of the Steel Company to the *Second* Indian War Loan (Jamshedpur Office)	58,500
Contribution by the Employés of the Steel Company to the *Second* Indian War Loan (Bombay Office)	5,400
Total contributed by the Employés of the Steel Company	3,48,900

APPENDIX F.

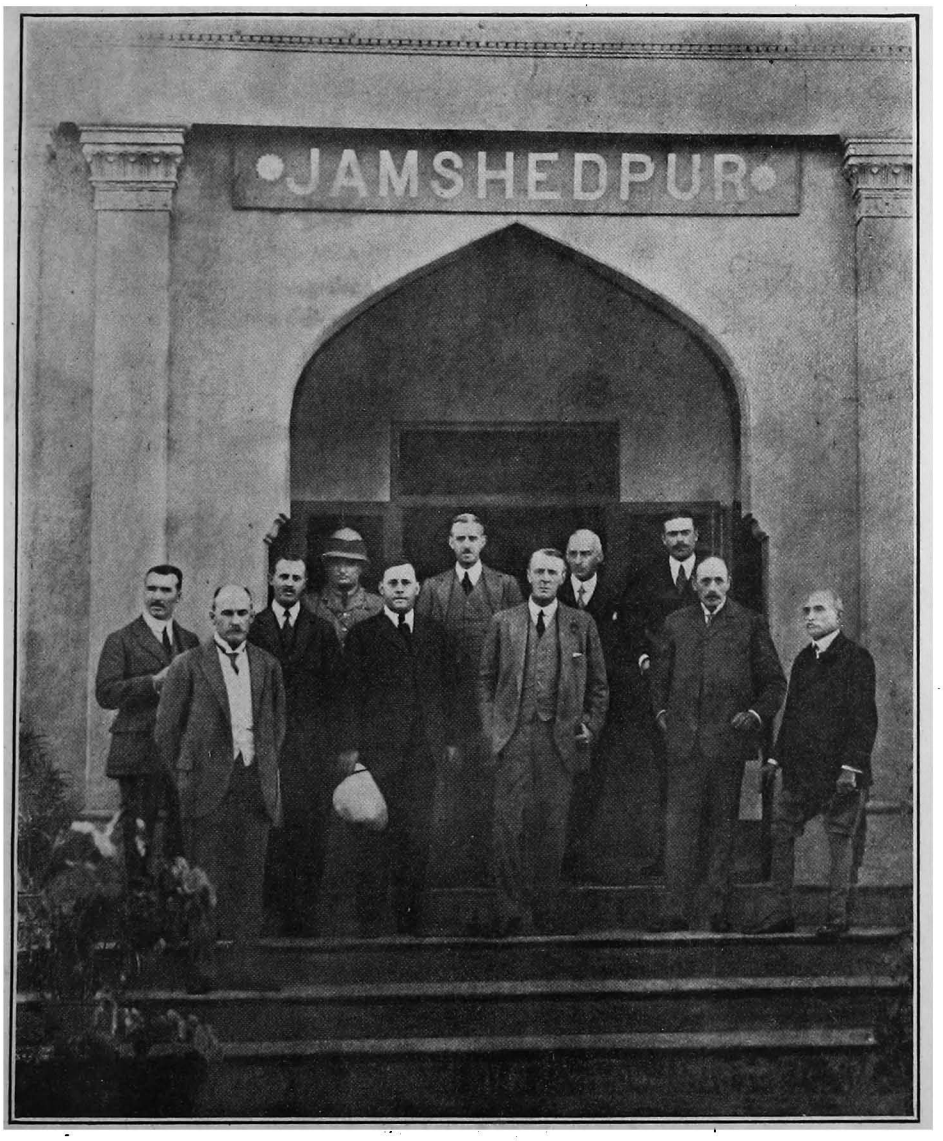
THE VICEROY'S VISIT.

H. E. Lord Chelmsford visited the Tata Iron and Steel Works at Sakchi on January 2nd, 1919. The following account of the visit appeared in *The Times of India* of the following day:—

His Excellency the Viceroy accompanied by the Hon. Sir George Barnes, Colonel Verney, Military Secretary, Colonel Austin Smith and Captain Ives, visited the Tata Iron and Steel Company's Works at Sakchi to-day. On his arrival by special train early in the morning at Kalimati Junction His Excellency was met by Sir Thomas Holland and later at Sakchi station received by Sir Dorab Tata, chairman of the company, Sir Sassoon David, director, Mr. Tutwiler, general manager, the Commissioner of the division, the Deputy Commissioner of Singhbhoom, the Deputy Inspector-General of Police, Dr. McWilliam, Government Metallurgical Inspector and a number of officials of the company. A guard of honour furnished by A company of the Chota Nagpur Volunteers was lined up at the station and was inspected by His Excellency.

The Viceregal party left by motors for the directors' bungalow where they were to stay for the day. The route was gaily decorated with flags and bunting and spanned by a number of triumphal arches with various and suitable inscriptions.

After breakfast at the bungalow, His Excellency motored to the works, over which he was taken in an observation car, accompanied by Sir Dorab Tata, Sir Thomas Holland and the general manager. His Excellency first visited the sulphuric acid plant, the bye-product plant, the bye-product coke ovens and the coppee coke ovens, after which the blast furnaces were inspected, where a cast of pig iron was seen being made. The power-house and the gas producer building were next visited; after which the



THE VISIT OF H. E. THE VICEROY, JANUARY 2ND, 1919.

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party was taken to the open hearth furnaces where His Excellency witnessed the tapping of molten steel. His Excellency inspected the blooming, the bar, the 28 inch and the finishing mills. A number of rails were then seen tested by the drop and the tension tests.

At lunch a number of officials of the Local Government were invited.

The works and offices were inspected after lunch. A visit was subsequently paid to the hospital, the boys' schools, the mechanics' school, the girls' school and the institute, and the party motored round the town.

On returning to the Directors' bungalow His Excellency from the steps of the bungalow and before a large gathering of people announced Jamshedpur as the new name of Sakchi town in memory of the distinguished founder of the Tata Company, the late Mr. Jamshedji N. Tata.*

In announcing the change of name His Excellency said :—

"Gentlemen,

I have come down here to-day in the first place to see this fine example of Indian industry. As you know, it is the policy of my Government to encourage all industries in India so far as is possible to do so. And I wanted to be able to see this fine example of Indian industry which has been set up at Sakchi. In the second place I wanted to come here to express my appreciation of the great work which has been done by the Tata Company during the past four years of this War. I can hardly imagine what we should have done during these four years if the Tata Company had not been able to give us steel rails, which have been provided for us not only for Mesopotamia, but for Egypt, Palestine and East Africa. And I have come to express my thanks to the Directorate of this Company for all that they have done and to Mr. Tutwiler,

* The Government of Behar and Orissa have since changed the name of Kalimati to Tatanagar.

the General Manager of this Company, for the enthusiastic work which he brought to bear in this behalf during the past four years. (*Applause.*) It is hard to imagine that 10 years ago this place was scrub and jungle; and here we have now this place set up with allits foundries and its workshops and its population of forty to fifty thousand people. This great enterprise has been due to the prescience, imagination and genius of the late Mr. Jamshedji Tata. (*Applause.*) We may well say that he has his lasting memorial in the works that we see here all round. But you will be pleased to learn when I tell you to-day that on account of the filial reverence of Sir Dorab Tata this place will see a change in its name, and will no longer be known as Sakchi, but will be identified with the name of its founder, bearing down through the ages the name of the late Mr. Jamshedji Tata. Hereafter, therefore, this place will be known by the name of JAMSHEDPUR. (*Applause.*) It is my privilege here to-day to have been able, on this the occasion of the first visit of a Viceroy to this place, to pay my tribute to the memory of that great man." (*Loud Applause.*)

Later in the evening His Excellency and party returned to Calcutta by Special Train.

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