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The Railways of India



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RAILWAYS OF INDIA.





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THE
RAILWAYS OF INDIA:

WITH AN ACCOUNT OF THEIR
RISE, PROGRESS, AND CONSTRUCTION.

WRITTEN WITH THE AID OF
THE RECORDS OF THE INDIA OFFICE.

BY
EDWARD DAVIDSON, CAPTAIN, R.E.,
(LATE) DEPUTY CONSULTING ENGINEER FOR RAILWAYS TO THE GOVERNMENT OF
BENGAL.

"Not in vain the distance beacons. Forward, forward, let us range;
Let the great world spin for ever down the ringing grooves of change,
Though the shadow of the globe we sweep into the younger day;
Better fifty years of Europe than a cycle of Cathay."

THOMSON.

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P R E F A C E.

As the Railways of India are proving themselves to be mighty agencies for the improvement of that empire, the Author hopes that this attempt to give an account of their rise and progress may be interesting to the many who have at heart the future welfare of India, and that as a record of facts, it may possess a certain value for the professional and general public.

The authorities for the statements in the following pages are to be found scattered through almost innumerable reports and records printed and in manuscript; and the Author has thought it better not to quote in each instance the particular paper referred to (had he done so the references would have been voluminous and intricate, and after all not very useful), but has preferred rather to use freely all the information obtainable, condensing or expanding it as seemed best to suit his purpose. He desires, however, here to express his obligations to all by whose writings or papers he has been assisted or guided.

To Sir Charles Wood (Lord Halifax), late Secretary of State for India, his cordial thanks are due for allowing him access to the records of the India Office; and to General W. Erskine Baker, Royal (Bengal) Engineers,

for aid in procuring that admission, and for kind encouragement to the idea of this work when it was first commenced. Mr. Noad, the Managing Director of the East Indian Railway Company, has always been most obliging in supplying documents; and Mr. A. M. Rendel, C.E., the Consulting Engineer to the East Indian Railway Company, has given much valuable information, especially regarding the works on the chord line of the East Indian Railway. He is much obliged also to the Secretaries of the Great Indian Peninsula and Madras Railway Companies; and more especially is he indebted to G. P. Thompson, Esq., the Assistant-Secretary in the Railway Department of the India Office, for his unwearied courtesy in meeting the many requisitions made for papers and records often requiring much trouble and search to find.

For dimensions and descriptions of the works on the different lines of railway, the Author has relied upon the reports and letters of the Chief Engineers of the East Indian Railway, Messrs. Turnbull, Power, and Sibley; of the Great Indian Peninsula, Messrs. Berkeley and Graham; of the Madras, Messrs. Bruce and Heppel; of the Bombay and Barodah, Colonel Kennedy and Mr. Forde; of the Scinde, Punjaub, and Delhi, Messrs. Brunton and Harrison; of the Eastern Bengal Railway, Mr. Purdon; of the Great Southern, Mr. Carr; and of the Calcutta and Mutlah, Messrs. Bolden and Wall.

He has also had the advantage of perusing many of the reports to their respective Governments by the

Consulting Engineers to the Governments of India, Bengal, Bombay, and of Madras; extending over a series of years, and written by Major (now Major-General) Baker, Majors (now Colonels) Yule, Strachey, Major-General Beadle, Colonel Crawford, Major-General Rivers, Colonel de Lisle, Major (now Major-General) Pears, Captains Johnston, Connell, Taylor, and De Bourbél; Colonel Drummond and Major Medley, all officers of the Royal Engineers, but belonging formerly to the regiments of Engineers of Bengal, Bombay, and Madras.

He has also obtained much useful statistical information from the lucid reports on the railways of India submitted annually by Juland Danvers, Esq., Government Director of Indian Railway Companies. Hann's Hand-book of the Eastern Bengal Railway has been consulted, as well as many other pamphlets and papers too numerous to mention.

Great care has been taken to secure as far as possible accuracy; but still, with records in many instances very incomplete, some reports and papers not having been received from India, and others having been mislaid in the office during the lapse of years, the task has been difficult. The difficulty, too, has been increased from the circumstance that data obtained subsequent to the preparation of reports often render an alteration in design necessary or desirable, and though the change may have been duly reported and sanctioned, yet the letter representing the need of modification may not be now forthcoming.

All obtainable reports, however, have been carefully collated, and errors or discrepancies have thus in a great measure been eliminated; and the Author trusts that the result will prove to be a satisfactory and reliable history of facts regarding the railways of India.

Few statistics and tables will be found in this volume, as such returns are seldom read or cared for and seem to be unsuited to the scope of this book, which has for its object an endeavour to give a popular, but at the same time an useful description of the railways of our empire of India. Those who may desire information on the subject are referred to the comprehensive statistical tables officially computed by Juland Danvers, Esq., the Government Director of Indian Railway Companies, and published in his annual reports to the Secretary of State for India in Council.

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THE RAILWAYS OF INDIA.

CHAPTER I.

INTRODUCTION.

Condition of India — Gradual Improvement under British Rule — Changes caused by the Steam-engine — Parallelism between Progress in Intercommunication and Civilization — An Indian Traveller in Times Past and Present.

THIRTY years ago India was practically stationary. Generation after generation had passed away, leaving the habits and the customs of the people more unchanged than those of any other race of which history bears record. The father, who had been a carpenter hundreds of years before, had been followed by a succession of sons of the same trade. The husbandman of the nineteenth century still tilled the field which his ancestors had ploughed at the commencement of the Christian era, caring little for the successive waves of conquest which had from time to time rolled from the north-western frontier over the plains of Hindustan. It was of little consequence to him whether his rent was paid to a Hindoo or a Mussulman, for sovereigns of either creed would equally oppress and grind.

His rupees were few, but so were his wants; and he was content to obtain from a soil, hardly scraped by a plough of a pattern invented it may be some 2000 or 3000 years ago, a poor and hard subsistence. He knew no better lot than that of his fathers, and longed

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for nothing more—ambition had little or no existence in his heart. It is true that of late years white-faced “Sahibs”* had proclaimed that justice and mildness were for the future to be the rules of the servants of “Companie Bahadoor,” but bitter experience had proved to him that promises were light and words not to be trusted. He had found the energy of the Englishman as decisively shown at the desk with the pen, as in the field with the sword. His tongue was servile and his body cringing, but in his heart of hearts he doubted the stability of British rule, and longed for its overthrow, even though it were to be succeeded by Moslem tyranny. But time heeded not the feelings of the Indian, and the activity of the English conqueror was constantly developing itself as years rolled on in ways as novel as they were unexpected. Schools were springing up; hospitals and dispensaries were founded. Written laws were taking more and more the place of summary jurisdiction; and above all there was constant talk, and in some places much work done, in forming roads, in constructing bridges, in excavating canals and other works for irrigation. The very energy of a Western is odious to an inhabitant of the East; and the native of Hindustan, with individual exceptions, loathes the restless character which was always suggesting enlarged and improved schemes of locomotion, irrigation, or education.

Still, though the Asiatic dislikes all innovation, yet he hates exertion more; and patiently therefore bearing every change, and awaiting what the future may disclose, resigns himself to the will of fate. The measures of the British rulers of India have been for the most part good and philanthropic in their tendency, and local potentates were during the last fifty years solely actuated by a sincere desire to benefit the people committed to their

* English gentlemen.

charge; but both measures and work were often misunderstood, and never fully appreciated. The tortuous reasoning of an inhabitant of India, no Englishman has ever been able to comprehend: and it is probable that the natives of India would have at once fallen back into the customs and routine of centuries past, had the pressure exercised by a dominant English Government been removed at any time anterior to 1850. But a more powerful agency than that of laws, roads, bridges, canals, or even education, was destined to arouse the Hindoo from his torpidity. The steam-engine, which had revolutionized European locomotion, had multiplied manifold the productive powers of England, and had increased in a marvellous degree the facilities of inter-communication, was now gradually advancing eastward; and with its advance was overturning prejudices, uprooting habits, and changing customs as tenaciously held and dearly loved almost as life itself. A sacred Brahmin now* sits in a third-class carriage in contact with a Dome (the lowest caste of Calcutta, employed in killing dogs and burying dead), and, preferring a saving in money to his caste exclusiveness, drops his prejudices.

A man who, before railways existed, on no account would have walked or carried a pound weight, but must have had a palkee and bearers, now cheerfully marches to the station with a carpet bag; and, strange to say, even unpunctuality and apathy vanish before the warning bell of a station-master.

Railways, which had gone far in England to annihilate distance, were in India to reduce to a manageable extent the vast distances of the continent;

* I saw an instance of this one day at a station on the East India Railway. The horror of the high-caste Baboo when, on entering the carriage, he saw the sweeper, and yet perceived, from the hasty exclamations of the guard, that he had the alternative of sitting with a Dome, or of being left behind, was most evident. He however went.

were to strengthen the Government; to bind races together; and by giving an impetus to commerce, to vivify and give such a bias to the character of the peoples of India, as ages had not effected, and ages would not efface. Railways, in short, placed upon the country itself the broad and indelible stamp of England; laws could be abrogated, education could be neglected, and even roads might be obliterated or canals choked up; but the conveniences of railway speed having been once experienced, they became a necessity; and, change what may, they will remain firm and unaltered memorials of British rule.

It is probable that it is not fancy merely which suggests, but that there actually is a parallelism between the material progress of a nation in wealth, power, and civilization, and advance in easy and rapid intercommunication. *The Romans the great makers of roads, the English of railroads.* -

The subject, however, is too large for consideration here in its general bearings, but a glance at our own country will indicate that a comparison might be drawn. The coracle, and clumsy cart dragged by oxen, are synchronous with the poverty and barbarism of the ancient Briton. The uncouth open boat and ship, the heavy wain dragged ponderously over the uneven sward or through the heavy morass of roadless England, are coeval with the ignorance and violence of Plantagenets, the misrule and discomforts of Tudors and earlier part of the Guelph dynasty; while the yacht, the clipper, and the steamer, the well-organized mail and the spring waggon rolling easily over macadamized roads, the engine dragging with facility on nearly frictionless roads burdens never dreamed of by our ancestors, bring us to the expansion in wealth, intelligence, and education of the nineteenth century.

But the object of this book has relation to India,

and there the accuracy of the remark is strikingly illustrated—and incisively marked. For many cycles India remained unmoved and unchanged; but the one century of British rule there which is spread out before us with distinct historic truth and certainty, has sufficed to exhibit a nearly roadless continent, with apathy and indolence probably unequalled in any nation; in contrast with railway ease of locomotion, and a sketch of life and enlightenment, which though not filled in or completed, yet promises from its outlines a finished picture of activity and prosperity. The hopes of all who have mourned over the debasement of India are now raised, and raised too from considerations sound and true.

Many are still living in quiet homes in England who have known the miseries of a journey of 1000 miles in a palkee at the rate of two or three miles an hour; or the still more monotonous, though less fatiguing voyage of a budjerow,* idly floating through salt-water channels with the tide at four miles, or leisurely dragged against the current of the Ganges by a string of men at the cheerful rate of one mile per hour.

What a contrast between the arrival of a cadet of olden times and that of a young man in 1868!

Landed in a little boat on the marshy shores of the Hooghly, near the factory of Calcutta, still really guarded by the Mahratta Ditch, he has just arrived in a comfortable tub safely moored at Diamond Harbour, which had for six months previously been beating against the trade winds somewhere between Madeira and the Cape. He is delighted to see once more the green of vegetation, and to place his foot on *terra firma*, but is bewildered and half-frightened at the extraordinary coffin-looking boxes into which, with frantic

* Native boat.

gestures, a hundred naked men, savages as they appear to him, are urging him to get. He looks round, hoping that some vehicle may catch his eye, but seeing none, he at last consigns himself, not without some difficulty and misgiving, to the care of the eager bearers, who, adjusting with a shake or two the burden to their shoulders, jig-jog off with the youngster to the friendly factor who awaits his arrival. Again, after a short stay in Calcutta, fancy him starting a few weeks afterwards for a journey up the country in the same strange-looking box called a palkee, and travelling, day after day and night after night, over paths or roads unused by wheels of any vehicle of better shape than those of a bullock hackery. His body is aching after a restless night, during which he has vainly tried to sleep between the intervals of shouts for "Bukshish" * at the conclusion of a stage, and starts caused by the glare and sickening odour of the flaring torch. The night has been hot and sultry, without a breath of air to cool his fevered frame; but towards dawn a slight feeling of freshness in the air tempts the languid traveller to a short walk, which he hopes may revive him. But soon the dreaded sun appears, bringing with it the hot wind, which parches his skin like the blast from a furnace, and causing soon that exhaustion which falls at mid-day like a weight upon all animated nature. He longs for rest, but no friendly dāk bungalow is to be seen. The only refreshment he can obtain is a "chupattee" † and a hard-boiled egg, eaten under the shade of a peepul-tree by the side of a well; and so he travels wearily on, until at long intervals the hospitable house of some fellow-exile receives him, and in the

* Equivalent to "The coachman, sir."

† Unleavened half-baked biscuit of flour and water, usually used in India by travellers as a substitute for bread.

kind welcome and pleasing contrast of the comforts of the bungalow he half forgets his toilsome way.

Or mark him embarked on a budjerow, lazily floating with the tide through the depressing silence of the salt channels of the Sunderbunds, stopping when the tide turns, and always anchored through the night. The uniform growth of evergreen underwood and low trees, which covers the vast and silent marshes through which the Ganges, by a thousand channels, discharges itself into the Bay of Bengal, oppresses his spirits and tires his eye; while the absence of life or sound adds to the languor of the scene.

It is impossible for any one who has not experienced it to imagine that a light green wood, which at first sight pleases and strikes the eye as lovely and attractive, should prove afterwards so trying and painful by its unchanging monotony. But the Sunderbunds are passed, and now his budjerow is slowly dragged against the stream of the Ganges at the rate of one mile per hour, with many a weary halt during daylight, and a certain anchorage at night. Some months are passed before Dinapore or Allahabad are reached, and the cadet is at last fairly launched on his Indian career.

But now how is it? The young officer leaves England in a swift and beautiful steamer from Southampton, or is swept across France in an express-train to Marseilles. Quickly reaching Alexandria, he crosses Egypt by a railway (boats, omnibuses, and camels being all superseded); and starting from Suez in another commodious vessel, arrives at Calcutta in a journey of five weeks, made pleasing and interesting by agreeable companionship and ever constant change of scene. Landing on a quay at Garden Reach, he finds carriages in numbers awaiting his call, to convey him to large hotels, from the windows of which he may still see the palanquins

which, though not yet exploded, no longer monopolize the locomotion of the city of Calcutta. Receiving orders for Meerut, he packs his boxes and carpet-bag, and seating himself in a covered carriage, small, but suitable to the climate, he drives over metalled roads to the ferry. There a steamer transports him across the Hooghly; and at the terminus of the East India Railway he finds a first-class carriage, with beds, washing-stands, and other conveniences, waiting to receive him. Leaving Howrah, he travels 1100 miles without a break, and in the course of a couple of days or so reaches Delhi—fatigued it is true, but still only with a weariness that a night's rest will remove.

And while locomotion has thus improved, India has passed from prevailing sutteeism, gross ignorance, and torpor, to a degree of civilization, intellectual advancement, and activity which give bright augury for the future; and from this example solely, it will probably be readily admitted that progress in intercommunication is a fair index of advancement in the material prosperity of a nation. Arguments, indeed, are not required to prove that the change in India since the railway era is great and immeasurable; but what has been written will illustrate the fact.

to not with that meaning. India in the past has been like a man asleep. India of the present is the same man awake. The powers, the intelligence, the vigour, the health, are alike in either state; but in the one case they are suspended and useless for the time, while in the other the whole energies of the man are available and in active operation for good for himself and others.

CHAPTER II.

A DESCRIPTION OF INDIA WITH REFERENCE TO THE
CONSTRUCTION OF RAILWAYS.

Description of India — Its Geographical Divisions — Hindustan — Deccan — Ports, the Natural Starting Points of Railways — Very few in India, Calcutta, Bombay — The Great Trunk Lines — Calcutta to Lahore — Howrah — Description of the Country traversed by the Line — Bombay to Allahabad — The Harbour at Bombay — Returns of the Imports and Exports of Calcutta, Bombay, and Madras — The Syhadree Ghâts — Bombay to Madras — Physical Peculiarities of the Presidency.

INDIA is geographically as well as geologically divided into several large districts, and the geographical boundaries generally coincide with those of the physical features of the country. The two great geographical divisions are those called Hindustan and the Deccan. Along the north, forming the boundary of Hindustan, stretch the mighty Himalayas, extending from 66° to 100° E. long. The eternal snows of these mountains are a natural barrier to intercourse and communication which is not likely to be surmounted for many years to come. Many efforts have been made from time to time to effect a practical opening through the chain, but they have hitherto resulted only in failure. These mountains cease somewhat suddenly about 27° N. lat., and sink into level plains, which, forming a wide belt, extend in a direction generally parallel to that of the Himalaya, from the 23rd to the 27th degree of north latitude. On the west, however, this plain is elongated towards the Indian Ocean, and in a triangular shape stretches as far south at 21° N. lat. This large level tract of country,

comprising the greater part of Bengal proper, the North-western Provinces, the Punjaub, and the Bombay Presidency, is watered by the Ganges and the Indus. Both rivers rise in the snows of the Himalayas, the Ganges flowing from west to east to Calcutta, the Indus from north to south to Kurachee. These rivers water the arid plain of Hindustan, and wherever their life-giving waters run or are brought by irrigation, the country is fertile in produce, rich, and populous. Where there is no water, the plain remains a dry and barren desert. This vast plain, called Hindustan, is bounded on the south by the Vindhya range of mountains, which forms at the same time the northern frontier-line of the second grand geographical division of India named the Deccan, which has now to be described.

The Vindhya mountains are divided into three ridges or ranges: that on the north, and which is geographically situated in Hindustan, is known as the Aravalli; that in the centre, or the Vindhya Range proper, which forms a line of demarcation right across India from the Gulf of Cambay to Rajmahal, on the Ganges; and that to the south, which lies within the boundaries of the Deccan, and is known as the Satpoorah.

The Satpoorah Hills, which skirt the Deccan on the north, join the Western ghâts, or Syhadree mountains, which form the walls of the great table-land which extends from lat. 20° to Cape Comorin.

Great rivers flow between these triple ranges of mountains. Between the Aravalli and Vindhya ranges are the Mye, falling into the Arabian Sea, and the Chumbul and Scinde, affluents of the Jumna, which itself flows into the Ganges. The Nerbudda, running in a westerly direction to the Gulf of Cambay, and the Soane, flowing in an opposite way towards the east,

and falling eventually into the Ganges, lie between the Vindhya and Satpoorah mountains. To the south of these ranges of mountains and rivers stretches the vast elevated table-land called the Deccan; which may be well described as an immense triangle with its apex reaching as far south as Cape Comorin, with abrupt walls of mountains on the north and western sides, and with an enclosing line of hills, called the Eastern Ghâts, of gentler contour, forming its eastern boundary. The whole plain dips towards the east, and excepting a tract between the rivers Godavery and Mahanuddy, is for the most part fertile and populous. The latter district, however, is still covered with vast forests, and is very thinly inhabited. The Deccan is watered by many rivers, all naturally following the fall of the country towards the east. The largest of these are the Mahanuddy, the Godavery, with its tributaries the Wurdah and Gunga; the Kistna, with its affluents called the Bheemah, and the Toongabudra; the Palar, and the Cauvery.

This very brief geographical sketch of India gives some of its leading characteristics; and before the scope and purpose of a railway system in a land can be intelligently comprehended, it is necessary that the features of a country should be known generally and understood.

India, however, is so vast a continent that it is impossible in one description to embrace its main physical peculiarities even. For instance, no phenomena can be more different than those presented by the delta of the Ganges, threaded by innumerable streams forming good and natural water intercommunication; and those of the dry and waterless plains of the western and north-western regions of Hindustan, dependent as they are upon artificial irrigation for fertility. The Himalaya, with its peaks covered with eternal snow, are directly contrasted with the elevated, but hot plateaux of Central

India; while these again differ equally widely from the rocky bluffs, running down the western coast near Bombay; and from the low-level sandy plains, called the Concan, lying between the Ghâts and the coast. The sands of Coromandel and Malabar also, dotted with palms and cocoa-nut trees, are the reverse of the vast and rocky district, covered with true forest, which lies between the Godavery and Mahanuddy. Instead, therefore, of endeavouring to condense a description of the obstacles to railway construction which the character of India presents, into a few general sentences (which would be a vain effort), this chapter will point out somewhat in detail the peculiar characteristics of each province of the Empire which has to be traversed by a railway.

In doing this, however, it will be necessary to keep in view that the object of the account is merely to describe the country with reference to railways, and only so far to delineate it as to render the objects of the various railways, and the difficulties which they had to overcome, tolerably clear to the reader.

The first great point to which a railway naturally tends is a commercial port, and of them, for its extent of coast-line, India has very few. Along the eastern shore, from the northern extremity of the Bay of Bengal to Cape Comorin, we look in vain for a really commodious harbour. Madras is the seat of a government, of a presidency, and from some other fortuitous circumstances has been forced into a position of some commercial celebrity; but it has no pretention to be called a harbour. With a dreaded surf, which ever breaks upon its shore, it is merely a dangerous roadstead, unfortunately situated even as an anchorage for shipping. From this remarkable want of a port, the trade of the country, seeking an exit, was attracted to the numerous mouths of the Ganges; and on one of them,

called the Hooghly, which some 100* miles or so inland has a deep and broad stream affording a good anchorage, the adventurous first agents of the East India Company founded the city of Calcutta; which, in default of a better, is the harbour of North-eastern India. The navigation of the Hooghly is tortuous and dangerous; but still, in spite of this great drawback and many others, fleets of splendid ships annually seek Calcutta in quest of the produce with which the fertile plains of Hindustan teem. On the western side of India a somewhat similar deficiency exists, for Bombay and Kurrachee are the only fairly good harbours, and the latter of these is only adapted to ships drawing little water. Beypore, it is true, claims to be a port, but is so wanting in several essential requisites that it hardly deserves that name.

It was natural, therefore, that Calcutta and Bombay, as the great outlets to the trade of India, should become centres of commerce, which requires civil and military protection; and consequently that those cities should become the political, as well as the commercial, capitals of the greater divisions of British India. From like reasonings it is clear that all trunk lines of railroads would be necessarily directed to these cities, and an examination of a map will indicate that the line first in imperial importance would be one connecting Lahore with Calcutta; and that the second line, even if it be second in value, would be from some central point between Delhi and Calcutta to Bombay. A third line possessing high political advantages is also required to

	Miles.
* The distance from the outer floating-light at the Sandheads, marking the limit of the Bay of Bengal, to Saugor Point is	35
From Saugor Point to the Port of Calcutta by the river	
Hooghly is	86
Total	<u>121</u>

afford to Madras speedy means of communication with Bombay. Many subsidiary lines would also at once suggest themselves as desirable and necessary; but those mentioned above are evidently of primary importance to India, and must be the trunk lines of the empire.

A description of the physical characteristics and formation of the countries these main railroads must traverse, will give, it is hoped, an idea of the difficulties, as well as the facilities for construction, which engineers would meet in introducing railroads into India.

First, then, a railway from Calcutta to Lahore. Calcutta, the metropolis of India, stands on one of the large mouths, or more accurately, on one of the large system of mouths called the Nuddeah rivers, through which the surplus waters of the Ganges, on their way to their main outlets to the eastward, discharge themselves into the Bay of Bengal. This mouth is a tidal channel, and is called the Hooghly, and the city itself is built on the left bank of the river.

A railway, therefore, leaving Calcutta for Mirzapore and Delhi must, if it had its terminus in the city, either cross the Hooghly at the outset, a most formidable and costly undertaking, or following its course on its left bank for some distance pass over it higher up.

The Hooghly* opposite Calcutta is at its narrowest

* On an average, spring tides in the Hooghly rise from 4·75 feet up to a height of 17·41 feet above datum at Kidderpore Dock. The greatest flood level ever attained was in 1823, when the reading of the gauge was 24 feet above datum, and the river overtopped its bank in many places along its margin. A diagram from Mr. James Kyd's observations at Kidderpore Dockyard, from the year 1806 to 1828, shows an average highest level for spring tides of 20' 3"; but from the register of the dockyard for the year 1845 to 1853, the average highest level was 23' 3". "The velocity of the flood tide is great. From the outer floating-lights to Saugor Point, a distance of 85 miles, it travels in one hour. From that to Calcutta, it moves at the rate of about

point (the Railway ghât) 1700 feet broad, with a maximum depth of about 40 feet below lowest water-mark, and a rise of tide of about 20 feet. The velocity of the flood-tide is 20 miles an hour. The bore of the Hooghly is very strong and dangerous, and the wave abreast Calcutta is sometimes 6 feet in height. Such a river, crowded with shipping, and with low banks presenting unusual difficulties for the formation of approaches, was an obstacle to an experimental line, which was likely rather to be avoided than faced. Still the advantages of a railway terminus in a city were manifest, and Calcutta itself, with a populated area of $7\frac{3}{4}$ square miles, would in time evidently require that convenience. In length from north to south Calcutta is about $4\frac{1}{2}$ miles, with an average breadth of $1\frac{1}{2}$ mile, and has a population of 450,000 souls—('Committee on the Drainage of Calcutta, 1857'); but if the populous suburban districts be taken into account, the total will not probably fall short of half-a-million. In the last ten years there has probably been a considerable increase. The difficulties of crossing the Hooghly sixteen miles above Calcutta, at Barrackpore, were also so great that the projectors of the infant company shrank from it; and little would be gained by pursuing the course of the Hooghly farther, as the Matabangah, requiring another large bridge, intervenes. The idea of a city terminus was therefore abandoned, and the railway was commenced from the right bank of the Hooghly, in the populous town of Howrah, the communication with Calcutta itself being retained by a steam-ferry.

20 miles an hour, travelling the 86 miles in four hours, and from that to Barrackpore, nearly 15 miles farther, it takes one hour. The rapidity of the down-stream current varies according to the season. In the rains it is from $4\frac{1}{2}$ to $6\frac{1}{2}$ miles per hour, but in its ordinary state its velocity is 3 to 4 feet per second.—'Report of the Committee of the Drainage of Calcutta,' 1857. Appendix, No. ii., pp. 1, 2, 3, 4.

In whatever way, however, a line might start from the metropolis for the North-western Provinces of India, it must for the first 120 miles of its course be formed through flat alluvial districts, part of the delta of the Ganges, liable to periodical inundations, both from rainfall and from the rising of rivers. On the right bank of the Hooghly, too, a peculiar danger had to be encountered in the Damoodah, a large and dreaded river, which rising in the hills of Ramghur, is liable to fierce and as yet uncontrolled floods. It is embanked, but with banks or "bunds" (as they are called in India) of so weak a section that they used to burst periodically; and its furious waters carrying everything before them as they rose, left, as they subsided, misery, barren lands, and desolation for miles. Unlike the Nile, the deposit left by the Damoodah destroys instead of fertilizing the soil. At the time the East Indian Railway was being laid out, this river was the cause of great anxiety, and peculiar precautions were considered necessary to guard against it, as the supposed greatest enemy to the safety of the line. Since that date the embankments have been removed from the right bank of the Damoodah, and its dangerous character has thus to a great extent been taken away, but large districts are now annually inundated by its waters.

Besides the Damoodah, however, and its old beds, there were on the right bank of the Hooghly several large streams and tracts of country subject to ordinary inundations. After crossing this broad diluvial plain, stretching more than 100 miles in length, the line must, as a matter of course, be brought to the coal-fields near Raneegunge; and there, near the 120th mile from Calcutta, on the direct course towards the north-west, quite a different kind of scenery from that of the level plains of Bengal is met with. But here also two routes present

themselves as practicable for a railway, and both need some description in order to make the reason for the selection of that by the Ganges comprehended by the reader.

By whatever course a railway to the North-western Provinces might be made, it was essential that it should touch Benares, as no line from Calcutta to Delhi could be laid out properly without passing the holy city of the Hindoos—at once a seat of great trade and a favourite resort for pilgrims. The more obvious route for the line was evidently the direct, by which the existing Grand Trunk road has been traced; but an examination of the country proved that many objections to it existed. Soon after the 100th mile from Calcutta is reached, undulations of a gentle character commence, which are soon succeeded by low hills, covered for the most part with dense jungle. In these hills, between the rivers Damoodah and Ajai, lie extensive coal-fields, which stretch also for some distance along the course of the Singarun and Barakar rivers.

Immediately succeeding to these coal-fields, usually called the Raneegunge coal-fields, is a hilly district extending for some 200 miles right across Bengal to the Soane. This tract is a portion of the great Vin-dhya range of mountains, and is triangular in shape, with the apex of the triangle resting on Rajmahal, and with sides running far down into Central India. According to the surveys then made, a railway formed through this district would require a steep ascending gradient of 1 in 100 in places to the Dunwāh Pass, where it would be 1280 feet above Calcutta; and then a steep descending gradient to the Soane, which, running into the Ganges, is about the level of its delta. The plain of Behar, through which the Soane runs, is about 200 feet above the level of Calcutta. Besides

this, the whole district is intersected with ravines and water-courses, dry or nearly dry, during the hot season, but the beds of furious torrents during the rains.

The Soane, too, is a peculiarly formidable obstacle on the direct line, for at the point at which the Grand Trunk road crosses it is $2\frac{3}{4}$ miles broad, with beds of sand of unknown depth. The country also is thinly populated, with few fertile tracts; the forests are unhealthy and infested with tigers; and after the coal-fields were passed, the district was not known to possess any mineral products of value. In short, excepting the directness of the route and its consequent shortness, little could be advanced in its favour.

But far to the northward of this straight course flows the mighty Ganges, and a railway from Calcutta to Lahore might be traced along its valley, instead of facing the inhospitable jungles and mountainous region just described.

There was much to recommend this route. The Ganges had been for ages the great artery of commerce for Northern India, through which from time immemorial the wealth and industry of Bengal has always flowed. Near its banks and within reach of its life-giving waters are fertile fields, crowded cities and populous villages. No one could witness the fleets of boats always on its waters, or the crush at their usual point of arrival and departure, the circular canal of Calcutta, without being aware that the Ganges was the origin and the main cause of the material prosperity of the province through which it passed. Such a river, had it possessed straight and constantly navigable channels, leading directly from the North-western Provinces to Calcutta, would have been a formidable competitor to a railway formed along its valley. But such is not the case. The Ganges in the province of Bengal

usually flows in a broad sandy bed, with its deep-water channel oscillating from the right to the left bank every few years, with a limit of variation in its channel of about thirteen miles. But the mountainous district forming the extremity of the Vindhya range compels the Ganges to maintain for about 300 miles a nearly straight bank on the right, in a direction almost due east, skirting the indurated soil forming the border of the hilly district. This course is maintained until the obligatory point, the rocky apex at Rajmahal, has been turned, and the river is free to enter the alluvial plains of Bengal Proper.

The Ganges, even then does not lose the easterly impetus it had received, and its main channels flow onwards far beyond the longitude of Calcutta to the Megnah, which runs past Dacca to the ocean. In passing, however, the river throws off a series of overflow channels falling directly from points near Rajmahal to Calcutta. These streams, though merely reliefs to the surplus water of the Ganges, partake during the rains of the character of rivers, and are known by the name of the Nuddeah rivers. During the floods, for about three months in the year, they form admirable natural navigable canals, leading directly to the metropolis. As soon, however, as the floods fall, all the traffic on the Ganges is obliged to follow the circuitous, tedious, and dangerous route by the Sunderbunds.

A railway, therefore, from Calcutta to the north-west might turn from the Ranegunge coal-fields to the north, might follow the direction of the largest of the Nuddeah rivers to Rajmahal, and then be traced along the bank of the great Ganges itself. The railway would thus avoid the ascent and descent of 1200 feet, necessary on the direct course, would supply a chain of intercommunication between Calcutta and the north-west,

which would be unbroken throughout the year, and would be independent of the seasons. It would pass through a rich district, and would accommodate the traffic of several large towns standing on the bank of the Ganges, as well as of the most densely populated districts of India.

The *détour* would be considerable, however, and the length of the line would be proportionately increased. Besides from being traced in a direction roughly parallel to and at no great distance from the Ganges, the railway would have to cross many of its large affluents at their widest points. The bridges necessary would be long and expensive, and the more so as their foundations would have to be laid in a soft and treacherous soil. Besides the tributary rivers and water-courses, inundated tracts, of so vast an extent as during the rains to resemble inland seas, are found at frequent intervals at a few miles distant from the margin of the Ganges, and wherever these occur, long and costly viaducts would be required. These large but shallow lakes are formed in accordance with the well-known fact that the immediate borders of all large rivers, like the Ganges, which periodically overflow their banks, and whose waters in floods are heavily charged with earthy matters,* are higher than the ordinary level of the plain through which the river may be flowing. As soon as a flood rises above the lip of a river and the water overflows, its velocity is at once much reduced, and particles easily swept along by the current of the main stream are rapidly deposited. The heavier the matter is, the quicker it sinks, so that a slope falling from the brink of the river to the interior is gradually formed. In this comparative hollow, the drainage of the country

* The flood-water of the Ganges is said to contain two cubic inches of soil per cubic feet of water.

and the overflow waters of floods accumulate, and remain stationary, until the waters of the river falling, they gradually find passages, through channels forced through the raised margin of the river, into its bed again.

The advantages, however, of the route by the valley of the Ganges, were held to more than counterbalance these drawbacks, and it was eventually determined on, but the wisdom of the decision has been often questioned. The fact is that as an imperial line for India, the direct railway is the better ; but as a provincial line, promoting especially the interests of Bengal, though not ignoring those of the Empire, that by the Ganges is the preferable. Experience has now proved that the trade of the country requires both.

From Benares, through Mirzapore, to Delhi, to Lahore, and to the Jhelum, a railway can pass in nearly a due north-westerly direction over vast plains of sandy soil, which if irrigated become very fertile, but if without water, soon deteriorate to a desert. The country is tolerably thickly peopled, but the density of the population depends, as in most tropical countries, upon water. The rains which fall are not sufficient for the purposes of cultivation, and water and population, population and water, are inseparably connected. Wherever rivers flow, or wells with water near the surface can be dug, or canals for irrigation are formed, there large towns and villages will be seen ; but if water be absent, they disappear, and are succeeded by a dreary waste of sea-like moving sand. Still no country could be better adapted for the construction of a railway, the only difficulty being the large rivers, which in the North-western Provinces flow into the Ganges, and in the Punjab, into the Indus. The bridges that would be required to span such rivers as the Soane, the Jumna, the Sutlej, the Ravee, and the Chenab, though obstacles

to a cheap railway, were not of a character to deter engineers from attempting their construction.

They would be works of first-class magnitude, the outlay of money and time would necessarily be great, but they presented no difficulty which money, skill, and endurance would not be sure to overcome. Beyond the river Jhelum, the plains merge into the hills forming the outworks of the gigantic ranges of mountains known as the Suliman and Hindoo Khush, and in this district many engineering difficulties would be encountered; but the science of engineers and the appliances now familiar to railway contractors would, without doubt, allow a railway to reach Peshâwar. This description will enable the reader to understand the physical difficulties that a main line of railway communication from Calcutta to the extreme north-westerly point of our frontier, running in a direction parallel to the Himalaya mountains, would meet.

The second great line of intercommunication required by India was, it will be remembered, that from Bombay to some central point on the railroad between Calcutta and Lahore.

Bombay, the port of India, is justly celebrated for its admirable harbour, and for the commercial enterprise and ability of its Parsee merchants. From its situation it has long been the leading city of the west of India, and as soon as the railroads which have now to be described shall be completed, it bids fair to supersede Calcutta as the metropolis. It is already placed in weekly communication with England, and soon nearly all the through passenger and goods traffic between Europe and the East will forsake the long sea-route round Ceylon, and will adopt the shorter, speedier, and more convenient course through Bombay, and so directly to either Calcutta or Madras.

The island of Bombay with Kolaba as its southern promontory, stretching far into the sea, and Mahim on the north, connecting it with the island of Salsette, may be described generally as formed by two parallel ridges of basalt, about two miles apart, enclosing a flat clay level between them, comprising an area $18\frac{1}{2}$ square miles. The elevated ridges of the island vary in height from 125 feet downward, but the central space on which the town is principally built is only just raised above high-water mark. The islands of Bombay and Salsette, lying in a slightly oblique direction to the main land, shelter a long arm of the sea running up to Tannah, some twenty miles or more in length, and varying in width from eight to ten miles. The upper part of this estuary is shallow, but the lower portion, which is protected by the island of Bombay from the ocean, and from the break of the dreaded surf of the Monsoon, forms the spacious and celebrated harbour of that name. The raised ridges that have been mentioned, shelter completely the harbour on the windward, *viz.* the western side, from which quarter the wind blows on a daily average of $18\frac{1}{2}$ hours *per diem*, and practically, as far as high winds are concerned, the harbour is land-locked, and its waters are quite calm, moved only by the gentle tide which has on ebb but a mean velocity of two miles per hour. Favoured thus by situation, the port of Bombay has, during the period of British rule, rapidly increased, though its origin was humble enough. It is thus described in the report of the census of Bombay, taken in 1864:—“When the island of Bombay came into the possession of Great Britain, in the year 1664, in fulfilment of the treaty with Portugal, the population was estimated at 10,000 persons, and a large portion of those dwelt in the northern part of the island, at Mahim, which was then of much greater comparative

importance than it is now. In the course of ten or fifteen years the inhabitants had increased greatly in number, and they amounted, according to Fryer, to 60,000 beings, "*a mixture of most of the neighbouring countries—most of them fugitives and vagabonds, no account being taken of them (i. e. such not being called to account), others perhaps invited hither—and of them a great number—by the liberty granted them in several religions.*"* At that time the town was a "*full mile in length, the houses low, and thatched with oleas of the cocoa trees, all but a few the Portugals left, and some few the Company have built; the Custom-house and warehouses are tiled or plastered, and instead of glass, use panes of oister-shells for their windows.*"

A census is mentioned as having been taken in the year 1716, giving only 16,000 persons, but it probably embraced only the fort and a portion of the island.

A census, taken in the year 1814–15, of which the record is imperfect, gave 11,000 as the population of the fort, and 221,550 as that of the whole island, and 20,786 as the number of houses.

During the present century, however, the rise of the town has been very great, and in the report by the Municipal Commissioners on a drainage system proposed for the town in 1861, the urban area of Bombay itself is estimated 1024 acres, to which a populous suburban district, containing 688 square acres more, has to be added, in order to form an estimate of the extent for which drainage had to be provided. On the night of the census, *i. e.* on the 2nd February, 1864, the total population amounted to 816,562, while the report observes that "there is much ground for believing that many persons escaped being enumerated, and that the

* Who "Fryer" may be, fame does not say; but his style ought to have secured him immortality.

recorded number is much below the actual amount of the population. There is no reason to suspect that double entries were made." Exclusive of 1458 buildings described as barracks or institutions, there were then 24,206 inhabited houses, of which 17,530 were tiled, and 6676 thatched huts. Bombay then though stretching over a much smaller space of ground, yet rivals Calcutta in population, even if it does not exceed it; while in enterprise and trade it has already far surpassed the Eastern port, as will be seen from a comparison of the interesting Tables (pp. 26-29) of the import and export trade of the cities of Calcutta, Bombay, and Madras, for which I am indebted to the courtesy of Campbell Prinsep, Esq.

But notwithstanding all the natural and artificial advantages which Bombay possesses as a trading and commercial emporium, it has one great deficiency. The difficulties in the way of communication with the interior were so great as to be almost insuperable. Unlike Calcutta, the province of Bombay has no delta intersected with navigable rivers and innumerable tidal channels; forming a capital system of internal canals, through which the products of the country are continually poured from the province of Bengal towards Calcutta, in a slow and tedious way it is true, but still cheaply and easily.

In Bombay there are no similar means of communication. No navigable river falls into the sea at Bombay itself, and the Taptee and Nerbudha, which flow into the ocean on the north, are hindrances rather than advantages to the movement of traffic between the richest province of the Presidency, Guzerat, and the port of Bombay. On the east, the high and precipitous range of mountains known as the Syhadree mountains, or Western Ghâts, form barriers to the easy flow of trade, and hem in at a distance of thirty miles, the narrow strip

RETURN of the TOTAL IMPORT TRADE of the Port of Bombay for TEN YEARS. (Compiled by CAMPBELL PRINSEP,
Esq., of the Statistical Department of the India Office.)

From	1855-56.	1856-57.	1857-58.	1858-59.	1859-60.	1860-61.	1861-62.	1862-63.	1863-64.	1864-65.
	£	£	£	£	£	£	£	£	£	£
Foreign Ports ..	9,549,912	11,732,745	13,488,753	15,538,540	16,534,671	14,988,009	18,471,434	23,879,991	30,013,761	26,273,636
Coasting Trade ..	2,027,092	2,751,894	2,827,251	2,918,527	3,940,320	3,638,292	3,385,154	5,138,719	6,326,547	8,197,429
Total ..	£11,577,004	14,484,639	16,316,004	18,452,067	19,874,991	18,626,301	21,856,588	29,018,710	36,340,308	34,471,065

TOTAL EXPORT TRADE of the Port of Bombay for TEN YEARS.

To	1855-56.	1856-57.	1857-58.	1858-59.	1859-60.	1860-61.	1861-62.	1862-63.	1863-64.	1864-65.
	£	£	£	£	£	£	£	£	£	£
Foreign Ports ..	8,519,780	10,708,552	11,943,618	13,637,642	13,381,961	17,323,431	18,774,371	26,374,538	37,761,049	40,865,155
Coasting Trade ..	1,772,186	1,870,942	2,731,742	2,313,240	2,133,491	2,164,609	2,525,591	3,764,666	3,506,977	4,955,673
Total ..	£10,291,916	12,579,394	14,675,360	15,950,882	15,515,452	19,488,040	21,299,962	30,139,204	41,268,026	45,820,828

RETURN of the TOTAL IMPORT TRADE of the PORT of CALCUTTA for TEN YEARS. (Compiled by CAMPBELL PRINSEP,
Esq., of the Statistical Department, India Office.)

From	1855-56.	1856-57.	1857-58.	1858-59.	1859-60.	1860-61.	1861-62.	1862-63.	1863-64.	1864-65.
Foreign Ports ..	£ 13,180,394	£ 13,959,734	£ 14,416,375	£ 15,621,253	£ 20,230,541	£ 14,933,861	£ 14,294,987	£ 14,970,021	£ 15,043,041	£ 17,769,046
Coasting Trade ..	933,964	732,923	1,623,564	1,460,694	979,935	1,137,696	1,056,045	1,303,449	1,960,014	3,345,283
Total ..	£14,114,358	£14,692,657	£16,039,939	£17,081,947	£21,210,476	£16,071,557	£15,351,032	£16,273,470	£17,003,055	£21,113,329

TOTAL EXPORT TRADE of the PORT of CALCUTTA for TEN YEARS.

To	1855-56.	1856-57.	1857-58.	1858-59.	1859-60.	1860-61.	1861-62.	1862-63.	1863-64.	1864-65.
Foreign Ports ..	£ 11,765,881	£ 12,830,768	£ 12,119,512	£ 13,468,415	£ 12,125,807	£ 12,574,859	£ 12,704,981	£ 15,564,911	£ 19,245,500	£ 17,904,340
Coasting Trade ..	797,419	1,142,284	1,534,470	1,784,416	2,073,729	3,000,946	3,185,072	3,841,008	6,708,918	8,642,845
Total ..	£12,563,290	£13,973,052	£13,653,982	£15,252,831	£14,199,536	£15,575,805	£15,890,003	£19,405,919	£25,954,418	£26,547,185

RETURN of the TOTAL IMPORT TRADE of the PORT of MADRAS for TEN YEARS. (Compiled by CAMPBELL PRINSEP,
Esq., of the Statistical Department, India Office.)

FROM	1855-56.	1856-57.	1857-58.	1858-59.	1859-60.	1860-61.	1861-62.	1862-63.	1863-64.	1864-65.
	£	£	£	£	£	£	£	£	£	£
Foreign Ports ..	1,948,956	2,059,431	2,107,588	2,232,834	2,575,205	2,608,947	2,762,008	2,620,402	3,038,066	3,197,559
Coasting Trade ..	465,978	394,284	563,070	491,128	379,351	411,665	534,914	1,304,180	1,635,653	1,042,655
Total ..	£ 2,414,929	2,453,715	2,675,658	2,723,462	2,954,556	3,020,612	3,346,920	3,924,582	4,723,719	4,240,214

TOTAL EXPORT TRADE of the PORT of MADRAS for TEN YEARS.

TO	1855-56.	1856-57.	1857-58.	1858-59.	1859-60.	1860-61.	1861-62.	1862-63.	1863-64.	1864-65.
	£	£	£	£	£	£	£	£	£	£
Foreign Ports ..	874,275	1,106,388	1,118,780	933,485	1,114,184	1,098,214	1,234,667	2,124,030	4,275,563	3,344,937
Coasting Trade ..	420,705	472,280	1,110,499	777,753	529,632	551,331	337,715	422,607	1,426,506	1,590,014
Total ..	£ 1,294,980	1,578,668	2,229,279	1,711,238	1,643,816	1,649,545	1,572,382	2,546,637	5,702,069	4,934,971

RETURNS OF SHIPPING.

29

NUMBER of VESSELS and their TONNAGE ARRIVED at and DEPARTED from the PORT of BOMBAY for the last TEN YEARS. (Compiled by CAMPBELL PRINSEY, Esq., of the Statistical Department, India Office.)

YEARS.		Arrived.		Departed.	
		Ships.	Tonnage.	Ships.	Tonnage.
1855-56	..	6209	491,909	4730	420,231
1856-57	..	7495	692,159	6208	611,655
1857-58	..	7368	802,025	6048	727,167
1858-59	..	6607	705,501	5466	647,432
1859-60	..	7556	672,960	6066	677,290
1860-61	..	8007	770,067	6035	710,042
1861-62	..	7365	761,380	5984	679,232
1862-63	..	7054	785,639	6024	666,464
1863-64	..	7339	789,135	5426	736,537
1864-65	..	6733	828,264	5654	834,021

NUMBER of VESSELS and their TONNAGE ARRIVED at and DEPARTED from the PORT of CALCUTTA for TEN YEARS.

YEARS.		Arrived.		Departed.	
		Ships.	Tonnage.	Ships.	Tonnage.
1855-56	..	1212	658,373	1201	649,019
1856-57	..	1011	572,127	1113	666,416
1857-58	..	1028	714,529	967	658,149
1858-59	..	950	672,140	960	676,196
1859-60	..	896	616,576	1018	661,735
1860-61	..	947	624,997	908	591,449
1861-62	..	979	688,448	998	672,049
1862-63	..	1020	730,393	1020	739,878
1863-64	..	1395	948,839	1282	899,886
1864-65	..	1404	1,028,643	1285	936,264

NUMBER of VESSELS and their TONNAGE ARRIVED at and DEPARTED from the PORT of MADRAS for the last TEN YEARS.

YEARS.		Arrived.		Departed.	
		Ships.	Tonnage.	Ships.	Tonnage.
1855-56	..	641	253,054	539	239,094
1856-57	..	635	279,725	543	273,293
1857-58	..	715	327,734	592	294,493
1858-59	..	644	259,560	549	230,194
1859-60	..	504	231,121	475	201,598
1860-61	..	428	186,880	402	163,374
1861-62	..	561	244,787	514	233,638
1862-63	..	574	251,266	497	242,018
1863-64	..	671	325,020	537	297,664
1864-65	..	645	306,141	539	293,980

strip of low coast-land called the Concan. These ghâts or cliffs rise abruptly from the shore level to a height of about 2000 feet, and until the railway era there were only two roads by which wheeled carriages could pass, and even over them the passage was a work of toil and great delay. Captain Crawford (Bombay Engineers), late superintending engineer of the Government Railway Department in Bombay, thus describes this remarkable range:—"As the subject (that of railways up the ghâts) will have to be submitted for the consideration of those who have never seen them, I may be excused for endeavouring so far to describe them as to allow of parties at a distance to picture to themselves something of the nature of these great natural obstacles which interrupt the communication between Bombay and the interior. This appears to be the more necessary, from having of late frequently seen the ghâts alluded to in terms from which I gather that they are by some looked upon as a range of hills or mountains running from north to south, and separating the Deccan from the Concan, and it is from this idea probably that mention is so frequently made as to the possibility of finding a pass *through* them.

"To conceive of these merely as a range of hills would give a very false impression of their character. They are in truth nothing less than a precipice, separating by one single and abrupt step the table-land of the Deccan from that of the Concan, 1800 feet below it. *Through* this range of precipices we know positively that no pass, in the ordinary acceptation of the term, exists; that is to say, there is no long valley or water-course having its head considerably to the eastward in the Deccan, and taking a westerly course *through* the wall of the ghâts to the sea. The very edge of the ghâts is the watershed line of the country, on which

the water parts, the one portion finding its way by a long course across the continent of India to the Bay of Bengal; whilst the other portion to the westward is precipitated at once from the edge of the cliff to the low ground of the Concan." Such an obstacle might well cause dismay to a Government bent upon forming complete lines of railway communication through the Indian Empire; still as there was clearly no way to be formed through them, as Captain Crawford so graphically explains, and as the range lay in the direct line between Bombay, the Deccan, and Mirzapore, or Allahabad, it was evident that it must either be surmounted or turned. The Great Indian Peninsula Railway Company under the professional guidance of Mr. Berkeley, their chief engineer, proposed the first. The Bombay and Barodah Company, directed by Colonel Kennedy, advocated the latter plan. The surveys required to decide which of the routes was entitled to be preferred, took some years to complete, but an account of these will more properly be given in the chapter on the commencement of the Bombay railway system. In the end the direct line was selected, and for the present it will be sufficient to state that the railway, after climbing the ghâts by an incline practicable for locomotives, which is a masterpiece of engineering science and skill, had very few other difficulties to contend with. From the summit of the ghâts stretches a vast extent of fertile land known as the Deccan, in which cotton, opium, and grain were produced in large quantities, and over these elevated plains the railway was able to traverse without difficulty.

The Nerbudha and Taptee rivers were crossed, but at points so comparatively near their source as to bring the bridges over them within the limits of ordinary engineering effort. Near the East India Railway, a descent from the level of Central India to

the plains of the Ganges had to be effected. The Kymóor hills here present an abrupt escarpment or step of rock similar to that of the Syhadree, only much lower. The total height of the crest varying from 100 to 300 feet above the plain, which was practically level. A steep incline down the face of the cliffs, though after the marvels of the Thull and Bhore Ghâts of little comparative consequence, was at first projected; but further investigation proved that the hills could be turned by a small *détour*—and the descent has actually been effected with easy gradients and works.

Seeing that Bombay, even with no navigable rivers or canals, no roads, and shut up as it were by mountains, easily secured the second place among Indian cities; it is not surprising that a brilliant future of wealth and prosperity was with confidence predicted for this port, as soon as railways might remove the bars which had previously shut it off from its own fertile provinces of Candeish, and Guzerat, as well as the other regions of India.

The third great division into which British India is divided, is the Madras Presidency; and though not so highly favoured by natural advantages as the sister presidencies, yet it has enjoyed for a long time the blessing of peace, and the advantage of a mild and settled rule undisturbed by insurrection or intestine commotions. It is not easy to ascertain, however, why the city which gives its name to the Presidency, was selected as the capital of the province. To a visitor who looks at the long sandy beach without an inlet or even the pretence of a navigable creek, who sees the fearful breakers foaming on the shore and causing a surf, varying from passable by Massulah boats,* to impassable and danger-

* A deep boat whose planks are sewn, not nailed together, in which a rough surf can be safely crossed.

ous, it seems most unsuited to be a commercial mart or the site of a city. A closer examination of the town confirms the first impression. Shipping, lying in an open roadstead, cannot land their cargoes except in boats tossing in the heavy swell of the Bay of Bengal. A storm signal may at any moment oblige all vessels to slip their cables and run to sea, or stop in the unsheltered roads at the imminent danger of being driven on shore and wrecked. On shore no river brings traffic from the interior to Madras, and no canal, except two parallel to the sea which have not been successful in a pecuniary way, adds a share to the commerce of the town. The roads, however, are good, and are maintained in admirable order. But though Madras is not a port, and has few local advantages, yet it is the seat of political and military power, and does possess some considerable amount of trade (*vide* return on pages 28-29); and to it therefore, in general accordance with that law which has been mentioned, all main lines of railway in that Presidency must tend. There certainly never was a large city which more urgently required the aid of a railway to develop its resources.

Lord Dalhousie's remarks on the subject of railways in Madras are interesting. "It is now to be considered," he observes, "whether the Presidency of Madras can be included in the general system of continuous railways in India, and what lines should be constructed therein. The connection of the capital of the Madras Presidency with the seat of the supreme Government, is even of less importance than a direct connection between Bombay and Calcutta." And then, after stating his reasons at some length, he adds, "I therefore do not recommend that a line from Calcutta to Madras should be taken into consideration." The connection of Madras, however, with the main line already recommended for Bombay,

and thereby with the main line in Hindustan, would be of value. The Presidency of Madras is even more unembarrassed with foreign frontier than the Presidency of Bombay. It contains seven regiments of European troops, and a numerous native army. At present this large force is in a great measure isolated, so far as the other portions of the continent of India are concerned. If, however, Madras were brought into direct communication with Bombay by means of a line of railway, the military power of the British Government throughout India would be thereby still further enhanced, and its means of prompt and concentrated action most materially increased. I apprehend also that the formation of this line direct to the great port on the western coast would be of much value to Madras in its communications with Europe, and probably in its general commerce."

Several lines of railway have been projected in this Presidency, and some have actually been carried into effect; but Lord Dalhousie's Minute, which was accepted in its integrity by the Government at home, evidently only contemplated a junction between Madras and Bombay as of imperial importance. To its construction, however, the physical characteristics of the country to be traversed presented grave obstacles.

Madras is on the level of the sea, on the eastern side of the Peninsula, and Bombay is in a similar position on the western; and in the direct line between them lies an elevated table-land with precipitous sides, more like natural retaining walls than an ordinary mountain range. The crest of both the eastern and western ghâts is about 2000 feet above the sea; and if the junction line were traced in any direction approaching straight, that height of 2000 feet would first have to be climbed and then again descended.

It is true that in lat. 11 N. there is a very remarkable

break in the western ghâts at Paulghât, the only gap between Bombay and Cape Comorin ; but this was of no use with reference to a line of communication between Madras and Bombay, the former being in lat. 13, the latter lat. 18. It would evidently be unwise to make such a *détour*, and the more so as the railway must then follow the line of the coast, and be traced directly athwart the direction of the drainage of the Concan.

So after much investigation and careful consideration, an account of which will be found in the chapters on the Madras system of railways ; it was determined to take the Trunk line through the districts of Cuddapah and Bellary, in nearly a direct course between the cities of Madras and Bombay to the river Bheemah ; and so on to Poonah, and then down the Bhore ghât to Bombay. The passage of the Cuddapah districts was difficult and costly, and the Bhore ghât incline was a triumph of engineering skill, a detailed account of which will be found in its proper place.

The general character of the railway and the country it traverses may be easily and concisely described. In starting from either Madras or Bombay, a level is first met with along the sandy coast line, succeeded by an incline up an abrupt range of cliffs, leading to a rough and undulating high-level plateau ; from which another steep descent conducts to the plain on the level of the ocean on the other side of India.

These few pages will suffice to indicate the nature of the difficulties ; but the difficulties themselves were serious and formidable, tasking at times to the utmost the skill and perseverance of British engineers to overcome them.

CHAPTER III.

ORIGIN OF RAILWAYS IN INDIA.

Views of Projectors — Messrs. White and Borrett — Sir Macdonald Stephenson — Formation of Committees in London — Application to the Directors of the East India Company for Aid — Preliminary Negotiations — Dispatch by the Court — Assumed Difficulties in making Railways in India — Mr. Simms sent to India — His Suggestions — Committee of Engineers in India — Their Report — Lines suggested — Opinions of Sir Herbert Maddock — Lord Hardinge — List of Lines — Recommendations of the Court — Delays by the Board of Control — Final Decision.

WHEN a country is ripe to receive any important impetus by the adoption of an invention, it generally happens that the idea of that invention, under various forms, occurs to more than one man at the same time; and that without any intercommunication or concerted arrangement, like proposals are simultaneously made from various quarters. When England was on the eve of her great manufacturing and material revival of the present century; Savoy, Newcomen, Trevethick, and many others, appreciating the capabilities of steam-power, devoted, within a few years of one another, their talents to improvements in that engine; which under the genius of Watt and Stephenson was destined to effect those marvellous results in trade and intercourse which are now witnessed. So it was with the commencement of railways in India. The idea of their construction in that country was first discussed about 1841-42, but it is not easy to state with perfect certainty the name of the projector to whom India is indebted for the first conception of her railway system.

Mr., now Sir Macdonald, Stephenson states in his evidence before the Committee of the House of Commons

in 1858, that the project of a railway in India first occurred to him in 1841, but it was not till the 2nd December, 1844, that he first made any recorded official proposal on the subject.

Previous to that date, however, Messrs. White and Borrett, on behalf of the "Great India Railway Company," a designation expressive of the wild magnitude, not to say folly, of the design, proposed on the 8th November, 1844, to construct a railway across the Deccan, from Bombay to Coringah at the mouth of the Godavery, as a grand trunk line, from which were to issue branches north and south, so as to intersect all India. This company also appears to have been the first suggestors of the guarantee system, for in their agents' (Messrs. White and Borrett's) letter of 8th November, 1844, they write thus:—"We think the great object which will induce the Government of India to take up and foster the formation of railways, may be well combined with the object of parties seeking safe investments, and resting satisfied with a low rate of interest provided it be duly guaranteed; and we would suggest whether, if the directors were satisfied by due safeguards and proper inspection that the scheme is sound and will be duly carried out, they might not offer a guarantee of (say) 4 per cent. return from the date of opening the railway or any portion of it; provided a counter-provision or guarantee were given, that if the profits exceeded 10 per cent., the surplus should go to a fund to be appropriated to the extension of the line or the formation of other lines under the sanction or supervision of the company, and subject when made to a like guarantee; such guarantee could be limited to any term of years (say twenty) which the peculiarity of the case might seem to render expedient."

This scheme of Messrs. White and Borrett was, how-

ever, so absurd and visionary that it should hardly be taken into account.

A railway from Bombay to the mouth of the Godavary is not needed; would be most difficult to construct; and would possess an alignment peculiarly unsuited to the commercial and political requirements of India.

The credit therefore of being first concerned in a tangible and practical line of railway for India, seems to belong to Sir Macdonald Stephenson. At the very outset, however, the projectors had to encounter the difficulty which naturally arises in the commencement of novel undertakings in distant lands: it was not possible to inspire the general public with that confidence in the success of the speculation which the originators of it themselves possessed. It was clearly seen by Mr. Stephenson, Sir G. Larpent, and others who were the earliest promoters of railways in India, that it would not be possible to obtain the vast amount of capital required for the successful conduct of such enterprises, unless some security could be given to the public that there would be a certainty of adequate return for the money that they might advance. It was true that the advantages to India, to British rule there, to commerce, and even to Great Britain herself, by the introduction of railways into India would be immense; but the general public knew little and cared less for such matters. They merely desired a safe investment at a fairly remunerative rate of interest; and so great was the want of confidence in such distant schemes as railways for India, that it was known that the attempt to raise money without the guarantee of some certain fixed rate of interest would certainly end in failure.

In accordance with this view Mr. Stephenson, as Managing Director of the East India Railway Company, in a letter of 2nd December, 1844, suggested that

the Honourable Court should guarantee 4 per cent. as a minimum dividend to railway shareholders, "the plan so successfully adopted by the French Government;" and in a further letter of 13th December, 1844, he says that "the plan of a guarantee of a minimum dividend is approved by the mercantile houses, who would under these circumstances, and under these alone, be prepared at once to take measures for carrying out the undertaking."

Very shortly afterwards, the Provisional Committee of the East India Railway Company having been formed, a prospectus was laid before the Court on the 20th January, 1845, and in it the Committee proposed that an interest of 3 per cent. shall be guaranteed by the Honourable Court on the cost of the work, which was not to exceed one million sterling. The railway was to be laid along the Mirzapore road towards Allahabad for a distance of 140 miles only, and the amount of the guarantee would be only 30,000*l.*; an amount, the Committee added, which "can scarcely be supposed to affect the consideration of the question, which is one rather of precedent and principle than of pecuniary difficulty." They also suggested that should a guarantee be thought objectionable, they would be content with a bonus of 30,000*l.* a-year "to encourage the introduction of railways into India, and on the condition that the bonus should be withdrawn when the railway net profits exceed 3 per cent. upon the outlay of one million.

Subsequently, at a meeting on the 25th February, 1845, the following resolution was passed by the Provisional Committee:—"That the guarantee of the East India Company to the extent suggested, or some equivalent pecuniary assistance and indication of the approval of the Court of Directors, is a preliminary and indispensable condition to the proposed measure."

After further consideration these moderate requests were modified in a very essential particular; and the demand was then made for interest to be guaranteed from the commencement of the undertaking, instead of from the date of the railway being open to traffic.

The object of this proposal was stated to be to meet serious objections existing in the minds of parties, who would otherwise be disposed to embark money in Indian railways as a permanent investment; arising from the great length of time which must necessarily elapse before the completion of the lines, during which their capital would remain unproductive. The applications by Messrs. White, Borrett, and Stephenson for the co-operation of the Honourable Court of Directors in the introduction of railways into India, were followed by several others; and the Court moved by these letters took the subject into consideration. After due deliberation, a dispatch was addressed by the Court to the Governor-General of India, calling his attention to the question on the 7th May, 1845, which is the first official recognition of the desirability of railways for India.

It is curious now, in looking over actual results, to notice the erroneous views held by the wisest men; and the diffidence with which the whole subject was approached, as well as the nature of the difficulties which were apprehended. It was supposed in 1845, that the profits of railways in India would mainly be derived from the carriage of goods and merchandize, and that the passenger traffic would be small. But experience has shown that the largest return has been derived in reality from the conveyance of third-class passengers, natives: and that the carriage of raw products has not proved so remunerating to Indian railways as was anticipated. It was supposed also, that the obstacles arising from climate would be almost insuperable, but

in point of fact the delays arising from that cause have been trifling and insignificant. The Court in their dispatch thus express themselves:—"According to the experience of this country (England), by far the largest returns are procured from passengers; the least from the traffic of goods. The condition of India is in this respect the reverse of that of England. Instead of a dense and wealthy population, the people of India are poor, and in many parts thinly scattered over extensive tracts of country; but on the other hand, India abounds in valuable products of a nature which are in a great measure deprived of a profitable market by the want of cheap and expeditious means of transport. It may therefore be assumed that remuneration for railroads in India must for the present be drawn chiefly from the conveyance of merchandize, and not from passengers. It cannot, however, admit of question that when railway communication can be advantageously introduced and maintained, it is eminently deserving of encouragement and co-operation from the Government."

Independently of the difficulties common to railroads in all countries, there are others peculiar to the climate and circumstances of India, which may render it advisable that the first attempt should be made on a limited scale. These peculiar difficulties may be classed under the following heads, *viz.* :—

- "1. Periodical rains and inundations.
- "2. The continued action of violent winds, and influence of a vertical sun.
- "3. The ravages of insects and vermin upon timber and earthwork.
- "4. The destructive effect of the spontaneous vegetation of underwood upon earth and brickwork.

"5. The unenclosed and unprotected tracts of country through which railroads would pass.

"6. The difficulty and expense of securing the services of competent and trustworthy engineers."

647. Moved by these considerations, and in the absence of any definite and scientific information regarding the applicability of railroads to India; the Court of Directors determined to depute a skilful engineer, fully and practically acquainted with the working of railroads in England; for the purpose of examining the subject of the practicability of the construction of railways in India, and of their suitableness to an Indian climate and requirements. He was to be associated in India with two engineer officers of tried and proved ability. The committee so formed was directed to investigate the question of Indian railways in all its bearings, and to suggest some feasible line of moderate length as an experiment for railroad communication in India. Mr. Simms, C.E., was the engineer selected by the Court, and he reached India in September, 1845.

The various projectors who had addressed the Court had evidently contemplated that railroads in India should be constructed and managed by means of private enterprise and capital. In this view the Court felt disposed to concur; but in addition to the stipulation for the usual command of railroads for Government purposes, and that at least the grand trunk lines should on settled terms be liable to become the property of Government; they thought it necessary to lay down the rules under which railroad communications in India would be sanctioned; and the Directors therefore gave the following, with the desire that they should be deemed suggestions, for consideration and comment:—

1. That the intended line of communication in the

first instance, and, at a subsequent period, the detailed plans and estimates, be submitted for examination to the Government.

2. That the constitution and terms of agreement of the proposed company be in like manner submitted to the Government.
3. That the books and accounts of the company be at all times open to the inspection of officers to be appointed by the Government.

It is probable that Mr. Simms thought that he, acting on behalf of Government, and on these instructions, was bound to name terms favourable to it; while no doubt he considered that his proposals would be much modified in negotiation, and was impressed with the conviction that the profits on railway properties in India would be sure and large.

However that may have been, he, soon after his arrival in India suggested—

1. That Government should grant a lease to a joint-stock company, empowering them to construct, maintain, and hold certain railways in India for a given number of years. The lease to run from the date of completion, which was to be fixed in a certain way described.
2. That the Government shall find and deliver, free of cost, all land required for the railway, and stations for permanent occupation. Land required by railway companies for temporary purposes during construction or afterwards to be paid for by them.
3. That Government shall impose no tax or duties upon the railway or proceeds thereof.
4. Railway companies are to have the most perfect control over their own servants.

In consideration of the above concessions, of which the free grant of land was the most substantial, the railway companies were to agree to the following terms:

1. That they shall execute all the necessary surveys and plans for submission to the Government Consulting Engineer for approval; and shall also make any further surveys, which the alterations, that the Government engineer may order, may render requisite.
2. That they shall construct the railway in accordance with a specification to be drawn up by the Government engineer, maintain *all works in perfect repair until the expiration of the lease, and shall then hand them over to Government without payment*. Plant of all kinds to be transferred to Government at a valuation, to be settled finally by arbitrators and umpire in the usual manner.
3. That they shall submit all plans, sections, and designs, and particular specifications to the Government engineer for his approval. No deviation from a sanctioned design to be admissible, and the Government engineer to have power to inspect, condemn, or stop, or order the reconstruction of any work; but in doing this it was to be distinctly understood that Government undertook no responsibility, but that on the contrary the railway company is bound to maintain the railway in perfect order until the termination of their lease. No deviation from any sanctioned design to be permitted, except with the consent in writing of the Government engineer.
4. That the railway from Calcutta to Delhi be opened in seven years from the date of the

grant of concession for that entire distance, on pain of forfeiture of the whole of the works. And similarly a stated time shall be named for the completion of every railway.

5. That if a railway company fail in any part of their engagements, or do not execute the works sufficiently rapidly, Government shall have the power to take the whole out of their hands, and do with the property as they may think fit.
6. That upon the completion of the line every regulation, rule, and bye-law, as respects the working of the line, the conveyance of passengers or goods, the tariff of fares and tolls, and scale of accommodation, the number of trains per diem, time of starting, and every detail of working the line shall be submitted for the approval of Government. Any alteration desired by Government shall be adopted by the railway company; and no line shall be opened for traffic until all proposed rules shall have been sanctioned; and subsequently no alteration shall be made without the approval of Government.
7. That every railway company shall carry Government mails, stores, troops, and persons, horses or cattle properly attached to troops, by ordinary or special trains, at reduced tolls.
8. That the failure to run one train per day from end to end shall be considered as evidence that a railway has ceased to be employed as such.
9. That parties proposing to construct a railway shall deposit 10 or 15 per cent. of the whole estimated capital as a guarantee of sincerity.
10. In order to secure uniformity in the general system of Indian railways, that all lines shall

be constructed on one specification, worked in one manner, with the same signals, and supplied with the same rolling stock, which should, as far as possible, be all made of one pattern, so that in the case of accident any part may be replaced at any station or store.

11. That every railway company shall keep their accounts of receipts and expenditure, of numbers of passengers, and quantities of goods and merchandize in correct and approved forms, and that Government shall have power to call for any returns—financial or statistical—that it may think necessary and proper.
12. That the railway company shall bind itself to accede to a general specification, in which every detail concerning mode of construction, quality, dimensions, and kinds of materials to be used shall be entered; and if not so included, nothing shall be done or employed without the previous approval in writing by Government.

And, lastly, Mr. Simms suggested that if Government should think it advisable to guarantee a small percentage upon the actual cost of the works, such guarantee shall not be in force until the railway be completed and opened for traffic; that it be in abeyance during any interruption of traffic; and wholly cease and determine if the traffic be not carried regularly and satisfactorily, or the railway cease to be used as a railway.

The document containing these suggestions is dated 6th February, 1846; and on the 13th of the next month, the Report by the Committee of Engineers on the practicability of introducing railways into India was submitted to the Government of India, which took both

communications into consideration at the same time. In order that the whole subject may be brought clearly before the reader, it will be convenient here to abstract the subjects reviewed by Mr. Simms and Captains Boileau and Western (Bengal Engineers).^{p42.}

At the outset of their Report the Committee commence by stating their opinion that "Railroads are not inapplicable to the peculiarities and circumstances of India, but, on the contrary, are not only a great desideratum, but with proper attention can be constructed and maintained as perfectly as in any part of Europe."

This broad and sensible statement is much dwelt on by the various members of Government, and evidently was of much value in strengthening their half-formed intention to facilitate in some substantial way the introduction of railroads into India. The engineers then took up and answered the difficulties which were named by the Court of Directors in their dispatch. While frankly admitting their existence in some degree, the committee at once pronounced them not insuperable, and recommended that they should not prevent measures being taken to foster the immediate prosecution of railway enterprise. The difficulties enumerated were—

1. *Periodical Rains and Inundations.*—With a judiciously-selected and well-constructed line no serious mischief to the works need be anticipated; and, referring to the numerous roads and river embankments existing through the country, they observed that if these could be maintained, as for a long series of years they had been, there could be no doubt but that the earthworks of railroads might with equal ease be kept in good order at a moderate annual outlay.

2. *The continued Action of violent Winds, and the Influence of a Vertical Sun.*—In their reply to this the committee rather curiously suggest that precautions will

be needed to guard against an inconvenience which, in practice, has not been felt. After observing, with some quiet satire perhaps, that "suitable arrangements in the construction of the works will overcome any difficulty arising from these causes to the line itself," they remark that more than usual attention will be requisite in watching and guarding against the friction of such parts of the engines or carriages that may be exposed to the most intense heat.

3. *The Ravages of Insects and Vermin upon Timber and Earthwork.*—The destructive action of the white ant upon timber was much dreaded, but the engineers suggested that the use of teak, iron-wood, or timber prepared by one of the preserving processes well known in England, would probably obviate this objection, but if not, stone sleepers might, they said, be used.

Practice has now shown that it has been difficult to obtain teak in sufficient quantities at reasonable rates, and that ironwood is so hard to work and plane that its general use is impossible. It is remarkable, also, that insects are found to do comparatively little injury to sleepers, as the continual passing of trains appears to prevent their progress, but rot and damp have proved most destructive. Prepared pine, saul, and many kinds of jungle timber have been tried as sleepers, but with small success. They all are short lived; and a good, durable, moderate-priced sleeper is still the desideratum for Indian railways.

4. *The destructive Effects of the spontaneous Vegetation of Underwood upon Earth and Brickwork.*—To obviate this evil, as well as any damage that may be done by vermin, nothing more is requisite than the faithful discharge of their duties by vigilant inspectors and gangs of labourers.

5. *The Unenclosed and Unprotected Tracts of Country.*

—A suitable fence of thorn or prickly pear, of timber or of stone, can with ease be formed.

6. *The Difficulty and Expense of securing competent and trustworthy Engineers (Engine-drivers).*—This difficulty, the committee considered, might be overcome by sending Native and East Indian youths to England to be trained as engine-drivers and fitters. On their return in charge of engines it would be easy, it was thought, by their means to lay the foundation for training as many native engine-drivers as might be required.

This proposal has up to the present time remained a dead letter; for natives of India, it has been considered, cannot be depended on for an occupation in which punctuality, forethought, and presence of mind are eminently needed. Numbers have been employed as engine-fitters, cleaners, and stokers, but as yet they have not been found fit to be trusted as drivers. The necessity of obtaining engine-drivers from England presents a great and growing difficulty to Indian railway companies; and probably ere long it will be found desirable to take some decisive steps for the purpose of endeavouring to train some natives to be drivers. There was a school of some kind in Madras for a time, but no sustained effort has as yet been made to obtain and train natives as drivers of engines.

Having thus dealt with the difficulties peculiar to India which were mentioned by the Honourable Court, and having recommended that railways should be introduced in India through the medium of private enterprise: the engineers proceeded to describe the route they would recommend for a railway from Calcutta to Mirzapore and from thence to Delhi, and the portion which they thought should be at once made as an experiment.

In a long and able report, they supported their views, which were in favour of the direct line from Calcutta

to Mirzapore. The terminus they proposed to put in the city of Calcutta itself; and the railway was to run up the left bank of the Hooghly for some distance, then crossing that river to pass near Burdwan, and following the direction of the Grand Trunk road to be taken in nearly a straight course to Benares; and then *viâ* the Ganges to Mirzapore and to Delhi. There were to be three branch lines, on the trunk line between Calcutta and Mirzapore—one from Burdwan to Rajmahal; another from Shergottee to Gaya, Patna, and Dinapore; and the third to Rajghat opposite Benares. Four other branches were suggested between Mirzapore and Delhi: the first from near Caunpore to Ferruckabad; the second from Agra to Allyghur; the third from Delhi to Meerut; and the fourth from Kurnaul towards Simlah in the Himalayan mountains.

The Committee, in short, rejected the idea of the Ganges Valley line, as not offering greater advantages as far as traffic was concerned, and in a political and military point of view decidedly inferior to a railroad running generally parallel to the Himalaya from Calcutta to the British frontier in the north-west; with a series of branches at right angles to its course leading to the principal towns on the Ganges. The bridges were intended to be of masonry, and it was recommended that they should be made wide enough to carry a rail as well as a common road. The earthwork and masonry were to be for a double line of rails, but a single line only was to be laid down in the first instance; though a second line was to be added as soon as a single line of rails throughout was completed, if the railway company were called upon by the Government to do so. An experimental line could, the committee thought, be made between Caunpore and Allahabad in the North-western Provinces; or if that be thought too

extensive for an experiment, then a line from Calcutta to Barrackpore would be convenient and suitable for the purpose.

This report by the Committee of Engineers was considered very carefully by the Government of India, in conjunction with the suggestions made by Mr. Simms regarding the agreement that Government should enter into with railway companies; and elaborate and interesting minutes on the subjects were written by each member of the Council.

The supreme Government of India then consisted of Lord Hardinge, Sir Herbert Maddock, the Hon. F. Millett, and C. H. Cameron.

As the Governor-General at this time (the hot season of 1846) was away from Calcutta, it fell to the part of the President of the Council, Sir Herbert Maddock, to enter into the details of the various questions.

Mr. Simms' suggestion that Government should provide land free of cost for railway companies, met with the approval of the President and the members of Council. The contribution which the Government may wish to make towards defraying the cost of the construction of railroads in India on their first introduction, could most appropriately they thought be made in this shape. The tenure under which land is held in India being complicated and intricate, it would be more convenient both to Government, to the proprietors of land, and to railway companies, that the Government should take up and adjust the claims for compensation for land required for railway purposes, than to grant compulsory powers to railway companies themselves.

The next question discussed was in what manner shall the Government of India secure itself the option of becoming hereafter the proprietor of railways which may now be constructed by private enterprise. On

this question Sir Herbert Maddock did not agree with Mr. Simms' proposal, that railway companies should deliver over to Government, at the termination of their lease, in good substantial repair, but free of cost, the whole railway; plant alone being excepted for transfer at a valuation. He doubted whether the projectors of any of these railways would consent to an arrangement to forfeit at a certain period the whole of the capital vested in the undertaking, nor did he think it certain that Government would then find it convenient to undertake the working of railroads. He thought that it would be quite sufficient to secure to Government the option of becoming the proprietor of a railway, at a certain date on settled terms at the expiration of a certain period, or of entering into a new engagement with the railway company.

It would be necessary also, Sir Herbert considered, that the agreement between Government and railway companies should make provisions for the consequences in case of failure by a railway company to construct or maintain a line which they may undertake to construct and work.

In the case of a failure to complete a railroad, the whole of the works, materials, and plant must be forfeited to the Government, but in the instance of a line not being properly worked after completion some negotiation would be requisite. He thought that it should be a question for arrangement; but he did not acquiesce in Mr. Simms' proposal, that the omission to run one through train each way each day, should be deemed proof that the railway was no longer used as such. His opinion of the probable traffic and profits was far more moderate. He wrote:—"In this country (India) there are seasons when intercourse is liable to be interrupted for several days together by the severity of the weather;

at such seasons a railway could not be profitably worked: few passengers would be willing to travel, and merchants would not venture to expose their goods to the risk of transit. At such periods the communications by railways will be subject to interruptions, and whatever may be decided upon as the conditions of regular operations of railroads, they will require modification according to season." Such a recorded opinion proves how little the real amount of work which railways in India would have to do was foreseen, and how imperfectly the advantage of locomotive communication, being as it is practically independent of seasons, was appreciated.

A deposit as a token of good faith was considered by all unwise and unnecessary, and all were opposed to the idea of a guarantee of interest on the money spent upon a railroad. "Any such guarantee," wrote Sir Herbert Maddock, "would no doubt prove a great encouragement to the projectors of railways in India. It might encourage persons to embark in speculations based on no reasonable calculation of ultimate profit. But, it is not the wish or the interest of Government to encourage any project of this nature, which does not hold out a fair prospect of moderate profit without being dependent on the Government for its dividends. The aid and encouragement which I propose to accord to those railway companies whose plans have met with our approbation, of giving them the use of land required for their operation free of cost, ought, I am convinced, to be sufficient evidence of the active part taken by the Government in promoting their objects, and this kind of aid and support is the most appropriate on all accounts that the Government can afford." But though thus unanimous in disapproving a guarantee of interest, yet all the members of Government concurred in thinking that Government should have the power of directing the plan and manner

of constructing any railway in India, and a control over its management when opened for traffic. Indeed they went further; and arguing that the free-grant of a lease of the land required, put a railway company under great obligations, stated that they thought that Government should have perfect control over, and should be the sole and final judge of what is best and proper on every point connected with direction, plan and construction of the road, and carriages to be employed on it, and should besides settle all tariffs at the proper time.

There remained but two more points for discussion, but both of them of the highest importance; the one, the line to be selected as the first railroad to be made in India, and the portion of it which was to be at once commenced as an experimental line; the other, the probable cost of constructing a railroad in India per mile, and the returns likely to be obtained from it when completed and brought into operation.

On the first point the Committee of Engineers had dwelt at considerable length, and their views on the subject have already been explained; but on the second they had been perfectly silent.

Sir Herbert Maddock pointed out in forcible language that there was no need to begin upon a short line; that the opinion of the engineers that railways may be constructed and maintained in India as well, and as efficiently as in any part of Europe, might confidently be relied on and accepted by Government; and therefore, that an experiment to prove this point was not required: but that if, on the contrary, the object of the Court in suggesting that a railroad of moderate length may at first be made as an experiment, is to test the ultimate advantage to Government, the public, and projectors, from the introduction of railroads; then a line

must be chosen connecting two points of political and commercial importance. Adopting the latter supposition as the more probable of the two, he urged that with this object it would be better to try a long than a short line; the long line would connect distant marts, fertile districts now without an outlet for their produce, with the port of Calcutta; would join arsenals, and would add to the moral and military strength of Government. He summed up his arguments by stating that "there is no valid objection to a line on account of its magnitude, but that, on the contrary, the ratio of benefit is likely to increase as the scale of the work is enlarged."

From these considerations the President of the Council argued that the long line from Calcutta to Delhi should be chosen as the railroad first to be encouraged; and the portion from Calcutta to Burdwan, with a branch to Rajmahal should be selected for experimental construction, if after all an experiment should be deemed necessary.

As the engineers in their report had not alluded to the probable cost or the remuneration to be eventually obtained from the outlay, a letter was especially addressed to the committee, requesting their opinion upon these points; and thus pressed, they replied that they thought that the average cost per mile of railroad completed for working, but without rolling stock, would not be less than 14,000*l.*, but more probably 15,000*l.* Experience has proved this to have been a good approximate estimate. They declined to give an opinion on the returns probable, as they were entirely without data on which to base calculations.

These minutes and the reports were all sent on the 9th May, 1846, to the Honourable Court of Directors, and a copy of them also was forwarded to the Governor-General, who was at Simla, when the opinions of the members of his council were written. Some months

afterwards, in July, he recorded a brief minute on this important subject, which is remarkable for the sagacious and clear views expressed in it regarding the need of more substantial aid to railway companies, if they were to be encouraged to form railroads in India, than his colleagues were disposed to grant.

Lord Hardinge concurred generally in the views taken by Sir Herbert Maddock, but did not think that the lease of land to a railway company, estimated roughly as a gift equal to 200*l.* a-mile, was commensurate with the advantages which the State would derive from a daily communication between Calcutta and Delhi. A contribution of 200*l.* a-mile to a work roughly estimated to cost 14,000*l.* a-mile seemed to the Governor-General too small assistance, and he observes, "I am confident, however, that English capitalists will not, without more information on these points (*i.e.* cost of construction and the probable profit) and more substantial encouragement from the East India Company, enter into the speculation;" and again, "I am confident the speculation of the railway company will entirely fail, unless it be largely and liberally encouraged by the East India Company."

A daily mail between Calcutta and Delhi would add greatly to the vigour and confidence of Government. Compared with the system of dāk runners, such a speed would seem to give ubiquity to Government. The political advantages which the State would obtain from a system of completed and efficiently worked railroads are so palpable and clear that they had only to be mentioned to be appreciated. Military considerations were even more cogent. Increased efficiency combined with numerical decrease of the army and consequent economy would follow directly from the facilities of movement which railroads would afford. "In this country," wrote Lord Hardinge, "where no man can tell one week what

the next may produce, the facility of a rapid concentration of infantry, artillery, and stores, may be the chief prevention of an insurrection, the speedy termination of a war, or the safety of the empire."

The commercial, social, and agricultural benefits were inestimable, and were admitted to be so on all hands—and therefore, from political, military and commercial considerations, Lord Hardinge thought that the Court of Directors should liberally give assistance to private capitalists, ready to make railways in India; without awaiting proof that the construction of railways will afford that profit on the outlay which it was reasonable to suppose would be the case.

And in conclusion, the Governor-General states that in his opinion, "on military considerations alone, the grant of one million sterling, or an annual contribution of five lakhs of rupees, may be contributed to the great line when completed from Calcutta to Delhi, and a pecuniary saving be effected by a diminution of military establishments."

Lord Hardinge's views were sound and liberal; and though avoiding any attempt to enter into details, yet he evidently grasped two points of importance—the one, that without great pecuniary aid it would be impossible for joint-stock companies to raise capital sufficient for the construction of the great railroads of India; the other that Government should not grant money except for work actually done. In working out the particulars of such a scheme, it might be difficult to blend the two conditions into harmony, but the principles advanced were judicious.

The whole subject of the proposed introduction of railways into India which had thus been investigated and discussed in India, was referred to England during the summer of 1846; and in October in that year a

committee of the Court of Directors presented their report upon the correspondence, the general question, and the number of projects which from time to time had been submitted to the Court. The annexed list of the proposals is curious, and shows how keen the feeling for speculation is in England, while a comparison between the projects and the railroads actually made is interesting.

The East India Railway has embraced four of these projects, *i.e.* Nos. 1, 3, 8, and 9; the Great Indian Peninsula two of them, Nos. 2 and 13; the Eastern Bengal three of them, Nos. 5, 6, and 7; and the Madras Railway is nearly the same as Nos. 10 and 11 projects; the Bombay and Barodah has taken the place of No. 14, and the Great Southern of India that of No. 15; while Nos. 4 and 12 have been abandoned.

Experience has therefore proved that the schemes originally formed were, for the most part, well considered and sound, and that though there were in the first instance too many Boards, yet that their ideas were wisely conceived. The two plans which have not been carried into execution were clearly proved to be useless; but two only, out of fifteen schemes, turning out to be futile, indicate that a greater measure of care and thought was given to the plans for Indian railways than is often bestowed upon projects promoted by joint-stock companies.

At the time, however, that these plans were submitted the Court declined to take any of them into consideration, but confined their remarks to the great question of the introduction of railways into India. Accepting the joint recommendations of the Committee of Engineers and the Government of India, strengthened by the opinion of Lieutenant-Colonel Forbes, of the Bengal Engineers, a man of striking talent and good

Designation.	Particulars of the Line.	Extensions.	Branches.
1. East India Railway Company.	Calcutta to Mirzapore.	Delhi	Rajmahal, Patna, and Dinapore, Benares, Coalfields, Meerut, The Hills.
2. Great India Peninsula.	Bombay to Coringah.		Aurangabad, Nagpore, Hyderabad.
3. Great Western of Bengal.	Calcutta to Rajmahal.		
4. Calcutta and Diamond Harbour.	Calcutta to Diamond Harbour.	George's Point.	
5. Calcutta and Great Eastern Bengal.	Calcutta to Moorshadabad and Bogwangolah.	Dinapore	Malda, Rungpore.
6. Calcutta and Barrackpore.	Calcutta, Dumdum, and Barrackpore.		
7. Direct Northern.	Calcutta to Bogwangolah.		From Ranaghat to Culra, from Kishnagur to Kishengunge, from Cossipore to Baraset.
8. Great North of India.	Allahabad to Delhi.	Mirzapore and Benares.	Meerut and other places.
9. Delhi and Loodianah.	Delhi, Meerut, and Loodianah.		
10. Madras Railway Company.	Madras to Wallajanuggur.	To Arcot, Vellore and Bangalore and Mysore, to Ouddapah, Bellary, and Hyderabad, to Salem and Trichinopoly.	
11. Madras, Vellore, and Arcot.	Madras to Vellore, Vellore to Cuddapah, by the River Pannair.	Hyderabad.	
12. Madras, Sadras, Pondicherry.	Madras, Sadras, Pondicherry.	Arcot.	
13. Bombay, Agra, Delhi.	From Bombay to Delhi, <i>via</i> Surat, Barodah, and Gwalior; or from Bombay to Delhi, <i>via</i> the coast to Mhow and Indore.	Mirzapore, Allahabad, from the Nerbudda to Bhopal, from Oojein to Cawnpore, <i>via</i> Jhansi, from Gwalior to Ferruckabad.	
14. Bombay, Surat, Barodah.	Bombay, Surat, and Barodah.		
15. Madras, Southern.	Negapatam to Palghat and Calicut.		

judgment, they resolved that it was desirable that the first line in India ought to be a long one, and that it was of great and primary importance to connect the seat of the supreme Government with the North-western Provinces.

Provided, therefore, that the more exact surveys of the country which had to be made, proved that no serious difficulties arising from the physical character of the country existed, the Court also decided that the first railway in India should be from Calcutta to Delhi, through Mirzapore.

It having been previously determined that railways in India should be constructed by the instrumentality of joint-stock companies, the conditions of the agreement to be entered into alone remained to be discussed and settled.

But it was found very difficult to suit the views of projectors, of the Commissioners for India, and of the Honourable Court; and a great deal of time was spent in fruitless discussion. It is, however, but fair to state that throughout the lengthy correspondence the opinions held by the Directors of the Honourable East India Company were liberal and practical, and are in strong contrast to the obstructive and narrow views taken by the Board of Commissioners.

The Court proposed to grant, on a lease for ninety-nine years, the land required by railway companies, but to require that the Government should have the option of purchasing the railways at the mean market value of the shares during the three last years. As regards the all-important question of guarantee, the Court was of opinion, notwithstanding the expressed views of the members of the Government of India, that the grant of land merely would not be adequate aid to a railway company, and that no such company would

be formed without a guarantee of some dividend, which might, they thought, be given in several ways.

1. On the amount of funds actually paid into the company's treasury, to be drawn out as required for the actual expenditure of the railways. This would render necessary and proper an efficient control on the part of the Government to see that the actual expenditure was judicious and provident.
2. On an estimate of expenditure; in which case the guarantee would be so much per mile of accomplished work.
3. On an estimate of the Government use of the railways; which would be a guarantee of a certain income for performing all the requirements of the public service.

The Court being mainly guided by the assumed expediency of a perfect control being exercised by Government over the plan and construction of railways, and over the management of them when opened for public use, adopted the first method, and the principle of a guarantee being thus admitted, proceeded then to consider the amount and rate of interest to be allowed.

After weighing the many points connected with the question, the Court proposed to guarantee 4 per cent. on all sums paid into their treasury during the next three years, to an extent not exceeding 5,000,000*l.*, or 333 miles of railway at 15,000*l.* per mile, requiring, however, the following conditions:—That the Court of Directors should be the sole judges regarding the expediency of extending the guarantee to sums required for extension; that all profits should be divisible between the Court and railway company; and that a deposit of one million shall be paid into the treasury of the

Honourable Court before the interest guaranteed shall commence.

The above resolutions were not passed and recorded unanimously, for three of the members of the Court expressed a strong dissent; alleging that the state of information regarding railways was too imperfect, and the estimate of cost was evidently too untrustworthy to afford good grounds for the Court's intended departure from the only sound principle on which a railway in any country ought to be constructed, *i.e.* that when finished it should pay a remunerative dividend; that should the Court claim and exercise the right to superintend and control the works of a railway company, they would certainly involve themselves in endless disputes and difficulties, and interminable liabilities; but, practically, it would be impossible to refuse in the middle of an undertaking to extend their guarantee to the capital needed for the completion of a long line which must be mainly dependent for its revenue upon its through traffic.

The opinions of the dissentients do not seem to have had much weight, for the recommendation of the majority of the Court was adopted, and submitted in the shape of a resolution to the Commissioners for the Affairs of India, by whom it received careful consideration.

On the 19th December, 1846, the result of their deliberations was communicated to the Honourable Court. The Board of Control accepted the general principles laid down by the Court, admitting that the early introduction of railways into India was of primary importance, and that for that purpose it would be desirable to employ the agency of a joint-stock company; but they objected, however, to many of the details of the proposed measure. Instead of five millions they limited the extent of the capital to three millions, a sum they deemed ample to construct 150 miles of railway at

15,000*l.* per mile, in two sections, one in the Lower and one in the Upper Provinces of the Bengal Presidency; they also modified the periods of purchase proposed, stipulating that Government should have the right of purchasing the railway at the end of twenty-five or fifty years, considering that Government ought not to be deprived of that advantage because at one time it may not have suited their convenience to avail themselves of the option.

To the very idea of a guarantee they objected strongly and *in toto*, and concurred with the Government of India in thinking that, land being granted, it ought to be unnecessary. The Board would only consent to such a concession, and that in a modified form, on the understanding that the Court of Directors had satisfied themselves that sufficient capital could not be raised without a guarantee, that it shall be strictly confined to the first experiment, and to it alone, and that under any circumstances it should not extend to a period longer than fifteen years. A deposit of 500,000*l.* was required, and the full and careful examination and approval by the Government of India of all the designs and operations of the railway company was to be insisted on.

The terms and conditions on which support might be extended by the East India Company to the introduction of railroads in India were communicated to the promoters of the East Indian Railway and Great Western Railway of Bengal. The chairman of the East Indian Railway, with which the Great Western Railway of Bengal shortly after this date amalgamated, replied in February, 1847; observing with satisfaction the proposal to grant land and to give a guaranteed dividend, but demurring, among other things, to several of the limitations placed on that essential point.

They objected, first, to the guarantee of interest applying merely to the sum of three millions, but

thought that it should also be applicable to the actual cost of the sections to be chosen, alleging that the estimate might prove a mistaken one; secondly, that it ought to be extended to the entire capital required to complete all the works needed to finish the entire line as a whole, the temptation of profit from the through traffic being the main inducement to the capitalist to accept a rate of interest so low as 4 per cent; and, thirdly, that to curtail the period of the guarantee to a date short of that fixed for the purchase of the railway by Government would certainly be fatal to the attempt to obtain the capital requisite.

The Court of Directors were at once willing to modify their terms so as to bring the negotiations to a practical point, but the Board of Control would not hear of any departure from the conditions that had been approved of by them. This decision was communicated to the East Indian Railway Company in March, 1847.

Considerable delay then took place, and the chairman of the East Indian Railway Company taking the opportunity of the formal completion of the constitution of the East Indian Railway Company by registration, reported the circumstance in June, 1857, and urging the example of the grant of liberal terms to a railway company wishing to construct railways in Ceylon and Trinidad, again pressed for a modification of the conditions proposed.

The chambers of commerce of Manchester and Glasgow nearly at the same time represented in strong terms their regret that the introduction of a railway system into India had not met with the encouragement from Government to which, under the peculiar circumstances of that country, it was entitled. It being an indisputable fact that good roads tend greatly to the prosperity of every country, they pointed out that

the peculiar rights which the Court of Directors possessed in India made it a matter of necessity and right that they should encourage the investment of capital in India, so as to develop its resources, and especially to promote the construction of good roads to convey cotton from the interior to ports for shipment. They urged a grant of land and materials, and a guarantee of a minimum rate of interest to the Great Indian Peninsula Railway Company, in the same way as had been in several instances granted to joint-stock companies for the construction of railways in various colonies of the British Empire.

In the same month, June, 1847, the Court of Directors addressed the Board of Control, submitting that "India has just reason to expect, that encouragement to the introduction of railways into that country will at least be afforded upon the scale (*i.e.* 5 per cent.) which Her Majesty's Government may have deemed to be necessary in the colonies." The Board reluctantly consented with reference to the then position of the money market, to raise the guaranteed rate of interest from 4 to 5 per cent. for a period of fifteen years; but on this acquiescence being communicated to the East India Railway Company, their directors pleaded for an extension of time from fifteen to twenty-five years. This also having on the recommendation of the Court, been yielded by the Board of Control, on the 15th July, 1847, as a final concession; the directors of the East India Railway Company, on the 18th August, 1847, agreed to make such arrangements on this basis as may be requisite for carrying into effect the construction of the two proposed sections of a railway from Calcutta to Delhi.

As soon, however, as these negotiations with the Board of Control and the East India Railway Company had advanced somewhat towards a settlement, and before any definite understanding had been come to; the Court

of Directors had in the month of July represented that it was desirable to construct a short experimental line, not only in Bengal, but in each of the Presidencies; and with that object proposed to the Commissioners for India to offer to the Madras and to the Great Indian Peninsula Railway Company encouragement, corresponding to that offered to the East India Railway Company.

The Board of Control, however, were unwilling to adopt this proposal until the result of the experiment which was about to be made in Bengal had been at all events to some extent ascertained; and until a professional judgment by engineers deputed by Government, of a weight at least equal to that given by Mr. Simms and Captains Boileau and Western, had been obtained upon the schemes for experimental railways that had been put forward for the Presidencies of Bombay and Madras. The result of such an investigation would, the Board considered, be more satisfactory to Government, and in all probability to those also who are disposed to embark their property in these undertakings, than the approval of plans hastily, and without full information. Prudence in the commencement of such undertakings as railways, would be likely to advance effectually the important object of promoting the early construction of railways in India. The adoption of an immature and imperfect plan would only deter capitalists from embarking in such investments for the future.

The Court in two letters again urged their views; stating that their sanction to the schemes would of course be dependent upon the result of more exact surveys, proving that no physical obstacles existed to the construction and maintenance of the lines proposed; but that the local character and circumstances of each Presidency were so different, that the experiment to be made in Bengal could not be relied on as affording data

for railways in Bombay and Madras. They were therefore anxious to aid experimental lines of short length in all the Presidencies.

Moved by these arguments, the Board of Control at last consented to take the subject into consideration on receiving a definite statement of the extent of the assistance which the Court of Directors contemplated as suitable to the undertakings in the minor Presidencies, and the length of line which they considered the respective experiments would require. In reply the Court stated that they proposed to give aid similar to that offered to the East India Railway Company, to a line from Madras to Wallaganuggur (Arcot) in length about 70 miles, and to a line from Bombay to Callian, in length about 35 miles; and in September, 1847, the Board somewhat reluctantly agreed to accede to the construction of the railway proposed and recommended, as an experiment in the Bombay Presidency; but they declined to entertain the proposition of a line in the Madras Presidency, as there was not a joint-stock company in existence pledged to any particular railroad there. The Court again remonstrated in strong terms against deferring for a longer period the consideration of a railway for Madras; stating that it had been ascertained that the Madras Railway Company would be reorganized at once if a prospect of assistance were held out to them similar to that afforded to the railways projected in Bengal and Bombay; that the Presidency would have just cause of complaint if it were excluded from benefits which have been conceded to the other Presidencies; and that the construction of a line from Madras to Arcot could not fail to be highly beneficial, and promote the welfare and interest of the inhabitants of Madras.

The Board, however, continued obdurate, deeming it

unnecessary to pursue the subject further until a company shall have been organized for carrying out a railway in Madras.

In Bombay, too, the negotiations progressed but slowly. The terms and conditions proposed by the Court of Directors were sent by the managers of the railway company to Messrs. Robert Stephenson, Clark, and Chapman to report upon. These gentlemen considered the proposals inadmissible, and strongly advised the directors of the railway companies not to accept them. "It appears" they concluded "on reviewing the above terms, and the comments upon them contained in the various communications from the Government of India, . . . that the practical effect of the whole will be that the Government will choose the line, control the details of its construction and mode of working, fix the period for its completion, draw up its regulations, limit its rates of charge and its profits, reserve to itself the power of producing very serious delays, and finally, withdrawing its guarantee confiscate the works to its own use and profit." The chairman of the Great Indian Peninsula Railway Company, on the strength of this opinion, endeavoured to obtain some modification in the terms offered by the Court; but on being met with a distinct refusal to take any changes into consideration even, and being pressed for an immediate answer, he agreed on the 6th June, 1848, to accept the conditions proffered. There was, however, at first great difficulty in making the required deposits, but after a good deal of delay and grants of extension of time, 60,000*l.* were paid into the Honourable Company's treasury on behalf of the East India Railway Company, and 30,000*l.* for the Great Indian Peninsula Railway Company by individual members of the railway boards of direction. In September, 1848, a further

difficulty arose regarding the nature and extent of the guarantee granted by the Court to the two railway companies. The directors of the railway boards understood the guarantee to be one of 5 per cent. to each individual shareholder for twenty-five years, while the Court of Directors intended the guarantee to refer to sums paid into their treasury by a railway company in its collective and corporate capacity.

Many letters passed between the secretaries to the Honourable Court and the boards of directors, and some personal interviews took place between Directors of the Honourable Company and Railway Companies, but with no useful result. The capital could not be raised, and many shareholders protested against the undertaking being carried on at all in this mutilated shape, and with so defective a guarantee. At last, on the 29th January, 1849, the Court, considering that no advantage would result from a continuation of these negotiations, proposed to the Board of Control to return the deposit of the railway companies and to cancel the agreement absolutely. The question thus fell into the hands of the late James Wilson, Esq., M.P., then secretary to the Board, who took up the subject energetically, and on the 19th March, 1849, a dispatch containing the modified opinion of the Board was sent to the Court. In this important letter the Board endeavoured so to alter the terms that had been up to the present time proposed, as to make them at once safe for the Government and acceptable to capitalists.

The Board observed that to guarantee 5 per cent. absolute dividend, as demanded by the railway companies, would be to remove all risk from shareholders, and thus to take away the strong motive which the hope of an increased profit gives for economy, care, efficiency, and good management. With the risk, the object for

vigilance would cease, and the scheme would simply resolve itself into the creation of East India 5 per cent. stock. If the guarantee were to be absolute, "it would be infinitely better that the East India Company should keep the whole control in their own hands." From these considerations, it followed that a guarantee of 5 per cent. on the capital expended was the utmost that could be conceded.

The Board were willing, however, to alter the terms of the guarantee, and the period to which it was to extend. They suggested that the East India Company should agree to guarantee 5 per cent. interest on all sums paid with their permission into their treasury as long as the railway company may continue to possess the railway; that if there be any loss in working the line the railway company shall bear it, but shall be at liberty to give it up to the East India Company at any time they please, on giving six months' notice of their intention to do so; and shall then obtain repayment of the actual capital expended on the construction of the line, plant, and rolling stock.

Practically, this was an absolute guarantee of 5 per cent., with a risk to the shareholder of six months only; as if a line were proved to be worked at a loss, and the East India Company declined to make up the deficiency, the shareholders would of course avail themselves of the option of re-payment of capital which the contract was to allow.

On the 22nd March, 1849, the Court, though stating that the modifications now proposed were at variance with the views which had been taken by them, yet, anxious to bring the question to an early and satisfactory conclusion, they consented to the alterations suggested.

A revised paper of terms and conditions was drawn up, and this ultimatum, as it was called, effected radical

changes in the character of the guarantee, all favourable to the shareholders. It was, in fact, a compromise between the conflicting views of the Government and railway companies, the Government yielding in reality the main points about which there had been dispute.

The East India and Great Indian Peninsula Railway Companies at once accepted the revised terms proposed, and the legal agreements were forthwith put in hand, and were finally signed on the 17th August, 1849.

Thus, after discussions extending over a period of nearly four-and-a-half years, a definite conclusion was reached; and in all fairness it must be acknowledged that the many and great delays which had taken place during the negotiations were not chargeable to the Court of Directors of the East India Company, but rather to the Board of Control. The result finally accepted has been viewed with much disfavour and challenged much criticism; but it was confessedly an experiment, and though it has not been a complete success, yet it has certainly not been proved to be such a failure as its opponents would maintain.

CHAPTER IV.

MEMORANDUM BY COLONEL KENNEDY.

Direct Saving in the Cost of Armies — Responsibility of the Indian Government as a Landlord — Map — General Schemes — Lines along the Coast and the Course of Rivers compared with direct ones — Twelve Rules proposed by Colonel Kennedy — Opinions by the Consulting Engineers — Captain Crawford — Plan impossible for Bombay — Major Pears — Unsuitable to Madras — Lord Dalhousie's Minute — Recommends Three Trunk Lines — Reasons for the Recommendation — Declines to accept the Ghât Route — Advises further Surveys — Recommends that Railways in India be constructed by Joint-stock Companies — Guarantee Supervision by Government — Opinion concurred in by Court of Directors.

It was natural, when the minds of thinking men were first drawn to such a wide field for thought and enterprise as the introduction of railways into a continent like India, that various schemes should be propounded by clever men, regarding the method which ought to be followed in doing so. Among the most elaborate and thoughtful was that drawn up by Colonel Kennedy, late of the Royal Engineers, and any account of railway history in India, without a review of his memorandum, would be incomplete. His opinions were bold, his condemnation of the past and of all that had ever been done in England unsparing, and his promises alluring; whilst all his views were urged with a force of language and assertion which, coming from a man of Colonel Kennedy's position, at once commanded attention and careful consideration from Government authorities.

Colonel Kennedy had been for a short time Consulting Engineer to the Government of India for Railways, but had resigned that post, and had subsequently returned to England, and became the Consulting Engineer of the Bombay and Barodah Railway Company. His

report or memorandum on a general system of railways for India, dated 14th September, 1852, and written shortly after his return from India at the close of 1851, was addressed to the Honourable Court of Directors, and embraced many subjects.

First, he endeavoured to prove from statistics and argument that on the introduction of railways into India, the military power of the Government would be so increased that the Indian army might be reduced numerically and still retain all its present, or even possess increased efficiency.

Starting from the axiom that mobility is the essential condition of offensive war; Colonel Kennedy argued that railways, which would allow of rapid concentration of an army on any given point of a frontier, would certainly permit a very large reduction of the normal strength of the force, fixed with reference to a country where months were required to traverse a distance that with the aid of railways could be accomplished in days. With these views, he thus deals with the military expenditure of Bengal:—

That amount being in 1851	£4,993,538
Deduct one-fourth of the whole as a reduction of expenditure due to the increased efficiency of the Army, to be produced by Railways	1,248,384
Subsequent Military charge for Bengal	<u>£3,745,154</u>

This reduction of expenditure in the military establishment of Bengal, which he maintained the construction of a railway from Calcutta to the north-west would justify, and still leave the army a much more powerful engine than it then was, would be 1,248,384*l.* per annum; which at 5 per cent. would enable the East India Company to raise a capital of 24,967,680*l.*, or at 4 per cent. 31,209,600*l.*, or at 3 per cent. 41,612,800*l.*,

with which to construct railways on Government account.

By the means of this capital (3 per cent.), 8322 miles of railway, at 5000*l.* per mile, could be constructed in Bengal alone, and similar proportionate distances in the other Presidencies of Bombay and Madras by like measures.

Besides the direct saving, which Colonel Kennedy stated would be caused by the construction of railways in India; he observed that the Government of India, drawing its revenue principally from the rent of land, was in the position of a landed proprietor in England, and should therefore be willing to expend money in improving its estate. If 20 per cent. only be allowed for this purpose, then the annual outlay Government should expend on improvements should be 2,854,854*l.*

Thus ample funds to cover all risk in granting a guarantee being forthcoming, Government had only to foster the industrial resources of India by a liberal outlay on public works, to render it possible to remove every tax, as the rent from land would soon prove sufficient for the wants of the Administration. The public works then which have the strongest claim for Government support are railways.

But railways to be good investments, must be judiciously planned and economically constructed, and above all must from the commencement be laid down on a general and broad system for the empire. "The first object must be to lay down the great trunk lines, with a view to the broadest future ramification." Colonel Kennedy also, with the purpose of elucidating his meaning, attached to his reports a series of maps, showing trunk lines which ought to be made at once by red lines, and future branches to these trunks in yellow. They show his schemes as they would have been finally com-

pleted, and explain what in Colonel Kennedy's opinion would be the most perfect and comprehensive system of intercommunication that can at any future time be looked forward to for India. His plans are based upon two suppositions; first, that for railways nearly a dead level is essential, if a paying traffic is eventually to be worked, and that therefore their course should usually be along the coast where such easy gradients are possible; secondly, that the directions of large rivers determine the position of population and trade, and that in fact they are the great arteries of commerce.

But besides a good general system of railway-intercommunication, Colonel Kennedy urged that a most careful scrutiny of all designs was essentially necessary; to prevent such grave errors being committed as that of the project of carrying the East India Railway through the Rajmahal hills to Benares, instead of following the course of the Ganges; and that of the Great Indian Peninsula in proposing to mount the ghâts, and to pass over "four unnecessary and fierce ranges of mountains" in a direct line from Bombay to Allahabad, instead of adopting the obviously correct course, *i.e.* from Bombay to Surat, and then by the valley of the Mye and Chumbul to Neemuch and Agra. For Candesh the railway should pass from Surat by the easy gradient of the Taptee into the heart of that cotton-growing province. "Nothing can exceed the eligibility of this mode (that of making railways along the course of great rivers, Taptee, Nerbuddah, Soane, Godavery, Kistna) of opening the communication of all these districts with Bombay. Nothing could be more preposterous than to think of carrying the traffic of any of them over the ghâts."

Colonel Kennedy then proposed twelve general rules as a protection "against similar errors (those pro-

posed by the East India and Great Indian Peninsula Railway Companies) in future, and with a view to direct, concentrate, and combine with useful effect the efforts of well-intentioned active minds."

1. That all railways constructed in India shall belong to one of two classes,—the first or the second class.
2. That the regulating gradient of the first class or trunk railway, shall not exceed 1 in 2000. By "regulating gradient" is meant the gradient which shall regulate the load of the engines.
3. That no regulating gradient of any second class or branch railway shall exceed 1 in 330.
4. That short, alternate, impulsive planes may be introduced to assist the ascent, not to exceed a length of half-a-furlong each, and not to be nearer to each other than $1\frac{1}{2}$ furlong.
5. That no line shall be undertaken when the estimated cost shall exceed the average rate of 5000*l.* per mile of single track, but that this rate of cost is not expected to include the bridging of large rivers, as the Soane, Jumna, &c., exceeding half-a-mile wide at flood level; such rivers are to be considered as breaks, or temporary termini, when goods and passengers are to be carried across on rafts.
6. That no line shall be sanctioned, except for a single track of rails, with masonry, cuttings, and embankments to correspond; the ground, however, required for a double track to be in all cases secured.
7. That no locomotive engine shall be introduced to India for ten years, except such as the ratio between the length of stroke of piston and the

diameter of the driver wheels shall sanction, with reference to the maximum load, notwithstanding any sacrifice of velocity on the journey. Rule No. 11 contains an exception from this restriction.

8. That when piling for foundations be requisite, the foundations are to be laid to suit a double track, although the superstructure is only carried up for a single track.
9. That no portion of any line shall be permitted to open for the transport of goods or passengers until the capital account for the construction of such portion shall have been closed.
10. That no more than one train daily shall run in each direction upon any line until the traffic shall furnish more goods and passengers than one engine can carry, after which a second may start daily each way; and that when the traffic calls for three trains, fully loaded, per day, then arrangements shall be made for laying down a second track of rails.
11. That, notwithstanding the tenour of Rule No. 7, if on any line it shall appear that the profits exceed a dividend of six per cent. per annum, it shall then be permitted, if thought advisable by the directors of the company interested, to introduce engines of higher powers of velocity, with a view of running passenger trains separate from goods trains.
12. That the height above the sea of all obligatory points throughout India, having reference to the construction of works, draining, irrigation, &c., such as the highest points or necks of valleys, the low passes in mountain ranges, be

obtained and recorded with all convenient dispatch on the maps now in progress of construction by the Surveyor-General's department; and that, in addition to this, the height of numerous points of inundation level be taken upon the rivers of India, and recorded upon the maps at intervals of two or three miles, so as to admit of the protraction of proximate sections of the slope of such rivers; and that any striking peculiarity in the lines of rivers, or of the ground between adjacent rivers, be reported upon to the Surveyor-General by his subordinate officers; such reports to be methodically arranged in his office as records.

The condemnation by Major Kennedy of all that railway engineers had ever done in England, was so hearty and complete, the promises held out so attractive, and the views so well put and plausibly argued, that the Court of Directors at home and the Government of India were startled. The Consulting Engineers to the Government of Bengal, Bombay, and Madras, were called upon for an opinion on the rules, and the whole subject obtained a full and careful consideration.

Captain Crawford, the Consulting Engineer at Bombay, considering the financial positions advanced by Major Kennedy beyond the scope of his duties, declined to enter into a discussion of them; but both Major Baker in Bengal, and Major Pears in Madras, pointed out that railways must always be in the hands of the people of the district through which they may pass; and though admitting that railways would greatly facilitate the preliminary arrangements of aggressive warfare, yet, bearing in mind the protective duties in which so large a part of the force is employed, they stated that in their opinion the estimate of the saving in military expendi-

ture possible on the introduction of railways into India was much overdrawn. The indirect advantages of railways in improving the means of intercourse, and in promoting the social and moral well-being of the people, would be by far the most important; while there was no need to strain any argument to prove that Government had the strongest reasons for supporting railways, and that lines judiciously selected, economically constructed and worked, would eventually be no charge to the Government which may guarantee a dividend.

The opinions on the rules have a great similarity. As regards gradients, all the consulting engineers agreed in thinking that it was quite sufficient to take care to secure the best possible gradient consistent with other points in each case, and that fixed rules would hamper and be really useless.

In Bombay and Madras no trunk lines—meaning thereby a line lying in the direction of greatest traffic—could be constructed with the gradients named by Colonel Kennedy for second class railways (1 in 300); while on the Ganges valley 1 in 1000 was named as the best gradient that practically was obtainable.

The system of impulsive planes was disapproved as useless. The suggestion that large rivers should not be bridged, and the proposal not to undertake any railway the estimated cost of which may be more on the average than 5000*l.* a-mile was negatived. Each ought to be decided on its merits. If a railway costing 10,000*l.* or 20,000*l.* a-mile would be remunerative, there is no sound reason why it should not be made. A rule is undesirable and unnecessary. The suggestions (Rules 6-8) regarding a double track were decided to be good, and were agreed to. The details regarding the character of engines and number of trains (Rules 7, 10, and 11), had better be left for future decision by local authorities, when the

lines were open and in working order; but there was no valid reason why passengers should all be conveyed by goods train, and at a goods train rate of motion. Any speed within the limits of safety should be granted to the public, provided only that velocity be paid for and made remunerative to the railway company. It was impolitic and unjust to deny it. As regards the 9th Rule, the consulting engineers observe that its tendency is wholesome; but that to carry it out strictly would manifestly be at once unwise and impracticable. The information which would be obtained by the adoption of the 12th Rule would be interesting and useful.

On these opinions being laid before Lord Dalhousie, he decided in his Minute (dated 20th April, 1853), that the low *quasi-level* gradients recommended by Colonel Kennedy were not practically obtainable, even in the valley of the Ganges, except by following the stream through all its windings; that in Bombay and Madras they were impossible; and that though the principle of easy gradients, so as to leave the greatest possible amount of tractive power for moving its load along the line, is sound, yet that the principle should not be pushed to an extreme degree. For many reasons it may be desirable to construct a line with steep gradients rather than have no railway at all. In few cases would it be possible in India to secure a gradient of 1 in 2000 without incurring such a heavy outlay of capital, and excessive increase in the length of the line, as to render it more likely to be profitable to relinquish the theoretical perfection and to work a steeper gradient. Rejecting, therefore, the proposed fixed rule, he advised the Honourable Court to require close attention to be paid to the subject of gradients, so as in each case to obtain the best possible.

The technical rules he thought should be decided on

in England ; and though economy must be strictly enforced, and a rate of 5,000*l.* per mile aimed at, yet he advised that no specific sum should be fixed as a limit not to be exceeded.

The Honourable Court acquiesced in these views, and the rules proposed by Major Kennedy were therefore not adopted ; but still the suggestions were of use in compelling authorities in India and at home to take the various questions relating to the construction of railways into consideration, and to form definite conclusions regarding them.

But, besides the rules for construction, Major Kennedy had proposed a general scheme of railways for India, and in an Appendix had sketched a plan for ascending the ghâts. The two proposals are intimately united, and can best be treated together. In his paper "On opening a Railway from Bombay into the Tableland across the Syhadree Range," he explains his plan thus :—assuming from reports that the rocks were suited to tunnelling, and from some experiments made by himself in the Himalaya, that a tunnel 21 feet high could be executed at a rate of 6*d.* per cubic yard, or at 17*s.* 6*d.* per yard forward, he proposed to carry a railway up the face of the cliff by a winding route along the face, tunnelling through salient projections, and embanking round re-entering curves.

Taking 1500 feet as the height to be surmounted, the line was to have an ascending gradient of 1 in 330, or 16 feet to the mile, for a rise of 93 miles in length, which, for a continuous rise, he considered to be the best. Should, however, his principle of impulsive planes be adopted, he would adopt a base of 50 miles, with a gradient of 30 feet to the mile, or 1 in 76. The cost of this railway was to be under 5000*l.* per mile.

His general scheme for railways will be understood

best by an examination of the map; but his principles were coast lines to secure flat gradients, and lines along the course of rivers as they were asserted to be arteries of commerce. In Bengal the plan in its main features had been adopted, as it was suitable and appeared judicious, but in the other Presidencies it met with strenuous opposition.

For a line from Bombay to Candeish, Major Kennedy proposed a railway along the coast to Surat, and a continuance up the valley of the Taptee; in opposition to the plan of the Great Indian Peninsula, of surmounting the Thull Ghât by a steep ascent, and of a straight route to Candeish.

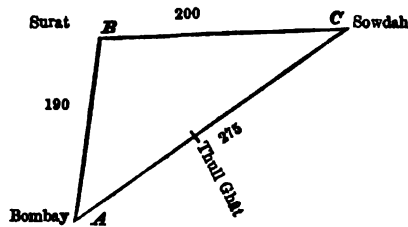
The Consulting Engineer to the Government of Bombay, Captain Crawford, pointed out that a railway from Bombay to Surat would have to cross the mouths of considerable rivers; and would be open to the very serious objection of crossing the whole drainage of the country at its broadest; and would be in direct competition with the sea throughout the distance.

The country traversed by the Taptee was little known, but it was thus described:—"As we advance into the DOUNG jungle, the spurs from the Satpoora hills and the tail of the Western Ghâts converge towards the river, the banks become very high—as much in some places as 150 to 200 feet. At Purkassa, however, the jungle begins, the villages and the cultivation gradually disappear until we arrive at Kookurmoonda, beyond which nothing but a few Bheel* huts, in clusters of three and four, and an almost impenetrable jungle, without a vestige of even a bullock track, exists; the surrounding country is also rugged and hilly, and is very much infested with tigers. This state of the country continues for a distance of 75 miles." The climate was

* Bheel—the name of a tribe of savages.

deadly, except to the few savages bred in it, for the larger portion of the year; and the entire country was intersected with ravines 150 or 200 feet deep. The facilities for the construction of a railway along the Taptee were evidently not so great as Major Kennedy supposed.

Again, taking any point in Candeish, it was clear from the map that a railway from Bombay *viâ* Surat and the Taptee, would form two sides of a triangle, and would therefore exceed a line up the ghâts which would be the third side.



	Miles.
A Railway from A to B would	= 190
" C to B "	= 200

Giving a total of .. 390 by the route proposed by
Major Kennedy ;

while A C, the route proposed by the railway company, would be 275 miles. Assuming for comparison the rate of 5000*l.* per mile (though very insufficient) named by Major Kennedy,—

The cost of his route would be	390 × 5000 =	£1,950,000
That of the Great Indian Peninsula Railway		
Company	275 × 5000 =	1,375,000
Showing a saving in favour of the direct line =		£575,000

Besides this, the difference in first cost of construction, there would be the expense of working and maintaining thenceforward 115 miles of unnecessary railway.

Again, the Thull Ghât line was traced in the direction of a large and annually increasing existing traffic, but a railway from Bombay to Surat would have to compete with a brisk sea-borne trade; while onward, the railway would pass through an uninhabited forest.

The project for mounting the ghâts is then discussed. This range of mountains, instead of having a slope of one perpendicular to three horizontal, as assumed by Major Kennedy, is a precipice in the strictest sense of the word. The ghâts are like a wall, broken by huge chasms, and in places by projecting spurs, but everywhere a sheer fall of from 200 to 500 feet is found along their whole length, not always at the crest, but generally between the middle and the top. It is broken by immense fissures, and during the monsoon cascades in all directions pour over the face. To construct a line of railway, gradually creeping for a length of 50 miles up the face of this cliff, is but one step from the impossible; and would certainly never have been entertained by any person who had—not carefully examined this range of mountains, but merely—ridden along their base and looked at them. The distance, by Major Kennedy's plan, from Callian to the top of the ghâts would be 125 miles, against $81\frac{1}{2}$ miles by the direct route as surveyed; and at 5000*l.* per mile the difference in first cost in favour of the latter would be 217,000*l.*, besides the expense of working and maintaining $43\frac{1}{2}$ miles of needless railway.

The cost of tunnelling is, by some error, made six times less than it should have been; and the rocks, instead of being suited to tunnelling, have been proved to be just the reverse. From consideration of time alone, a scheme which contemplated half-a-mile in every mile as tunnel must be avoided.

A railway constructed up the face of the ghâts would be right athwart the drainage of the district, and as at Khandalla, the annual fall of rain varies from 180 to 200 inches, concentrated usually within a period of three months; the difficulty of making and of keeping open a line over which such a flood—falling over such a

cliff—would rush, can only be surmised. For Bombay Presidency, Captain Crawford pronounced Major Kennedy's proposal practically impossible.

In Madras too, Major Pears, the Consulting Engineer, pointed out in conclusive and lucid arguments the objections to Major Kennedy's plan. The question to be decided, he observed, was to determine whether railways in India ought to be laid out, with reference to the physical characteristics of the different parts of the country, or to the present arrangement of the population.

In his opinion they ought certainly to be traced with reference to the existing resources and necessities of the country. Holding these views, coast lines appeared to him of secondary consequence, expensive to construct, of little commercial value, and as long as we have the command of the sea, of no political importance.

Major Kennedy did not propose any definite plan for mounting the Eastern Ghâts; but Major Pears incidentally mentions that the adoption of the easy gradients named by Major Kennedy would really amount to a prohibition of any line from the level Coromandel coast to the table-land of Mysore. The plan of one uniform easy slope would have the effect of compelling all traffic inland to be worked up an incline; whereas, the alternative of a level line from the coast to the foot of the ghât, and a sharp incline up them, followed by another level on the table-land of Central India, would permit all loads passing over either the first or last links of the chain to be worked with ease, and at a cheap expenditure of engine-power: the through traffic only being debitable with the cost of the charges due to the expenses of the steep gradient of the ghât. In fact, a short line with steep gradients may be a cheaper line to work, as well as to construct, than a longer one with easier

gradients. And consequently he concludes that it would be impolitic and unwise to refuse the boon of railway communication to Central India, because there are physical obstacles in the way which compel the use of gradients steeper than mere theory would desire. A line, therefore, should in his opinion mount the ghâts.

As regards the various railways suggested along the course of the Godavery, the Kistnah and the Pennaar, the Palar and the Cauvery, Major Pears observes that these rivers are not, and never have been arteries of commerce.

All these rivers exhibit in different degrees the same characteristic features. "They rise on the table-land (some on the crest of the Western Ghâts), they pass over it, by a course more or less circuitous, till they reach the eastern limits of that table, and they then plunge on the Coromandel plain, either falling over abrupt ghâts, or reach the level of the coast by a tortuous course, among an uninhabited or very thinly peopled range of rugged hills covered with forest. Some of these rivers are dry during a portion of the year, and all are subject to very great variations in their volume of water." Unlike the Ganges, the Indus, and the Nile, which contain a great body of water all the year round, and are true "arteries of commerce," the Mahanuddy, the Godavery, and the Kistnah have no populous or busy town on their banks throughout their length. "Instead of passing through a dense and industrious population, their course for several hundreds of miles lies through a region of mountain and forest, where the sound of man's voice is never heard."

Major Pears considered, therefore, that the proposal to make railways parallel to the course of such rivers, under the impression that in so doing they are sure to be in the course of traffic, is erroneous; and reiterates his opinion that railways should be traced according

to the wants and occupations of the inhabitants of a country, and not merely with a view to easy gradients, however desirable in themselves such easy gradients, if obtainable, are.

Major Kennedy's Memorandum and the comments which it elicited from the various consulting engineers in India having been laid before Lord Dalhousie, the then Governor-General of India, together with various references from the Honourable Court regarding railways in the different Presidencies, and the mode to be adopted for their construction: he wrote an able and memorable Minute on the subject, which is justly considered the foundation of the Indian railway system. This Minute is dated the 20th April, 1853.

The question of primary importance was that of the general system of railways for India proposed by Major Kennedy. He glanced first at the immeasurable advantages to be derived from the introduction of railways throughout the length and breadth of India, enabling full intelligence of every event to be transmitted to Government at five times the speed now possible; as well as the concentration of its military strength on every given point, in as many days as it would now require months to effect. Mentioned next the commercial and social advantages which the establishment of railways would afford; allowing great tracts teeming with produce they cannot dispose of, to part with it to others, sadly needing that which cannot now be conveyed to them. Ships from England and every part of the world, filling the ports of India in search of cotton and produce, which cannot be carried at a profitable rate from the interior to the coast.

Such facts, Lord Dalhousie remarked, indicate that a wisely designed system of railways in India, "would surely and rapidly give rise within this empire to the same encouragement of enterprise, the same multiplica-

tion of produce, the same discovery of latent wealth, and to some similar progress in social improvement, that have marked the introduction of improved and extended communication in various kingdoms of the Western world." Experiments are no longer needed. It has been proved that the country and climate of India present no obstacle to the construction of railways which engineers cannot overcome. There is no reason to doubt that natives will largely use railways, if it be their interest to do so; that, "if the lines be judiciously selected in the first instance; well and economically constructed; safely and thriftily worked;" they will be so far remunerative as to relieve the Honourable Court from the onus of the payment of the interest guaranteed on the capital expended in their construction. Still should it, contrary to the expectations of those best qualified to form an opinion, prove otherwise; yet the burden of the payment of a part of the interest may be cheerfully borne by the Honourable Court, considering the indirect advantages to be obtained from a complete system of railways and the position in which the Court stands towards the people of India. To secure, however, these advantages, the system of railways must be broad, extensive, and complete. This premise being accepted, Lord Dalhousie proceeded to consider the particular lines that ought to be constructed.

Major Kennedy's attempt to lay down a perfect and comprehensive system of railways covering the surface of India he deemed premature and impractical. He preferred rather to direct his attention solely to those great trunk lines which are of primary importance, and stated the main considerations which should determine their selection to be—

1. The extent of political and commercial advantages which it is calculated to afford.

2. The engineering facilities which it presents.
3. Its adaptation for a trunk line in the ordinary acceptance of that term.

Tried by these tests, the line from Calcutta, by the valley of the Ganges to the Punjaub, is of the very first importance. It will give Government the power of massing, with ease and speed, by an interior line of the best class of communication known, a large military force on any point of the long northern frontier of the empire of India that might be threatened by invasion. It will pass through every important military station from Calcutta to the Indus. In addition to the political advantages which such a railway would afford, it will be eminently adapted, from its position, to facilitate commerce. It will join the coal-fields of Burdwan to the metropolis; and will permit the traffic of the North-western Provinces to come by a direct and speedy route to Calcutta.

As regards construction, surveys have proved that besides the costly, but not impossible passage of wide rivers, such as the Soane and Jumna, &c., there are no engineering difficulties, and any number of minor lines could with ease be brought to it at any points along its course. It would form, in short, a backbone to a railway system for the northern district of India, and contain in itself all the requisites that a trunk line deserving the support of Government should possess.

But second only in importance to this line, if indeed it be second to it, would be a railway to connect Hindustan—understanding by that the provinces bordering upon the Ganges and Indus—with the great western port of India, Bombay.

Bombay, having no foreign frontier, would be able, if a railway were in existence, to afford most valuable aid to Government in the case of an attack upon Bengal; but at present without any means of rapid communication,

the co-operation of the armies of the sister Presidency is lost to Bengal. Nor is it only in time of war that such a railway would be valuable. Invalids returning to England would of course all go home that way. Reliefs of regiments arriving in India by that route might at once by railway be transported to such a station in the upper provinces as might be thought best adapted for ensuring the health of the corps.

But besides these evident advantages to be gained by a railway, Lord Dalhousie, adds, "Furthermore I hope before long to see the cost of conveyance of troops to India reduced by still another step. . . . When the railway in Egypt shall be completed from Alexandria to Suez, as it undoubtedly will, and if a railway shall be formed from Bombay to Upper India, as I trust it may, a regiment may be carried in steam transports from England to Alexandria, conveyed in twenty-four hours from thence to Suez, hence landed by the ships of the Honourable Company at Bombay, and moved up to their station in Hindustan by rail, in less time, and with infinitely less trouble than they now could march from Calcutta to Benares."

There can be no question regarding its commercial value. Most of the passengers to and fro between England and Hindustan would be attracted by the easy and rapid railway journey, and prefer it to the sea voyage round Point de Galle; and goods arriving from Europe at Bombay would enter markets in the interior at an advantage, when compared with similar goods shipped to and forwarded from Calcutta.

For these reasons Lord Dalhousie advocated its construction as a line of imperial importance.

But though a railway was clearly desirable, it was by no means certain which would be the best route for it to follow.

The consulting engineer to the Bombay Govern-

ment concurred with the engineer of the railway company in rejecting the Malsej Ghaut line, a route first suggested by Messrs. Chapman and Clarke, as not only ineligibile, but economically impracticable; but they both wished to cross the Syhadree range, and recommended for that purpose lines up the Thull Ghât in the direction of Candeish and Calcutta, and up the Bhore Ghât in the direction of Poonah and Madras.

Major Kennedy had in his Memorandum strongly condemned both plans, and in lieu of the Thull Ghât, had named for a trunk line a railway along the coast to Barodah, and then following the course of the Mye and Chumbul to Agra; and for Candeish, a railway along the coast to Surat, and then by the Taptee.

Lord Dalhousie, after carefully weighing the various arguments, came to the conclusion that the information possessed of the districts to be traversed was not sufficient to enable a sound and reliable judgment to be formed on the various plans; that it was clear that Major Kennedy, writing in ignorance of the localities referred to, had fallen into error; but still unless it was proved to demonstration by surveys, that passes admitting the construction of lines with better gradients could not be found along the range, he was unable to recommend that either the Thull or Bhore Ghât or Taptee river scheme should be sanctioned. He advised rather that careful surveys of the sea and river routes proposed should be at once undertaken; and that a careful and deliberate examination of the Syhadree range be made, for the purpose of determining that no better entrance to the table-land of the Deccan exists, and the precise nature and character of the improvements to the Thull and Bhore inclines, of which the engineers believed them to be capable.

The general question of connecting Madras with the Indian railway system remained to be considered. A

line direct by the coast from Calcutta to Madras, as suggested by Major Kennedy, being laid aside as undesirable, both on political and commercial grounds, the proposal to construct one directly from Madras to Bombay had to be examined.

The Presidency of Madras has a considerable army, but hardly any foreign frontier. If a railway connecting the Presidency with Bombay were in existence, the army of Madras would at once be available for imperial purposes, and the military power of the British Government would be enhanced. Troops in the Madras Presidency could, with a direct railway communication, be either closed up on Bombay, if the northern frontier of Hindustan were threatened, or could be forwarded rapidly to Madras for transport by sea to the eastern provinces, if there were need of their services there. Such a line would also probably be of commercial value to the Presidency of Madras itself.

Major Pears's full and clear reports on the various local lines proposed enabled Lord Dalhousie to indicate the railways for Madras which specially deserved consideration. That by the Godavery, suggested by Major Kennedy, having been proved by Major Pears to be inadmissible and undesirable from physical causes; two lines, one for the north-western the other for the south-western traffic, were evidently the most needed.

To meet the first want he advised that a line be constructed for Madras, *viâ* Arcot, Vellore, Salem, and so on to the western coast through the gap at Paulghât; a branch being thrown off to Bangalore through a pass giving great facilities for an easy gradient near Vaniambady, discovered by Major Pears; and another to the foot of the Neilgherries, near to Octacamund. Bangalore is the great military station of the Madras Presidency; a European regiment is always stationed at Cananore, and it is proposed to keep another at a sana-

torium in the hills. The political advantages of a line passing through these points require no comment, while Major Pears's carefully prepared statistics proved that the probable traffic would be adequate to make this line remunerative.

For the accommodation of the second stream of traffic Lord Dalhousie recommended that a line be made from Madras through the Cuddapah district to Bellary; and then by the valley of the Bheemah to Bombay, should a survey of the country prove that a good line can be constructed in that direction. Still the knowledge of all the districts lying between Madras and Bombay was slight and imperfect, and surveys of the routes proposed ought to be undertaken forthwith.

The circuitous route, *viâ* Paulghāt, and along the coast to Bombay, seemed to possess no features entitling it to favourable consideration. It would be long, would cross the entire drainage of the country at its worst point, would have to pass through or avoid foreign territory at Goa, and altogether seemed not to be suited for a junction line between Madras and Bombay.

The only other question on which an opinion was required was the agency by which these railways shall severally be constructed. On this point Lord Dalhousie recommended that railways in India should be made by joint-stock companies, under the control and supervision of Government. He foresaw that in guaranteeing interest, inducements to economy and exertion might be supposed to be wanting on the part of the companies; and that the exercise by Government, through its officers, of a close and vigilant and real control over the operations of a railway company would be, or would be considered to be, a vexatious and obstructive cause of complaint. These objections however he deemed not well founded, and therefore advised the Honourable

Court to entrust the construction of railways in India to private companies.

This Minute of Lord Dalhousie which has thus been briefly abstracted, is admirably clear and comprehensive; and the Honourable Court did not take long to come to a resolution to adopt and follow out his recommendations.

His Minute was sent home with a letter dated 4th May, 1853, and on the 17th August of the same year the Court replied. Admitting the great political, commercial, and social advantages which must ensue from the construction of an extensive and well-devised system of railways in India, they fully concur in the desirability of at once beginning the undertaking in a large and comprehensive spirit. They give their assent to the immediate commencement, in various parts simultaneously, of a line from Calcutta by the Ganges valley to Delhi. For Bombay they desire that surveys of the ghâts, and of the various other routes proposed, should at once be made. With regard to the railways projected for the Madras Presidency, they will be prepared to sanction a line from Madras to Bombay, *viâ* Cuddapah and Bellary, should the result of the intended survey prove satisfactory. The South-western line, *viâ* Vellore and Coimbatore, to the Malabar coast, they will take measures to have constructed.

Accepting the suggestion to entrust the construction of railways in India to private companies, they observe that "the Government officers should be required to exact the utmost economy consistent with perfect security and efficiency in the original construction of the line, and in all buildings and works of every description connected with it."

CHAPTER V.

THE PECULIAR ADVANTAGES AND DIFFICULTIES IN
MAKING RAILWAYS IN INDIA.

Exempt from Parliamentary Expenses — Land a Free Gift by Government —
Tables — Rates of Labour — Cost of Materials — Pay of Superintendence
— Wages — Natives as Artizans — Effect of the Mutiny — Materials
procurable in India — Iron — Table of Exports from England — Stone —
Bricks — Laterite — Limes — Timber — Great difficulty in procuring it in
India — Indian Forests wasted — Methods used to preserve Timber —
Iron-pot Sleepers — Description of the Timber used on Railways in India.

AN account of the struggles of the infant system of railways for India has been given in previous chapters: but, even after preliminary difficulties had been surmounted, and after railways themselves had been placed upon a satisfactory basis by Lord Dalhousie's Minute, in which the principles and means for their construction had been settled and discussed; their progress was by no means easy or smooth.

In England, now-a-days, if a railway has to be formed, there are a dozen firms of wealthy contractors, who will undertake to make it at so much per mile with nearly the same ease and readiness, as a manufacturer will contract to deliver so many yards of cotton goods; but in India, in 1855, there was a vast difference. There all regarding railways was surmise; all was strange and uncertain; and English contractors held aloof, or wanted terms which were thought exorbitant. Engineers had to feel their way step by step, and, petty Indian contractors failing one after the other, had often themselves to carry out their own designs. In one respect,

however, railways in India were fortunate. They were exempt from the so-called control of Parliament.

In England, at the commencement of the railway era, directors of railway companies had either to contend, at a vast cost, with frivolous oppositions before Parliamentary Committees, or to dispose of unprincipled and exorbitant claims by payments, which in truth were bribes. The legal expenses consequent upon investigations before Committees of the Houses, and upon the various arrangements and negotiations which adjudication on disputed claims of opponents involved, were enormous.

The parliamentary and legal expenses of the Midland were 597,890*l.*; those of the Great Western, 760,270*l.*; and of the North-western, 869,771*l.*; while those of East Indian were only 4093*l.*; Great Indian Peninsula, 4124*l.*; and of the Madras, 1183*l.*; sums which bear a very insignificant proportion indeed to the capital of these companies. The subjoined Table, extracted from one prepared in 1859 by Mr. Juland Danvers, the Government Director of Indian railways

Railways.		Total Capital of Company.	Law and Parliamentary Expenses.	Proportion which the total Parliamentary Expenses bear to the total Capital.	Average of 8 English and Indian Railways.
Eight English.	Eastern Counties	11,611,085	268,201	2·3	2·79
	Great Northern	11,444,404	334,219	2·92	
	Great Western	27,430,710	760,270	2·77	
	London and Brighton ..	7,799,257	43,690	·56	
	North-western	34,041,013	869,771	2·55	
	South-western	9,506,225	313,702	3·6	
	Midland	20,712,981	597,890	2·8	
	South-eastern	11,044,592	515,707	4·66	
Eight Indian.	East Indian	17,000,000	4,093	·02	·108
	Madras	8,500,000	1,183	·01	
	Great Indian Peninsula ..	12,000,000	4,124	·08	
	Bombay and Baroda ..	2,500,000	3,083	·12	
	Scinde	3,000,000	2,383	·07	
	Eastern Bengal	1,250,000	926	·07	
	Great Southern of India ..	500,000	466	·09	
	Calcutta and South-eastern	250,000	1,174	·46	

at home, gives the proportions which law and parliamentary expenses bear to the total capital of eight English and eight Indian railway companies respectively.

As the capitals of Indian railway companies have been very largely increased since 1859, the ratio of legal expenses for India has still further been reduced.

The legal expenses of Indian railways were the legitimate costs of their proceedings before the Houses of Parliament; and it is no small gain to shareholders in Indian railways, that they have been spared the ruinous expenditure on this account with which English undertakings are burdened. But in addition to this advantage they also have had nothing to pay for land; for, in accordance with the terms of the guarantee-deed, the Indian Government have bought with their own funds all the ground required for Indian railways. The outlay on this head has hardly as yet been clearly ascertained. Mr. Danvers estimates the cost at 300*l.* per mile, but this is probably considerably under the actual cost. The land purchased for the Sealdah terminus of the Eastern Bengal Railway at Calcutta was 141 acres, and cost 98,307*l.*, to which must be added the value of a remission of annual revenue amounting to 20*l.* The total cost of the site for this terminus was therefore 102,347*l.* or 725*l.* per acre, taking the value of the abatement of assessment at twenty years' purchase. On this site there were no valuable buildings to pay for, and the ground itself was, before its purchase by Government, comparatively of little value. The land for the terminus of the South-eastern and Calcutta Railway, near the same spot, was still more costly. The area was 61 acres, and the sum paid was 66,137*l.*, to which has to be added the value of a loss of annual revenue amounting to 46*l.* The land of the South-eastern terminus at Calcutta therefore cost Government 67,057*l.*, or at the rate of

1,099½. per acre. But these values are, of course, exceptionally high, as the land bought was in the immediate vicinity of Calcutta. The following table gives the value of the land first purchased for the Eastern Bengal Railway, 108 miles in length, and of that bought for the Calcutta and South-eastern Railway, 29 miles in length. The table does not include the cost of the entire lengths of the lines, as at the time it was made up, some purchases had been referred to arbitration.

Limits of Sections from which the Averages are calculated.		Length of Section.		Average Number of Acres per Mile.	Average Cost per Mile.	
From	To	m.	ch.	a. r. p.	£.	
Narcooldangah Road	Belgatchy Road	2	37½	46 0 16	11,848	} A high bank at this point.
Belgatchy Road ..	Dumdum Road	0	68	46 0 16	4,665	
Dumdum Road ..	Titayhur Road	8	67	28 0 8	892	
Barrackpore		2	21	19 3 38	1,701	
Barrackpore	Bhutparah ..	6	2	20 1 15½	368	
Bhutparah	Katalparah ..	1	70	17 0 30	636	
Katalparah	Ranaghât ..	21	23	20 1 25	267	
Ranaghât		2	55	19 1 66	896	
Ranaghât	Mutteearee ..	22	1	25 0 10	105	
Mutteearee	Koomar River	24	40	23 3 17	74	
Koomar Road	Ganges	16	5	29 3 25	152	

Average cost per mile for the length = £1964.

CALCUTTA AND SOUTH-EASTERN RAILWAY.

		m.	ft.	a. r. p.	£.	
Intally Road	Gobrah Road ..	1	20	21 3 38	13,770	
Gobrah Road	Talgillah Road	0	2250	15 0 5	4,361	
Talgillah Road ..	Sirampore Road	1	200	17 3 22	2,359	
Sirampore Road ..	Punchagrām ..	0	3700	16 2 38	1,232	
Dharcoorealli		1	67½	16 0 0	732	
Taldee Khali		17	48	27 0 87	466	

Average cost per mile for the length = £3820.

From the above figures the cost of the land required for a railway per mile, within 100 miles of Calcutta, may be safely assumed to be about 2890½. per mile, as the country traversed contains a fair average of both cultivation and jungle.

Such an average, however, would not of course apply to the extensive tracts of jungle and uncultivated land which in Central India are traversed by railways at times for many miles; but in the total length of line sanctioned, *viz.* about 5600 miles, it is hardly probable that the length of such absolutely uncultivated districts can exceed 1000 miles. On this assumption, the pecuniary value of the land given by the Government of India as a contribution towards railroads in India, will not probably amount to less than ten millions of pounds sterling.

4600 miles at 2000 <i>l.</i> per mile	=	£9,200,000
1000 miles at 300 <i>l.</i> per mile	=	300,000
Eastern Bengal Railway, Calcutta terminus		102,000
Calcutta and South-eastern terminus		67,000
Land for about 18 other terminal stations, say :—		
9 at 80,000 <i>l.</i>		720,000
9 at 2000 <i>l.</i>		18,000
		<hr/>
		£10,407,000

The parliamentary and legal expenses of Indian railways being of no consequence as compared with the capital raised, and the land on which the lines are constructed having been given free of all cost by Government to the various companies; the economical construction of Indian railroads depended, it will be evident, upon the rates at which labour could be obtained and materials could be purchased.

The labour required for the construction of a railway is of three kinds: the skilled superintendence of engineers and of managers of departments; the skilled mechanic and artizan; and the ordinary labourer. No difficulty in obtaining any of these classes of labour has been felt, but the expense of European superintendence, whether by engineers or by traffic and locomotive managers, was great; and the cost of procuring the

higher classes of mechanical or artizan labour, such as engine-drivers, inspectors of brickwork, foremen carpenters, smiths, fitters, &c., was excessive when compared with English scales of payment for men of that class.

Engineers and managers of departments, whether engaged in construction or in maintenance, receive about double the pay given in England, and in most instances, considerable additional allowances besides. Engine-drivers and foremen tradesmen get from 20*l.* to 30*l.* a-month, and this pay, though high, is not the only expense connected with European agency in India; for to it has to be added the cost of transporting men to India, of medical care of them there, and the frequent need of filling vacancies. The class of men from whom these artizans are drawn, are accustomed to work hard, and often to live hard; and exposures, excesses, and carelessness, which in a temperate climate might be harmless, become under a tropical sun either fatal, or induce such serious illness as to render a return to Europe on sick leave imperative. In either case the railway company suffers heavy loss. Statistics seem to prove that the average number of deaths and retirements from ill-health per annum is 4·7 per cent., but the returns from which the percentage is derived are imperfect.

The employment, however, of an expensive European agency in India, is a drawback to the economical construction and maintenance of Indian railways, and some of the companies have made great efforts to substitute for it Eurasians or natives. Much success has not as yet attended their efforts, but as the system becomes more developed, India will no doubt be looked to more and more as a school for the wants of the locomotive and traffic departments. In Madras alone, of all the Presidencies, has much progress in this direction been made; but in all there has been a commencement, and in every instance

it has been found far easier to train natives to be good mechanics, such as turners, fitters, lathemen, and smiths, than to make them good and trustworthy engine-drivers.

Natives are wanting in presence of mind, courage to deal with emergencies, forethought and caution, qualities which a good driver of engines must have before he can be competent to manage an engine and train. But on the other hand, natives of India possess a fineness of touch and quickness of apprehension, which soon enables them to handle lathes or any steam-driven machinery, and to acquire the mechanical skill needed to manage a steam-engine or drive a locomotive; but then they are wanting the nerve, the punctuality, and constant attention to cleanliness, which such a charge requires.

Clerks, book-keepers, and accountants were obtainable in any number, as the Indian mind shows an aptitude for figures; and the English language, as a passport to employment, is usually learnt fairly well by intelligent young men of the upper class.

Masons, carpenters, and smiths in considerable numbers have always found employment in India, but previous to the introduction of railways the demand for them had never been greater than the supply. But as soon as these great works were fairly set on foot, this was altered; and wages rose rapidly, and numbers of men attracted by the increased pay began to qualify themselves as tradesmen. The system of caste in labour which had been so long existing in Bengal, at first threw difficulties in the way, and tended to repress elasticity in the movement; but money in this, as in most other instances, presented an irresistible attraction. Rates of wages vary almost infinitely with localities and with the nature of the works to be done; but the subjoined table which, though imperfect, has been formed from various sources, indicates a great advance in

material wealth, more especially in Bombay and Bengal. The effect of the mutiny also, in causing a rise in the price of labour and materials, was marked and curious. The increase in rates, which is almost sure to occur after the commencement of any works on a very large scale, is very trying to engineers, who have based their estimates upon current prices; and to shareholders who have accepted their calculations: but such rises, if caused by the simple operation of the laws of supply and demand, and not forced by combinations or strikes supported by trade unions, undoubtedly are signs of general improvement in the prosperity of the country, and in the welfare of individuals.

	Bengal.		Bombay.		Madras.		Scinde.	
	Before the Railway era.	After the Railway era.	Before the Railway era.	After the Railway era.	Before the Railway era.	After the Railway era.	Before the Railway era.	After the Railway era.
	per day. s. d. s. d.	per day. s. d. s. d.		per day. s. d. s. d.		per day. s. d. s. d.		per day. s. d. s. d.
Foremen, Masons, Smiths, & Carpenters	1 3 to 1 8	3 4 to 5	No exact information, but probably a little higher than the rate obtained for Bengal.	2 6		..	..	..
Masons	6d. to 9d.	9d. to 1s.		1 9	No exact information.	7½d. to 10½d.	..	1 3
Bricklayers ..	"	"		1 3		7½d. to 10½d.	..	1 3
Smiths	"	"		2 0		..	..	1 3
Carpenters ..	"	"		1 6		9d. to 10½d.	..	1 3
Miners	6d.	9d.		9d.	per day.	..	..	6d.
Labourers ..	3d. to 4d.	6d.		6d. to 7½d.	1d. to 2d.	1½d. to 2d.	..	6d.

Although these rates are very much below those paid in England, yet probably there was not very much difference between the effective value of each description of labour in either country. Wages, it is true, were lower, but then the quantity and quality of work done was less, and putting one against the other, the result obtained was nearly the same in both countries.

In labour, the advantage to India was not really much; and in other respects there were some expenses peculiar to the country, which were serious drawbacks to economy in construction. The materials chiefly needed for a railway are iron, stone, lime, bricks,

and wood. Iron ore is found in many parts of India, but the mines have not as yet been worked to any extent. That which is manufactured, is charcoal iron of good quality, but of a high cost; and there are neither appliances nor skill in India sufficient to make iron for bridge work, iron rails, &c., &c. Some tenders for iron-work were, at the very commencement of railway construction, called for in Madras; but the offers were so high, and the means at the disposal of the tenderers so feeble, that it was soon clear that in that Presidency, as well as in Bengal and Bombay, all iron-work, as a rule, would have to be imported from England. It is possible that eventually the iron needed for renewals may be manufactured in India at a cheaper rate than it can be brought from England; but some years must elapse before this can occur.

Iron began to be exported from England to India in 1850, and the following table shows the amounts exported, year by year, to 1867, by each company. The iron consists mainly of rails, chairs, girders for bridges, turn-tables, engines, locomotive and stationary, and machinery for shops. The freight has varied a little, year by year, and at one time, fears were entertained that competition for it, by railway companies, would raise the cost of the construction seriously; but the amount of trade between India and England is so large, and has increased so rapidly, that no difficulty in obtaining freight at moderate rates has been experienced. The balance of trade is always, also, so much against England, that until railway companies commenced exporting dead weight to India, shippers were in the habit of sending many ships to India in ballast, relying upon the freight home to pay for both the outward and homeward voyages. The average freight paid for dead weight and measurement goods, up to 1860 and

TABLE showing the QUANTITY of IRON EXPORTED from ENGLAND to INDIA for the USE of RAILWAYS, from 1850 to 1867. Based on Statistics given by JULIAND DANZERS, Esq., Government Director of Railways.

	East India Railway.	Great Indian Peninsula.	Madras.	Bombay Barodah.	Scinde.	Punjab.	India Fictitia.	Eastern Bengal.	Great Southern of India.	Calcutta & South-eastern.	Delhi.	Indian Branch.	Total Tons.
1850 to 1854	..	927	..	..	..	..	..	..	..	..	..	..	927
1851	..	6,584	..	..	..	..	..	..	..	..	..	..	6,584
1852	..	4,925	..	..	..	..	..	..	..	..	..	..	4,925
1853	..	6,192	..	..	..	..	..	..	..	..	..	..	7,547
1854	40,000	9,850	1,415	..	..	..	..	..	..	..	..	..	57,217
1855	58,000	12,870	40,772	..	..	..	..	..	..	..	..	..	111,642
1856	65,000	26,668	23,727	3,215	8,225	..	..	..	..	..	..	..	126,835
1857	48,000	33,117	5,877	16,367	19,742	..	..	..	..	..	..	..	123,103
1858	35,126	63,032	13,989	19,313	16,365	..	..	..	..	..	..	..	147,845
1859	32,094	50,228	37,407	31,075	26,489	12,293	1,843	12,569	..	..	..	..	209,978
1860	56,448	25,973	38,848	32,980	2,055	24,106	1,240	30,333	17,189	6,088	..	..	234,710
1861	64,465	36,225	39,230	10,327	1,842	13,696	168	10,342	4,797	1,529	..	..	182,621
1862	32,911	38,703	24,002	13,263	2,651	48	14,408	10,689	1,124	234	..	..	138,013
1863	47,880	8,144	62,672	26,235	4,414	14,021	288	173	2,293	1,220	..	..	166,840
1864	18,117	22,910	36,073	12,434	3,157	5,446	74	917	3,060	72	38	..	109,318
1865	31,370	59,496	44,352	14,916	2,729	2,251	10,96	2,660	16,762	236	23,279	..	199,147
1866	69,827	97,894	22,751	55,763	610	1,103	5,046	7,016	14,618	3,212	49,505	..	326,845
1867	97,506	125,634	53,826	19,402	1,149	1,968	273	14,254	7,504	228	18,581	4	338,329
Total	696,244	622,812	457,808	249,310	89,428	73,932	24,436	88,933	67,297	12,819	91,403	4	2,474,426
Add an amount of Dead Weight in Rails, &c., exported by railway companies during the years 1850 to 1859, but not included in the above Return, distributed proportionately.)	536,634	357,680	178,840	89,420	89,420	..	..	..	..	..	..	..	1,251,994
Grand Total	1,232,878	980,492	636,648	338,730	178,848	73,932	24,436	88,933	67,297	12,819	91,403	4	*3,726,420

* Mr. Danvers gives this total as 3,628,191. I cannot account for this discrepancy; but it is probably some typographical error.

1861, was 1*l.* 5*s.* per ton; but since then the average has risen to 1*l.* 11*s.*, and during the years 1865 and 1866, as much as 40*s.* and 45*s.* have been paid.* The total quantity of materials exported from England to India by railway companies, up to the end of 1867, was 3,726,420 tons, valued at 23,252,581*l.*, and 5339 ships have been employed to convey it—56 of which have been lost. The loss by sea has been small, and has always been covered by insurance, but the transport of such a weight, long distances inland from Calcutta, Bombay, or Madras, has caused much difficulty, loss, and expense. The East Indian Railway had to build a fleet of barges and steamers for the purpose of carrying their iron-work, which was particularly heavy; the native boats having altogether failed, and immense losses having taken place from the use of them. The Great Indian Peninsula had also to overcome great difficulties in getting their iron-work up the ghâts.

In the mountainous and hilly districts of India, stone of good quality is usually found, but most of the masonry on the East Indian Railway, excepting a district near Chunar and Mirzapore, has been made of brick. Indian engineers have usually to turn brick-makers themselves, for bricks made by natives are so badly manufactured, that they cannot be relied on. A native takes any clay that happens to be near at hand, digs it up, wets it, kneads it with his feet for a short time, and then moulds the bricks on the ground, and leaves them to dry in the hot sun and wind. Bricks so made are badly tempered, badly shaped, and are, besides, usually cracked and badly burnt. For the large bridges over the Adjai, Mor, and the Soane, the engineers had to establish their own brickfields; and after a few

* At the commencement of the Abyssinian expedition freights reached in some cases 60*s.* per ton.

failures at first, their success was, in each instance, satisfactory. At the Soane Bridge especially, bricks of a very superior quality, both as regards material, weight, and manufacture, were made for the foundations of the piers, under the superintendence of Mr. Power. The clay was carefully tempered and well puddled; the bricks were then moulded on tables under sheds, where they were allowed to dry and harden, sheltered from the direct rays of the sun and the blast of the hot winds, and were afterwards burnt by wood or coal in flame kilns. So manufactured, Indian bricks have proved a good and lasting building material, quite different from the perishable and treacherous brick produced by native brickfields. A rapid and constant supply of bricks has, however, been a great want in Bengal, and the delay and uncertainty in their manufacture caused much anxiety; and on Mr. Rendel's advice, it was determined to substitute iron girders for brick arching in most of the bridges of large span.

Near Chunar, excellent building-stone is obtainable; and for the bridge over the Jumna, at Allahabad, a fine grained, compact sandstone, of a light reddish colour, was procured from quarries about thirty miles from Allahabad. The engineers of the railway company were obliged to work the quarry themselves, and obtained from it the greater portion of the large ashlar blocks for the piers of the Jumna Bridge. The quarry was 330 feet long by 120 broad, and the beds of stone, which were nearly horizontal, were 7 feet thick.

In Bombay, excellent building-stone is generally procurable throughout the length of the Great Indian Peninsula line of railway, and has been extensively used. Various qualities are met with suitable for either hammer or chisel-dressing; while the sharpness of the rough blocks and stones adapt them for strong rubble masonry.

Good brick-earth is said to be rarely met with in Bombay, but as stone is so readily procurable, trouble in searching for clay, and in the manufacture of the bricks themselves, similar to that which was forced upon engineers in Bengal, has probably not been taken.

In Madras, also, stone is met with in most parts, laterite and granite being very common. Near Bangalore granite is so abundant, and so easily quarried, that large blocks of stone are used for many purposes, where in other places wood would be employed. Telegraph wires, even, are carried on granite blocks instead of wooden or iron supports. Granite blocks, 24 in. $\times$ 24 in. $\times$ 12 in. were used also as sleepers on part of the Madras railway, but they were not found to answer well, as they caused the road to be unduly rough and rigid. Blocks of laterite were tried near Madras for the same purpose, but they proved treacherous, splitting readily, and the use of them was also abandoned. In buildings in Madras, laterite is largely employed; but unless protected from the action of weather, especially rain, it softens, and causes failure of various kinds.

In Scinde, an arenaceous limestone, of a pale colour, was used on the railway works to a large extent, and the stone was found an admirable building material, hardening with exposure, but easily worked.

Good limes can be purchased or manufactured in nearly every part of India. Two kinds are commonly used, one made from nodules of *kunkur*, a peculiar kind of limestone, found in layers in large quantities in very many parts of India. This lime, if burnt from well-selected, ripe *kunkur*, free from earth, is of admirable quality and hydraulic; but it is rather brown in colour, and not well adapted for plastering or finishing. The other kind is a white lime burnt from ordinary limestones or from shells. Lime so made is usually not

hydraulic, but is of a fine white colour, admitting a beautiful finish and polish. As good sharp sand is seldom procurable, brickdust pounded fine is used, and forms a good substitute.

The only remaining material that needs notice is timber, which is moreover the most important of any to an Indian railway engineer. The permanent way is for the most part laid on wooden sleepers; and experience has proved that the opening of a railway depends more upon the adequacy of the supply and the transport of sleepers and permanent way, than upon the speed and skill with which bricks or ballast can be manufactured: in short, the great difficulty which constructors of Indian railways have had to encounter has been the provision of sleepers. This was a cause of delay both unexpected and unforeseen; for it was well known that India abounded in forests containing quantities of good timber trees, and it was at first assumed that there would certainly be no trouble in obtaining from Indian resources as much wood as the railways of India might require.

Good timber for sleepers is the more important as entering directly into the subsequent economical maintenance of an opened railway, which must depend much upon the endurance of the permanent way. Many methods have been adopted to secure an adequate supply of sleepers; and the Government, by establishing a forest department, have lately taken measures for the conservance and future protection of valuable properties, which had previously been left uncared for. Great numbers of forests, the undisputed property of Government, had been so carelessly treated and so wastefully denuded of timber; that the reports of the conservator are filled with statements regarding the reckless way in which timber is being felled, and the difficulty of resuscitating ruined tracts, where once

rich and extensive forests, with an abundance of teak or sāl timber, had flourished. Supposing that sleepers of Indian woods only be used, the number of sleepers required for laying a single line over the 5600 miles of sanctioned railway at 1760 sleepers per mile, is 9,856,000, and the renewals annually are so numerous that a like number would be needed about every ten or fifteen years.* Assuming that square heart wood be insisted upon, sappy and half-round sleepers being rejected, then as, according to Dr. Brandis, the Government conservator of forests, from three to five sleepers only can be cut from one tree, $3\frac{1}{4}$ or $1\frac{3}{4}$ million of timber trees would be needed at every fifteenth year. But as teak and sāl trees take a period, variously estimated at from twenty-five to thirty years to come to maturity; and as but few trees of any value or age are reported as left in forests at all adjacent to the lines of railway; the immense difficulty, or rather impossibility of procuring an adequate number of sleepers from the timber of India alone, will be evident.

Besides teak and sāl, there are other descriptions of trees in Indian forests from which sleepers can be cut; but they are defective either in durability or abundance, or unsuitable from their excessive weight and hardness, and therefore cannot be taken much into consideration. But the best kinds of jungle woods, as they are called, will be afterwards described.

With the view of meeting this pressing want, many plans have been adopted; Indian jungle woods have been creosoted, burnettized (chloride of zinc), and kyannized (corrosive sublimate), and subjected

* Mr. Turnbull considers that 226 new sleepers per mile per annum would be required for maintenance, and 10 per cent. more for sidings. On this calculation 1,388,800 of sleepers would be needed yearly for Indian railways, which at five sleepers a tree would require 277,760 trees to be felled in the forests of India per annum.

to various chemical processes with no very certain success. Cast-iron sleepers of different patents and descriptions have been freely tried, and England, Ceylon, Singapore, and Australia have also been laid under contribution. But as time in railway making is a most essential element for financial success, the plan of obtaining a supply of creosoted pine sleepers from the English timber market, sufficient to lay down the permanent way of the railway in the first instance, has been frequently adopted. The European timber market is practically inexhaustible; and an English timber merchant can execute an order for creosoted fir timber sleepers for 100 or 200 miles of railroad, during the time that the embankment and bridges on the line are being constructed: while the same period does not permit managers of railways to organize in India an establishment for cutting and procuring sleepers; and contractors for Indian sleepers, with few exceptions, cannot be relied on.

Before describing the different kinds of wood used for sleepers in India, it should be stated that as early as 1856 and 1857 the sleeper difficulty had forced itself into prominence; and Mr. Turnbull laid down on the experimental line near Calcutta some cast-iron sleepers of a shape invented, it is believed, by himself. They bore the traffic of slow and steady trains well; but proved quite unable, with the ballast procurable in Bengal, to sustain the passage of ordinary trains at a rate of thirty miles an hour, or that of heavy coal-trains, weighing 313 tons. Mr. Turnbull therefore recommended that the use of cast-iron sleepers should be discontinued; and in support of his advice mentioned that during 1856 the breakage of cast-iron sleepers had been at the rate of 1·8 per mile per month, but that in the first half of 1857 the breakage rose to 4·35 per mile per month, and was con-

stantly on the increase. This was deemed conclusive, and no more cast-iron sleepers were used until lately on the East Indian Railway. In Madras, Greaves' cast-iron pot sleepers were laid with great success, as fine sandy ballast, with which the pots could be readily filled, was there found; but with the ballast of kunkur, gravel, and broken bricks or clay, usually met with in the northern provinces of India, the pots could not well and satisfactorily be filled. In Bombay also, on the Great Indian Peninsula, Greaves' "pots" were also laid.

In addition to trials with cast-iron sleepers, pine sleepers, pickled by various processes, were also used, but the reports regarding them and their value were discrepant. It is, however, clear that good, seasoned, heart Indian wood, even if unprotected by any preparation, will last many years; but that sap wood of the best kinds of Indian timber, decays with great rapidity; and that most jungle woods were, as sleepers, nearly useless, and extravagant in cost; as they required to be renewed within a few months after they were put down. Good Memel fir timber cut to a rectangular section, and creosoted under such a pressure that the creosote should really* enter the wood to a depth of some inches all over, will last five, six, or ten years without decay; but if imperfectly creosoted at any point they begin to perish almost as soon as they are put in the line.

If sleepers well impregnated with the oil be left exposed to the sun and wind, without good ballasting, they are very liable to split and warp; and if any portion of the wood in a crack be left exposed to the action of the weather, the wood loses all its qualities rapidly,

* Fir sleepers on the East Indian Railway were on an average, 10 ft. long by 10 in. $\times$ 5 in. in section, and were retained in a cylinder under a pressure of 130 lbs. to the inch for twenty-four hours, so that the sleepers should imbibe 10 lbs. of oil to the foot cube, as ascertained by weighing the sleepers before and after the process.

disintegrates and becomes decayed. The sleepers of fir steeped in corrosive sublimate (kyanized), others that had been burnettized, *viz.* impregnated with chloride of zinc, and others with sulphate of copper, were found to last for a considerable time; and some Indian woods were also subjected to the same processes, but with no satisfactory result. White ants, which were so much dreaded, have not been found such enemies to wood as had been anticipated, as they cannot carry on their work under the vibration of constantly passing trains. These ants make covered galleries of earth as they advance, and thus concealed they prosecute their depredations; but as the passing train shakes the gallery off, they are compelled to cease. A wrought-iron road, consisting of a bridge rail secured to a continuous longitudinal bearing of wrought-iron, was also tried by Mr. Turnbull, but has not been adopted.

Mr. Turnbull was, in 1857, of opinion that the East India Railway must be laid on *sāl* wood sleepers. "Granting, however," he writes, "that both well-creosoted and burnettized sleepers are durable and eligible; still, considering the variability and uncertainty of freights from England, and also considering that sound *sāl* wood free from sap is very durable, and makes admirable sleepers, the quality of *sāl* wood being superior to teak for strength and toughness; and that immense stores of *sāl* forests are in existence in India: it seems to me to be only the pressure of peculiar circumstances, which has induced us to lean so much to the English fir-wood sleeper."

An Australian wood called Jarrah, (Australian mahogany) and a blue and white gum-tree, were also tried in Bombay, Madras, and Scinde; but they were objectionable on account of their great weight—Jarrah weighed from 52 to 64 lbs. per foot cube, their liability

to split by the driving of spikes, and from the high price which prohibited their use as sleepers.

Pyemadow timber, and one or two kinds of iron-woods imported from Burmah, were also experimentalized upon. They were extremely durable, but so heavy and so hard to work as to prove of no practical use. A few specimens of woods from Ceylon were also sent to Calcutta; and though good in quality, the cost was high, and no large quantities were readily obtainable, as labour was scarce and freight hard to get. The tendency at present seems to be to the more continual use of sāl and teak wood sleepers of the best quality, when procurable, and when not so, to the employment of iron sleepers. The use of sleepers of inferior woods, or of inferior kinds of good timber, has been universally condemned as bad, both as regards economy and safety.

It is not worth while to enumerate the numbers of soft, spongy woods that have been tried and rejected, but it will be useful to give a brief description of those timbers, whose durability and value have been proved by experience.

In Bengal, Bombay, and Madras, Sāl (*Vatica vel Shorea robusta*) is the commonest and best kind of timber for sleepers and other purposes, if the trees are cut in a ripe and sound condition. It is a hard, strong wood, with a long grain, tough and durable. In a green state it weighs 78 to 80 lbs. per cubic foot, but when dry and well seasoned, this is reduced to about 55 lbs. It will then float; but it has the property of imbibing water, and rafts of sāl have always to be kept afloat by bamboos or an admixture of light woods. A large quantity is usually for sale in the various marts, but the supply is not nearly equal to the demand. Sāl forests are found on the flanks of the Himalayas, near Nepaul and Oude, and over im-

mense tracts in Central India, known as the Vindhya and Satpoora ranges, through which the rivers Nerbudha, Mahanuddy, Godavery, and countless others flow. A good sound sāl wood sleeper, free from sap, will last at least seven years in the road.

Teak (*Tectona grandis*) is found over a region as wide as the sāl, but for general purposes is not so useful. It is an oily wood, of great toughness and durability, and for ship or carriage building is most valuable. It is obtainable in great quantities from Burmah, and is also to be procured from Central India and in the Malabar districts. The teak of Malabar is superior to that of Burmah, but is not so plentiful, and more costly. The price of good sound teak, however, from whatever source obtained, is so high that its general use for sleepers is hardly possible. When unseasoned it weighs from 55 to 60 lbs. per cubic foot, but when well seasoned the weight of good, close grained, should be about 40 lbs. per cubic foot. Most of the railway carriages in India are made of teak.

Next to sāl and teak is the Deodar (*Cedrus deodara*), which grows on the slopes of the Himalayas, towards their north-western extremity. It is a close, firm, and durable wood, with an aromatic scent, which deters white ants from attacking it. It is obtainable in fair abundance on the banks of the five rivers of the Punjaub, even as low down as Kurachee. The logs are of large girth, but rather short, as the trees are felled on the mountain slopes, cut into convenient lengths, and then rolled to the nearest torrent; from whence, at the melting of the snow, they are carried into the rivers, where, at suitable points, they are watched for and landed. It is a valuable timber, but is only to be got in the Punjaub—where it has been

long known and appreciated—and near the Indus. When thoroughly seasoned, deodar weighs $31\frac{1}{2}$ lbs. per cubic feet. It floats easily in water.

In Bombay and Madras the following trees have been proved to produce wood of good quality: the black or Rosewood (*Dalbergia latifolia*) makes an admirable timber, but is not very plentiful. It is close grained, strong, and durable. When green it weighs from 58 to 62 lbs. per cubic foot, but when dry this is reduced to 48 lbs. The Errool (*Inga xylocarpa*) is not attacked by white ants. It is a close grained, very heavy wood, and takes paint or varnish well. When unseasoned it weighs from 68 to 74 lbs., when seasoned 58 lbs.

The Acacia or Babool tree (*Acacia odoratissima*, *Catechu*, *et Arabica*) extends over Madras and Bombay into Scinde, and is found in three species, known as Khair, red and white Eyne in Bombay and Scinde, and as Venjay and Karavallum in Madras. This wood is extremely hard, and resists the ravages of the white ant. It is durable, and does not warp or crack; but as it is not found in straight lengths, it is not of much use for sleepers. It is a heavy wood, and when dry weighs from 50 to 56 lbs. per cubic foot.

The timbers above mentioned may be considered of first-class quality: but besides these some others have been more or less used in Central and Southern India; viz. the Beeja-Sāl (*Pterocarpus marsupium*), the Unjun, or Aucha (*Hardwickia binata*), the Saj, or Kurrah murdah (*Terminalia glabra vel tomentosa*), and the Mowah, or Dud eloopay (*Bassia longifolia*). The *Terminalia glabra* grows to a large size, and is abundant, but the wood is of a treacherous quality, although apparently durable; and the best heart wood will, if exposed to air or buried in the ground, crumble to dust in a very short

time. The fruit of the *Bassia longifolia* makes the tree so valuable as to prevent it from being felled to any extent as a timber tree.

In Northern India the following woods have been useful and deserve notice :—

The Sissoo (*Dalbergia sissoo*) is a first-class wood, but scarce and costly. It is oily, hard, tough, and close grained, and for curved work, such as wheels and for framings, it is the best wood in Hindustan. Its toughness and durability make sissoo very valuable; but it grows very crookedly, and is therefore not well adapted for sleepers, even if it could be purchased. When green it weighs 65 lbs. per cubic foot, and when dry 47 lbs.

Assun (*Pentaptera tormentosa*) is a tough and durable wood, but is very liable to split, and therefore is not much used. Toon* (*Cedrela Tooni*) is a soft wood, moderately durable, and answers well for inside work, but would not answer for sleepers. Teak and acacia were successfully used to make keys and treenails, as experience proved that compressed keys would not stand an Indian climate; and that oaken keys, when slightly tapered, so that they might be driven home from time to time, were rapidly destroyed by a kind of carpenter insect, which speedily riddled them. By degrees, however, iron spikes have been substituted for wooden treenails of any kind, and with much advantage in economy and safety.

An average sleeper may be taken as 10 feet long and 10 inches wide by 5 inches deep, and has a cubic content of $3\frac{1}{2}$ feet. The following Table gives the weight of sleepers of the various kinds of wood mentioned, assuming the wood in each instance to be seasoned and dry.

* Dr. Moore, Curator of the Botanic Gardens, Dublin, has kindly looked at these names, and informs me that they are all correct.

One of Greaves's cast-iron pot sleepers weighed 80 lbs.

		Weight per Foot Cube in Pounds.	Weight per Sleeper, containing 3½ Feet Cube.
			lbs.
Memel	41	143½	
Sal	55	192½	
Teak	40	140	
Deodar	32	112	
Rosewood	48	168	
Acacia	58	196	
Errool	58	203	
Jarrah	52	182	
Yellow Pine	25*	87½	

From this brief description it will be seen that India was well supplied, nay, rich in all the productions (iron excepted) required for the construction of railroads; and that capital to pay and skill to direct were alone requisite to ensure success.

* Weighed in India.

CHAPTER VI.

THE GUARANTEE SYSTEM.

The General Objects of the Undertaking — Lord Dalhousie's Sketch — George Turnbull — Difficulties inseparable from the Guarantee System — The Nature of the Guarantee — Advantages and Disadvantages of it — Position of Consulting Engineers to Government in India — Complaints — Investigation by a Committee of the House of Commons — Beneficial Results therefrom — The present satisfactory Relations between Government and Railway Authorities in India.

THE East Indian Railway is an administrative as well as an engineering work of the first class, in conception, in magnitude, and in execution. Its termini are Calcutta and Delhi: the former, the metropolis of British empire, and the seat of that Government, which, from a mere factory on the swampy banks of the Hooghly, has spread its sceptre over the whole of India, from the Himalayas to Cape Comorin, from the Indus to the Irrawaddy; the latter, the renowned seat of Mahomedan conquerors, from whence, until after the reign of Aurunzebe, a real authority over a vast dominion was exercised, and to which, as the historical centre of native rule, every ambitious spirit in India looked. During the mutinies every eye was turned to Delhi, and on its possession the fate of British rule seemed to rest.

It is no wonder that Lord Dalhousie's eloquent pen described the advantages of the construction of this line in graphic terms; and that there was no dissentient voice among the members of Government regarding its primary importance to the political stability of the power of England in India, as well as to the social and commercial advantage to the peoples of Northern Hindustan:—"The line I have sketched," writes Lord

Dalhousie, in 1853, "from Calcutta to Attock, even though it should not be carried at present beyond the river Jhelum, will constitute a very noble work, replete with the highest advantages to the Government and to the public." After stating his reasons for believing that the states of Cabul and Nepaul are the only powers from which hostilities are likely to proceed, he adds,—

"Whether these hostilities shall come from Cabul or Nepaul, the line of railway I have referred to would be of incalculable value.

"Touching every important military station from Calcutta to the Sutlej, connecting every depôt, Allahabad, Agra, Delhi, Ferozepore, with the arsenal in Fort William; it would enable the Government of India to assemble upon either frontier, or, if it were necessary, upon both, an amount of men and materials of war amply sufficient to deal with any such emergency, and within a period which would be measured by days; whereas months must elapse, with our present means, before we could provide the same extent of military defence.

"Inasmuch as the consciousness of our power thus to concentrate our means wherever we might desire would deter Native States from resorting to combined attacks, which they have hitherto happily neglected to attempt; it is probable that the army we now maintain might be numerically reduced without unduly diminishing our military strength.

"The weary reliefs of corps periodically traversing long distances, at heavy expense to the State, with grievous loss of time, and occasionally with loss of life, would in a great measure be obviated. The heavy tax upon the people of districts, which is often unavoidably inflicted by reason of the necessity of carriage for the troops, would be removed.

"European stores, tending to benefit the health and

affect the conduct of our troops, would be easily obtained, quickly and cheaply ; and in various ways, which it is unnecessary to follow in detail, the power of the State would be increased, and its interests materially promoted."

"The course which this railway would follow for these political purposes is at the same time the very best which it would be possible to select for the interests of trade and for the local advantage of this portion of India. The sections that have been already sanctioned will open the only coalfield which has as yet been brought into extensive operation in Bengal ; and afford means of conveyance for the great mass of traffic, which, excluded from direct communication with the port of Calcutta by the imperfect navigation of the Nuddeah rivers, is compelled, during a great portion of the year, to find its way by the circuitous and inconvenient channel of the Sunderbunds."

"The construction of the line from Calcutta to Rajmahal will at the same time afford new and great facilities of carriage for the rich produce of districts that lie upon the left bank of the river Ganges.

"Proceeding onwards to Allahabad, the line will skirt the hilly tracts that are now under examination with reference to the mineral wealth they are said to contain ; it will open out the opium districts, and will meet the trade of the Nerbudha valley at Mirzapore, its chief emporium. Beyond Allahabad it will run along the entire doab, skirting the frontiers of Oude, whose great fertility and natural resources will one day contribute largely to the traffic of the line."

The idea of this grand work, the prospects of which were thus lucidly foretold by Lord Dalhousie, was first conceived, it is believed, by Mr., now Sir, Macdonald Stephenson. Mr. Stephenson was for several years indefatigable in his endeavours to secure for railways in

India the material support and countenance of Government; and states in his evidence before a Committee of the House of Commons in 1858, that the project of the East Indian Railway was first discussed in India in 1841; but that it was not till 1844 that the scheme was officially recognized. The agreement between the Directors of the Honourable East India Company and those of the East Indian Railway Company is dated 17th August, 1849. For some years also Mr. Stephenson was the Managing Director of the East Indian Railway Company in Calcutta, and by his tact and ability much facilitated the commencement of the working of the system of guaranteed railways with the Supervising Department of the Government of India, which had then just been organized.

But however great the credit may be which belongs to Sir Macdonald Stephenson, as the enterprising originator and able advocate of the East Indian Railway; yet the main responsibility of the construction of the vast undertaking, as well as the labour involved in the carrying out the great design, rested upon the Chief Engineer, George Turnbull.

The Chief Engineer of a railway like the East Indian, constructed under a Government guarantee, must not only have the scientific knowledge, the comprehensive grasp of design, and the habit of looking into minute details, which the head of every large constructive enterprise must possess; but also a power of dealing with other men and an administrative ability seldom found combined in one man. In selecting Mr. Turnbull as their Chief Engineer, the railway company made an excellent choice. He was a clever engineer, an able designer, and a courteous gentleman; and though somewhat defective in administrative power (administration has hitherto been the peccant part in the East Indian Railway), well deserved the eulogy

which Lord Elgin passed upon him when retiring from India in 1863 :—

“His Excellency the Governor-General gladly accepts this opportunity of acknowledging the services rendered by the officers of the railway company in the prosecution of this great work, and of expressing the strong sense he entertains of the high engineering skill and the steady devotion to his duties exhibited by Mr. George Turnbull, the Chief Engineer of the company in Bengal, who in a few days will give up the direction of the works which he has now seen completed. Although not in the immediate employment of the Government, Mr. Turnbull has, in the opinion of his Excellency, well earned the expression of the thanks of the Governor-General for his professional services, which have indeed been rendered as much to the public as to the railway company. In all Mr. Turnbull's dealings with the officers of the Government he has invariably shown that moderation and desire to conciliate which were essential to the harmonious and successful carrying on of the railway works, under the peculiar conditions imposed by the terms of the Government guarantee; and the Governor-General has much satisfaction in signifying, on behalf of the Government of India, his high estimation of the manner in which all Mr. Turnbull's relations with the Government have been conducted.

“His Excellency the Viceroy will not fail to bring to the favourable notice of Her Majesty's Government the long and excellent services of Mr. Turnbull, who, having been the first railway engineer employed in India, has now happily seen the portion of this great work on which he was more particularly engaged brought to a close after many years of arduous and persevering labour, under circumstances of unusual difficulty, with the most complete satisfaction to his employers and to the Government, and to the highest credit to himself.”

The railway company and the Indian Government are also much indebted to Mr. Power, the present Chief Engineer of the Bengal division of the East Indian Railway; and to Mr. Sibley, the Chief Engineer of the North-western portion. Both were employed for some time under Mr. Turnbull, and both were conspicuous for their talents and success in carrying to a successful termination the great works peculiarly in their charge. Mr. Power commenced, and has in a great degree the credit of the completion of, the gigantic bridge over the Soane; and Mr. Sibley, by his powers of organization and arrangement, successfully carried through and completed the very heavy bridging on the line just beyond Burdwan, as well as the large and difficult bridges over the Adjai and Mor rivers.

Both gentlemen were not only able engineers, but proved themselves peculiarly well fitted to deal with Government and its officers, in the difficult relations in which they were placed under the conditions of the guarantee.

And here it will perhaps be convenient to describe rather more in detail than has hitherto been done, the nature of this guarantee, and the obligations under which the officers of Government and of the railway company were put by it. The history of the negotiations and various modifications through which this guarantee passed have been given in the third chapter; but the agreement in its final shape was much altered from the original proposals. The guarantee is given in a lengthy legal document, about the exact meaning of which in some of its clauses there has been at times some misunderstanding, but the general purport of the agreement may be thus concisely stated:—

1. That the design and execution of certain railroads in India are entrusted to joint-stock companies.

2. That the Indian Government guarantee interest on moneys duly raised by companies and paid to Government; controlling also their expenditure and operations.

The principal concessions granted under this agreement are the following :—

1. That Government guarantee interest from $4\frac{1}{2}$ to 5 per cent. for ninety-nine years on all moneys paid with authority into their treasury; giving also an option to the railway company to demand the repayment, at six months' notice of their intention to surrender the railway, of the whole of the capital duly expended upon the railway.
2. That Government lease to the railway company, free of cost for ninety-nine years, all land required for the permanent works of the railway, and further provide all other land temporarily needed for its construction. Land not permanently needed for railway works, being returned to Government as soon as possible.

In consideration of the above grants of aid, the Government have the power to select the line, to define the limits of all works, to supervise expenditure and operations in England and in India, to examine accounts, to inspect works and line under or after completion, to regulate tolls and time-tables, and generally to control the affairs of the railway company. Mails are to be carried free, troops and Government stores on the usual favourable terms.

Besides the above provisions, which are those of main importance, the indenture also contains various other stipulations.

A Government director is to sit at Boards of Directors of railway companies in England, having a veto on all

their proceedings except those connected with communications with their legal advisers.

Capital and revenue accounts are to be kept separately and made up from time to time. Receipts from traffic in gross are to be paid into the Government treasury by the railway company; and if profits above the guaranteed interest be obtained, they are to be equally divided between Government and shareholders until the debt of the railway company for guaranteed interest be repaid. After that all profits are to go to shareholders. Powers to surrender by the railway company; to purchase by the Government; and to execute repairs, or to take possession in case of failure of agreement, are also given. Surplus moneys, subscribed but not expended, are to be returned by Government to railway companies. All money transactions are to be calculated at 1s. 10d. per rupee.*

This guarantee of interest (though at the time it was said that it was not so) is practically absolute; as, should the Government at any time decline to pay the full interest, the shareholders having the power to claim repayment of their capital, would doubtless use their privilege. Shareholders being under all circumstances safe from heavy loss, find in the shares of guaranteed railway a safe investment free from risk; and there has therefore been no real difficulty in getting funds as they have been needed.

As the interest which Government possess in Indian railways is large and direct, and as in case of entire or partial failure, the loss must fall upon Government; many have thought and still think that it would have been better had railways been constructed on a loan raised by Government, by the instrumentality of

* In a contract, signed in 1866 (Oude and Rohilcund), these terms have been somewhat modified; and among them 2s. is named as the rate for the rupee.

officers immediately subordinate to itself. It is possible that some improvement in administration and discipline, and perhaps economy, might have been thus secured; but on a review of the whole question, the problematical advantages overweigh the certain disadvantages.

The great, the *immense*, advantage which the guarantee to the capital of joint-stock companies has given, has consisted in the ready and unfailing supply of money needed for construction. All Government works of utility, such as canals or roads of acknowledged importance, hardly inferior to that of railways, are seldom duly fed even when Indian finances are prosperous; but are sure to be totally suspended or starved during years of turbulence or of pecuniary pressure. The grant for public works is the first to be reduced, without reference to capital sunk in undertakings that remain unprofitable because unfinished; and had the loan for railways been raised directly by Government, it would not have escaped the rapacious hands of some needy Indian Minister of Finance.

Indian railway joint-stock companies have for the most part been able to raise without difficulty, on the faith of the guarantee, sufficient funds; and the money so subscribed, though deposited with Government, is still only put in their treasury for a specific purpose, and cannot be touched; and thus it has happened that, even during years of great anxiety and commotion, funds sufficient for the annual outlay on railways have always been forthcoming.

This advantage will be acknowledged by all; but can only be fully appreciated by those who have seen with dismay, canals almost useless for want of distributing channels; roads entirely so from the absence of bridges over torrents and streams; and buildings half erected falling to ruin for want of a roof. The steady and unfluctuating supply of needful funds is a

great and decided benefit, for which Indian railways have to thank the guarantee system. Had they been constructed on funds raised by a direct loan by Government, the Indian railway system would not in all probability have been half completed by this time, instead of being nearly finished as it is.

But there is another side to the question.

Under the contract the powers of Government over the proceedings of railway companies were almost unlimited; and in the earlier years of the guarantee system the Court of Directors very strongly urged a real and positive control. In November, 1849, in a dispatch to Lord Dalhousie, they write, "It is our desire that while the supervision and control should be entire and efficient, every facility compatible therewith should be afforded to those who may be employed by the railway company for the purpose of carrying out the undertakings." And again in November, 1849, they say, "It has been deemed necessary in the arrangement which has been entered into to insist upon complete supervision and control by the East India Company of the railway companies and their officers, servants, and agents, in all accounts, matters, and affairs whatever, both during the construction of the railway, and after it shall have been opened for the conveyance of passengers and goods." And though subsequently, under pressure from the public without, the reins were somewhat relaxed; yet on the whole an endeavour has been honestly made to carry out the provisions of the agreement, as regards supervision, in their integrity.

The control in England is exercised by an official director, who sits at the Boards of all guaranteed railway companies, and who has the power of a veto on their proceedings; and in India it was at first retained by the Government of India in its own hands, acting on the advice of a consulting engineer. But a reference

to the Supreme Government on all matters of detail being found cumbrous and tedious, the supervision has in a great measure been for some years entrusted to the Consulting Engineers to each Local Government, and the following rules have been laid down for their guidance :—

1. All questions of general importance shall be referred to Government for decision.
2. Under the above will be included the general direction of all lines of railway, the position of stations, and the general arrangements of the more important stations and works. But after the general sanction of the Government has been given to any project, all questions of detail can be disposed of, within the limits of the original sanction, by the Consulting Engineer.
3. All matters of routine, or payments, or acts in accordance with rule, precedent, or special agreement duly sanctioned, or undisputed contingent expenditure, may be dealt with by the Consulting Engineer without reference to Government.
4. All designs, estimates, and indents, whether for works or for establishments for carrying into effect objects already generally sanctioned by Government, may also be disposed of finally by the Consulting Engineer.
5. The Consulting Engineer may, without reference to Government, reduce the amount of indents, or direct designs or proposed operations to be modified if he thinks it necessary; but the agent in such cases, if dissatisfied with the decision of the Consulting Engineer, may always request that the matter may be referred for the final orders of the Government.

6. In all cases in which the Consulting Engineer has any doubt as to the decision to which he should come, the question should be referred to Government for orders.
7. When the sanction of the Consulting Engineer is given to any proposals of the agent, in which both of these officers concur, excepting in those matters of great importance specially excepted above, the sanction so given shall, so far as the Government is concerned, be considered final.
8. The Consulting Engineer shall submit to the Secretary of the Government a weekly schedule of his proceedings, in the usual form, in which shall be explained concisely the nature of all sanctions or directions given under the authority now granted to him.

It is clear that any officer acting under the above regulations required much judgment, professional ability, and tact, to exercise the firm, thorough, but gentle control which the contract required.

And however judicious or competent the officer might be, the system had its drawbacks. Responsibility was not so clearly imposed as it ought to be; it was divided between the engineers of the railway company and of Government. The engineers of the railway company had to design everything; but could execute nothing without the sanction of the consulting engineer both as to design and estimate. The engineers of Government could originate nothing; but had the responsibility of approving all, both plans and works.

If, therefore, as in the earlier days of railway construction was frequently the case, a railway engineer sent up for approval such general plans and sketch estimate as would pass probably at a Board of Directors in England; the Government engineer, with whom the

responsibility of sanction rested, felt unable to approve the designs in their then state, and asked for explanation and details. A cry of causeless delay, of minute interference and obstruction was at once raised, and both sides felt themselves aggrieved: the one, at the design not being sanctioned as it was submitted; the other, at being asked to sign as approved papers and plans so prepared that a due professional judgment could not be safely passed.

In fact railway officials disliked at first giving such full and detailed designs and estimates as would admit of a real opinion being formed on the proposal; being fearful, perhaps, of being exposed to unfair or captious criticisms by men for whose professional decision they at least had no high respect. And Government engineers, feeling that they were being pressed to decide very important points, involving large outlay and much responsibility, on imperfect information, were constrained to pause.

If a reference to Government were made, great delay was certain; and the result usually was that the additional information required was called for authoritatively, and was submitted; and after much delay and some heart-burning, a design, somewhat modified, was at last accepted to save time, though probably it was not fully approved.

All this was vexatious and annoying to gentlemen on both sides; the irritation caused, in some instances, was great; indeed to such an extent did it rise that influential members of the House of Commons, some of them Indian railway directors, obtained in 1857-58, a committee to inquire into the causes of the delay which had occurred in the construction of railways in India. The whole subject was carefully and thoroughly sifted, and especially the alleged delay caused by the supervision of Government engineers. After a lengthy and careful investigation the committee reported,

that though "some cases have been cited in which the Government superintendence has been productive of vexation and annoyance to railway officials, and has tended to impede that harmonious action between the Government and the companies which is essential for the rapid completion of their great works, yet no very material delay in the construction of the various lines appears to have resulted therefrom." "From the evidence adduced," continues the report, "your committee are led to believe that the progress of railways under construction in India will bear favourable comparison with that of English lines. Willing testimony has been given by many of the railway authorities to the value of the Government control to the interests of the companies themselves when rationally and temperately used." And, finally, in summing up, the committee state their conclusions thus: "That, under a system complicated in its character, and necessarily somewhat cumbrous in its machinery—a system, moreover, the greatest defect of which is the facility it affords for the evasion of responsibility—a clear and distinct definition of the duties, responsibilities, and extent of jurisdiction of all heads of departments, and those under them, is essentially requisite for its smooth and successful working; always assuming that due care be taken to entrust discretionary power only to men who are to be relied on as competent to distinguish an effective general control from too minute an interference in details. By a judicious adherence to the spirit rather than the letter of the contract, your committee feel assured that arrangements may be simplified, united action for one common object secured, and railway enterprise in India may before long assume proportions commensurate with the vast commercial, agricultural, and mineral resources of that country."

The effect of the investigation and of this report by

the Committee of the House, which is dated July, 1858, was highly beneficial. The most that could be said against the system of Government supervision having been freely stated; and, after calm consideration, a decision having been recorded by an impartial tribunal that no change was desirable or expedient; men of all ranks, both agents and engineers, more cordially accepted the position in which the contract under the guarantee had placed them, and worked with a will to make the best of the arrangement.

Of late years there has been a marked improvement. A growing feeling of mutual confidence and respect between railway and Government engineers has sprung up; and has been strengthened by continual intercourse, and the greatest benefit has arisen therefrom. The officials of railway companies have learnt that the engineers with whom they have to deal are competent as well as practical men;—obliged to be so from the very nature of the duties they have always had to perform—and that no captious opposition, or unjust criticism, was to be anticipated from them. This knowledge has given confidence; designs are fully prepared and discussed; differences of opinions are frankly stated, and as frankly considered; and for some time plans and estimates have usually been thoroughly thought over and determined upon between the engineers of railway companies and Government, before they have been submitted for official approval and sanction.

CHAPTER VII.

THE EXPERIMENTAL LINE OF THE EAST INDIAN
RAILWAY.

Position of the Terminus at Calcutta—Opinion of Mr. Simms—Howrah selected the Terminus of Line—Ganges Valley—Direct Line—Gauge of Indian Railways—Uniform Dimensions—Double or Single Track—Views held by Mr. Simms—Colonel Kennedy appointed Consulting Engineer—Advocates the Ganges Valley Route—Mr. Turnbull concurs—Line from Calcutta to Raneegunge commenced—Let in small Lengths—Failure of Contractors—Bridges—Culverts—Bank Slopes—Inadequacy of the Terminus at Howrah—Opened by Lord Dalhousie.

WHEN however the experimental line of the East Indian Railway was commenced, the difficulties which surround the guarantee were unknown; and though some may have been foreseen, yet, at the time, the public mind dwelt upon the advantages of railways to India, and the desirability of their speedy introduction into that vast empire.

It was at first determined to construct a single line from Calcutta to the coal-fields near Burdwan; and a place of no importance in itself, but centrally situated to most of the coal-pits then at work, called Raneegunge, was selected as the terminus. It is 121 miles from Calcutta. Besides the evident advantage of opening out the mineral districts of the hills near the Barrakur, this experimental line was intended to prove whether the natives would avail themselves of the improved means of locomotion afforded by a railway; whether in actual practice there were any serious obstacles to the construction of a railroad in India; and whether its financial

results would be such as to justify the Government in granting a guarantee to further extensions. These, indeed, were the professed objects with which the line was begun; but in truth, there was hardly any need for the experiment. It was evidently advantageous to connect the coal-fields of Bengal with the port of Calcutta by a railway; and the construction of a railroad in India, even though it had proved far more difficult than it has, was still only a matter of comparative cost; and as regards traffic and returns, the results on the Raneegunge line were of very little use as data for those of other railways in India, which were sure to be quite differently situated.

Still some important facts were demonstrated by its construction. It was proved that it was as easy to make a railroad in India as in England, and that the natives appreciated the railroad keenly and used it largely. These circumstances encouraged Lord Dalhousie to recommend, and the Court of Directors to adopt, the enlarged scheme of railways for India which we now see under construction.

The contract for the experimental line from Calcutta to Raneegunge was signed in August, 1849. Mr. Turnbull, the Chief Engineer of the railway company, reached Calcutta in May, 1850; and although surveys could not with safety be pushed rapidly during the hot weather, yet the plans for that portion of the line which lies between Calcutta and Serampoor were so far advanced by the end of that year, that the Valuation Commissioner was able to make over the first section of land in January, 1851. Serampore is on the right bank of the Hooghly, and along that bank it had been resolved to make the line, although Calcutta itself is on the left of the river.

Mr. Simms, the Consulting Engineer to the Govern-

ment of India, sent out by the Court of Directors, had finally decided to place the terminus for the Raneegunge line on the right bank, although he had previously, in May, 1846, submitted a recommendation of a contrary tenor.

He at that date proposed that the terminus should be at the eastern extremity of the Chitpore road, with a branch along the Strand road to Fort William—contemplating a subsequent extension to the steamboat docks in Garden Reach, and eventually to Diamond Harbour. He considered that such a position would best unite—

1. The convenience of commerce in the exportation and importation of merchandize, as the terminus would be on the river Hooghly, and have practically unlimited river frontage.
2. The convenience of Government, by connecting the terminus with Fort William and the arsenal.
3. The convenience of the public generally, by being near the centre of the mass of the population.

He supports his views by several arguments, drawn more from what he thought Calcutta ought to be, than what it was, or is. The narrow undrained street called Chitpore was to be enlarged so as to be a good approach; the Strand road was to be paved, the bank revetted, and wharfs made. Import and export docks were also to be constructed near the terminus—improvements all very desirable, no doubt, but not likely to be made. Another site for the terminus mentioned, but not recommended by Mr. Simms, is that which has been selected by the Eastern Bengal Railway Company as their terminus.

When, however, an experimental line, with a capital of 1,000,000*l.* only, was eventually sanctioned; Mr. Simms

changed his views, contracting his scheme in proportion to the money sanctioned. In April, 1850, he thus writes:—"In May, 1846, I expressed myself in favour of bringing the railway into the heart of the town; and it is therefore due to myself now to state that when that report was penned, there appeared to be every probability of an abundance of money to carry out the whole of the railway project from Calcutta to Delhi, with bridges spanning the great rivers, the Jumna, Soane, and the Hooghly; and therefore in so magnificent a project, the extra outlay (large as it would necessarily be) to make so great a work quite complete by bringing the railway into the heart of the town, would, under such circumstances, be quite unworthy of consideration in comparison with the whole cost of the undertaking."

In subsequently choosing Howrah as the terminus he was mainly influenced by the limited sum of money fixed for the capital; and Howrah no doubt presented many advantages. It was on the bank of the Hooghly, with a good frontage, deep water, and facilities for raising or discharging goods by piers from craft which could lie alongside. It has of course the great objection of being separated from the warehouses of Calcutta by a deep and wide river, and of involving all the inconveniences of a steam-ferry, with long, troublesome landing-stages for passengers. These piers, too, are expensive to construct and very costly to keep in repair.

It is probable that eventually a bridge will be constructed over the Hooghly near Pulta Ghāt at Barrackpore, or nearer Calcutta, at Cossipore. The passenger traffic and merchandize for the city of Calcutta itself will be brought to or near the terminus of the Eastern Bengal Railway; the Howrah yard being used for minerals and for export and import goods only. With this object Mr. Turnbull prepared a design for the bridge

over the Hooghly at Palta Ghāt;* but the project is open to the objection that it would be necessary for the East Indian Railway to secure running powers over the sixteen miles of the Eastern Bengal Railway, *viz.* between Barrackpore and Calcutta.

Besides the settlement of the position of the terminus at Calcutta, it also fell to Mr. Simms' lot, as the first Consulting Engineer to the Government of India, to recommend the gauge for Indian railways. He selected 5 ft. 6 in. as a convenient medium between the narrow and broad gauges of England, and as a width which combined adequate room for the construction of commodious locomotives and carriages with economy of construction. Mr. Simms also very strongly urged upon the authorities in India and in London, the desirability of compelling the strictest uniformity in the very minutest details of the construction of rolling stock and railway fixtures, and his reasonings were to some extent accepted. A meeting of all the consulting engineers of railways took place in London, and certain fixed dimensions were agreed upon as constants for all railways in India. Subsequently diagrams were prepared, showing with precision the various dimensions permitted to maximum moving and minimum fixed structures; and it is believed that no deviations from the figures given in the diagrams have anywhere been permitted, so that eventually carriages may run from Lahore to Trichinopoly, to Madras, or to Calcutta, without any change or break.

The gauge was fixed at 5 ft. 6 in.; and the following are the dimensions of certain parts of the rolling stock and roadway which in 1856 were fixed by the

* Archdeacon Pratt, of Calcutta, solved the mathematical problem connected with the security and stability of the bridge designed by Mr. Turnbull, and published an interesting pamphlet containing his calculations.

consulting engineers of all the Indian railway companies:—

Minimum clear width between tracks	Ft. In.
" distance of platform wall from rail	6 0
Projection of nozing not to exceed	2 6
Minimum clear height for all over openings above rail in	0 3
centre of each line	14 6
Breadth from centre to centre of buffers	6 5
Height of centre of buffers above rails	3 6
Extreme width of body of passenger carriage	8 6
" " roof	8 10
" " steps	10 0
Maximum length between centres of wheels (carriages and	
waggons)	11 0
Minimum diameter of turn-tables	15 0
Engine and tender to turn on tables of diameter of	40 0

All carriages and waggons to have spring buffers and draw springs at both ends.

The importance of general uniformity in dimensions will be keenly appreciated in England; but Mr. Simms pushed his views too far when he wrote as he did on the 6th February, 1846:—

“Not only should the line be constructed after a specified manner, * * * but as much as possible a duplicate system should be introduced in all the details of the railways, so that an accident happening on any line to an engine or train from another line, or to any parts thereof, may be replaced at the nearest station or storehouse; as well as all similar parts should be as much as possible constructed from the same pattern.”

Had these opinions been acted on, all improvement and invention would have been officially proscribed; and there would have been a strong tendency to allow every item to remain in one uniform condition or pattern, however troublesome and awkward practice may have proved it to be. The consulting engineers of the railways of India, in determining at their meeting in London to fix some few main dimensions only, leaving

elasticity in all minor forms and arrangements, doubtless chose the wisest course.

Mr. Simms also was strongly impressed with the importance of securing a good permanent way; and he considered that it would be a false economy to use rails lighter than 84 lbs. to the yard, with joint chairs weighing 38 lbs., and with intermediate chairs of 21 lbs. These views have not been followed, and the rails actually used by the different railway companies have varied considerably from one another in weight. Some have been as low as 65 lbs., but the average rate per yard of the rails that have been sent out to India is 75 lbs.

The question of the construction of a double or single line of railway was also dealt with by Mr. Simms; for the Court of Directors, while sanctioning a capital of one million only, had expressed an opinion that "it would be unwise to make the experiment upon a single line." Mr. Simms did not agree with this. He made some calculation regarding the probable cost of constructing railroads in India, and came to the following conclusions:—

That a double line would cost	..	..	£10,237	per mile.
„ single	„	..	6,673	„

And that as the money available for the construction of the experimental railway was 950,000*l.*, that sum would allow of the construction—

92 miles of double line.
142 „ of single line.

Consequently if a double line were made, the railway would fall about twenty-three miles short of the proposed terminus in the coal-field; and as such a plan would not be accepted, he recommended the experimental line to be constructed with embankments and brickwork for

a double, but carrying only a single line of rails. This method of construction seemed to him applicable not only to the railroad between Calcutta and Raneegunge, but also to all proposed extensions in India, and this advice has in practice been acted on.

Besides the settlement of these details, Mr. Simms gave a decided opinion upon the direction of the proposed experimental line. A project for connecting Calcutta with Rajmahal by a line running nearly parallel to the rivers Bhagarutty and Hooghly, had been much discussed, and had been favourably received; but Mr. Simms clearly demonstrated that that direction, which was in truth a part of the Ganges valley line, would be more costly to construct, and would according to his calculations hold out no prospect of better returns than the direct line towards the North-western Provinces.* On the whole he felt no hesitation in recommending the capital sanctioned for the experiment to be spent on the *direct* route, leaving the direction onwards from Burdwan to be subsequently settled. If the Ganges valley route were to be eventually selected, he considered that the main line should branch off from Burdwan.

The submission of these recommendations was the last official act of Mr. Simms as Consulting Engineer to the Government of India, for he left Calcutta in the spring of 1850 and had nothing to do with the actual construction of the line, as the work of the Indian Railway did not commence till January, 1851.

Lord Dalhousie, then the Governor-General, appointed, during the summer of 1850, Colonel Pitt Kennedy

* Mr. Simms estimated the returns on the Calcutta and Raneegunge line at 6321*l.* per month, or for 115 miles, 55*l.* per mile per month; a calculation avowedly based on very imperfect data, but interesting when compared with the actual revenue of the East Indian Railway. According to the returns of 1866 the average receipts per month were 160,025*l.*, or for 1131 miles, 141*l.* per mile per month—more than double.

as his Consulting Engineer. Colonel Kennedy had formerly belonged to the Royal Engineers, and had served with that corps for ten years, but afterwards left it for the purpose of carrying on certain public works in the Ionian Islands. Sir Charles Napier took Colonel Kennedy to India as his Military Secretary in 1849, and Lord Dalhousie offered to him the post of Consulting Engineer to the Government of India, in the railway department, just at the time that Sir Charles Napier was leaving India. Colonel Kennedy did not join his appointment till November 1850, and his health having failed, he resigned in the spring of 1851. Colonel Kennedy subsequently became Consulting Engineer to the Bombay and Barodah Railway Company, and has always taken great interest in the success of railways in India.

In March, 1851, on Colonel Kennedy's departure, Major (now Major-General) W. Erskine Baker, of the late Bengal Engineers, was appointed Consulting Engineer to the supreme Government, and continued to hold that post till November, 1857; and it was from Major Baker's judgment, unwearied industry, and tact, that the cumbrous machinery unavoidably necessary for the management of a guaranteed railway, was at first set in motion.

But although Colonel Kennedy was so short a time Consulting Engineer, yet he during that brief interval obtained the decision of some important questions, and wrote some brilliant reports; urging his own views regarding the Ganges valley route, and the marvellous results obtainable from flat gradients.

With his approval and advice a system of a monthly audit of expenditure on an abstract of outlay and of work done was introduced; and had his plans been faithfully carried out, much economy and efficiency would

certainly have been effected. He truly observes, "When the money is all gone, it is of very little use to find out that it has gone without producing commensurate results; and herein final accounts in such cases are of no other avail than to inform the sufferers of their irreparable loss, while that loss might have been averted by the early and frequent rendering of accounts with reports; bringing forward for careful discussion all future operations which may require further consideration."

It was also on Colonel Kennedy's recommendation and powerful advocacy that the Ganges valley line was selected, instead of the direct route, as the main line. In a Minute of July, 1850, Lord Dalhousie had sanctioned the construction of an experimental line between Howrah and Pundooah, with earthworks and masonry for a double line of rails, and had at the same time recommended an extension of the railway to Raneegunge Collieries, but no decision as to the further prolongation of the lines had been formed.

The original project of the East Indian Railway had been to form a line from Calcutta over the Shergotty hills, through Mirzapore to Delhi, with three branches.

One from Burdwan to Rajmahal		140 miles.
One from some point on the main line to Patna	40 ..	"
One from " " Benares	15 ..	"
Main line from Calcutta to Mirzapore		<u>466</u> "
Making a total length of	661 miles to Mirzapore	by the direct hill route.

But on this route the railway would have had to encounter, as has been previously stated, not only a rising and falling gradient of considerable severity, but would also have had to pass through a barren and sparsely inhabited district.

Colonel Kennedy assumed that on the direct hill

line from Calcutta to Mirzapore there would be, as compared with the Ganges line, the following results:—

		Rise in Feet.		Fall in Feet.		Total Rise and Fall.
Hill Line		2044	..	1804	..	3848
Ganges Line		240	..	nil	..	240

He estimated the length, by the Ganges valley route, from Calcutta to Mirzapore at 595 miles, and assumed also that 1 in 100 would be the ruling gradient of the hill line, instead of 1 in 2000 on the Ganges line. Indeed he thought that it ought to be 1 in 12,000. On these data he argued that it would take as much engine power to carry one ton over the hill as four tons along the river line; that the working and locomotive expenses would consequently be much greater; and that the capital required for the hill line would be better than a quarter of a million more than that needed for the Ganges valley, while the railway would traverse the best traffic district of Bengal instead of the worst. These arguments, though not devoid of truth, were much overstated. It is now known that the difficulties and cost by the Ganges route in bridging rivers and inundated tracts was much undervalued; that gradients of 1 in 1000 even were not attained; and experience has further indicated that instead of doubling the circuitous river route, it is wiser to make a loop-line through part of the hilly districts, giving a more direct access to the North-western Provinces.

Still, for Bengal itself, there can be no doubt that the railway which joined all the great marts that dot the Ganges with Calcutta, and which kept parallel to the existing stream of traffic, was the right line to construct first.

Mr. Turnbull, the Chief Engineer of the East Indian Railway Company, also took the same view, and writes

on the 26th February, 1861 :—" Although, as I have stated, our examination of the country was a cursory one, yet its general features are so broadly marked and well defined, that, in an engineering point of view, we had no difficulty in coming to the conclusion, after much careful investigation, that the Ganges route was in every respect preferable to the other." And again, "I have only to add that its advantages over the other, as a 'paying line' of railway, are to me so apparent, after seeing both routes, that I would have recommended the adoption of the Ganges line, even although the other had been on a dead level all the way from Calcutta to the river Soane."

Upon these grounds, therefore, Colonel Kennedy felt able, with the utmost earnestness and confidence, to recommend the extension of the East Indian Railway by the route of the Ganges, and not by the hill route. This advice was accepted by Lord Dalhousie, and sanction was eventually given to the Ganges line. The only other points on which Colonel Kennedy dwelt strongly, were the expediency of executing the work in small contracts, and of employing natives largely as workmen and drivers.

Turning now from the account of preliminary discussions, and of the views held by the originators of railways in Bengal, the actual shape which the scheme of the East Indian Railway finally took has to be described. Starting from Howrah, opposite Calcutta, the railway was carried to Burdwān, from whence, throwing off a branch to the Raneegunge coal-fields, the main line was taken *viâ* the Ganges to Mirzapore, and so onwards to a terminus at Delhi, a distance of about 1130 miles. Subsequently, the junction line from Allahabad to Jubulpore, 225 miles, was ordered, making a total of 1355 miles; and to this the length, about 145 miles, of the

direct line by the Kurhurballee collieries, now under construction, will have eventually to be added, making a grand total of about 1500 miles. Attention, however, has first to be directed to the primary section from Calcutta to Raneegunge, 120 miles in length.

There was at first some delay in getting possession of the land, in consequence of the Legislative Act, giving permission to enter upon private properties for the purpose of surveying, not coming into operation until the 20th December, 1850; but in January, 1851, out of the first 40 miles from Calcutta to Pundooah, there remained but 5 or 6 miles of jungle and trees to clear, while 15 miles had been surveyed, and a length of 10 miles of section completed. Without, however, awaiting the completion of the survey or sections, tenders were invited in Calcutta for the construction of the line from Calcutta to Pundooah, and seven were sent in. A length of 25 miles from Howrah to Hooghly was given to Messrs. Hunt, Bray, and Elmsley, of London, and a further distance of 10 miles to Messrs. Burn and Co., of Calcutta. Very shortly after this date, the Court of Directors, on the recommendation of Lord Dalhousie, decided that the railway should be carried onwards from Pundooah to Raneegunge, and the further lengths were let in the following way:—

	Miles.	
Messrs. Hunt, Bray, and Elmsley	26½	Howrah to Hooghly.
Messrs. Burn and Co.	10	Hooghly to Pundooah.
Messrs. Remfrey (first let to Mr. Daniel, of Calcutta)	5	Pundooah to Bainchee.
Mr. Daniel	11	{ Bainchee, westwards to Mundeepoohur.
Mr. Ryan	10	to Mymaree.
Messrs. Burn and Co.	22	to Burdwan.
Messrs. Bray and Elmsley	36½	Coolool to Raneegunge.

Total distance from Calcutta to Raneegunge 121 miles.

Previously, however, to this arrangement being com-

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pleted, the Directors of the railway company, or rather their Managing Director, Mr. Macdonald Stephenson, had made in London great efforts to induce some of the great contractors of England to undertake the construction of Indian railways; but, excepting a Mr. Jackson, all held back; thinking, apparently, that the profits to be obtained on contracts so strictly supervised by Government as those for railways in India, would not be sufficiently large to warrant their entering upon the business. Mr. Jackson of London, in August, 1849, sent in a tender, however, for the first 70 miles out of Calcutta, at a rate between 8000*l.* and 9000*l.* per mile; agreeing to the condition that the distance should be opened for traffic within three years from the date of acceptance of the tender. Mr. Jackson's proposal was favourably received, and recommended by the Directors of the East Indian Railway Company; but after a consideration of three months by the Honourable Court, and the Board of Control, it was rejected without any reason being alleged for its being declined. If Mr. Jackson's tender was unobjectionable in other respects, as it is understood to have been; the rate, instead of deterring the home authorities from accepting it, should have had an exactly opposite tendency: for 8000*l.* per mile, for a completed line, is more moderate than the cost at which any railway in India has been finished. But at the time erroneous opinions that railways could be made in India for about 5000*l.* a-mile, were prevalent.

This having been the result of the negotiations with contractors in England, it is not surprising that when the agreement between the Honourable Court and the railway company was at last finally concluded, it was determined to make an attempt to use contractors who might come forward in Calcutta. The contracts in India were made, however, somewhat hastily, and on

imperfect information, and though they were entered into with the sanction of the Government of India, yet the contracts did not receive their cordial approval. It was known to Colonel Baker, the Consulting Engineer to the Government, that the men who tendered had, in some instances, little capital; that the time stipulated was too short for the work to be completed; he expected that there would be a partial failure, and so it eventually proved. Still, as the Managing Director, Mr. Stephenson, wished to give the contract system, as obtainable in India, a trial; as the tenders were in themselves fair, and as the men said they had capital, and were anxious to proceed with their work, their offers were accepted. Excepting, however, Messrs. Hunt, Bray, and Elmsley, of London, Messrs. Burn and Co., of Calcutta, and Messrs. Norris and Co. subsequently, all failed to carry out their agreements; and one by one the lengths had to be taken out of their hands, and the works completed by the engineers of the railway company themselves.

As early even as August, 1853, Mr. Turnbull, the Chief Engineer, felt obliged to bring to notice the great backwardness of some of the lengths let to contractors; and he gives the following Table as indicating the position of the works:—

	Mr. Daniel's Contract.	Messrs. Burn & Co's. Contract.	Messrs. Hunt & Co's. Contract.	Mr. Ryan's Contract.
	Cubic Feet.	Cubic Feet.	Cubic Feet.	Cubic feet.
Total brickwork	1,000,000	1,600,000	1,600,000	300,000
Brickwork completed ..	44,000	150,000	860,000	„
To be done	956,000	1,450,000	740,000	300,000
Bricks required to com- plete the above }	11,472,000	17,400,000	8,880,000	3,300,000
Bricks made and ready for use }	3,000,000	13,000,000	8,000,000	2,000,000
Bricks required to be made }	8,472,000	4,400,000	880,000	1,300,000

And judging from the above, he states that Messrs. Burn and Hunt will in all probability finish their contracts by the end of 1853; that Mr. Ryan may possibly do so, but that Mr. Daniel certainly will not. Mr. Ryan, however, is reported as completely misunderstanding his position as a contractor, and as quite ignoring all orders and instructions given by the engineers of the railway company. In consequence of this report Mr. Daniel's contract was taken out of his hands, with the sanction of the Governor-General. Some small quantity of work was done by a firm which appears to have been Mr. Daniel's security—or rather Mr. Jackson's, Mr. Daniel's senior partner—but who was allowed to withdraw from the contract at an early stage; but the arrangement evidently proved unsatisfactory, for in October, 1853, Lord Dalhousie sanctioned the completion of that portion of the line by the railway company under the supervision of their own Resident Engineer. Still, notwithstanding these failures, 95 miles out of the 121 from Calcutta to Raneegunge were executed by contract, but the contracts included only excavation, earth-work, masonry, ballast, and laying the rails.

The iron-work of the bridges was ordered by the railway company in England, was imported by them, and was erected under the supervision of their own engineers. The embankments on this length were made with very flat slopes to resist the action of the floods, from which much danger was apprehended. In the section accompanying the specification for the contracts, a slope of 5 to 1 is shown, and in a great portion of the length this form was maintained. As there were no cuttings in the alluvial plains of the Ganges, all the earth needed for the banks had to be excavated from pits near the toe of the slope. The section at first prepared required no less than thirty-four acres of land

per mile; but this section was subsequently modified at Colonel Kennedy's suggestion, so as to require $11\frac{1}{2}$ acres per mile for permanent occupation. The average height of the banks in the delta of the Ganges was 6 feet, and the width of the embankment was 33 feet at top. The gradient was unexceptionably good throughout the 121 miles, and there was a slight descent from the coal-pits to Calcutta, which for the peculiar nature of a mineral traffic is a decided advantage.

It is always a matter of some difficulty to recover detailed information regarding works executed some time ago, but the system of detailed Progress Reports introduced upon the guaranteed railways in India promised an accuracy of data, which however, on examination, they are found hardly to realize. The figures are very numerous and the statements are elaborate, but even the totals of work to be done vary so much month per month, as to prove either considerable clerical inaccuracy or errors in the original estimates.

It may, however, be asserted, with a certainty that there will not be much mistake in the statement, that there were 258 millions of cubic feet (cubic yards are not used in Bengal) of earthwork in bank, besides 7 millions of cubic feet of excavation in tanks, and $2\frac{1}{4}$ millions of cubic feet in foundation, in the 121 miles of railway between Calcutta and Raneegunge.

The country traversed by the railroad being very low and subject to floods and inundation, a very large number of flood arches were provided; but in the statements on record, running from September, 1852, to May, 1853, there are considerable alterations in the number of culverts; and for the Burdwan district, in which the flood arches were peculiarly numerous, so as to provide waterway for the rush of water likely to arise from the Damoodah bursting its banks, there are no returns

obtainable. At the time the railroad was making the Damoodah used to burst its banks nearly annually, and special precautions were necessary; but since the embankments on the right of the river have been removed, this catastrophe, which formerly caused misery and desolation to numbers, has never (it is believed) occurred on its left.

From the returns signed by Mr. Turnbull it seems that there were about 212 culverts of dimensions not exceeding 12 feet, and many of course much smaller, in the first 26 miles from Calcutta; and no less than 360 in the next 16 miles, many of the openings being as much as 15 feet each. In the Raneegunge district, 36 miles in length, there were 175 culverts varying from 12 feet in span downwards. In the Burdwan division of 43 miles in length, flood arches were provided in great numbers, but the reports on record are silent regarding them. There were five large bridges in the 121 miles, over the Ballee Khall, the Sursuttee, the Mugra, and Bankah; but the Progress Reports unfortunately give no dimensions and no information regarding them whatever excepting their names.

The bridge over the Mugra Khall, which was nearly the first, if not the first, iron bridge erected by a railway company in India, consisted of three spans of four Warren's girders. There were two girders for each line, and in 1858 one set of girders rested on wooden and the other on brick piers. The length of the girders was 85 feet, and their depth was 6 ft. 3 in. The area of the cast-iron plates in top at centre of the span was 62·25 square inches, but the dimensions of the plates diminishing from the centre of the span to the piers, the area of the cast-iron plates was there 52·19 square inches.

The dimensions of the wrought-iron bars forming

the bottom of the girder, which also diminish in size, from centre to piers, were as follows:—

		In.	In.		Ft.	In.
Centre,	8 bars, each	$9 \times \frac{5}{8}$	length	5	10	
Next set,	6 "	" $9 \times \frac{11}{16}$	"	13	8	
"	4 "	" 9×1	"	13	8	
Piers	2 "	" $9 \times 1\frac{1}{4}$	"	13	8	

When the girders were tested with a load of 58 tons, the deflection in motion was $\frac{2}{15}$ ths of an inch, and when stationary, $\frac{1}{2}$ inch. The weight of the platform on one span was 15 tons. All the bridges have stood well, and have borne a constant and very heavy mineral traffic; but they rattle much, and need a good deal of supervision.

Most of the other bridges are now spanned by iron girders, but some of them were in the first instance constructed of wood for the purpose of hastening the opening of the line; but by the end of 1859 all the wooden structures had been replaced either by girders or brick arching. Altogether between Howrah and Raneegunge there were 1029 yards of bridging and 6690 yards of culverts and flood openings.

The terminus at Howrah has been a constant source of anxiety and trouble, not from any inherent defect in its design, but from its being always too small for the traffic which has been from time to time worked from it. Mr. Turnbull from the very first pressed the desirability of a large area of land and a length of river frontage sufficient for all possible future requirements being secured; but with the small capital of a million it was not at the time thought proper to sanction a comprehensive scheme for a mere experimental line. From time to time additions have been made to the station buildings, to the coal wharfs, and to the workshops; but the facilities afforded have always been below

the requirements, and the terminus at Howrah has never given that satisfaction which a larger and more complete design would have done. A terminus of a trunk railway should be framed on a scale sufficient to meet the largest prospective wants, but prepared in such a way as that it may be undertaken and finished piecemeal, each portion being in itself complete.

There is a good frontage to the river, with deep water nearly up to the bank, so that lighters can receive coal or discharge heavy cargoes directly from the jetties; but the mineral traffic has increased so largely, and the ordinary work in like proportion, that it has been found desirable to separate them. It has been lately proposed that the present station area should be reserved for ordinary traffic only, that the station buildings should be largely added to, and that the workshops should be re-erected elsewhere. The site of the salt golahs,* close to the Howrah terminus, which is the property of Government, has been pointed out as a place suitable for the mineral traffic, and it is believed that the above scheme will eventually be carried out; if so, Howrah may become a terminus suitable to the work of a first-class line of railroad, which at present it is not.

The stations, too, and the platforms on the experimental line were all at first built on a parsimonious scale, and have, as the traffic has grown, needed great enlargement. Each of the stations at Serampore, Chandernagore, Hooghly, and Burdwan was estimated in May, 1852, to cost only 1868*l.*, and this was the sum originally sanctioned for each of them by the Government. This estimate must, however, have been very defective, and before they were completed in a state fit for the first experimental opening, it was found necessary to authorize an outlay of 2730*l.* upon each of the stations of Seram-

* Storehouses for salt; formerly a monopoly of Government.

pore, Chandernagore, and Hooghly; while for Burdwan, which was the station where the trains for Raneegunge and Rajmahal would be made up separately, a sum of 4481*l.* was eventually allowed. Subsequently, when the line was doubled, increased platform and other accommodation was provided at all the stations.

Notwithstanding the novelty of the work in India, the general progress made by the experimental railway was very satisfactory, and quite as rapid as could fairly be expected. In January, 1851, the railway company first commenced their operations, and in September, 1854, the line was opened as far as Pundooah, a distance of about 37 miles; and in February, 1855,* Lord Dalhousie, the Governor-General, officially opened, at a banquet given at Burdwan, the 121 miles of railway from Calcutta to Raneegunge, which formed the experimental line. The journey was completed with expedition and safety, and from the very commencement the traffic began rapidly to expand, more particularly in the third class.

* Lord Dalhousie was present at Howrah on that day, but was not well enough to go to Burdwan.

CHAPTER VIII.

MAIN LINE EAST INDIAN RAILWAY, BENGAL SECTION.

Major Baker, Bengal Engineers, appointed Consulting Engineer — Route between Rancegunge and Rajmahal selected — Route between Rajmahal and the river Kurumnassa, the Boundary of Bengal — Bengal and North-western Sections — Works let in small Contracts — Many Failures — Causes of Failures — Viaducts over the Adjai and Mor — Well-sinking — Works in the several Divisions of the Bengal Section — Monghyr Tunnel, Keeul and Hulohur Bridges — The Poonpoon — The Kurumnassa — The Soane Bridge — General Dimensions — Mr. Power, Chief Engineer — Bengal Section of Line opened.

IN the previous chapter the progress towards completion of the experimental line has been described ; but long before that portion of the railway was fit to receive the locomotive, arrangements had been made for the prosecution of the important extension of the trunk line from Burdwan to Delhi.

In February, 1851, Mr. Turnbull, the Chief Engineer of the East Indian Railway, and Major Kennedy, the Consulting Engineer to Government, had conjointly reconnoitered the directions by which the extensions to the north-west might be carried ; and unanimously rejecting the direct line, on which there was, as it then seemed, an obligatory ascent of 1280 feet above Calcutta at Dunwah, or 1030 feet at the Chuckai ridge, and then a descent of nearly similar steepness to the level of the plains of Behar ; had selected the Ganges valley route as the more feasible for a trunk line of railway. The reasons which guided these engineers in their recommendations have been already stated, and need not be again entered into.

The general route having been determined, no time

was lost in making the necessary more detailed examination of the ground. In the cold season of 1851-52, Mr. Turnbull and Major Baker, Bengal Engineers, who had succeeded, in the interval, Colonel Kennedy as Consulting Engineer to the Government of India, examined the country between Burdwan and Rajmahal. A trial section was ordered; and a set of levels with a longitudinal section of 118 miles in length, was finished, and submitted by Mr. Turnbull in February, 1852, thus completing the section from Howrah to the Ganges at Rajmahal, a distance of about 199 miles.

A ruling gradient of 1 in 1000 was at first adopted, which was that which had been the gradient of the opened line; but as in truth this was a refinement which it was in no way necessary to carry out, in execution this rule was considerably modified. A ruling gradient of 1 in 500 was selected for general guidance in the extension, and has been worked to, with some exceptions of 1 in 300 or 400 at peculiar points, such as that of the Seetapahar cutting, and other places. This was a highly favourable section for a railway, and the nature of the ground permitted it to be obtained without an undue extension of the length of the line, and without resorting to excessive labour and cost in embankment and cutting.

A few months subsequently to the transmission of the report on the *reconnaissance*, orders were issued to proceed with the regular survey of the extension to Rajmahal; and in March, 1853, a working section had been made, and the centre line marked out on the ground for the first 45 miles beyond Burdwan, as far as the river Mor. The surveys for the land needed had also been nearly completed. On the remaining length of 76 miles to Rajmahal, nothing further had been then done, as the available staff of engineers was only

sufficient to carry on the preliminary operations on the lower portion of the line.

In the same report Mr. Turnbull describes the country to be traversed, and gives his first views of the various engineering difficulties to be surmounted between Rajmahal and Allahabad; and although the original designs were much modified afterwards, in accordance with information obtained from further experience and researches, yet it will here be convenient to give an account of the works on the entire length of the extension from Burdwan to Delhi. The description, however, will apply to the works as undertaken and finished, and will not usually comprehend the original designs.

During the year 1851, proposals had been made by the Court of Directors that the East Indian Railway Company should construct a railway from Burdwan to Rajmahal, in continuation of the so-called experimental line, and they had been accepted; but on the receipt, early in 1853, of the surveys of the further extension to Allahabad, the previous agreement for the proposed railroad to Rajmahal only was abandoned, and in lieu of it a contract was entered into to construct an extension line from Burdwan to Delhi. The country between Burdwan and Allahabad having been examined and the route determined, there was no difficulty in conceding an extension for the line from Allahabad to Delhi; as the nature of the latter district was well known through the surveys made for the Ganges Canal, to present no engineering difficulties. A contract similar in its terms to that of August, 1849, was therefore drawn up and signed in London on the 15th February, 1854; but long previously to the conclusion of the legal agreement possession of some of the land on this extension was obtained, and the works commenced.

The total length of the extension line which it was

now determined to construct was about 1000 miles, and for the purposes of supervision it was divided into two parts, having boundaries conterminous with those of the administrations of Bengal and the North-west Provinces. Each of these great lengths was placed under the charge of a chief engineer, controlled by the Lieutenant-Governors of the Provinces, advised by their own consulting engineers: the supreme Government of India having considered that the time had arrived for entrusting the details of management to local government.

The boundary of the Bengal lieutenant-governorship was the river Kurumnāssa, and that was also fixed as the limit of the Bengal division of the East Indian Railway, which Mr. Turnbull kept in his own immediate charge. The North-western Provinces division of the railway was at first entrusted to Mr. Purser, subsequently for short periods to Messrs. Le Mesurier and Evans, and finally to Mr. Sibley, who has successfully carried out the 'great undertaking. The Bengal division was, for the sake of engineering supervision, divided into the following districts:—

										Length in Miles.
South Bheerboom district	..	..	..	..	..	..	..	..	..	45
North	..	..	..	..	..	..	..	..	..	33½
										Miles.
South Rajmahal	..	..	..	..	..	..	..	..	..	23½
Centre	..	..	..	..	..	..	..	..	..	26
North Rajmahal	..	..	..	..	..	..	..	..	..	25
Peerpointy	..	..	..	..	..	..	..	..	..	26
Bhagulpore	..	..	..	..	..	..	..	..	..	23
Jehanjerah	..	..	..	..	..	..	..	..	..	20
Monghyr	..	..	..	..	..	..	..	..	..	31½
Keeul	..	..	..	..	..	..	..	..	..	7½
Hullohur	..	..	..	..	..	..	..	..	..	14
Barh	..	..	..	..	..	..	..	..	..	31½
Patna district	..	..	..	..	..	..	..	..	..	81½
Soane	..	..	..	..	..	..	..	..	..	78½
Total length of extension line in the province of Bengal,										416½
or from Burdwan to the river Kurumnassa										416½

The North-western division of the East Indian Rail-

way, in the North-western Provinces, was for a like purpose similarly divided.

										Length in Miles.
Benares district	..	..	..	..	..	..	..	..	..	56½
									Miles.	
East Mirzapore	..	..	28	}	Mirzapore district	..	..	..	..	91½
Middle "	..	..	32							
West "	..	..	31½							
Lower Futtehpore	..	..	63½	}	Allahabad "	..	..	..	..	123½
Upper "	..	..	60							
Cawnpore district	..	..	..	..	..	..	..	..	..	27
Etawah "	..	..	..	..	..	..	..	..	..	92½
Agra "	..	..	..	..	..	..	..	..	..	81½
Delhi "	..	..	..	..	..	..	..	..	..	82
Total length of extension line in the North-western Provinces, or from the river Kurumnassa to Delhi										554

The total length of the extension line was therefore 970½ miles, to which, if the length of the main portion of the experimental, about 90 miles, be added, a total * of about 1060 miles is obtained for the Trunk line of the East Indian Railway. Besides this, there are several branches, and taking them into consideration and adding the length of the Jubbulpore junction line, *viz.* 225 miles, and that of the Chord line, which is still under construction, a grand total of about 1500 miles, entrusted to the administration of the East Indian Railway Company, is reached.

The works in the Bengal division were first taken in hand; and notwithstanding the partial failure of the system of giving contracts to Europeans resident in India, which had taken place on the experimental line, it was again determined to try the same plan for the

* The above distances are those which are given in Mr. Turnbull's reports, but they do not tally exactly with the mileage shown subsequently, when the railway had more nearly approached completion, and was open to Benares—

The distance from Calcutta to the Benares Branch	Miles.
Terminus (excluding branches) is	539
The distance from Benares to the Delhi Terminus	
(excluding branches) is	478½
The total length of line from Calcutta to Delhi	1017½

greater portion of the extension railway. The failures which have been noticed were attributable to several causes; partly to the inexperience of the men who undertook the contracts and to their want of good professional aid, but more especially to their deficiency of capital, which prevented them from prosecuting their contracts with energy, and on a large economical scale; and practically also precluded the agent of the railway company from placing any pressure upon them. If advances were suspended, the break-down of the contractor immediately followed; if advances were made, they were usually made without adequate security; and when at last penal measures on the part of the railway company became imperative, the advances usually proved to be partly irrecoverable.

It is stated by Mr. Noad, in his evidence before the House of Commons, that the Directors of the East Indian Railway Company had wished to have the working sections of the railway sent home, with the intention of entering into contracts with firms of English railway contractors; but this was not at the time understood in India, where it was believed that English contractors had declined to have anything at all to do with contracts for Indian lines. It had been determined that contractors should, for the most part, be employed in the construction of the railway; yet it was also settled that a trial of the plan of making it by the direct agency of an officer of the Company should be made. With this object, during the early part of 1853, Mr. Sibley, an engineer of conspicuous ability, was selected by Mr. Turnbull for the construction of the first 45 miles of the line from Burdwan, on which length there were some works of peculiar difficulty.

At the end of 1854, a preliminary report of progress, merely mentioning that land had been obtained,

and that earthwork had been commenced, was submitted. From this it seems that the railway had been subdivided for construction in the following way :—

	Miles.	
South Beerbhoom district	45	{ Mr. Sibley, C.E., Engineer of the Railway Company.
North Beerbhoom district, as far as Colgong	139	Messrs. Nelson and Co.
From Colgong to Bhaugulpore ..	80	Messrs. Macintosh and Co.
From Bhaugulpore to Patna ..	80	Messrs. Ward and Co.
From Patna to the Kurumnassa (exclusive of the bridge over the Scane)	80	Messrs. Burn and Co.
Total	424	

This distance is the same as that before given as 416½, but the discrepancy arises from the length of some small branches being included in the latter total; and it is found, indeed, that the mileage given in the various reports varies much, as the length of short lines and branches is comprised or left out in the calculation.

In the north-western division of the railway, three contracts alone appear to have been carried out, the remaining portion of the line being executed without the intervention of contractors. The portions done by contract were—

	Miles.	
The Benares district	50	Messrs. Burn and Co.
The Mirzapore „	95	Messrs. Hunt and Co.
The Allahabad „	121	Messrs. Norris and Co.

Eventually, from one cause or another, every other contractor succumbed. In some cases, the Santhal rebellion was the proximate cause; in others, the destruction of plant, the upsetting of all arrangements for the supply of labour, and the great enhancement in the prices of everything, caused by the great mutiny of 1857; but, whatever was the cause, the result finally was, that in all but three instances, the contracts were given up by all the contracting firms.

The exceptions were, Messrs. Burn & Co., in the Soane and Benares districts; Messrs. Hunt and Elmsley, in the Mirzapore districts, and Messrs. Norris & Co., on the length between Allahabad and Cawnpore. Messrs. Burn & Co. and Norris & Co. finished all their contracts regarding earth and brickwork, satisfactorily and well, without dispute or any disagreement with the engineers of the railway company; and though this cannot be said of Messrs. Hunt & Co., yet in the end their portion of the line too was duly executed.

The contracts made by these firms extended to the bank and smaller bridges of the railroad merely, but did not include the large and difficult viaducts, nor the laying of the permanent way. In some instances, the laying of the permanent way was at first contemplated by the contract, but it was not carried out by the contractor; and in every instance all the larger engineering works on the East Indian Railway calling for unusual skill and energy were executed directly by the engineers of the railway company, without the intervention of any contractors.

The heavy works requiring the special ability of selected engineers; the ordinary works on the great length of embankment on 1000 miles of railroad; the millions of bricks which had to be burnt in places far removed, not merely from marts of trade or commerce, but even from human habitation; were severe tests of the perseverance and exertion of all the engineers employed on this line; employed as they were on duties so professedly novel to them as those of the actual construction of a railroad.

Some delay and extra cost were involved in the change of system from the employment of contractors to the direct agency of officers of the railway company themselves, but the engineers soon obtained experience;

and the successful completion of the noble series of works from Calcutta to Delhi, which has now to be described, will prove a lasting monument to the talent and energy of British engineers.

Commencing then from Burdwan junction, where the experimental line first trends towards the north, and taking the works in detail, those in the South Beerbhoom division have first to be described—

SOUTH BEERBHOOM DIVISION : 45 Miles.

From Burdwan Junction to the river Mor.

The bank on this division was not very high, but still there were $120\frac{1}{4}$ millions of cubic feet of earthwork to be raised by manual labour: for in India the appliances of tilt waggons, &c., &c., are not used; and all the earth is brought by men, women, or children, in small baskets on their heads, from excavations alongside the line.

This, though it seems a primitive and slow method, is, in practice, found sufficiently speedy wherever labour of any kind can be collected. It is the custom of the country, and the simple work, requiring no thought and no plant but a small basket, suits well with the unenergetic character of the population. It allows, too, the whole strength of a family to be employed, from the grandsire down to the girl and boy of ten or twelve. The bank has in all cases been finished without difficulty wherever the labourers have been punctually and fairly paid; and trouble has been experienced in those spots only where contractors have in the first instance failed to pay accurately and readily.

Besides the earthwork in the bank, there were also seven millions of cubic feet of excavation in foundations; and five millions of brickwork. All the works

in this division were carried on with method, and in a thorough workmanlike way, both by Mr. Sibley, who commenced them, and by Mr. Wilson, who succeeded to the charge on Mr. Sibley's falling sick.

A better idea of the large amount of brickwork in the division will be formed when it is stated that there were 117 openings and culverts of 10 feet and under, 146 bridges of spans, varying from 12 to 20 feet, and four road bridges of 30 feet span each.

Besides the above, two viaducts, one of nine openings of 24 feet arches, and another of fifteen openings of 24 feet, were constructed, together with the two first-class undertakings, *viz.* the bridges over the rivers Adjai and Mor.

The Adjai was spanned by thirty-two arches of 50 feet each, and the Mor by twenty-four arches of 50 feet. The total length of the Adjai was divided into four bays by piers, of solidity sufficient to enable them to act as abutments, and that of the Mor into three bays, the abutment piers being of triple thickness.

The foundations of these and of nearly all the larger bridges on the East Indian Railway were formed on blocks of masonry perforated with wells, which were sunk by means of workmen entering the wells and excavating the earth until the water becomes too deep. As the earth and sand are removed, the blocks, which are built on curbs of wood or iron, sink into the soft soil. When the water becomes too deep for a man to work with ease in it, an instrument called a jham (a kind of very large curved shovel) is used, which is lowered down to the bottom, and when filled by divers is drawn up. The machine is kept constantly going night and day by relays of men, so as to prevent the sand from settling round the block. For the purpose of obviating danger from movement in the sand or from scour, curtains of

blocks are often sunk both on the up and down stream side of the bridge across the river, and the abutments and wing-walls usually rest on similar perforated blocks. The piers are generally sunk through the soft sand to clay or gravel, when beds of that kind of material are to be found; but when this is not the case, the piers, resting merely on the sand, prove to be a stable and good foundation. Within the curtain walls inverters were turned beneath the arches, which were, at the Adjai and Mor, of concentric rings of brick. It was necessary that foundation blocks should be well sunk below the level of the sand before the Rains commenced, and they were then found uninjured when the floods subsided. If, however, the wells were left near the surface, the current, acting upon them, usually threw the blocks out of the perpendicular, and often partly upset or contorted the whole mass of masonry.

But at the Adjai and Mor all proceeded well. In August, 1858, the piers of the Adjai Bridge were above water; and on the 20th July, 1859, Mr. Turnbull passed over the bridge on an engine to Cynthia on the bank of the Mor. The Mor bridge was only a little later, and was completed on the 5th December, 1859. The line was opened for public traffic as far as the Adjai on the 3rd October, 1858, and to Cynthia on the 3rd September, 1859. Plenty of natural ballast, consisting of quartz, gravel, ironstone, and kunkur* gooting, was obtainable in this division, and generally throughout the length of the extensions; so it was no longer necessary, as it had been on the experimental line, to burn clay for this purpose; an expedient which proved after all a costly and but an indifferent substitute for natural ballast.

* A kind of nodular limestone.

THE NORTH BEERBHOOM DIVISION: 33½ Miles.

Extending from the river Mor to the Puglah.

The works in this division, together with those of the Rajmahal districts, were at first let in contract to Messrs. Nelson; but their proceedings were tardy and unsuccessful, and ere long the works were taken out of their hands by the railway company.

The amount of earthwork in the division was 67½ millions of cubic feet, and no difficulty was found in collecting labour for putting it in bank.

There were, according to Major Goodwyn's report of April, 1857, 246 openings or culverts from 20 feet to 8 feet; and at that time some long arched bridges of brick were designed for the Canal, Dwarka and Braminee rivers. This part of the plan was subsequently modified, it being considered by Mr. Turnbull and the directors of the railway company impossible to manufacture bricks in sufficient quantity within any reasonable time.

Mr. Rendel, the Consulting Engineer to the railway company, was sent to India to report upon the question, and it was then decided, some time in 1858-59, that wrought-iron girders should be substituted for the brick arching previously contemplated. Eventually the heavy works in this division were constructed with brickwork foundations and piers, and iron girders.

For the canal bridge there were three spans of 54 feet each, instead of five openings of 30 feet each. Over the Dwarka river there were seven spans of 60 feet each, the foundations resting on wells sunk to a stratum of clay, which was found 20 feet below the bed of the river. In February, 1859, the brickwork of both these bridges was finished, and the arrival of the girders was awaited. The Moonrah was spanned by three girders of 60 feet each, and the next important bridge was that over the Brahminee. This river, like the Dwarka,

has well-defined boundaries, and the stream flows between clay banks on a sandy bed. A stratum of clay for the piers to rest on was found at a depth of about 15 feet below the surface of the river bed. For the passage of this river seven arches of 30 feet each, divided into bays, and nine girders of 60 feet each were required.

The Puglah Bridge was originally designed for forty openings of 15 feet each, but in pursuance of the change to iron before alluded to, twenty-five spans of 28 feet and four spans of 60 feet were substituted for it. This bridge was the last large work in this district; but there were also three others of comparatively small dimensions: three spans of 28 feet at a nameless stream, three spans of 28 feet over the river Lalla, and over the Sangutta three spans of 60 feet.

In February, 1859, these bridges were all well advanced, and Mr. Turnbull urged the immediate dispatch of the girders, especially those of the larger spans.

This division was opened for traffic at the same time as the Rajmahal districts, which have now to be described.

RAJMAHAL DISTRICTS: 100 Miles.

		Miles.			Miles.
South Rajmahal	..	25		North Rajmahal	.. 24
Centre	..	25		Peerpoyntee	.. 26

These districts were all under one superintendence, and may conveniently be treated as one, though in some of the reports the works in each division are separately detailed. The exact amount of earthwork in this division is not given; but there was much difficulty in collecting and retaining labour, as visitations of cholera were common, and the dreaded disease was most destructive in its effects upon gangs of men brought from a distance. This method of procuring labour the engineers were forced to adopt, as the inhabitants of the Rajmahal hills, the Santahals, were unwilling to work in any numbers upon the railway; and this unwillingness or

inaptitude for labour, combined with high banks and some deep rock cuttings at Seetapahar, made the execution of this portion of the line peculiarly tedious.

The first work of any magnitude in the Rajmahal division is the bridge over the Banslai, where in 1857 a waterway of 542 feet was provided, but it was finally arranged to erect eight spans of 60 feet each. Next, at a spot called Putterghatta, four spans of 28 feet each were provided, in lieu of more ample waterway which in 1857 was deemed necessary. At the Gambria, where there was a bridge of three spans of 60 feet each, there was peculiar difficulty, the country being flooded annually to a considerable depth, covered with jungle, and a great scarcity both of labour and materials of all kinds prevailing. The information regarding the remainder of the works in this division is neither clear nor full; but bridges, none however of great size, over the Kauhloi, Goomanee and Dumdumma, Bussunpore and Bhogra, were built. From the extreme unhealthiness of the Goomanee valley, and the bad character of the water, the works at the Goomanee proved to be the measure for opening the railway to Rajmahal, but in themselves they present no features either of interest or difficulty.

There was a great length of waterway in culverts to be provided in this district, amounting in all to $1\frac{1}{2}$ mile of culverts, requiring $5\frac{1}{4}$ millions of brickwork. In despite of all obstacles, however, the works were pressed on with great vigour and energy, and a trial trip from Burdwan to Rajmahal was made on the 4th July, 1860; and the line was opened as far as Rajmahal in state, by Lord Canning, then Viceroy and Governor-General, in October, 1860: in commemoration of which event Lord Canning had a medal struck,* and presented to all the officials employed at that time on the line.

* Gold medals were given to Colonel Baker, Sir M. Stephenson, and Mr. Turnbull; silver medals to the rest.

THE BHAGULPORE DIVISION : 23 Miles.

After leaving Rajmahal, the railway is traced on the high land between the deeply inundated districts in the interior and the Ganges; and though the ground is higher, within a few miles of the great river where the railroad has been constructed, than it would have been more inland; still the line at intervals has to cross the spaces through which the flood waters, confined for the most part by the raised margin of the great river, find a channel at intervals to the Ganges. This is the case in the Bhagulpore division, and the earthwork in the divisions was consequently heavy, amounting to no less than 88 millions of cubic feet. Where the bank was exposed to the force of waves of a large expanse of inundation, the slopes of the bank were made three to one, as a precaution against denudation. Besides the usual amount of culverts, there are some heavy bridges, which proved to be works of unusual difficulty. The foundations had to be sunk very deep into a soft silt of unknown depth, and the labour in excavating the wells on which they stand was great. The size of the bridges will indicate how much waterway had to be provided.

At the Coah, Geroah, Ghogah, and Chumpun rivers, similar bridges were provided, consisting of five spans of 60-feet girders, but though difficult and troublesome to construct, there was nothing in their character calling for special description. Forty flood-arches of from 15 to 20 feet were also constructed. After the floods of October, 1860, which were remarkably high and were a severe test of the adequacy of the waterways provided and of the stability generally of the railway, it was found desirable to add to the size of the Geroah Bridge, as there were signs of a dangerous tendency to scour, from the waterway being too contracted.

The ballast for this division and most of the others,

was gravel and kunkur, found at various points near the line, and brought by ballast waggons along the railway. Bhagulpore, a place of importance, both socially and commercially, and conveniently situated for obtaining a share of the Ganges traffic, was selected as the next point after Rajmahal to which the railroad should be opened; and just twelve months after the celebration by Lord Canning, at the latter place, the line was opened for traffic as far as Bhagulpore, in November, 1861.

Great expectations had been formed regarding the traffic that would accrue to the railroad as soon as the line reached Rajmahal. It was believed that history proved that there was always deep water in the Ganges near this town, and that though the main current of the Ganges might desert the walls of the city for a time, yet that there was no reason to apprehend that the river close to the shore would ever be impassable for vessels drawing 5 feet of water.* Experience, however, falsified these anticipations, and shortly after the railroad was opened to Rajmahal, the Ganges withdrew from that vicinity, and in its ever shifting channel took a direction far distant from it. The Ganges flows in a vast sandy bed many miles wide, and in this and neighbouring districts it is seldom less than 10 to 13 miles in width. After every flood the current of the deep-water channel, which during the cold season may be from $\frac{1}{2}$ to 2 miles across, oscillates from one side to another of this wide bed. There is no doubt, therefore, that after some years the deep-water channel will again revert to the town of Rajmahal, but in the mean time great disappointment was felt at this unforeseen and unexpected contingency; and the opportunity of again touching upon the Ganges at Bhagulpore was doubly acceptable.

* Canal Report, 1841, Colonel Forbes, Bengal Engineers. Mr. Turnbull's Report, 23rd February, 1852.

JEHANGERAH DIVISION : 20 Miles.

The Jehangerah division, 20 miles in length, has now to be described. The railroad still runs on an alignment roughly parallel to the bank of the Ganges, raised by the deposit of the silt and mud suspended in its waters at times of flood above the general level of the country; but, although this is the case, the works in the division are not above the average. There were 59 millions of cubic feet of earthwork in the embankments, and only three bridges of a large size. Over the Ghoorghat and Burriarpore rivers there were three spans of 60-foot girders, and over the Mariah five spans of a similar width.

As the distance from Calcutta increased, the difficulties consequent upon the transport of heavy iron girders in boats not well adapted for the purpose, through the tortuous and dangerous navigation of the Sunderbund, were aggravated; and the dragging them over temporary roads in native carts, and the fixing and riveting the girders, without the appliances and skilled labour common in England, demanded an exertion of personal labour and energy which can only be appreciated by those who have had experience of such operations in India. Great delays and vexatious losses were constantly occurring, and were to be expected.

THE MONGHYR DIVISION : 31½ Miles.

In this division is found the only tunnel on the East Indian Railway, and though it is not in any degree remarkable for its length, yet great labour was required before it could be driven. The total length of the tunnel was 900 feet only;—the material to be pierced was for 600 feet clay slate, which was worked with ordinary ease and rapidity; but the remaining 300 feet were found to consist of quartz rock of excessive hardness, in which

for a considerable time progress at the rate of 4 feet only per month could be effected, even after every care had been taken in the organization of the labour and in training the native miners. The unexpected delay and expense in making this tunnel was the more provoking, as the tunnel had been at first designed for the purpose of saving 3 miles of railway to Monghyr, which, after all had to be made. In 1860, a branch line to the river Ganges, $5\frac{1}{4}$ miles, had to be laid down, as Monghyr proved to be the only spot where there was deep water throughout the year, and where the heavy bridge materials required for the Keeul and Hullohur bridges could conveniently be landed. The machinery for the workshops at Jumalpoore also had to be landed at this point.

The blasting and quarrying were prosecuted night and day without intermission, and the headings met on the 27th March, 1860. The tunnel was completed with brick lining under most of the clay slate portion, so as to ensure perfect safety to trains, by the hot season of 1861. The stone found in this division did not prove so suitable for masonry as had been hoped, and brickwork had to be largely used. There were in all $1\frac{3}{4}$ million of cubic feet of brickwork and masonry in this division. The earthwork amounted to $52\frac{1}{4}$ millions of cubic feet. There were no bridges in the length requiring comment.

KEEUL DIVISION : $7\frac{1}{2}$ Miles.

HULLOHUR DIVISION : 14 Miles.

Beyond Monghyr, westward, the engineers had to encounter one of the most serious obstacles met with on the line of railway. Near, but beyond the town of Sooragghurrah, the accumulated inundations of the Ganges find their way through the elevated bank of the river, and during the rains the district for a length of 10

miles is under water to a depth from 5 to 10 feet. This immense channel, through which, as the waters of the Ganges rise or fall, there is a considerable current, is also traversed by two rivers called the Keeul and Hullohur. The Keeul was 500 feet in width, but 1350 feet of waterway, in nine spans of 150 feet each, were found to be necessary. The Hullohur was 150 feet wide, with about 16 feet of water in the channel in the driest season, and an average depth of 40 feet during the rains, and it was spanned by a bridge of four girders of 150 feet each, giving a total waterway of 600 feet. The bottom of these rivers was composed of soft sand and mud of unknown depth. The foundations were on wells of 10 feet in diameter at the Keeul end, and of 20 feet at the Hullohur, which at the Keeul were sunk to a depth of 25 feet below low water, and at the Hullohur to no less than 45 feet. The abutments at the latter also were founded at a depth of about 36 feet below low-water level. The wells were all built on strong iron curbs, and were sunk in the usual way.

These bridges provided waterway for the two rivers; but, for the inundation generally, 600 flood arches of 15 feet each were at first constructed, and when the floods of 1860 warned the engineers, by showing an inclination to scour, that there was a deficiency of waterway, 30 more flood openings of a similar span were supplied; altogether a linear aggregate of 21,700 feet of flood arching (about 4 miles) was allowed, giving a cross sectional area of 200,000 square feet. The amount of earthwork in the two divisions was 60 millions of cubic feet; and great difficulty was at first experienced in collecting and maintaining adequate gangs of labourers on a plain so inundated and so sparsely inhabited. The millions of bricks, too, that had to be burnt in a spot naturally so unsuited for a brick manufactory, increased the drawbacks which the energies of the resident engi-

neers had to overcome before the $8\frac{1}{2}$ millions of cubic feet of brickwork in these divisions could be finished.

As far as Monghyr, the railroad was opened in February, 1862, but the bridge works at the Keeul and Hulohur were only completed during the following year, at about the same time as the still larger work over the Soane.

THE BARRH DIVISION: $31\frac{1}{2}$ Miles.

No work of importance was found within this division. The earthwork was heavy, amounting to $73\frac{3}{4}$ millions of cubic feet, but there was less than half-a-million of cubic feet of brickwork.

THE PATNA DIVISION: $31\frac{1}{2}$ Miles.

There was little of interest in this division also; the only work of any size being the bridge over the Poonpoo, of nine arches of 40 feet each = 360 feet, which was finished at an early date in 1859. The waterway provided by the railway stands in striking contrast to that given by an old native bridge which carries near this point the united waters of the Morhur and Poonpoo through seven arches, having a waterway of 132 feet. The total amount of earthwork amounted to 61 millions of cubic feet, which is below the average, but the brickwork was heavy, and was 3 millions of cubic feet, a great portion of which, however, was in the bridge over the Poonpoo.

SOANE DISTRICT: $78\frac{1}{2}$ Miles.

All the divisions which have been named were in the hands of the engineers of the railway company themselves, but the arrangements in the Soane district of $78\frac{1}{2}$ miles were so far exceptional, that they were let to Messrs. Burn and Co. The contractors prosecuted their

works with spirit, and undeterred by the interruptions caused by the mutiny, pressed forward their undertaking to a successful termination.

In the district there were 153½ millions of cubic feet of earthwork, and 240 bridges and culverts, including the bridge over the Kurumnassa, consisting of thirteen arches of 40 feet each, which was the boundary of the Bengal division of the railway. This district suffered severely from the mutiny of 1857 and the insurrection of 1858. The regiments at Dinapore mutinied on the 25th July, 1857, and shortly after, all the country was overrun by rebels. Bungalows were burnt, and all property and materials destroyed. Work was again recommenced in February, 1858, but on the 21st April, 1858, Koor Singh, with some followers, entered the district, burning and plundering all that came in their way.

In June, some rebels visited the bridge works at the Kurumnassa, drove the work-people away, plundered all they could find, and burnt or destroyed all store-houses, bungalows, workshops, and timber. The piers of the bridge were then enclosed in a dam, and were still 10 feet below low-water mark, but fortunately it did not occur to the rebels to destroy the dam. Had this been done, a work of much cost would have been rendered useless and a season would have been lost. Messrs. Hamilton and Nelson, as soon as the mutineers moved off, recommenced the works, and pushed on the piers so successfully, that the piers and abutments on the east side were carried safely above low-water mark before the floods rose and stopped the works for the season, thus certainly saving a year in the completion of the bridges. The value of the property destroyed in 1857-8 by the mutineers at the Soane bridge alone, was 42,000*l.*; but it is estimated that the cost of the East Indian Railway from destruction of property, from delay caused by it, and from the enhancement in the price

of labour and materials, was increased by the mutiny to an extent equivalent to three millions sterling.

SOANE BRIDGE: $\frac{7}{8}$ Mile in length—1577 yards.

Twenty-eight Spans of 150 feet each.

In the Soane district, but separated from the contract of Messrs. Burn and Co., was the Soane Bridge, a work of great magnitude, and worthy of comparison with any in the world. The Soane river is thus described by Colonel Dickens, R. A., who has examined and surveyed the district through which it flows with care and in detail, in his project for canals from the Soane:—"The river rises along with the Nerbudha and Mahanuddee, on the elevated plateau of Central India, near Ummurkuntuk, and runs 325 miles through a high rocky tract, receiving tributaries only from the south. . . . After quitting the elevated rocky region of Central India, the Soane enters the valley of the Ganges, and by a straight course of 100 miles through the plains of South Behar, joins the sacred river between Arrah and Patna. . . . The chief peculiarity of the river is its great width. Opposite Tiloohoo it attains a width of nearly three miles, and for the greater part of the 100 miles it is more than two miles wide. This immense bed consists of sand, and during eight months of the year contains a stream of only a quarter of a mile wide, so that it appears to the traveller like a sandy desert. The depth of this wide channel is on the average under 20 feet, and in its deepest parts hardly exceeds 30 feet. The strong dry westerly winds, which prevail from January to April, and sometimes till June, heap up the sand on many parts of the eastern bank to 12 or 14 feet above the level of the country, with a sharp descent upon it at the angle of repose of the material, thus forming a natural embankment for many miles. The drainage

area of the Soane is nearly 23,000 square miles. Its extreme discharge in floods is about $1\frac{3}{4}$ million cubic feet per second, which, continued for twenty-four hours, would be equal to a drainage of $2\frac{3}{4}$ inches from the whole surface in that time. The heavy floods, however, are of but short duration, hardly ever exceeding four days; and the river, even in the rainy season, seldom fills its channel. In the dry season the lowest discharge is usually about 4000 cubic feet per second."

Such a barrier to the construction of a railway as a river between two and three miles wide, formed of course a subject of much thought and examination, but after a careful examination of the banks of the river by Colonel Baker and Mr. Turnbull, they both came to the conclusion that it would be practicable and safer to construct a bridge at a point where it was exceptionally narrow, not very far from the direction the railway would naturally take. The river here was only 4000 feet broad, and the banks were of clay and high. A bed of clay too was found by borings under the sandy bed across the whole width of the river. It was decided by the engineers, and on sound reasonings, that it would be easier to make a bridge over such a river as the Soane, at a spot where the section was somewhat contracted, than at a wider place where the stream of the river meanders from one side to the other of its wide sandy channel. The bed, as has been stated, is hardly ever entirely covered with water, and even if it be so at distant intervals for a short time, yet the depth is very little, and over a considerable portion of the area thus superficially covered, no perceptible current exists. Still the costly nature of a bridge $\frac{7}{8}$ ths of a mile long naturally made the engineers consider whether it could not by any means be dispensed with, and in Mr. Turnbull's report and estimate of March, 1853, a break at the Soane was included. A break, however, involved

two stations, turntables, platforms, in the bed of the river, and a ferry; and his estimate amounting to 45,000*l.*, suggested forcibly that it would probably be wiser to construct a permanent bridge, forming a perfect communication, than to adopt a plan at once temporary, incomplete, and expensive: a break too on a line of railways is, especially in goods traffic, to be avoided.

The idea of a break was not entertained by Government, and at the time that the extension was sanctioned, a bridge over the Soane was also approved. The site recommended by Colonel Baker and Mr. Turnbull was accepted, and the design was then carefully considered. Mr. Turnbull at first submitted two schemes for a bridge over the Soane, one of brick and the other of iron, recommending the former for three reasons: first, because an arched bridge for two tracks would cost considerably less than an iron bridge for one; secondly, because orders had been issued by the home authorities not to ask for anything from England, a substitute for which could be obtained in India; and thirdly, because of the difficulty in obtaining freight for the quantity of iron needed. Afterwards on Mr. Turnbull going home and conferring with Mr. Rendel, the Consulting Engineer to the railway company, an iron bridge instead of an arched brick bridge was preferred—the railway directors believing that the difficulty of making bricks would be excessive, and representing that they thought it would take ten years to get the bricks and materials ready for an arched bridge over the Soane.

It was finally decided that a brick foundation on wells, with piers of a similar material, should be used to support a wrought-iron lattice superstructure of 150 feet span each, designed by the late Mr. Rendel—carrying the rails on the top, and having a roadway for foot-passengers beneath. The works were commenced in

1856, and the progress was fairly good during that year, although there was at first a slight failure in the manufacture of bricks. Experience, however, showed how this might be overcome, and bricks were soon after made at the Soane as good as could be desired, and equal to, if not better in quality and solidity than any that had been previously made in India.

The foundation of a pier, composed of twelve wells, were first sunk in 1856, to ascertain whether there would be difficulty in managing the sinking of clusters of wells at once, without causing any considerable divergence from the perpendicular. This was proved, and all was going on well when the regiments at Dinapore mutinied on the 25th July, 1857, and, marching towards the west, came to the bridge work, and plundered and destroyed everything. The resident engineers, their wives and children, together with the inspectors and overseers, and their families, escaped in the iron boats belonging to the railway company to Dinapore, and the mutineers left nothing untouched that was destructible; then, continuing their march along the line, they came to Arrah, where Mr. Boyle, the resident engineer, had fortified a house. To it the European residents, sixteen in number, with forty-five Sikhs retreated, and bravely defended themselves for a week against immense odds. The mutineers, after crossing the Soane, had been joined by a chief called Koor Singh, and numbering about 2500, had invested the house occupied by the residents of the civil station of Arrah, against which they fired a field gun which was in their possession. The little garrison, however, bravely held the place until relieved by a force under Major Eyre, Bengal Artillery, who, marching from Buxar, defeated the rebels in an action near the town of Arrah.

During 1857 nothing at the bridge itself could be

attempted, but large preparations were made at a place called Sherpore, on the banks of the Ganges, near Dinapore, and about 16 miles from the site of the bridge. Here curbs for the piers were made, and a great quantity of plant manufactured under the orders of Mr. Power, who had been appointed to the charge of the bridge, so as to be ready for recommencing the works with spirit as soon as the country should be pacified.

The Soane Bridge* works had, after the mutinies, practically to be recommenced, and the country remained in a disturbed state so long after actual fighting had ceased, that it was not till November, 1858, that the piers were again begun. The design for the piers was now modified from that originally proposed. The piers were sunk on wells 20 feet in diameter, built on very strong wrought-iron curb shoes, having vertical rods attached to them, connected with horizontal rings of iron in the brickwork up to the top of the wells, so as to form a skeleton of iron, which was subsequently enveloped in brickwork. This added very much to their solidity, and made them far stronger than wells usually sunk for foundations. None but the soundest and best-burnt bricks were used in these foundations and piers, which were constructed in the most durable and permanent manner possible. In some instances—more commonly, however, in Madras than in Bengal—wells for the foundation of bridges are sunk merely to a certain depth in sand or silt, their stability depending upon friction, upon a wide floor or apron, and upon there being no scour and little eddy; but at the Soane they were sunk through the sand, well into the clay, to an average depth

* My friend Mr. Power kindly promised to supply me with full details of the Soane Bridge, and with drawings of the piers; but the pressing and urgent character of his duties has hitherto prevented him from doing so. He has favoured me with some information on which the above description is based.

of $31\frac{1}{2}$ feet below the bed of the river. Nothing, says Mr. Power, is more trying to the patience than "the passage from the sand *into* the clay. Although the curb shoes may appear to be touching the clay at almost every point of its circumference, the sand will force its way through some small crevices and nearly fill the well again and again." During the years 1859 and 1860, the work was pushed forward without any intermission, and by the 30th June, 1860, Mr. Turnbull was able to report that all the piers were in progress, though they were not all then sunk to their full depth.

During 1860 Mr. Power's failing health compelled him to leave for England, and he was succeeded by Mr. Schmidt. In June, 1861, out of 2780 feet of sinking in twenty-seven piers—the aggregate depth in feet which the wells had to be sunk—2753 feet had been completed, leaving only 27 feet to be done. Towards the completion of the work the labourers had become so expert that the latter portion of the well-sinking was executed with great rapidity, a depth of no less than 792 feet having been sunk in January, 1861, which was equal to $28\frac{1}{2}$ per cent. of the whole.

The following are the general dimensions of the work:—

	Feet.
From average bottom of foundation to low-water	31'68
Ordinary low-water level to flood line of 1855	20'00
Flood level of 1855 to under-side of girder	15'60
Under-side of girder to level of rails	15'32
From bottom of foundation to level of rails	<u>82'60</u>

LENGTH OF BRIDGE.

	Feet.
28 Spans of 150 feet each	4200
27 Piers of 12 feet each	324
2 Abutments	207
Total length of bridge over all	<u>4731</u>

As soon as the piers were finished, the girders were erected by the aid of a wooden staging, and were put

together with ease and rapidity; six weeks only being needed to put up one girder.

By the end of 1861 nearly all the work at the bridge was finished, and its final completion was simply delayed by some pieces of the iron-work having been lost in transit, and from the necessity of obtaining duplicates of the missing parts. The amount of brickwork in the bridge is 1,375,000 cubic feet, and only 47,127 cubic feet then remained to be done. The missing materials reached Calcutta safely some time in March, 1862, but most unfortunately a cargo boat containing some of it was wrecked in the Sunderbunds. By great exertions, however, the whole was recovered and was sent on without any delay of serious moment. The bridge was forthwith completed, and the bank having been consolidated by the rains of 1862, the railway from Calcutta to Benares, a distance including branches of 609 miles, was officially opened by Lord Elgin, the Governor-General and Viceroy, in February, 1863.

Mr. Turnbull, the Chief Engineer, having seen the great works on the Bengal section of the railway thus brought to a satisfactory conclusion, resigned his post to Mr. Power, and in March, 1863, left for England, carrying with him into retirement the esteem of both the Directors of the East Indian Railway Company and of the Government of India.

The Bengal section of the East Indian Railway has now been opened several years, and the stability of its construction has been tested by the continuous conveyance of an extremely heavy traffic. During 1866, fifteen trains were running each way nearly daily, and the railway was earning 40% per mile per week. This heavy and continuous traffic, which might have been much greater had the railway been capable of carrying more, has tried severely the bridges and permanent way; and

experience proves that with the foundations and brickwork obtainable in Bengal, it is not safe to allow brick arches to be subject to the constant vibration of passing trains without the protection of a thick layer of clay over the crown. A more extended acquaintance too with the floods of Bengal has also shown that the bridges, as at first designed, afford generally a somewhat contracted waterway, and in several instances it has been found necessary to construct auxiliary openings. Above Burdwan, nearly all the foundations of the bridges having become partially undermined by the action of water, have been strengthened and secured by the laying down a pavement from the invert as far as the foot of the slopes, terminating in a drop wall of a depth sufficient to counteract the tendency to scour and undermine. So extensively indeed have such arches cracked or begun to fail, that it has become evident that it would be better to substitute iron girders for brick arching, even for small spans, and on the Chord line now being constructed this has been done.

STATEMENT of the QUANTITIES of BRICK and EARTHWORK in the SEVERAL DIVISIONS of the BENGAL SECTION of the EAST INDIAN RAILWAY.

	Length in Miles.	Brickwork* as per Statement, dated 18th Aug., 1858.	Earthwork.†	Remarks.
South Beerbhoom ..	45	5,013,259	120,313,829	* In a return of Aug. 1859, there are some discrepancies, as noted, caused probably by the substitution of iron girders for brick arches.
North ..	33½	2,277,350	74,000,000	
South Rajmahal ..	23½	1,075,560	70,000,000	
Centre ..	26	1,262,680	72,250,000	
North ..	25½	1,205,436	No return.	† There are also some variations in the amount of earthwork given in the Annual Reports, but those entered are very nearly full and correct.
Peerpoyntee ..	25½	1,655,800	51,994,760	
Bhagulpore ..	23	2,000,000	88,230,000	
Jehangerah ..	20	1,400,000	59,000,000	
Monghyr ..	31½	1,672,342	52,274,052	
Keelul ..	7½	1,100,000	60,000,000	
Hullohur ..	14	7,100,000		
Barrh ..	31½	400,000	73,739,000	
Patna ..	31½	8,078,917	61,000,000	
Soane ..	78½	7,431,400	153,495,000	
Total ..	416½	36,672,744	..	

CHAPTER IX.

MAIN LINE, EAST INDIAN RAILWAY, NORTH-WESTERN
PROVINCES.

Mr. Sibley, Chief Engineer — Description of the Line — Bridges the great Difficulty — The River Tonse — Jumna Bridge, Allahabad — Minor Works between Allahabad and Agra — The Huyatpore — The Jhirnah — The Hindun — Jumna Bridge, Delhi — Table of Earthwork and Masonry.

THE extension of the line from Burdwan to Delhi having been decided upon the report and trial sections submitted in 1853, the portion of the railway falling within the boundaries of the Lieutenant-Governorship of the North-west Provinces, was entrusted to a separate administration. A deputy agent was appointed for the North-west Provinces, and a Chief Engineer also. The gentlemen first selected for the responsible post of Chief Engineer of the North-west Provinces, did not, for various reasons, remain long in charge; and there were several changes, until Mr. Sibley, who had shown remarkable skill in organization, as well as professional ability and tact, was appointed in 1859; and under his vigorous and able management the works have been successfully designed and finished.

After leaving the river Kurumnassa, the railway follows closely the course of the Ganges on the right bank, as far as Mogul Serai; and from that place, throwing off a branch line, $6\frac{1}{4}$ miles in length, to Raj Ghât opposite the city of Benares, it is taken on the same alignment to Allahabad, where the railway crosses the Jumna. From Allahabad the railway runs in nearly a straight course to Agra, *viâ* Cawnpore and

Etawah. The station for Agra is reached by a branch off the main line, and is formed on the left bank of the Jumna, in a position similar to that for Benares.

Thirteen miles before Agra is reached, the main line, bending northward at a junction called Toondlah, follows, *viâ* Allygurh, the left bank of the Jumna to Delhi; where it enters the terminus of the East Indian Railway by a beautiful bridge over the river Jumna, a few miles beyond the junction with the Punjaub and Delhi line, at a place called Ghazee-o-deen-nuggur, or Ghazeeabad.

As far as Agra there had been no uncertainty regarding the direction of the railway, but beyond that point there had been a good deal of vacillation. It was at one time intended that the Jumna should be bridged at Agra, and the line brought by the right bank of that river to Delhi, and then, *viâ* Umballa and Ferozepore, to Lahore, crossing the Sutlej at or near Ferozepore. Near this station a series of borings were made by Mr. Le Mesurier, on behalf of the East Indian Railway Company, in 1858 and 1859. Twenty borings were taken, three of them in the channel of the river, and a bed of clay was found to extend nearly across the whole width at an average depth of 13 feet below water; but it was shortly after decided that the East Indian Railway should stop at Delhi, and that the extension from Delhi to Lahore should be entrusted to another company.

The idea of a bridge over the Jumna at Agra was however sometime after given up, and it was determined to construct one over the same river at Delhi, and from thence that the railway should follow the course above indicated. Finally, in 1862 and 1863 the Government of India decided that the railway should be traced along the left bank of the Jumna, instead of on the right, as had been intended; and should be taken to

Lahore *viâ* Meerut, Seharunpoor, and Umballa, thus leaving Delhi off the main line of communication. As soon as this decision had been formed, the question at once arose whether it would be worth while to make a costly bridge for the railway over the Jumna at Delhi, or whether it would not be wiser to accommodate Delhi in the same way as Calcutta, Benares, and Agra. The piers of the bridge, however, were so far advanced, the girders too having been manufactured, and having actually reached Calcutta, that it was determined to complete the bridge, and the East Indian Railway therefore now stretches direct from Howrah, at Calcutta, into the city of Delhi.

The only difficulty experienced on the extension line in the North-west Provinces was similar to that felt in Bengal, *viz.* that of bridge building; for there were no tunnels, and the gradients and curves were unexceptionable. The line was practically nearly level, embankments over low ground and at rivers only being needed, and there were unusual facilities for choosing a straight course. In the Agra district it is noticed in the reports on the preliminary surveys, that there will be a straight run of 42 miles, with a bank of about 3 feet in height, and in the Delhi, another straight distance of 56 miles.

Commencing now the detailed description of the works, the first district on leaving the Bengal division is called—

THE BENARES DISTRICT: 56½ Miles.

From Kurumnassa to Mogul Serai	..	..	..	50 miles
From Mogul Serai to Ganges	..	..	..	6½ „

The works in this division were under contract to Messrs. Burn and Co., and were executed by them in a satisfactory and straightforward manner, reflecting great credit upon the firm. The main portion of the

earthwork and masonry in the district was finished before the mutiny in 1857, but Messrs. Burn and Co. received their final certificate on 1st June, 1859, the latter half of 1857 and 1858 proving to be periods when no work could be done or measured. The total amount of earthwork in the division was 41 millions of cubic feet. There were no bridges of large span in the length, and the number of culverts was under the average; the amount of brickwork in them being only 206,200 cubic feet. The railway was opened to the public as far as Benares on the 22nd December, 1862.

THE EAST MIRZAPORE DISTRICT: 28 Miles.

This length, as well as the two districts next succeeding, called the Middle and West Mirzapore, in total a distance of $96\frac{1}{2}$ miles, were let under contract to Messrs. Hunt, Elmsley, and Co., with whom during the execution of it there were many disputes; the work, however, after a good deal of delay, was at last finished by Mr. Elmsley. The contract as usual did not include the large bridges.

A great portion of the working seasons of 1855 and 1856 was lost through disputes, which were subjects of arbitration, and then in 1857 and 1858 the mutiny prevented the rapid prosecution of the work.

Still, in August, 1859, notwithstanding all the drawbacks, much had been done, and out of the 57 millions of cubic feet of earthwork in the division, 10 millions only remained to be executed.

The foundations of all the bridges in this division rested on piers sunk in the same way as in Bengal, but arches of stone instead of iron girders were principally used. The workmanship was first-rate, and the structures were imposing, and in themselves deserving of all praise, and reflecting much credit upon the engineers

who designed and built them. But the cost of the stonework was very great.

The longest bridge was that over the river Jurgoo, of seven arches of 60 feet each, and there were also two more bridges of one arch of a similar span. A bridge of three arches of 50 feet each was erected over the Kulukea. One arch of 40 feet, ten of 30 feet, four of 25 feet, and eleven of 20 feet, were besides constructed over various streams and nullahs. The centres were all struck satisfactorily, and there were no failures. The total amount of masonry in the bridge and culverts was $1\frac{1}{4}$ million of cubic feet. The opening of this length was delayed by various causes, principally by the want of sleepers and permanent way, and it was not till 1st January, 1864, that the railway from Benares to Mirzapore, a distance of $39\frac{1}{2}$ miles, was opened for traffic.

THE MIDDLE MIRZAPORE DISTRICT: 32 Miles.

The earthwork in this division was rather above the usual average, and amounted to $64\frac{3}{4}$ millions of cubic feet, the bridging also being peculiarly heavy. Over the river Kadjourah there were three openings of 80 feet, spanned by iron girders; and over another stream near there was one similar opening. The river Bulwan required eight arches, the Kurnowtee five, and the Ooglah three, all of 60 feet each. The piers with their cut-water and pilasters, the abutments, wing walls, string course, and parapet, were all of dressed ashlar, and the arch stones were carefully finished. The total amount of masonry in the division was about $1\frac{1}{4}$ million of cubic feet; and, in addition to the bridges mentioned, included four viaducts, with a total of seventeen openings of 17 feet iron girders, and ten viaducts with twelve openings of 12 feet girders.

THE WEST MIRZAPORE DISTRICT: $31\frac{1}{2}$ Miles.

In this division the amount of earthwork was about $6\frac{1}{4}$ millions of cubic feet—nearly the same as in the last district. The bridging was, in the aggregate, less than usual; but the great work over the Tonse, containing seven openings of 150 feet iron girders each, was situated in this division.*

The river Tonse is, at the point where it is crossed by the railroad, about 1000 feet wide at ordinary flood level, and the average depth of the channel below the banks is 49 feet. The floods are very sudden and rapid, the currents at such times flowing at the rate of 7 miles per hour. A rise of 25 feet in four-and-a-half hours, in May, 1856, is recorded by Mr. Broadrich, C.E., the resident engineer. In this bridge there were $7\frac{1}{2}$ millions of cubic feet of masonry, and in consequence of the drain upon the stone labour-market for the Jumna Bridge works, it was determined to make the piers and abutments of brick, the cutwaters only being faced with dressed ashlar. Great difficulty was experienced in sinking the wells at this bridge on account of the irregularity of the beds of clay which had to be pierced. When the soil of a river bed is of an uniform sandy character, the wells sink regularly, and retain their vertical position; but if it be of a variable quality—in some places hard, in others soft—the wells in being sunk get out of the perpendicular, and much trouble is sometimes experienced before they can be righted, or so far rectified as to make the foundations safe for building on. This was the case in the wells at the Tonse. Each pier rests on ten wells of 12 feet diameter each, and two of 10 feet diameter, carrying the cutwaters. The wells are built on radial

* Medley: 'Professional Papers on Indian Engineering,' vol. iii., No. 93. 'Tonse Bridge,' by G. Broadrich, Esq., C.E., Resident Engineer.

wooden curbs, secured by strong frames of sāl, iron rods binding together the top and bottom of the wells, being built into the brickwork of the circumference, similarly to those described as used at the Soane Bridge. The ninety-three wells in the bridge were sunk satisfactorily, though slowly, at the rate of 1 foot per well per month, with the exception only of the wells of one pier, which became extremely out of the vertical. As they could not be righted, a dam of piles of whole timber was formed round the pier, driven to the full depth to which it ought to have been sunk, and the pier then built up solid from a depth of nearly 10 feet below low water. All the wells when sunk were cleaned out and hearted with concrete, composed of lime, brickbats, and brick-dust (soorkee). The work was pushed on with vigour, and in December, 1862, out of two abutments and six piers, one abutment and five piers were at their full height, with bedstones fixed and ready for girders.

The following general description of the Tonse Bridge girders, and which will apply, with some variations, to all the lattice bridges on the East Indian Railway, may, it is hoped, be intelligible, and have some interest for even an unprofessional reader.

The girders of the bridge, designed by A. M. Rendel, Esq., were of a tubular character, the sides, however, not being solid, but of open lattice, and the top and bottom formed by transverse iron beams. The total length of the girder was 157 feet 6 inches, the clear span being 150 feet, and width of the pier 12 feet at its narrowest part. The beams of the top are 4 feet apart, covered with iron plates, and carry the railroad; those of the bottom are 3 feet apart, covered with a double layer of sāl planking, 5 inches thick in all, and carry the roadway, which is 12 feet wide and 12 feet high. Each side of the tube may be described as a double-

flanged girder; the upper flange consisting of a box (2 feet wide $\times$ 1 foot 9 inches deep) made of boiler-plate $\frac{3}{8}$ of an inch thick, increasing in a graduated ratio in strength and thickness from the piers to the centre; the lower flange consisting of iron bars 5 feet $\times$ 1 inch on edge, made rigid by uniting bolts, similarly increasing in strength from two bars at the piers to twelve at the centre: and the web, composed of two sets of alternate ties and struts so arranged as to intersect one another at right angles, conveying the weight of the bridge and load to the standards on the piers, and therefore increasing in strength and section from the centres to the piers. These bars are of a channel section riveted back to back, and each set of lattice bars is strengthened by cross-bracing of a zigzag form. The lattice bars and cross roadway beams were riveted to the top and bottom parts of the girder. Deflexion is permitted by fixing the extremity of each girder firmly to a casting, the under-side of which is concave, and which rests on a cast-iron saddle with a convex upper surface, so as to admit of a vertical movement. At one pier this cast-iron saddle is fixed, at the other it rests upon cast-iron rollers working in a wrought-iron planed frame, allowing free horizontal movement, as the under-surface of the saddle is also planed smooth. The maximum horizontal movement due to Indian heat was found to be $1\frac{1}{2}$ inch. The weight of iron in the bridge was about 1200 tons, and the first cargo of ironwork reached the Tonse in 1861.

The bridge was finished by February, 1864, and the girders were then carefully tested by Major Drummond, R.E., with both a running and standing load, with a result which was entirely satisfactory. Two engines and tenders drawing ten trucks, loaded to 12 tons each, and equalling in all to about 192 tons, at a speed of 17 miles per hour, was the test applied, and the maximum deflec-

tion was a little under $\frac{4}{8}$ ths of an inch, and the oscillation less than $\frac{1}{8}$ th of an inch.

As soon as the bridge over the Tonse, which had been the measure for the completion of the line in this division, was finished, the railway from Mirzapore to Allahabad was opened to the public on the 1st April, 1864, thus forming on that date a continuous line of railroad from Calcutta to Agra, the bridge over the Jumna at Allahabad alone being excepted.

This lattice bridge, with its double road, thus proved to be as strong and easily erected as in appearance it was light and elegant. The parts in themselves were small and easily movable, a great point in India; and a bridge more useful and suitable to Indian wants than that over the Tonse could hardly have been designed.

JUMNA BRIDGE (ALLAHABAD).

Fourteen openings of 205 feet each, 957 yards, or $\frac{9}{16}$ ths of a mile nearly.

The West Mirzapore district was bounded on its western extremity by the river Jumna, and the railway crosses just where it enters the sacred river. The bridge over the Jumna is formed with larger openings than those over the Soane, and though not so long as that by 620 yards, yet is still a work of great magnitude and difficulty. The position for the viaduct was early decided in September, 1855, but in consequence of changes in the chief engineers, nothing was done as regards the design until after the Mutiny in 1857, and the actual work at the bridge was not commenced until the dry season of 1859. The site for the bridge had at first been selected apart from any military considerations, but after 1857, Lord Canning ordered the suspension of the work for a month, while the question was discussed whether this viaduct should not be constructed so as to

lead into the fort at Allahabad, or at all events in such a position as to allow the guns of the fort to command the bridge and the approaches to it. It was decided, however, that this was not desirable upon reasonings which were deemed undeniable and imperative, and the site first selected was adhered to. The design for the bridge was at first for fifteen openings of 205 feet each, but Mr. Sibley, the Chief Engineer, maintained a careful record of the rise and fall of the floods in the Jumna, at Allahabad; and after consideration reported in 1862 that one span of 205 feet might be dispensed with, thus effecting a saving of about 18,700*l*. Mr. Sibley's observations are published in the Indian Professional Papers, and extend over a period of four years, from 1861 to 1864.*

The results obtained show that there is a variation between low and flood water level of from 30 feet on the lowest recorded flood to 50 feet as a maximum. The maximum measured velocity in the height of the flood was 12 feet per second. At the period of greatest discharge the mean velocity of the whole stream was more than 9 feet per second, and the sectional area of the river at that level being 145,000 feet, the discharge of the river Jumna at highest flood must have been nearly $1\frac{1}{3}$ million of cubic feet per second. The low-water season extends from the month of November to the middle of June, and that of flood from the latter portion of June to the end of October.

As soon as the work was actually commenced, the well sinking was prosecuted with vigour. Each pier is founded on twelve wells, resting on strong iron curbs, and in June, 1859, when the floods rose and stopped further work, the wells of one pier had been sunk to a depth of 41 feet below low-water level. As soon as the

* Medley: 'Professional Papers on Indian Engineering,' vol. ii., No. 73. 'Jumna Floods,' by George Sibley, Esq., C.E., Chief Engineer E.I.R.N.W.P.

wells were founded they were filled up with concrete. On the whole the wells of this bridge were sunk with tolerable facility, but the progress was rather slow: pieces of timber, trunks of trees, lumps of stiff clay, and masses of carved stone were met with at intervals, and had of course to be removed before the well sinking could be continued. Diving by means of a helmet was tried and used with much success in removing such obstacles, which no doubt had been brought down from time to time by floods. The wells were sunk to various depths, from 42 feet to $22\frac{1}{2}$ feet in those of the south abutment, but in each case care was taken to sink the piers into the clay, and the wells were all hearted and built up as soon as they were founded.

In August, 1862, the foundations were far advanced: of the thirteen piers ten were completely founded; one had to be sunk 6 feet, and another 14 feet. The remaining pier gave much trouble, as half the wells became disturbed, and a cofferdam had to be formed before they could be rectified. The dam being formed, and the water being then lowered 9 feet below the low-water level of the river, the wells were cut down, and a flooring of large ashlar stones laid over them. On this flooring an arch of stone masonry 52 feet in diameter was sprung, and over this the pier was built, the cutwater being flatly battered so as to form backing to the arch. There are about $2\frac{1}{2}$ millions of cubic feet of masonry and brickwork in the bridge, and in the north approach there was a viaduct of twenty-four spans of 30 feet each. The iron work of this bridge was designed by G. Rendel, Esq. It consists of a wrought-iron lattice girder of an open tubular shape, carrying the railroad on the top, and a carriage road beneath very similar in its general features to that which spanned the Tonse, and which has already been described in some detail.

The total length of the girder is 216 feet, with a clear span of 205 feet. The sides are open lattice, and the top and bottom transverse beams supporting the roads. The beams at the top, for the railroad, are 4 ft. 6 in. apart, and those at the bottom, for the road, 6 ft.

Considering the sides of the bridge as double-flanged girders; then the upper flange consists of a box 1 ft. 9 in. deep and 2 ft. 3 in. wide, with the bottom removed, each side being composed of two $\frac{1}{2}$ in. plates riveted together, and the top of $\frac{3}{8}$ th boiler plate, of one thickness at the pier, and of three at the centre. The lower flange is formed in the same way, but being inverted resembles a trough in shape. The web consists of alternate tension and compression bars: the ties being of bars 5×1 near the piers, but of a lighter channel section at the centre, riveted to the outside of the troughs, and the struts of two angle irons riveted to the inner sides of the troughs. The struts and ties are cross-braced with light channel bars. The arrangements for allowing deflection and expansion are the same as those described at the Tonse. The bridge at the centre is 18 ft. square outside dimension, and the roadway is 14 ft. wide by 16 ft. in height.

The bridge was opened to the public in August, 1865, thus allowing uninterrupted traffic between Calcutta and Agra. But previously the whole superstructure had been tried. The first train ran over the bridge on the 15th of July, and on the 8th of August the girders were carefully tested by a load upon the railway composed of five engines and tenders, exactly covering the span of 210 ft. from saddle to saddle, weighing 265 tons, and with a load of 65 tons on the road beneath, making a total load of 330 tons on the span. The train of engines was then run over at speed, and the maximum vertical deflection was only 1.67 in., the total lateral oscillation being .20 of an inch, or .10 either way from

a state of rest. As this test was with a weight far heavier than the bridge will in practice have to bear, the actual working deflection will not exceed 1 inch, a result entirely satisfactory in every way.

FUTTEHPORE DISTRICT : $123\frac{1}{2}$ Miles.

Lower Futtehpore district, $63\frac{1}{2}$; Upper, 60.

The works on this length were extremely light and easy, and were let to Messrs. Norris & Co., who satisfactorily performed the contract entrusted to them; and it is perhaps owing to this that the information regarding this district is scanty, and somewhat meagre. By the 30th September, 1856, it is stated that $87\frac{1}{2}$ millions of cubic feet of earthwork had been completed, and about one-seventh is reported as still to be done. The total amount of earthwork in the 120 miles was about 100 millions of cubic feet; 1 million cubic feet of brickwork was on the same date finished, and in all there were about 2 millions of cubic feet of masonry and brickwork in the Futtehpore divisions. This masonry, however, was in culverts and small works, for a bridge of one arch of 53 feet span over the Lohundah nullah was the largest work in these divisions. There was also a small bridge over the Pandoo nullah. During the year very satisfactory progress was made, and by the close of it the railway was so far advanced towards completion, that on the 3rd of February, 1857, an engine ran for the first time to a point 26 miles from Allahabad. By May, 1857, it was hoped that rails would be laid for 35 miles.

In that month, however, the mutiny burst out, and great efforts were at once made to open the entire length for imperial purposes. This was done, and though the distance from Allahabad to Cawnpore, 123 miles, was short, yet the convenience and advantage of railway

communication for even that length was much felt and appreciated by Government. But although this portion of the railway was opened to meet an emergency in 1857, yet Messrs. Norris did not receive their final certificate till the 1st of March, 1862; and in the same year it was that the line from Allahabad to Cawnpore was opened for traffic to the public. At Allahabad a branch three miles in length was made to the Fort. The station works both at Allahabad and Cawnpore are very extensive. Large workshops, some of them 300 ft. $\times$ 60 ft., ranges of barracks for engine-drivers and workmen, with stables for engines, being erected at these important stations.

CAWNPORE DIVISION: 27 Miles.

This division also contains no work of importance.

The length was at first let to Messrs. Brandon & Co., of Cawnpore, who up to September, 1856, had put 17 millions of cubic feet of earth in bank. But they had always been unpunctual in their payments, and carried on their work in an unsatisfactory way, and the contract was in 1856 taken out of their hands by the railway company. In this division there is also a want of specific information. The bridges were small; those over the Pandoo and Rhind streams being the most considerable. The bridges were of brick and arched, the Rhind being crossed by three arches of 60 feet each; the only work of any size in the division. The total of earth-work in the division was about 25 millions of cubic feet, and that of brickwork 775,000.

At Cawnpore, a short branch of $2\frac{3}{4}$ miles in length was made to the river Ganges, at a spot where there is sufficient water all the year round to allow of boats unloading alongside a wharf; with the intention that the traffic on the river should thus be intercepted and brought on to the main line.

ETAWAH DIVISION: $92\frac{1}{2}$ Miles.

The works in this division were the easiest and lightest in the whole railway, but the statements regarding the quantities and character of the works are not very precise, probably on account of their insignificance. In September, 1856, $53\frac{3}{4}$ millions of cubic feet of earth-work were in bank, and by the end of 1857 the whole, amounting to about $75\frac{1}{4}$ millions of cubic feet of earth-work, would have been completed had it not been for the interruptions caused by the mutineers. There were no large bridges in the length, and the number of culverts was about the average; but the total amount of brickwork is not stated. As it was, the embankment was not completed till 1859, and had permanent way and sleepers been then available, the line here might have been at once opened; but there was much delay in the dispatch of iron from Howrah, a good deal of mismanagement in the yard there, and great losses in the boats on the Ganges in transit.

The subject was frequently brought prominently to notice, and at last the native boatmen and contractors having practically proved untrustworthy and a failure, the railway company built a transport fleet, at a great cost, for themselves. The failures of the first plans for the conveyance of permanent way from Calcutta to the North-western Provinces, the consideration of a decision regarding the means to be adopted, and the construction of a fleet of barges and steamers took much time, and great delay was the consequence. In February, 1860, it was still only hoped that materials might arrive from Calcutta in time to commence plate-laying in April; but in fact a start was not made till the end of August, and the completion of the line was therefore delayed till 1861. There was also consider-

able delay in sending on permanent-way materials from Allahabad; as in September, 1860, an extraordinary grain transport, to meet the demands of the famishing population round Delhi, commenced, which took up all the trucks and carriages that were in store. But during 1861 the difficulties were overcome, and the line from Cawnpore to Etawah was open for traffic on the 1st of July, and to Shekoabad, the end of the district, by the 13th of November, 1861.

AGRA DISTRICT: $81\frac{1}{2}$ Miles.

From Shekoabad to Agra, *via* Toondlah Junction, $36\frac{1}{2}$; from Toondlah Junction to Allygurh, $44\frac{1}{2}$.

This distance was about equally divided by the junction station at Toondlah, from whence there was a branch line of $12\frac{1}{2}$ miles to the station for Agra, on the left bank of the Jumna; and from whence also the main line turned to the north and was carried on towards Delhi.

The Eastern subdivision, from Shekoabad, at the end of the Etawah district, to Agra, a distance of 36½ miles.	{	From Shekoabad to	Miles
		Toondlah Junction	24
		From Toondlah Junction to Agra	12½
		Total	36½

This portion was taken in hand some time before the Western subdivision. As early as 1856 the central line was marked out, and the works which were in the hands of the engineers of the railway company had been commenced in February, 1857. The greater part of 1857 and 1858 were lost, in consequence of the Mutiny, but in December, 1859, the whole of the embankment was reported complete. The amount of earthwork was about the same as usual; but exact information regarding the total of it, as well as that of brickwork, is wanting. There were twenty-eight bridges in this subdivision, most of them of small dimensions, and the greater number of them of brickwork arched. The

work of skill in the length was the building a bridge of a single arch of brickwork of 90 feet in span over the Jhirnah. The wells for the abutments were sunk about 20 feet, where a good stiff bed of clay was found, forming an admirable foundation. An arch of 80 feet span crossed the Huyatpoor nullah; and there were besides, two bridges, containing in the aggregate four arches of 30 feet each, one bridge of 25 feet, and three of 20 feet each. All the works in this division were finished some time before the sleepers and other permanent-way materials could be obtained, and the opening was delayed somewhat by the want of them. But during the working season of 1861 and 1862, great progress was made, and the line from Shekoabad to Agra, $36\frac{3}{4}$ miles in length, was opened on the 1st of April, 1862; thus connecting Agra with Allahabad by a continuous line of railway, 280 miles in length.

The Western subdivision, from Toondlah to Allygurh, $44\frac{1}{2}$ miles.

The direction of the line as far as Ghazeeabad, some distance beyond Allygurh, was sanctioned by Government in May, 1859; but in consequence of a change in the staff of the engineers of the railway company, there was delay in the commencement of the land plans, and the orders for their preparation were not issued till November, 1859: but so much energy was then shown in getting them ready, that they were all submitted in December, 1859. In this subdivision there were no masonry works larger than a culvert. The amount of earthwork in bank was $31\frac{1}{2}$ millions of cubic feet, and that of brickwork $\frac{1}{4}$ million. In December, 1862, the opening of the line was only delayed from the want of sleepers and permanent way, and the line was actually opened for traffic in the following year, on the 1st of March, 1863.

DELHI DISTRICT : 82 Miles.

The direction of this part of the railway was determined in 1859, and in February, 1860, the land-plans for the greater part of the division were sent in. The design for the bridge over the Jumna at Delhi, together with the arrangements for the terminal station, had been submitted for consideration in the December previously. They were all promptly dealt with, and the chief engineer commenced the heavy works in this last division of the line with his usual good management and vigour. The total of earthwork in this district in banks and cuttings, including the approaches to the Hindun and Jumna bridges, was considerably above the average, and amounted to 150 millions of cubic feet ; and in March, 1861, three-fourths of the total amount had been completed. The amount of brickwork in culverts, excluding the masonry in the bridges over the Hindun and Jumna at Delhi, was rather more than half a million of cubic feet. The works were pushed on with unremitting industry, and in November, 1862, the whole of the masonry in culverts was completed, and the line was ready for permanent way :—even by the end of the previous June, 20 miles of rails had been laid, further progress being stopped by the want of sleepers. The line from Allygurh to Ghazeeabad, 66 miles in length, was not however, opened to the public till the 1st of April, 1864.

There were two works of magnitude in this division, *i. e.* the bridge over the Hindun and that over the Jumna, both of which were situated on the branch line to Delhi, beyond the junction of the East Indian with the Delhi and Lahore Railway at Ghazeeabad.

In 1859–60, some borings were made at the proposed crossing of the Hindun, and it was then intended

that there should be three openings spanned by iron girders of 150 feet each; and two piers with this purpose were commenced. Subsequently, Mr. Sibley in January, 1860, reconsidered the design, and determined upon constructing an arched brick bridge of six openings of 70 feet each. The abutments and piers were all built on wells sunk to an average depth of 28 feet below low-water level; and on the down-side of the stream a continuous line of wells was carried across the river so as to form a curtain. In August, 1862, the whole of the piers and abutments were founded, and the piers were built up so far that the arches might be turned during the dry season of 1862-63; in December, 1862, nearly all the arches were completed; and in 1863, the bridge was finished.

DELHI JUMNA BRIDGE.

Twelve openings of 205 feet each: 820 yards, or $\frac{1}{2}$ a mile nearly.

The site for this bridge was fixed by the engineer in December, 1859, and having been shortly after sanctioned by Government, the works were begun.

Nearly all the large bridges on the East Indian Railway are built on wells, sunk either through sand to clay, or resting on sand and silt at a great depth; but the peculiarity in the foundation of this bridge was that rock was found a few feet beneath the bed of the river over a considerable portion of its breadth. In December, 1862, the western abutment was built up without wells from the rock, which was from 3 to 7 feet only below the surface. The wells of the pier next to this abutment reached rock at 14 feet, which was thought satisfactory, but as it turned out they gave more trouble than all the others. The floods of 1861 disturbed them, and on an examination of the rock down to which they had been sunk, it was found that they were resting

partly on a tolerably flat surface, and partly on a sharp slope; the wells therefore when acted upon by the floods soon became out of the perpendicular, but happily not to such a degree as to throw the centre of gravity outside their base. They could not be sunk deeper or righted; and the engineers therefore determined that the wells should be so underpinned as to give a full and fair bearing throughout their circumference. Wells of small diameter were also sunk in the interstices between the wells of large diameter, which were out of the perpendicular and were connected with them by strong iron bands. Six piers had also been sunk to rock at various depths from 17, 26, to 37 feet, and had been hearted and built up, and the remaining four had reached clay and kunkur, at depths varying from 35 to 39 feet, but had not been completed. The wells forming the eastern abutment and the wing walls had been sunk to 18 feet, where rock had been found.

When in October, 1862, the Government of India determined to prolong the main line of railway to Lahore through Meerut, and not through Delhi, an idea was started of turning this bridge over the Jumna into an arched-road bridge, and of utilizing the 205 feet girders elsewhere; but after some little consideration the original plan was resumed and carried out. The total quantity of brickwork and masonry in the bridge was 1,161,618 cubic feet, and in December, 58 per cent. had been executed. The bridge was opened for public traffic in 1866, thus completing the last link of the trunk line between Calcutta and Delhi.

Delhi, however, is a fortified city, and warned by past dangers the Government determined that the bridge over the Jumna as well as the entrance of the railway into the fort of Selimgurh and the palace ought to be made defensible. A complete scheme prepared with this object by Lieut. Shepherd, R.E., and in design approved,

was on the score of cost rejected: the Government of India finally deciding that the idea of a bridge-head should be abandoned; considering that it would suffice if the railway bank of the approach were undermined by a girder drawbridge, the abutments of it being, by a loop-holed wall, provided with gates across the roads leading through it, joined with the abutments of the great bridge across the Jumna. The roadway of the bridge was closed with strong movable iron gates. The entrances of the railway through the rampart of the fort and the walls of the palace citadel were provided with similar barriers, were well flanked, and commanded by batteries and a retrenched front, specially constructed for the purpose.

These precautions were judicious, and the neglect of them for such an important post as a terminus of a railway at Delhi would have been inexcusable. All the stations in the North-western Provinces, moreover, have after the Mutiny been designed so as to be more or less defensible.

STATEMENT showing the AMOUNT of EARTHWORK and MASONRY in the DIVISIONS of the EAST INDIAN RAILWAY in the NORTH-WESTERN PROVINCES.

	Distance in Miles.	Brickwork.	Earthwork.
Benares	56½	206,200	41,000,000
East Mirzapore	28	1,451,387	57,000,000
Middle Mirzapore	32	1,416,889	60,873,000
West Mirzapore	31½	1,916,756	64,394,000
Jumna Bridge (Allahabad)	..	2,498,631	
Lower Futtehpore	63½	2,000,000	100,000,000
Upper do.	60		
Cawnpore	27	775,000	25,000,000
Etawah	92½	No return	75,180,000
Agra (Eastern Subdivision)	..		
Delhi (Western)	81½	217,990	81,444,000
Delhi	82	*603,931	150,000,000
Jumna Bridge, Delhi	..	1,161,618	
Total	559		

* Exclusive of the amount of brickwork in the bridges over the Hindun and Jumna.

CHAPTER X.

CHORD LINE—EAST INDIAN RAILWAY.

Preliminary Surveys — Obstacles on a Direct Line — Various Passes explored — The Narjungoo Pass selected — Lump-sum Contract determined on — Messrs. Brassey, Wythes, and Co., Contractors — Route between Seetaram-pore and Luckee-Serai — Kurhurballee Coal-fields — Short Singarun Branch — Description of Bridging — Girders — Piers — Sleepers — Rails — Kurhurballee Colliery Branch — The Jynteah River.

RANEEGUNGE, the first terminus of the experimental line of the East Indian Railway, was placed with much impartiality at a point which, while not reaching the coalfields at all, was, as nearly as possible, equally inconvenient to all the collieries. This was acknowledged; and it had always been intended that the line should be extended through the whole length of the coalfields, so as to give nearly similar facilities to coal-owners to make short private branch lines from their collieries to the main railway.

With this object in view, Mr. Turnbull, in 1859, submitted a memorandum on a proposed extension of the railway from Raneegunge to the river Barrakur, with a branch up the Singarun valley, and the proposition was shortly after recommended, approved, and carried into execution. Soon after the main line *viâ* the Ganges valley, had been finished and opened, a traffic surpassing the expectations of Government, and surpassing, too, the carrying powers of a single line of railway, very speedily developed itself; and it then became necessary to decide whether the line from Khanoo Junction to Allahabad should be doubled, or whether the project of forming another more direct line from Raneegunge towards Patna, which had again found

favour with many, should be adopted. This was in 1862-63; and during the cool seasons of those years the country was explored by Mr. Power, the Chief Engineer of the East Indian Railway, and subsequently thoroughly examined and surveyed during the cold seasons of 1862-63 and 1863-64.

The selection of a line neither requiring works of excessive cost nor gradients of peculiar severity was a task of no ordinary difficulty; for, as has been before stated, the hilly country between Raneegunge and Benares on the direct line, and also between the Grand Trunk road and the Ganges, presented formidable obstacles to the cheap or easy construction of a railroad. An examination of the passes through the western hills soon proved that a line in this direction would be very expensive, as the railway would have to be made on a bench cut out of the side of a valley, requiring heavy rock-cutting and many tunnels, and would have to be carried over innumerable deep ravines, and a very broken and irregular country. This idea was speedily abandoned, and a careful study of the passes to the north-west of the Grand Trunk road was then instituted. Accurate surveys of the three known passes called Bhettiah, Halwan Ghurry, and Sank were made, one of which, the Bhettiah, had previously been examined by Colonel Baker and Mr. Turnbull some years before, but they were all steep and difficult; and it seemed impossible to obtain gradients by their means of 1 in 100, which was the object that was being aimed at.

About this time, however, Mr. Bourne, C.E., who was employed upon this survey, discovered another pass called Narjungoo, heretofore unknown; and on being surveyed it turned out to be by far the best, and the only one indeed presenting the possibility of a gradient of 1 in 100 without works of excessive cost and labour. After due and deliberate investigation, this direction was

selected and approved; and the centre line was staked and nicked throughout in the early part of 1865. The East Indian Railway Company determined in this instance to adopt the plan of a lump-sum contract, which had answered so well in the construction of the Eastern Bengal Railway. The same contractors, Messrs. Brassey, Wythes, & Co., were entrusted with the execution of the work, and the agreement was signed on the 19th December, 1865.

The branch into the Raneegunge coalfields had reached some time previously a point called Seetarampore, distant 137 miles from Calcutta; and the contract with Messrs. Brassey for the chord line extended from this temporary terminus, Seetarampore, to Luckee-Serai station on the main line. This was 327 miles distant from Calcutta by that line; but by the chord now being made the distance would be 260 miles; so that the saying in distance from the North-western Provinces to Calcutta would be 67 miles by the latter route. This was a great advantage to the Government and the public—saving both time and cost—while it tended also to the welfare of the shareholders of the company, as increased facilities for locomotion, if not secured at too extravagant an outlay, always lead to larger business and more remunerative returns.

But the principal inducement to make the railway, was that it passed near some valuable coalfields called Kurhurballee, to which a branch single track, $23\frac{3}{4}$ miles in length, from Muddapore was projected and included in the contract for the chord line. The coal of the Kurhurballee collieries was far superior to that of Raneegunge, and for locomotive purposes was indeed stated to be 13 per cent. better. The colliery also was more centrally situated for the system of the East Indian Railway Company than the Raneegunge coalfields; and as it appeared certain that coal would gradually take the place of wood

in many of the great cities of the North-western Provinces, a large mineral traffic would thus be created. But especially would the shareholders benefit by a reduction in the cost of fuel for locomotives. The saving in this respect was estimated by Messrs. Rendel and Power at no less than 5000*l.* a-year for every train run each way between Allahabad and Calcutta. Besides, as the enormous flood of traffic which suddenly rose over the main line of railway as soon as it was opened, had rendered a doubling of the line imperative, it was considered that it would be pecuniarily cheaper to make a new chord railway with a double line of rails, than to lay down another set of rails on the existing loop line.

This at least was so stated, and the probable saving was estimated at 800,000*l.*; but the data on which the calculation is based are not stated, and the estimate seems to require proof.

Still on the whole there can be no question that the decision to construct a double chord line near the Kurhurballee colliery, a large part of which was in the hands of the East Indian Railway Company, was judicious and more likely to yield a good revenue than the plan of doubling the loop line.

Adopting as usual the method of describing the railway in sections, the first length to be noticed was that from—

RANEEGUNGE TO BARRAKUR: 21½ Miles.

BRANCH UP THE SINGARUN VALLEY: 11½ Miles.

The line on leaving Raneegunge passes over an undulating country in a westerly direction, keeping as nearly as possible in the centre of the coalfield. The drainage of the country falls to the river Barrakur and is crossed by the railway; but the works on the line were on the whole very light, the only bridge of any consequence at all being that over the Nooneah.

The line stops on the eastern bank of the river Barrakur, which indeed bars further advance except at an outlay which, for a mere colliery line, it would not be worth while to incur. The works, however, were of the most ordinary description and require no special comment.

The Singarun branch also was a line formed by works of the easiest kind. It commenced at Undul station, about 10 miles short of Raneegunge, and is carried parallel to the course of the stream called Singarun for the accommodation of several large collieries that were worked in that neighbourhood.

These branches were commenced and finished some years before the chord line was set on foot; and when that was surveyed it was determined that it should leave the existing railway from a place called Seetarampore, 6 miles to the east of the terminus of the colliery branch at Barrakur.

SEETARAMPORE TO LUCKEE-SERAI, ON THE MAIN LINE:
123 $\frac{1}{4}$ Miles:

BRANCH FROM MUDDAPORE TO KURHURBALLEE
COLLIERIES: 23 $\frac{3}{4}$ Miles.

The surveys having been completed, Mr. Power, the Chief Engineer, came to England, and in concert with Mr. Rendel, drawings on which a contract could be based were prepared. As some brick arches on the main line had failed, apparently from an insufficiency of earth and ballast over the crown, but still evincing some general weakness in the stability of the brickwork of Bengal when exposed to the continuous wear and tear of heavy trains; it was determined that every opening, even culverts 4 ft. wide, should be covered with girders. Another alteration from the normal plan of the original main line was also made by laying out,

from the first, the railway for a double set of rails, experience having now proved that more traffic was ready to come upon the line than could be carried on a single track, while with that accommodation only, it seemed unlikely that a profit of more than 5 per cent. would be earned.

The system of unity of parts was also adopted to a very great extent, the spans for bridges being made either 28, 60, or 84 feet, which was the widest span used. The bank was formed with slopes of 2 to 1, the width at formation level on the main line being 28 ft., and at rail level 22 ft. For the colliery branch a single line was considered sufficient, the width at level of formation being 15 ft. 6 in., and at the rails 10 ft.

As the bridges are all composed of similar units, one description will apply equally to all. The foundations rest on wells, two for each pier, shod with iron curbs, which for bridges composed of spans of 28 or 60 ft., were 10 ft. in diameter; and for spans of 84 ft., were 12 ft. in diameter. A plan for strengthening the brickwork of the wells, similar to that which had been successfully made use of at the Soane, was adopted. Wrought-iron tie-rings, four to each well, being built in the brick sides of the wells at 10 ft. intervals, and being connected with the curb by wrought-iron rods $1\frac{1}{2}$ in. in diameter. This iron skeleton, so to speak, materially tended to strengthen the well and to make the mass firm and compact.

. The piers were also of brickwork, varying in thickness according to height and span. Exceptional cases being considered separately: piers of bridges of 28 ft. span are 3 ft. wide at top when the height above flood-level does not exceed 15 ft.; for spans of 60 ft., are 5 ft. when the height does not exceed 20 ft.; and for spans of 84 ft., are 6 ft. thick when the height does not exceed

30 ft. Below flood-level they are in each case to be 1 ft. thicker. The abutments are similar to the piers, but protected in front by a brick pitched embankment, with a slope of 1 to 1 in front, and of 2 to 1 on the sides.

The girders are of wrought-iron, for the largest span, on Warren's principle; for the others, of boiler-plate. The depth of the girders for the span of 84 ft. is 7 ft., that of the 60 ft., 4 ft. 6 in., and of the 28 ft., 2 ft. 6 in. The very best iron is used, and the strength is specified to be such that plates shall bear a tension of not less than 22 tons, and bar and other iron, 24 tons the square inch. Particular care was taken to ensure the accurate fitting of the holes and pins of the triangular girders, a point always requiring much attention; the rivet-holes being punched by gauge, and the pins being finished perfectly true and straight.

All cast-iron has been manufactured from a mixture of such strength, that test-bars 3 ft. 6 in. $\times$ 2 ft. 1 in., placed on knife-edge bearings 3 ft. apart, shall bear without bending a weight of 30 cwt. suspended in the middle. Cast-iron bowl-sleepers having on trial been proved a failure and expensive with the ballast obtainable near Raneegunge, wooden sleepers, 10 in. $\times$ 10 in. $\times$ 5 in., either of sāl, teak, iron-wood, or of creosoted fir timber, are to be used; all fir-wood being creosoted with the best creosote oil in such a way that each cubic foot of timber shall imbibe 10 lbs. of the oil. The line is to be laid with rails weighing 74 lbs. per yard, the maximum length of each rail being 24 ft. Fourteen stations are provided on the line, each having platforms 600 ft. long and 16 ft. wide, and for all joiners' work in them teak is to be used.

After leaving Seetarampore, there is a good deal of heavy bank and cutting for the first 10 miles; and for the next 20 miles the railway runs towards the north

on a ridge between the Barrakur and the Adjai; and then at the 37th mile descends to the Jynteah river. The branch to the Kurhurballee colliery leaves the main line at a place called Muddapore, and runs 23 miles in a nearly due westerly direction to the coal-fields; while the main railway continuing its former course, crosses the summit of the Vindhya Hills at the selected pass Narjungooby an uniformly ascending gradient of 1 in 100 for 5 miles, and then descends to the level of the valley of the Ganges, terminating in the loop main line on the east side of the Keeul river near the Luckee-Serai station. The largest works are the bridges over the Adjai, consisting of ten openings of 48 ft. span, with piers 24 ft. above level of bed of river, and with wells sunk about 50 ft. below it; and over the Jynteah and Pulnoo of eight spans of 84 ft. each; the piers being 35 ft. and 37 ft. respectively above the low-water level of the rivers, and the depth of the foundations about 23 ft., and 18 ft. below that line. The rivers Burwah and Oosriah were crossed by bridges of seven and six spans of 60 ft. each, while two others were of five spans, two more of four spans, and there were seven streams requiring bridges of three openings of 60 ft.; making a total of three bridges composed of 84 ft. spans, and fourteen of 60 ft. spans. There were also eight bridges 28 ft. in width, varying in length from four to two openings, and one viaduct of eight spans of 12 ft. each.

The works on the line were, it will be noticed, numerous, but not of an extraordinary character or presenting features of great or surprising difficulty; and the contractors, aided as they now will be by experience and by bands of workmen trained on the great works recently erected on the East Indian Railway main line, will no doubt with ease accomplish their task by the date named, *viz.* 1st January, 1870.

CHAPTER XI.

THE EASTERN BENGAL RAILWAY.

Communication with Burmah — Prejudices of Native Troops — Projected Road between Dacca and Akyāb — Views of Lord Dalhousie — Existing Road between Calcutta and Dacca — Great Delays and Difficulties on it — Reports by Lieutenant Greathed and Major Abercrombie — Railway from Calcutta towards Dacca, projected by Messrs. Fergusson and Peterson — Report by Mr. Purdon — His suggested Route to Khoostea — Recommendations by the Government of India — Contract arranged in England — Tender by Messrs. Brassey — Terminus at Sealdah — Rivers Koomar and Ishamuttee — Iron Piers sunk by the Pneumatic Process — Method of Sinking — Screw-piles — Extension to Goalundo.

Soon after Lord Dalhousie annexed Burmah to the empire of India, the question of the reliefs of Native troops became important, and was brought prominently to notice. Our power in India seemed at that time to rest upon the loyalty of our Native troops, and the custom, which had been for so long a time observed of yielding to their prejudices and wishes, was still in full force. The higher castes in the army shrank from the thought of crossing the "Black water," as they called the Bay of Bengal, as it would in their view be pollution; and they let it be clearly understood that they would not go to Burmah by sea, even if ordered, but that they had no objection to march by land wherever they were wanted. This willingness had been proved in the Affghan and other campaigns; but, a few regiments excepted who had enlisted for general service and had the name of volunteers, the great bulk of the Indian Native army of Bengal had entered the service with the understanding that they were to serve in Hindustan only; and it was feared, no doubt with good reason, that if the usual

periodical relief of troops in Burmah were attempted to be carried out by sea, a mutiny would be the result.

The Government of India, compelled on the one hand to permit the usual change of corps on foreign service to take place, and unwilling on the other to place themselves in hostility to the dictation of caste, which practically had for so many years been a ruling principle in the management of the large Native army of Bengal; determined to attempt to overcome the difficulties in their way, and to solve the dilemma, by constructing a good metalled road between Dacca and Akyāb. From Akyāb the communication with Prome on the Irrawady, could be obtained by means of inland navigation through creeks, as far as the islands bordering the coast would permit; and from thence by a road over intervening mountains, which was skilfully planned and executed by Lieutenant Forlong, the superintendent of the mountain road between Arracan and Pegu.

To inland navigation, when every evening they could land and cook, the Native troops were thoroughly accustomed in Bengal and on the Ganges; and to this they could raise no objections. Great sums of money were spent upon this road, and many valuable lives were lost in the unhealthy jungles of Chittagong and Arracan: but the traffic was so little, the difficulties in maintaining the road open and free from jungle so immense, and the entire system of Indian armies so revolutionized by the events of 1857, that it has been allowed to fall into decay; and no practical advantage has been secured from the outlay upon its original construction.

When, however, this road was commenced in 1852-53, Lord Dalhousie intended that it should be finished as speedily and efficiently as possible, so as to make it an easy and satisfactory trunk road for communication between Eastern Bengal and Burmah. It was natural

therefore that attention should also be directed at the same time to the improvement of the wretchedly dilatory and slow means of communication existing between Calcutta and Dacca. It was a marvel of delay and is even now but little better. The distance between Calcutta and Dacca on the direct line *viâ* Furreedpore is about 177 miles, which a mail runner could with difficulty traverse during the season of inundations in seventy hours. Lieutenant, now Lieut.-Colonel, W. Greathed, R.E., thus describes the method by which the mail was conveyed between these two cities in 1854-55. Increased facility and rapidity in the transport of mails is, he remarks, "a crying want; the time occupied at present during the inundations, being seventy hours between Calcutta and Dacca, giving an average speed (not susceptible of improvement) of $2\frac{1}{2}$ miles per hour; and this time is considerably exceeded at the commencement of the rains when the road is impassable, continuously, either on foot or in a boat, and perhaps twenty changes of mode of transit have to be made between the starting-point and destination. The passage of troops is by a process so slow as to be liable to cause most serious inconvenience to the State."

The question of an improved communication with Dacca and the Eastern districts in connection with the line of road which was being opened up beyond Dacca, through Chittagong to Akyāb, was taken up by the Government of Bengal in the early part of 1854; and Lieutenant Greathed, R.E., being deputed to examine the country, submitted his report upon the whole subject in 1855. He proved from satisfactory data that there was a vast amount of traffic between the Eastern districts of Bengal and Calcutta, carried on under extraordinary difficulties arising from the delay and dangers of the navigation of the Sunderbunds; and that there were

good reasons for believing that any means of considerably improving the safety and speed of transit of passengers and goods would hardly fail to be remunerative.

This improvement in the communication, which was so much desired, might be obtained in several ways: by a direct canal; by a road, more or less completely bridged, with steam-ferries over the Ganges and other large rivers; or by a railroad. The late Major Abercrombie, Bengal Engineers, to whom the report was submitted, advocated a fourth method; *viz.* that of improving the route for steamers, by opening a navigable channel from some point in the Hooghly near Calcutta, through the Sunderbunds to the great system of rivers on the eastern side of the Sunderbunds, called generally the Megna. By this means securing a direct and calm passage by steamer, as good as could be desired, between the metropolis and Dacca, Assam, and Sylhet.

The project of a direct canal between Calcutta and Dacca was not viewed with favour either by the senior officers of engineers at the Presidency, or by Government; and Lieut. Greathed had shown that the construction of an ordinary road would be most costly and difficult to maintain, even if unbridged to a great extent, while if bridged the expense would be excessive, and the result after all unremunerative. Such a road would cost nearly the same as a railway, the permanent way excepted. All authorities, however, concurred in thinking that a railroad striking the Ganges somewhere near the direct route to Dacca would intercept and receive a very great portion of the trade flowing to the capital from the Eastern and North-eastern provinces of Bengal, and that the passenger traffic on such a line would also certainly be large. Acting upon the information contained in these reports by Lieutenant Greathed and Major Abercrombie, two enterprising gentlemen resident in Cal-

cutta, Messrs. Fergusson and Peterson, put forward a prospectus of a company, dated March, 1855, to form railways throughout the delta of the Ganges; but particularly mentioning two lines, one from Calcutta *viâ* Barrackpore, to a place called Khoostea, on the Ganges opposite Pubnah; and the other branching off from some junction near the metropolis, and running *viâ* Jessore to Furreedpore, and from thence to Dacca.

This proposal met with the approval of both the Governments of India and Bengal, but being unsupported by any professional opinions, their approbation was expressed in general terms only, and further action on the project, and information regarding its details were awaited. This was in 1855, and in the course of the next year an engineer of standing and ability, Mr. Purdon, was employed by the promoters of the proposed company to make a careful survey and estimate of a railroad through the Ganges delta to Dacca. His reports of 1857 showed that the expense of making a line on the direct route would be very great, and the time requisite for its construction excessive; while the list of rivers to be bridged showed that he did not over-estimate the difficulties in the way.

There were fourteen large rivers requiring viaducts, one more than $2\frac{1}{2}$ miles in length, besides innumerable smaller streams of from 100 to 200 feet in breadth; while for 50 miles or so the line must have been carried through a district which during the rains becomes an inland sea. The adequate provision of waterway for the passage of this flood under the line when the rivers subside at the termination of the wet season would have been very difficult and inordinately costly. In the view of these obstacles, Mr. Purdon boldly proposed to turn them by passing to the northward, and carrying a line nearly parallel to the Matabangah river as far as

Khoostea, where the banks of the Ganges seemed somewhat more stable than usual, and where the stream was then contracted to a narrow and deep channel. Here he intended to construct a bridge over the Ganges; and the line then passing through a country difficult from rivers and inundations, but still much easier than that to be encountered on the direct line between Calcutta and Dacca, would reach the Jumoonah, the present main channel of the Burrampooter. Here a steam-ferry would be required, but onwards from the left bank of the Jumoonah to Dacca there were no works of engineering difficulty.

This project was laid before the Government of India in a lucid and comprehensive report by Mr. Purdon; his plan was received with favour, particularly by Sir John Peter Grant, who at that time, as Member of Council, had the special charge of the administration of public works carried on under the Supreme Government. As Sir J. P. Grant was expecting to be shortly appointed to be Lieutenant-Governor of Bengal, he took peculiar interest in the affairs of that Province, and thought that in Mr. Purdon's schemes he saw a means of increasing the material welfare of the people of Bengal, by laying down in this railway a main stem, from which branch lines of communication would eventually spring.

The Reports, on being sent to England, were supported by the recommendation of the Government of India, and the Court of Directors were willing to acquiesce in it; but at that time some of the inconveniences of the departmental system of construction were beginning to be felt in the East Indian Railway. It was therefore suggested that the English plan of contracting for the construction of the entire railway for a general lump-sum, based on a schedule of prices, should be adopted, in preference to that of letting the work in

small contracts, or to executing it directly by the engineers of the railway company themselves.

While the surveys in India were being prosecuted, under the superintendence of Mr. Purdon, as Chief Engineer; a company in London had become incorporated by an Act of Parliament, as the Eastern Bengal Railway Company; and had on the 30th July, 1858, entered into a contract with the Court of Directors of the East India Company for making and maintaining a railway from Calcutta to Khoostea on the Ganges, with an ultimate extension to Dacca. This agreement having been signed and settled, the Eastern Bengal Railway Company lost no time in arranging, under the guidance of Brunel, as their consulting engineer, for the construction of the line. A tender by Messrs. Brassey, Paxton, Wythes, and Co., based on certain general drawings and specifications prepared by Brunel, which were among the last works of that great engineer, was accepted; in which the contractors agreed to finish the line entirely, and supply a fixed amount of rolling stock for the sum of 1,045,000*l*.

This contract with Messrs. Brassey was dated 31st December, 1858, and simultaneously Mr. Purdon started for India to superintend the work there. The general direction of the railway was at once carefully considered and fixed, and the site for the terminus of the line at Khoostea was approved by Government, in February, 1859. The terminus at Calcutta was on the commanding position which Mr. Simms had originally proposed as the terminus for the East Indian Railway, had it been constructed on the left bank of the Hooghly. It is situated at the junction of Bow Bazar with the Circular Road, and has been built on a very large and comprehensive design. The area of land taken up is 141 acres, which is ample for any additional buildings which may become

necessary as the traffic of the line increases. But even as it now is, the terminal buildings are far larger and more commodious than those at Howrah. The two platforms are each above 1000 feet in length, and 27 feet in width. Between the arrival and departure lines there are six lines of railway, which give facilities for cleaning and storing the rolling stock of the company. The roof of the station is of wrought-iron, in three divisions, each 53 feet in span and 615 feet in length. The offices, for the working departments of the company are large, conveniently arranged, and complete, and are adjacent to the station itself; but the most remarkable feature of the terminus is the great waiting-hall, 200 feet long by 40 feet in width and height. This large hall has no windows, but is lighted and ventilated by a method which is believed to be original, by means of an arcaded clere-story forming an arched gallery. This arrangement, which seems to have been suggested by the designs* for the principal rooms of the palaces of Nineveh and Khorsabad, has been found to answer its intended purpose well; the galleries, by their own width, excluding glare, damp, and ordinary rain, while admitting light and air. The rain of excessively violent storms is excluded by mat screens.

The difficulty of making the terminus at Sealdah was very great; for encircling the city of Calcutta there are two large canals, always crowded with boats and barges, and it was essential that the line should pass over them at such a height as would not interfere with the navigation. To effect this, the entire area of the terminus had to be raised, and some large tanks filled in. There were peculiar obstacles in getting in the foundations of the main walls of the building in the treacherous and yielding soil of the large and deep

* Fergusson's 'Handbook of Architecture,' vol. i., pp. 170, 171.

water-tanks or ponds. In several places the bottoms of the walls are as much as 45 feet below the ground-floor level, and are from 8 to 10 feet thick. Water which was continually rushing in had to be kept down by means of steam-pumps; and in places where the earth was peculiarly bad, the sides of the excavations had to be retained by sheet piling while concrete was being thrown in. The foundations, indeed, were so deep and extensive, that the amount of brickwork buried beneath the surface exceeds in quantity that which appears above it. The railway is passed over the two branches of the canal by ordinary wrought-iron girder-bridges, one of 110 feet, the other of 90 feet opening; but there is nothing in their character requiring special remark.

The two great works on the railway are the large bridges over the rivers Koomar and Ishamuttee, which in construction and method of erection were identical; and one description, therefore, will equally apply to both. That over the Koomar consisted of twelve spans of 80 feet each, the wrought-iron girders being 8 feet deep, while that over the Ishamuttee required five similar spans. The abutments in either case are of brick, protected by long wing-walls, and the piers are formed by cast-iron cylinders sunk to a total depth of 75 feet beneath the intrados of the girder. During the rainy season the bridges give a headway of 16 feet; but during the cold weather the rivers are nearly dry—a peculiarity which gave great facilities to the contractors for the erection of the bridges.

The average depth of the bed of the rivers is 42 feet below the underside of the girders. The cylinders were sunk by Hughes's pneumatic principle, which in India was novel in its application, but proved to be well adapted for obtaining stable foundations in shifting sands. It is in nature the same as the brick wells sys-

tem of foundations so long known and largely used in Bengal, though improved in rapidity and efficiency by modern skill and appliances. The cylinders are in lengths of 6 feet: the lower portion of the pier being 7 feet in diameter, weighing 3 tons each length; the upper, 4 feet and weighing 2 tons, the varying diameters being united by a cone piece.

The method of sinking may be briefly described, as it is in India somewhat novel, and singularly rapid and efficacious: a staging being fixed across the bed of the river, the cylinders were put in place by a travelling-crane, and several lengths were securely bolted together and made air-tight, the lowermost length being provided with a knife edge. The cylinders are then loaded by a heavy weight of 30 tons, which force them down some few feet. A cylindrical apparatus, technically called a "bell," weighing 9 tons, is next fastened to the top of the cylinder, and air is pumped into the lower lengths until the atmosphere within becomes so compressed as to expel all the water from the lower lengths of the pier. Excavators then pass to the bottom through the bell; which is fitted with valves and trap-doors for the admission of workmen, or the passage of baskets of soil, and is worked exactly in the same way as an ordinary canal-lock, air, however, instead of water, being the fluid. The earth is removed from the inside of the cylinders by men, and is passed up in large buckets through the traps in the bell to the surface. As the earth is removed the heavily weighted cylinder rapidly sinks, sometimes as much as 1 foot in an hour.

The process is, it will be observed, just the same as that used in ordinary well-sinking in India, with the addition, that the inside of the pier is kept dry by the use of compressed air, the men working under a weight of atmosphere instead of under water. The method

requires the use of a costly and heavy plant, but is far more certain and quick than any other plan hitherto employed for obtaining foundations for bridges in the sandy soil of an alluvial district in India. When the piers have been sunk to the requisite depth the interior is filled with the best concrete, and the bell is then removed, and other piers are similarly sunk. All the piers are fitted with a cap-piece, and strongly secured by lateral cross-bracing. The work of sinking these piers was carried on with great expedition, and the whole time employed in the erection of the bridge at the Koomar was only one cold season of five-and-a-half months; the entire structure being completed without a delay or impediment. Although the Koomar is nearly dry for many months, yet in the rains there is an average flood-depth of 27 feet, with a strong current; and this method of cast-iron piers seems specially suited to rivers liable to sudden and fierce floods, as they present so little surface for the action of the water. The bridges have now been tested by time, and have proved themselves to be stable and safe.

The viaducts over the smaller streams, swamps, and inundated districts, are similar in principle with the large bridges, but of a modified design. The piers are formed of cast-iron cylindrical piles, which were not, however, sunk by the pneumatic process, but being fitted with a Mitchell's screw to their bottom length are screwed down by means of a cap and levers by manual power. When screwed as far as they will go, they are filled with concrete to the top and fitted with a cap, on which rests a wrought-iron girder. The only stream of any consequence was that called Echapore, which required a bridge of five spans of 30 feet each; but the swamps, or "bheels," were numerous, though presenting no features of difficulty calling for special

remark. The total aggregate length of viaduct on the line is 1 mile, all resting on screw piles. The bays are uniformly 16, 32, or 30 feet in width.

The only brick structures on the railway, besides stations and culverts, are six bridges of 30 feet span each, over the main roads near the Calcutta Canal, and one over a road to Jessore. All the works were pushed on with unremitting energy by Mr. Henfrey, the able agent of Messrs. Brassey, and the line was opened for traffic throughout in the month of November, 1862; the actual time expended in the construction of the railway being about three-and-a-half years, a rapidity which was both creditable to the contractors and satisfactory to the Government and shareholders.

At Khoostea a bridge over the Ganges had been proposed by Mr. Purdon, and had been estimated by Brunel to cost about half-a-million of money; and with this object the main line was at first directed to the point most favourable for its construction. Eventually, after further consideration, it was determined to establish the terminus at Khoostea, on a piece of hard and stable bank suitable for a town, leaving the junction to the future bridge, if ever erected, to be formed by a branch. This was in 1859, and the experience of the few years spent in the construction of the railroad showed that the decision was happy. In that brief time the Ganges completely shifted its deep channel, leaving Khoostea unapproachable by boats even, in consequence of the formation of a wide shoal in front of it, and cut out for itself a new course more nearly approaching Pubnah.

Under these altered circumstances, as the design of a bridge at Khoostea over the Ganges, as a deep and narrow river, was frustrated; a branch of about $2\frac{1}{2}$ miles in length to a deep reach of the Ganges, or rather the Goraie, was at first formed.

In 1865, however, it was determined to extend the line from Khoostea to Goalundo, situated at the junction of the rivers Ganges and Burmupooter or Jumoonah, a distance of 45 miles; and thus at once to avoid bridges or ferries over the Ganges and Jumoonah, and to intercept the traffic coming down those large rivers before their waters become dispersed into the numerous creeks called the Sunderbunds, so difficult and tedious for navigation.* The chief obstacle was the bridge over the Goraie, one of the rivers of the Ganges delta, over which a bridge had to be constructed on iron cylinders similar in principle to those over the Koomar and Ishamuttee.

The communication with Dacca, Naraingunge, Serajgunge, and Assam is maintained by steamers, some of them belonging to private companies, and some belonging to the Eastern Bengal Railway Company; and it is probable that this means of communication may be found the best adapted to the requirements of Eastern Bengal, intersected so largely as it is by navigable rivers and creeks; and that further extensions of the Eastern Bengal Railway in the direction of Dacca may not be necessary.

* In a 'Report on the Proposed Extensions of the Eastern Bengal Railway beyond the Ganges,' written by me in March, 1860, I suggested that this prolongation would be desirable. "Before passing on, it may just be mentioned that as a bridge across the Ganges must always be a gigantic work, and that as ferry-breaks in a railway communication are most objectionable, it appears to me that it ought to have been clearly ascertained that the obstacles existing between the present line of the Eastern Bengal Railway and the junction of the Ganges and Jumoonah were really insuperable, before what Mr. Purdon calls the northern route was finally chosen. Could a railway have been brought to that junction, the bridge across the Ganges would have been avoided, and on the through line to Naraingunge there would have been only one ferry. It may be that the difficulties in reaching this junction from Calcutta and Dacca are insurmountable; but it is not known they are so, and, judging merely from the map, it is not clear why they should be so considered."

CHAPTER XII.

CALCUTTA AND MUTLAH, OR SOUTH-EASTERN RAILWAY.

Wild Views of Original Projectors — Soon abandoned — Navigation of the Hooghly — New Town at Canning — The Mutlah — Peculiarities of the Line — Description of the Mutlah — Unhealthiness of the Settlement of Canning — Terminus at Calcutta — Bridge over the Piallee — A Difficult and Costly Work — Railway finished by the Close of 1862 — Abandonment of the Undertaking by the Directors of the Company.

THE promoters of the South-Eastern Railway when first forming a company, entertained large schemes of making railways through the Sunderbunds from Calcutta towards or to Chittagong; but these wild views were quickly abandoned, and the South-Eastern Railway Company, as it is now constituted, contemplated merely the construction of a short line of railway from Calcutta to a new port at Canning, on the Mutlah; and the improvement of the settlement itself by the construction of wet docks, &c.

The navigation of the Hooghly, on which Calcutta stands, is so long, tortuous, and dangerous, that some means either of improving the Hooghly itself or of forming some subsidiary port, had long been pressing upon the attention of the merchants of Calcutta; and the originators of the plan of making Canning on the Mutlah, answer for Calcutta, the position of a Blackwall for London, were so sanguine regarding the success of the scheme itself, that they thought that they would be able to imbue the general public with a like confidence. In this, however, they were disappointed, for after an unsuccessful attempt to obtain capital without a guarantee sufficient for all their objects, they were obliged

to apply for assistance. The Government of India did not view their projects with any favour, but the Secretary of State for India, after some negotiation, agreed to concede a guarantee of 5 per cent. upon the capital required to construct a railway between Calcutta and some point on the Mutlah, but declined to include in it any other portions of the general plans of the Directors.

The contract to this effect, with the usual conditions between the Secretary of State for India and the Calcutta and South-Eastern Railway Company, was signed on the 15th March, 1859, Lord Stanley being at that time the Secretary for India. The railway company determined to dispense with contractors, and to construct the line by means of their own engineers. The distance from Calcutta to Canning is about 30 miles, and the country is a dead flat, the only gradient requisite being necessary in order to obtain sufficient headway for bridges over a canal called Tolly's Nullah, and a tidal channel named the Piallee.

The Mutlah, though often called a river, is in truth an arm of the sea with no fresh-water stream of any consequence flowing into it, and it is therefore far less liable to change and shifting shoals than the Hooghly, which is a discharge mouth of the Ganges. On a certain reach of this estuary, which presented many facilities as a harbour for shipping, a settlement, to which the name of "Canning" has been given, was founded. It was a dreary spot, with its surface somewhat below the level of spring tides, without houses or inhabitants, and with bad, brackish water.

The climate also is extremely unhealthy, and the infant town has had to encounter these peculiar difficulties, as well as those which must always be experienced by a would-be port, without docks or slips, or any conveniences for the repair, loading, or victualling ships.

Still perseverance has already accomplished much; the commissioners of the town have expended 600,000*l.* upon improvements; and the future of the port may perhaps equal the bright hopes of its founders.

But if at Canning the railway company had to face many difficulties, at Calcutta itself the terminus was peculiarly good and convenient. Situated alongside the station of the Eastern Bengal Railway, with which it was connected by a branch, the terminus possessed the advantage of a central position for the traffic of Calcutta; while from the direction of the line, the high banks and filling-in necessary at the terminus of the Eastern Bengal Railway were not required for that of the Calcutta and Mutlah line.

The only work of importance on the line was the bridge over the Piallee, which gave far more trouble and cost much more than had been expected. It was a narrow, deep tidal creek with soil of a bad and treacherous character; but the difficulties in that respect were not greater than might have been anticipated. Labour was very hard to procure or retain; and some efforts to sink wells having been unsuccessfully made, the design was altered, and a bridge was built over an excavated channel into which the Piallee was subsequently to be diverted. Large pits were sunk, and after much delay the abutments were carried up and girders fixed; but the engineering labours were not even then brought nearly to a conclusion. The trouble encountered in filling up the old bed of the river was excessive, and the soft yielding soil seemed to swallow up all that was thrown into it, without any sensible effect for a long time being produced. As soon, however, as the bed was so far closed as to divert the main current into the new channel, the great slowness of the labour previously performed was to some extent com-

pensated for by a quick deposit of silt in the old river bed. Still, after all, the work was very tedious. A high bank of approach to the bridge over the new river Piallee had to be formed over the old one, and the subsidence of the embankment was extraordinary. Two or three times the cubic content, apparently necessary to fill the opening, had to be thrown in before the channel could be closed; and even after the bank had in appearance become solid, several subsidences of a dangerous character occurred. The line commenced in 1859, was opened for traffic throughout at the end of 1862, and communication between the ports has since been regularly maintained; but the receipts have been insufficient to cover the working expenses, and a further heavy loss has been incurred by the company from the subsidence of a jetty, which they had erected on the banks of the Mutlah for the convenience of shipping.

NOTE.—While this has been passing through the press, the directors of this railway company have determined to withdraw from the undertaking, and to hand it over to Government in accordance with the terms of their agreement.

CHAPTER XIII.

THE GREAT INDIAN PENINSULA RAILWAY—BOMBAY
AND ALLAHABAD.

Schemes of Projectors—Natural Difficulties—The Ghâts—Mr. Chapman—Old Tracks up the Bhoze and Thull Ghâts—Improved by the Duke of Wellington—Road up the Bhoze Ghât—Sir John Malcolm—Mr. Clarke—Malsej Ghât—Mr. James Berkeley—Malsej Ghât proved Impracticable—Hesitation of Lord Dalhousie—Further Surveys—Taptee Route—Report by Captain Crawford—Final Recommendations by Lord Dalhousie—Description of the Works—Bombay Terminus—The Thull Ghât—Branch to Nagpore—Godavery—Wangoor—Masonry badly built—Taptee—Nerbudha—Branch projected to Indore—Iron Mines—Jubbulpore—Country between Jubbulpore and East Indian Railway—Surveys—Jubbulpore the Junction for the East Indian and Great Indian Peninsula Railway Systems—Rivers Huron, Newar—Kymore Hills—Allahabad.

THE Great Indian Peninsula Railway was projected at a date as early as its contemporary the East Indian Railway, and in importance and political value it is its equal. If the latter connected the modern and ancient capitals of India, Calcutta, and Delhi, the former had for its object to join the seats of Government of the three Presidencies into which the British Indian Empire is divided. A committee for a railway company in Bombay was formed in 1844-45; and it was at first intended only to construct a railroad from the port towards the ghâts, and there to stop,—an idea so dwarfed as to be of little use, and it was soon abandoned; and in May, 1845, a letter was addressed by the committee to the Government of Bombay, intimating that the original association had merged into another having far more extended objects, *i. e.* the construction of the line which would be most advantageous to Western India. But the

difficulties in the way of making a railroad from Bombay towards either the north or south-west were great. The ghâts presented a barrier in both directions which seemed insurmountable under all ordinary economical conditions, and the project, though supported by the Bombay Chamber of Commerce and warmly received by the then Governor of Bombay, Sir George Arthur, did not obtain much encouragement from the Government of India.

In the same year, however, in October, 1845, Mr. John Chapman, as manager of the Great Indian Peninsula Railway Company, reached Bombay, accompanied by Mr. Clarke, a civil engineer, who had been for a long time connected with the Great Western Railway in England; and they at once commenced an examination of the country, with the view of designing a railroad from Bombay to Nagpore. Shortly after the Provisional Committee of the railway company applied for a site for a goods terminus between the Apollo pier and Arthur Bundur, with a passenger-station near the entrance of the fort known as Church Gate. The committee proposed also to carry the railway along the verge of the esplanade. This proposition regarding a terminus was strongly objected to by the local engineer and marine authorities, and was laid aside. Colonel Jervis, the Chief Engineer in Bombay, suggested that the railway company should be allowed the privilege of reclaiming land along the shallow sea-beach on the eastern shore of Back Bay, and should form their terminus there instead of on the site proposed. In the meanwhile, Mr. Clarke prosecuted his explorations of the ghâts.

To enable the reader to understand the obstacles which this range of precipices presented, it must be remembered that they run parallel to the sea, at a dis-

tance of about 30 miles from the coast, without any break or pass, with an average height of crest above the sea of 2000 feet. These cliffs are the retaining-wall (so to speak) of the Deccan; and by them, at one step, is the descent from the elevated high-land of Central India to the plain called the Concan, which is only slightly raised above the sea-level. From time immemorial droves of pack-bullocks had struggled with the utmost difficulty and delay by two tracks, barely passable even for animals, from Central India to Bombay, carrying sacks of grain and other things, in which a small and uncertain trade was maintained between the two districts. The track which led towards Agra and Calcutta was known as the Thull Ghât, and that towards Poonah and Madras as the Bhore Ghât.

Up the Thull Ghât, a good metalled road, which is mentioned by Mr. J. Berkeley, the Chief Engineer of the Great Indian Peninsula Railway, as "a masterpiece of engineering," had been formed under the orders of the Government of Bombay some few years before the railway era; and by it the mail from Bombay to Calcutta was conveyed on mail-carts. The old Bhore Ghât road was not so good; and its wretched condition attracted the attention of the Duke of Wellington so far back as the beginning of this century, who caused a road practicable for artillery to be made from the foot of the ghât to Poonah. This was, however, comparatively a small improvement on the old path, and the road was still barely passable for wheel carriages.* Subsequently, in 1830, Sir John Malcolm opened the Bhore Ghât road for cart traffic, and recorded a Minute replete with encomium and satisfaction at the finished work.

* Speech by Sir Bartle Frere on the occasion of the opening of the Bhore Ghât.

“On the 10th November,” he says, “I opened the Bhore Ghât, which, though not quite completed, was sufficiently advanced to enable me to drive down with a number of gentlemen in several carriages. The height of the mountain is nearly 2000 feet, and the length of the road is $3\frac{1}{4}$ miles. It is impossible for me to give a correct idea of this splendid work, which may be said to break down the wall between the Concan and Deccan. It will give facility to commerce, is the greatest of conveniences for troops and travellers, and lessens the expense of European and other articles to all who reside in the Deccan. This ghât will besides prove a positive creation of revenue, for I am satisfied, from the decrease of hamallage, and the offers already made to farm the duties, that the first year will produce twenty thousand rupees, and that the ordinary revenue will hereafter rise to more than thirty thousand; while on any military operations occurring in a quarter which required the troops in the Deccan to move, the outlay would be paid in a twelvemonth by the cheap transmission of stores. That Government have had such a return for the lac of rupees expended on this work is chiefly to be ascribed to the enterprise, skill, and unwearied industry of the contractor, Capt. Hughes, who, in his desire to do credit to himself, will be found, I believe, when the completion of the work is reported (which it will be before the 1st of January) to have done more, particularly in the breadth of the road, than the terms of the contract made obligatory. He has built, at his own cost, a small but neat lodge at the gateway, where the duties are to be levied, and on this he has inscribed on a small marble slab the year in which the work was made. I wish him to be instructed to place another beneath it, with an inscription stating that this ghaut was constructed by Capt. Hughes, and was opened on the 12th

November, 1830. I shall not anticipate the approbation Government may give Capt. Hughes when the completion of the work is reported and is examined, or the consideration they may have for any useful work he may have done beyond the terms of his contract. This respectable gentleman will, I imagine, bring no claims upon the Government. He is very sensible to the favour and indulgence with which he has been treated in being aided with a detachment of pioneers for a few months; but he merits the most liberal encouragement, for he has not only executed in a superior manner a work of great importance, but has set an example which, if followed, will be attended with all the beneficial results that must attend the establishment of contracts for such public works to all who reside in the Deccan."

The work, however, which was thus highly eulogized, was at its best merely a mountain road, ankle-deep in dust in the hot season, and a mass of mud in the monsoon, with frequent interruptions by torrents, which cutting through the track rendered it dangerous and hardly passable from boulders and masses of rock. Mr. Berkeley differing much from Sir John Malcolm, describes the Bhore Ghât road as steep, tortuous, ill-made, and less skilfully constructed than the Thull Ghât road.

It is not surprising then, that Mr. Clarke, on surveying these roads, was daunted by their character. In 1847 he pronounced the Thull Ghât to be unfitted for railway purposes, and that "it was in a very high degree improbable that any practicable line into the Deccan should exist between Mowhe and the Thull Ghât and the Deccan." His opinion of the Bhore Ghât was not more favourable, for though admitting that there were facilities for reaching a certain height on the cliffs by a spur which projected into the plains, "yet the ground above, a part of which is traversed by the present road, is for six or

seven miles almost, if not quite, impracticable." Deterred therefore by these obstacles, Mr. Clarke thought that it would be better to make one railroad only, up the ghâts, and then, having reached the summit of the table land, to direct from thence one branch towards Calcutta and another towards Madras. By this means he hoped to concentrate his difficulties and to have one set of inclines, requiring the aid of a stationary engine to work them.

With this object he selected the Malsej Ghât, about midway between the Thull and Bhore roads, and completed a survey and section of a line up it. The height of the Malsej Ghât was rather greater than that of the Bhore and Thull, the Malsej being 2062 feet above the sea, the Bhore 2037, and the Thull 1912; and the survey of it though not complete or satisfactory was accepted by the railway company and proposed to Government; who, without subjecting the scheme to any severe test or examination, agreed to the general project, and incorporated it in the contract entered into by them with the railway company on the 17th August, 1849, for the purpose of constructing a railroad from Bombay to or near to Callian, with the view of an extension thereof to the Malsej Ghât. This Malsej Ghât project involved an incline of six miles, with a gradient of 1 in 18, up which traffic was to be worked by stationary power, and beyond this a severe locomotive ascent for 20 miles further, with a maximum gradient of 1 in 113.

In 1850, Mr. James Berkeley was appointed Chief Engineer of the Great Indian Peninsula Railway Company, and in the early part of 1851 he examined and studied carefully the proposed Malsej Ghât Railway ascent, and was soon convinced that the difficulties in the way of making a railroad there were almost insuperable. The more careful and deliberate surveys now made discovered some errors in the sections first prepared,

amounting in the aggregate to 164 feet of vertical height, which of course seriously affected the gradient of the incline; and the estimates prepared indicated that the actual cost of the works would far exceed the calculations originally made. One item alone, that of tunnelling, was considered now to be under-estimated by 384,000*l.*, while a more serious drawback even than the expense was the excessive time which their execution demanded. It was thought that the piercing one of the tunnels would take seventeen years to complete, during which period the traffic above and below the ghâts would be of course broken. Under these circumstances it was agreed on all hands, both by Government and the railway company, that the Malsej Ghât project had been too hastily accepted and must be abandoned.

Mr. Berkeley having arrived at this conclusion, again in 1851 carefully inspected the whole of the district, and recommended a detailed survey of the Bhore and Thull ghâts, as the points most likely both to present facilities for obtaining a favourable incline for railroads, and to suit the directions in which the lines of imperial importance towards Calcutta and Madras could best be traced. Accordingly in 1852 inclines up the Bhore and Thull ghâts were laid out, and at the end of that season's operations Mr. Berkeley submitted his designs with a confident assurance that he had selected the best practicable routes up the ghâts for railroads; but at the same time believing that further study would enable him to mitigate the most objectionable features of both inclines, and to trace eventually a line up both ghâts, with a gradient suitable for locomotives.

Just at this time the whole question of railroads in India was referred for the decision of Lord Dalhousie, together with Col. Kennedy's startling paper condemning the extravagance of English engineers, and particularly

denouncing as preposterous the idea of carrying traffic up the ghâts.

Col. Kennedy, it will be remembered, proposed as an alternative, a line along the coast to Surat, then by the rivers Taptee and Godavery to the eastern shore of India, and thus parallel to the coast to Madras. This proposal to construct a railroad near the Godavery and along the Madras coast, having been rejected by Lord Dalhousie in his Minute of 20th April, 1853, he acquiesced in the design that the railroad from Bombay towards Madras should mount the ghâts: but he directed a thorough examination of the Syhadree range towards the south-west to be undertaken, so as to prove conclusively that no better or more practicable route than that of the Bhore Ghât was obtainable. He wisely hesitated permanently to burden communications between Bombay and Madras with such an objectionable feature as an ascent of 15 miles with an average gradient of 1 in 48, although unwilling to forego the advantages of railroad intercommunication, if the physical character of the country rendered it imperative to have such an incline.

Similar reasonings made him recommend that the Thull Ghât scheme should not be sanctioned, either as part of a local project to join Bombay with Candeish, or as an integral portion of a trunk line between Bombay and Calcutta, before proof by actual survey was submitted that the Taptee line was undesirable, and that, if the ghâts must be surmounted, and not turned, no better route than that by the Thull Ghât could be obtained. In accordance with this opinion accurate surveys of various ghâts, both towards the north and south were ordered and were undertaken by Mr. Berkeley, and of the river-route by Col. Kennedy; so that on the submission of authoritative reports on both proposals, the Government of India might be in a posi-

tion to determine which route would be the most profitable and valuable to the general interests of the empire. The surveys were not to be confined merely to the localities about which mainly there was dispute, but were also to comprise the extensions contemplated to Agra by Col. Kennedy, and to Allahabad by Mr. Berkeley.

These instructions were issued to the Directors of the Great Indian Peninsula and Barodah Railway Companies by the Hon. Court of Directors of the East India Company, on the 10th August, 1853. On receipt of these orders active measure were at once taken in India to prosecute the necessary surveys, and Col. Kennedy was the first to lay the result of his explorations before the authorities in Bombay. In the meanwhile Capt. Crawford, Bombay Engineers, the Consulting Engineer to the Government of Bombay, was directed personally to examine the routes respectively advocated, so as to be in a position to advise definitely upon the subjects under consideration, as soon as the projects in a complete shape were submitted. In May, 1854, he forwarded his opinion upon Col. Kennedy's survey and proposals, which were twofold in object.

The first was a grand trunk line from Bombay to Agra in the North-western Provinces, with two alternative routes, both having one length, that between Bombay, Barodah, and Ahmadabad, in common. From Barodah the two routes suggested for choice were, one through Ahmadabad, Deesa, and Ajmere, to Agra; the other through Neemuch, Chittore, and Tonk, to Agra, with a branch from Barodah to Ahmadabad.

Captain Crawford at once admitted, if the idea of having a railway communication between Bombay and the North-western Provinces be entertained, that the first portion of the scheme, *viz.* that of a railway between Bombay and Barodah, was determined by the geo-

graphical features of the country ; as the ocean on the one hand, and the Syhadree range of mountains on the other made the direction proposed compulsory. But he felt unable to give any opinion upon the suggested extensions to Agra until surveys of the two routes named by Colonel Kennedy were made and examined, and until he had had an opportunity of comparing them with the projects of the Great Indian Peninsula Railway which were under preparation. The line by Deesa and Ajmere was, moreover, so far removed from competition with any route which the Great Indian Peninsula could propose, and passed through so distant and distinct a tract of country, that the idea must, on the surveys being ready, be decided on its merits *per se*. The second great object which Colonel Kennedy had in view and on which he seemed to lay more stress than on the first, was the proposal to construct from the Bombay and Barodah Railroad a branch up the river Taptee to the valley of the Nerbudha, and so onwards to Allahabad to join the East Indian Railway.

This design was antagonistic to that of the Thull Ghât by the Great Indian Peninsula Railway, and as the surveys of both had reached a common point called Julgaon, a town 10 miles distant from Malligaum, near the Taptee, a comparison between the two plans was drawn by Captain Crawford ; but mention of his views can be more conveniently made when the whole subject was subsequently laid before Government on the completion of the Great Indian Peninsula surveys of the Nerbudha valley.

Confining attention therefore for the present to the main scheme, a very few sentences will record its history. Colonel Kennedy had himself reported that it was an open question how the extension from Barodah towards

the North-western Provinces ought to be carried; and Captain Crawford, noticing that the section by Neemuch contained such objectionable features as two tunnels each of about $2\frac{1}{2}$ miles in length, and an incline of 1 in 120 on an aggregate length of 10 miles, had reserved his opinion altogether, until the alternative routes had been surveyed.

Lord Elphinstone, the Governor of Bombay, jumping at the conclusion that the Governor-General had in his first Minute authoritatively stated that the Thull Ghât route, as part of a trunk line towards Calcutta could not be entertained, thought that one of the proposed routes must eventually be adopted.

The question was then referred to Lord Dalhousie, who, considering the information submitted less full and accurate than desirable, declined to give any opinion upon the projected extensions, or upon the Thull Ghât dispute; but gave his sanction to the immediate construction of the line between Bombay, Barodah, and Ahmadabad, as he was satisfied, by the concurrent opinions of the members of the Bombay Government, and its consulting engineers, with its eligibility as a trunk line to connect Bombay and Bengal. Mr. (now Sir J. P.) Grant thought that the Government of India, in authorizing the construction of a railroad from Bombay to Ahmadabad, on the grounds of its local value and utility in connecting the very fertile province of Guzerat with the port of its Presidency, should not commit itself to any ulterior project, inasmuch as the extensions would bring the junction with the East Indian Railway too far to the westward to be convenient for Calcutta; and he was besides impressed with the great political and military objects which a line by the Nerbudha valley would attain. He believed that when the surveys were completed and the information neces-

sary to the solution of the question submitted, that the cheapest, the most useful, and commercially the most profitable, junction-line between Bombay and the Ganges valley line would be a road *viâ* the Nerbudha to Allaha-bad or Mirzapore.

On reconsideration the Governor-General withdrew his proposal to authorize the Bombay and Barodah line as a first section of an intended line of railway from the Western coast of India to the North-western Provinces, and simply sanctioned its construction generally. He, at the same time, stated that as far as explorations had hitherto gone, he was inclined to think both the suggested Neemuch and Dessa extensions objectionable, and recommended an immediate and close survey of the Nerbudha line. The field was thus left open for the engineers of the Great Indian Peninsula Railway who, during the interval, were prosecuting with care and industry their surveys of the Thull Ghât, and of the line by the Nerbudha; and in October, 1854, Mr. Berkeley was able to lay the entire survey before the Directors and the Government.

The spot at which the rival lines would converge was Julgaon on the Taptee, in Candeish, and the comparison had to be drawn between their respective advantages from Bombay to that point, as beyond it, the same direction would be followed by either line. The Great Indian Peninsula Railway had some time previously been opened for a short distance from Bombay to a point called Callian, and as it had been decided that this portion of railway must be common to any line entering the island of Bombay, the distances and calculations were based on this assumption.

Mr. Berkeley's surveys proved that the adoption of the river Taptee route would require 131 miles of additional railway, and would cost 1,098,000*l.* more to

execute, estimating the Taptee and Ghât lines to cost 7337*l.* per mile, and allowing the extra cost of a complete double line upon the ghât.

There would of course also be savings in time and in working expenses by the shorter Ghât route, which were estimated at about five hours for passengers, and between seven and eight for goods, and for working expenses, at 43,400*l.* per annum less on the ghât, than on the Taptee line. This increased cost on the capital, outlay, and permanent expense of working the Taptee line diminishing likewise the probability of a satisfactory profit.

In addition to the saving in length and cost of the ghât project, Captain Crawford had previously demonstrated, that notwithstanding an execrable road, all the traffic from the interior followed, at present, the Thull Ghât road instead of that by the Taptee; and that the proposed line by the ghât would therefore be in the direction of the existing trade—no slight advantage; that the ghât line would benefit a larger extent of population and would pass through more important towns; and that though both tracts were unhealthy, yet that the jungles on the Taptee were known to be pre-eminently deadly. Capt. Crawford, indeed, laid so much stress upon this fact, as to think that it would not be possible, within a reasonable time and at any reasonable cost, to construct the large works that a railway would demand, in such an awful climate as that through which a line by the Taptee must pass. Mr. Berkeley too, though not participating so fully in these fears, thought that at least two years more would be needed for construction of a railroad on that line than on the Thull Ghât route.

Lord Elphinstone, adopting partly Col. Kennedy's recommendations, combated these views, but his arguments were not conclusive; and his advice that a guarantee

should be given both to the line *viâ* Thull Ghât and to that by Taptee, as far as Julgaon; and to the further extensions of both companies jointly, or to the one which shall first reach Julgaon; was emphatically condemned by the Consulting Engineer to the Government of India, and by Lord Dalhousie.

"On no account," writes Col. Baker, "should Government guarantee, should scarcely even permit, competing lines;" and Lord Dalhousie is no less decided. "I am altogether unable," he says in a Minute dated 18th July, 1855, "to concur in the opinion of the Governor of Bombay, that a guarantee might safely be given to both of the lines which are competing for the communication between Candeish and the coast. Unnecessary and multiplied competition between railway companies has been the bane of that class of enterprise in our own country. The supposed advantage of railway competition to the public, whom it seems to serve, has long been perceived to be an utter delusion. I trust that the Government of India will take timely warning, and will not only lend no countenance to the so-called competition of railway companies in this country, but will steadily discourage it, looking to secure the interests of the public by other and more reliable means."

In the same Minute Lord Dalhousie withdrew his objections to the ghât route, and frankly acknowledged himself converted to the scheme, as the one giving the best means of connecting Candeish with Bombay. He also thought that the projected line from Bhosawul through the provinces of Berar and Nagpore, both cotton-producing districts, should be constructed; as it would afford the shortest, the most direct, and the best line of conveyance for this most important staple to the great and established port of Bombay. But as a great trunk line, he still considered the Thull Ghât route objectionable: and with

much earnestness and force urged the exceeding importance of a direct line from Bombay to Agra or Delhi in a political and military point of view. He thus expresses his decided opinion, "That if a line can be found from Barodah to Agra or Delhi, which is practically feasible, it ought to be constructed, even though it be very costly in construction, or commercially unpromising in itself; for I am well convinced that the benefits which the State and the public would derive from its construction would be such as ought to render the Honourable Court content to pay a considerable portion of the guaranteed interest, if it should be requisite, in the first instance." Feeling, too (in July, 1855), that this was the last occasion on which it would be his duty to offer his advice officially upon this subject, he felt himself impelled to urge the value of this direct line in the strongest terms upon the attention of the Honourable Court.

These opinions were recorded in 1855, but the sanction of the Court of Directors to the Thull Ghât line was not given till the 31st January, 1856. A conclusion was thus at last obtained from these long investigations caused by Lord Dalhousie's natural and judicious hesitation, to allow such an incline as the Thull Ghât upon the main railway communication between Bengal and Bombay, until it was satisfactorily proved that such a drawback was unavoidable. As soon, however, as it was shown to be possible so far to improve these gradients and curves as to make it a safe and practicable line for locomotives, many of the objections to the route were at once removed; for as nearly all the heavy goods traffic would naturally come from the Deccan to Bombay, the fall on the ghât, and on the long incline of 1 in 100 for eighteen miles, between its foot and Wasindree, would expedite rather than delay the conveyance of goods in that direction. Passenger-trains would as easily surmount

the ghât incline as they had ascended short similar gradients in England.

Proceeding now to a particular description of the works upon the Great Indian Peninsula Railway, the contrast between the physical difficulties which engineers had to encounter on the western coast of India, and those met with in the eastern and northern tracts on the East Indian Railway, at once strikes attention. It is no longer a question of the time required to make bricks; for admirable building stone in abundance, suited for every purpose, is found everywhere. The difficulties in sinking foundations in sand of great or unknown depth have not here to be struggled against; as good rock foundation is as a rule everywhere to be found. There are here no bridges of extraordinary length or of great span; but attention is rather concentrated on the clusters of laborious works, massed on the barren scarp of a mountain precipice; tasking the resources at once of the highest class of engineering skill, and of administrative talent needed to retain and feed the labour required for their execution.

The method adopted for the construction of the railway differed too from those pursued in Bengal or Madras. A system of large contracts, given usually to some English firm of wealth and respectability, was employed in Bombay; instead of the plan of small contracts or of departmental execution of work which had found favour in the other Presidencies. Experience has proved that the Bombay system, though not satisfactory as regards the character of the work done, certainly possessed the advantage of giving great facilities for the smooth working of the supervision required by the guarantee.

BOMBAY TO CALLIAN: 33 Miles.

The terminus of the Great Indian Peninsula Railway Company is on the eastern side of the island of Bombay, and is conveniently situated on the harbour, a little to the north of Fort George, near a spot called Boree Bunder. The terminus trenches on the extreme northern portion of the esplanade, and having a good quay frontage, the line has the advantage of bringing goods straight to the point of shipment. The area of the terminus* is only 19 acres, which is very small (the Calcutta terminus of the Eastern Bengal Railway contains 141 acres), and situated as it is on the esplanade of the fort, the site is deemed a temporary one, and all the buildings are of that character also. The line is made on the quay parallel and close to the sea, and the various buildings and sheds are placed behind it.

From the terminus the railway runs in nearly a straight line between the city and the harbour by Chinch Bundur for about a mile till opposite Belvidere and Mazagaon, when it turns gently towards the west to Bycullah near the race-course. At Bycullah, two miles from the terminus, are the workshops of the company, brass and iron foundries, locomotive erecting and fitting shops, warehouses, offices, and dwelling-houses for engine-drivers and European workmen. The area covered at Bycullah with the works of the railway is $18\frac{3}{4}$ acres. Beyond Bycullah the railway is joined to the Bombay and Barodah Railway by a short junction line, and then passes through the centre of the island of Bombay, past Parell, to Sion, at the extreme north-eastern point of the island; a small branch $1\frac{1}{2}$ mile in length being taken to Mahim at its western extremity, which formerly

* A site for a permanent terminus, 108 acres in extent, on land reclaimed from the sea by the Elphinstone Land Company, has been lately promised to the Great Indian Peninsula, and 52 acres have been already made over to them.

was a place of more importance than Bombay itself. When in 1664 the island of Bombay was ceded to Great Britain by Portugal, nearly the whole population of the island, which was then estimated at 10,000 persons only, dwelt near Mahim; and though still thought of sufficient consequence to claim a railway for itself, yet Mahim has waned before the rising prosperity of Colaba, Fort George, and the city near it known as Bombay, all lying at the southern end of the island of that name.

From Sion the railway crosses a wide marsh by an embankment to the island of Salsette, to the eastern side of which it clings closely as far as Tannah, which is $22\frac{1}{4}$ miles from Bombay. At Tannah the line crosses an estuary to the mainland of India, and keeping to a direction nearly north-west, is taken to Callian, the end of the first section of the railway.

The works on this section are of no great moment; though in the city of Bombay itself there are some expensive bridges carrying the traffic of the most frequented thoroughfares. Through the Sion marsh there was a troublesome and rather costly embankment, and over the arm of the sea at Tannah two viaducts were made, consisting for the most part of masonry arches of 30 feet span, of the respective lengths of 111 and 193 yards. This viaduct had a headway of 30 feet above high-water mark, and the deepest portion of the channel was spanned with a wrought-iron plate box girder, 84 feet in length. Beyond this, in the Concan on the mainland there are two tunnels, one of 103 and the other of 115 yards.

From Bombay to Callian a double line of rails is laid. The gradients were much steeper than those which had been used in the northern portions of India; and as soon as the Concan, which was a rough district much intersected with ravines, was reached, 1 in 150 had to be employed, but that was the steepest gradient on

the section. The whole work was let out in contracts, and the contractors executed their work satisfactorily. The first sod was turned on the 31st October, 1850, but Messrs. Faviell and Fowler did not commence till February, 1851. The line from Bombay to Tannah, with the branch to Mahim, $22\frac{1}{4}$ miles in length, was opened on the 18th April, 1853, and from Tannah to Callian, $12\frac{3}{4}$ miles more, on the 1st May, 1854.

CALLIAN TO EGUTPOORAH: $51\frac{1}{2}$ Miles.

THE THULL GHÂT INCLINE: $9\frac{1}{2}$ „

Before Lord Dalhousie wrote his celebrated Minute on Indian Railways, the Hon. Court of Directors, on receiving the reports of Mr. Berkeley and the recommendations of the Bombay Government of 1852, had sanctioned an extension of 18 miles in length in the direction of the Thull Ghât, from Callian to Shahpore. A legal agreement was entered into to that effect on 2nd August, 1853, but this small concession was soon merged in the great project for Indian railways, and lost sight of. The great point for determination was whether or not the railway should mount the Syhadree mountains at all, and if so, whether the ascent should be at the Thull Ghât. The conclusive proofs of the advisability of adopting the ghât line advanced by Mr. Berkeley and Capt. Crawford have already been explained, and it now only remains to state the reasons for selecting the Thull in preference to any other ascent.

The northern Concan by which the Thull Ghât is approached is covered with thick jungle and is extremely rugged and cut up by watercourses; but happily for the success of the enterprise, a spur from the Syhadree range of mountains extends for 30 miles westward towards Bombay: and on this, by means of careful study, Mr. Berkeley was enabled to lay out a line, which by a

long ascent and steep but fairly workable gradient, mounted at Kussarah to a height of 1040 feet above the sea, leaving 972 feet only to be dealt with at the actual ghât—the difference of level between Callian and Kussarah being 849 feet. This ridge divides the river Basta on the south from the Wyturnee on the north, and on its southern flank the line has been constructed.

Many difficulties in doing so had to be encountered; rocks projected, requiring 520,493 cubic yards of rock cutting; and ravines, over which four viaducts had to be erected, continually interrupted progress:—the two longest were respectively 124 and 143 yards in length, the gorges being so deep as to compel a height of 127 and 122 feet respectively. Besides the viaducts there were forty-four bridges of 30 feet span and under, and 117 culverts, and the earth in bank amounted to 1,353,317 cubic yards. By means of these heavy works Mr. Berkeley succeeded in obtaining a line with gradients of the ordinary average for the greater portion of the distance, but for $21\frac{3}{4}$ miles was obliged to adopt a gradient of 1 in 100, rising for $18\frac{3}{4}$ miles, and falling for 3 miles.

At Kussarah commences the Thull Ghât incline, which has been admirably described by the late Mr. Berkeley, from whose detailed paper the following abbreviated account is compiled.

The Thull Ghât incline begins to rise from the Rotundah nullah,* which it crosses with a viaduct 66 yards long and 90 feet in height; then passes through a rock, by a tunnel of 130 yards in length, and reaches the Manda Sheyt nullahs; which are spanned by two viaducts, one 143 yards long and 84 feet high, and the other 66 yards long and 87 feet in height. Close to the torrent called Manda Sheyt are two tunnels of

* Stream or torrent.

that name, one of 490 yards in length, and the other of 80 yards. This brings the line in a distance of about $3\frac{1}{2}$ miles to Kussarah; where by means of a double track at an acute angle, called a reversing station, a sharp curve is avoided, the direction of the line altered; and the railway is taken through a low pass in the mountain ridge at the Massobah Khind, to the northern flank of the great spur, on the Wyturnee side of the hill.

Beyond Kussarah, at about the 4th mile, it was necessary to make three tunnels round the bluff near Massobah, of 235, 113, and 123 yards respectively, and one viaduct of 66 yards in length and 90 feet in height. Between the 5th and 6th mile the most formidable works on the whole incline were encountered; consisting of a viaduct over the Ehegaum nullah of 250 yards in length and no less than 200 feet in height, and four tunnels of 490, 412, 70, and 50 yards respectively. These being passed, at about the 7th mile the Beemah nullah was reached, along the left bank of which the railway laboriously climbed to the summit of the pass; requiring between the 7th and 9th mile the construction of a viaduct 150 yards long and 60 feet in height, and three long tunnels of 261, 140, and 58 yards. Besides the above-named viaducts there are fifteen bridges of various spans, from 7 to 30 feet, and 62 culverts.

The total quantity of cutting, which is mainly through rocky ground, is 1,241,000 cubic yards; and the amount of embankment is 1,245,000 cubic yards.

The total length of the incline is 9 miles 26 chains, of which 3 miles 27 chains are straight, and 5 miles 79 chains curved.

The sharpest curves are one of 17 chains radius for a length of 33 chains, and another of 20 chains radius for 47 chains in length. The curves of 20 and 50 chains radius are 4 miles 31 chains in length, and those between

50 and 100 chains radius are 48 chains in length. The steepest gradient is 1 in 37 for 4 miles 29 chains, and 1 in 45 for 13 chains; and the remainder are between 1 in 50 and 1 in 148: the distance level being in the aggregate only 46 chains.

The Manda Sheyt tunnel, 490 yards in length, had to be pierced through basalt of the very hardest kind, requiring the use of steel drills, and progress was so slow that two shafts had to be sunk at much cost to expedite the work. The Ehegaum tunnel, also 490 yards in length, did not present nearly so much difficulty; the drift advanced rapidly, and the entire tunnel was finished without a shaft. All the viaducts are of masonry except that over the Ehegaum nullah, which is crossed by three spans of triangular iron girders on Warren's principle, with semicircular arches of 40 feet at either end. The raising of these large girders to a height of 200 feet was a work of difficulty, requiring care and skill, but it was accomplished without accident. The direct incline as constructed was commenced in February, 1858, but the contract for it had been let in the previous August to Messrs. Wythes and Jackson. The Thull Ghât itself was opened for traffic in 1865, but the incline from Shahpoor to Kussarah on the 22nd January, 1861.

Before passing on to the sections beyond the ghâts, a brief account of the alternative lines proposed for their ascent which were surveyed by Mr. Berkeley must be given. The choice presented to the engineer was not great. Between the Malsej and Thull Ghâts the precipice itself was most forbidding and abrupt, and the approaches, both below in the Concan and above in the Deccan, difficult in the extreme. Baffled here, a survey of a ghât to the north of the Thull, called the Sheer Ghât, was made; but the summit was found to be 92 feet higher than the Thull, and requiring the use

of a gradient of 1 in 26. This idea being therefore abandoned, an attempt to find a better ascent than the Thull was made by laying out a line from the Mussobah Khind across the Wyturnee river, and so up the opposite side of the hill. This incline was named the "Dawan-dee," and though presenting perhaps some advantages in gradients, yet it was rejected, as the viaduct over the Wyturnee, 320 yards in length and 200 feet in height, and the works adjacent, would be immense and costly, and because the steep part of the ascent would be longer than that on the Thull. The engineers were thus obliged to fall back on the Thull Ghât, but in staking out the incline (1857) the idea of making a "*corkscrew*"* line suggested itself; the works being heavier and more expensive, and the curves rather worse, but with a gradient flattened to 1 in 60 in lieu of 1 in 37.

This project, though not recommended by Mr. Berkeley, found favour with the Government, and the question was referred to Mr. Stephenson, who, after full consideration, recommended the adoption of the direct incline, as it has been actually made.

EGUTPOORAH TO MUNMAR: 77 Miles.

Beyond the Thull Ghât, in the plain at the head of the Godavery, no engineering difficulty of any moment presented itself; but information regarding the section is very sparse and meagre.

In the first design, submitted in 1852, a tunnel 387 yards long was proposed near Egutpoorah; but, on a more careful study of the ground previous to laying the line out, an alternative direction was adopted by which this tunnel was avoided. The line from the ghâts to the Indyhadree range at Munmar runs through the

* This line was traced to wind round and round the main hill, and thus obtained this name.

fertile country from which the Godavery rises, and in which much wheat, grain, and linseed are grown; then passing near Nassick, a town of considerable importance and a place of Hindoo resort, about 30 miles from Egutpoorah, it is taken near the town of Chandoor, which is about 40 miles from Nassick. The Indyhadree range of mountains, the boundary of the province of Candeish, is then reached; and through them the railway is carried at a gap in the hills near Munmar, where the mountain is completely broken down, by easy gradients and with works of quite an ordinary kind, into Candeish itself. This section, which was executed by contract, was commenced in October, 1857; and a portion of the line, *viz.* that from Egutpoorah to Nassick, was opened to the public on the 22nd January, 1861.

The only large bridge which is mentioned in the reports on this length is a viaduct over the Godavery, 145 yards in length, consisting of nine arches of 40 feet each. The foundations rest on rock, and the depth of the river during floods is 36 feet.

MUNMAR TO JULGAON: 99½ Miles.

After surmounting the Indyhadree hills, the railway, traversing the rich cotton-producing district of Candeish, keeps near the course of an affluent of the Taptee, called the Girna, as far as Julgaon, a place of some interest during the period of the Taptee and Thull Ghât controversies as the point at which the rival lines would converge. Julgaon is near Nusseerabad on the Taptee, and by the Great Indian Peninsula line, as now opened, is 261 miles from Bombay.

The principal bridges on this length are four in number, all constructed over streams flowing into the Girna, and nearly all with 30-foot openings. The Munmar is 40 yards in width, the Tetoor 90 yards, the Bola

about the same, and the Korundah 40 yards. Exact details regarding them have not been obtainable, but they were works of no special difficulty, as the foundations were all on sound rock, and plenty of good building-stone was everywhere procurable.

Throughout the Great Indian Peninsula Railway the gradients are steeper than those used in Bengal, but they are about the average of those in the line on the Concan. Out of the 100 miles 17 are on the level, 55 on gradients between level and 1 in 200, and the remaining 28 miles on inclines varying from 1 in 186 to 1 in 102—which is the steepest, and extends for 40 chains only. The curves are unobjectionable, being from 40 to 180 chains radius for $26\frac{1}{2}$ miles, the remaining distance of $73\frac{1}{2}$ miles being straight.

JULGAON TO BHOSAWUL: $14\frac{3}{4}$ Miles—Main Line.

Near Julgaon and Nusseerabad, the railway bending more to the east crosses the river Wangoor, a tributary of the Taptee. All detailed information is here again wanting; but the channel of the Wangoor is 300 yards in width, and is crossed by a bridge consisting of ten openings, spanned by iron girders on Warren's principle. Bhosawul has sprung up to be a place of importance, from having been chosen as the junction for the valuable and important branch to Nagpore, for which, from the character of the valleys traversed by the rivers Taptee and Poonah, it presented many advantages.

NAGPORE BRANCH.

BHOSAWUL TO NAGPORE: $214\frac{1}{2}$ Miles.

This branch was of especial importance to the traffic of the Great Indian Peninsula Railway Company, as connecting a district in which the best and largest cotton crop in India was produced, with the port of Bombay.

It was reported upon by Mr. Berkeley in 1855, on data furnished by a survey taken during the previous seasons, and the route which he then selected has, with few deviations, been actually adopted. Its direction is guided by the course of the river Poonah, a tributary of the Taptee, along the valley of which the railway is traced as far as the town Oomrawattee, a cotton-mart of considerable importance. There it meets a hilly district, which, however, the railway traverses without requiring severer gradients than 1 in 150, passing in its course a summit which is 1150 feet above high water at Bombay, and 760 feet below the top of the Thull Ghât. It then crosses the rivers Mund and Wurdah, which are the most formidable obstacles encountered on the line, and is thus carried to Nagpore, the important commercial emporium and political capital of Central India.

Between Bhosawul and Oomrawattee, the railway passes over a number of affluents of the river Poonah by bridges, usually of 30-foot arches, but none of a size calling for special mention excepting the viaduct over the river Mund, which needed fifteen openings of 60 feet each, with piers about 70 feet in height, and was an expensive work. The stream Katee Kourah also required a bridge of twenty-one iron girders of 30 feet each, with piers 37 feet in height. The greater number of the rivers crossed by the railway run over beds of rock, so that trouble regarding foundations was usually obviated.

The river Wurdah was more than 1000 feet in width at the point where the railway passes it; but as the depth of water in the channel was small, it was considered that a viaduct with twelve openings of 60 feet each, would suffice. The rivers Ham and Warrah, between Akola and the town of Nagpore, were crossed by viaducts of eight and six spans of 60 feet each respectively,

and are the only other bridges on the line deserving mention from their magnitude. The total number of bridges and viaducts on the Nagpore Branch is 351 containing 950 spans. It was also suggested that it would be desirable to continue this railway to the military station of Kamptee, about 14 miles distant; but as a large river called the Khahan intervened, the idea was abandoned, more especially as the prolongation to Jubulpore *viâ* Nagpore, instead of by the valley of the Nerbudha, was evidently undesirable; the district to be traversed on the former route being mostly barren, covered with jungle, and sparsely populated, instead of being rich and fertile like the latter.

BHOSAWUL TO KHUNDWAH: 77 Miles.

Soon after leaving the junction at Bhosawul, the line approaches the river Taptee by a curve of half-a-mile radius, so that the bridge is constructed at right angles to the stream. The channel of the Taptee is 590 yards in width, and the river is subject to sudden and excessive floods, amounting at times to a depth of 78 feet. It is spanned by a viaduct 875 yards long, consisting of five openings of 138 feet, and fourteen of 60 feet, covered by iron girders, and twenty arches of 40 feet each. The beds of both the Taptee and Wangoor are of solid rock, and foundations therefore of an admirable character have been obtained with ease; but here, unfortunately, the masonry is unsatisfactory, and some of the arches have showed signs of failure.* As at the Wangoor, and at some of the viaducts on the ghâts, the contractors, acting upon a rather loosely worded specification, seem to have built much of the masonry of the piers without thorough bonding or sub-

* It has been found necessary to reconstruct this bridge on a new design with piers of iron cylinders filled with concrete.

stantial hearting, and consequently, shortly after the opening of the line for traffic, numerous defects became apparent. Many of the bridges had to be repaired, and some even had to be taken down and rebuilt.

Near Boorhanpoor there are three small bridges over affluents of the Taptee. About three miles after leaving the small town of Boorhanpoor, the foot of the Satpoorah range of mountains is reached, and up it the railway climbs for a length of 12 miles. The summit of the Satpoorah mountain, at the pass through which the railway is carried, is at a place called Asseer, and between it and Boorhanpoor, in a distance of 23 miles, there is only one mile level, 10 miles with gradients between level and 1 in 200, and the remaining 12 on inclines varying from 1 in 161 to 1 in 100, the latter of which extends for a distance of $1\frac{3}{4}$ miles. Beyond Asseer, the line still passes over a rough country for 53 miles more, out of which 6 miles are level, 6 miles with gradients from level to 1 in 200, and $41\frac{1}{2}$ miles on inclines varying between 1 in 188 and 1 in 132. The total length of straight on the section is 53 miles, and the curves are kept within a ruling radius of 40 chains. Considering that the railway here ascends a formidable range of mountains, the slopes and curves upon this section are remarkably good and easy. There are no works of any magnitude on this length, but a bridge was required for the river Pandar, which flows into the Taptee, and has a channel of about 55 yards. There are also small viaducts over three other streams, which fall on the northern side of the Satpoorah range into the Nerbudha.

KHUNDWAH TO SOHAGPORE: 143 Miles.

A few miles beyond Charwah the railway enters the valley of the Nerbudha, and is traced along its left

bank for about 200 miles, nearly as far as Jubbulpore. The country traversed is flat and suited for a railway, but there are heavier bridge-works on this part of the line than on any other portion. The first viaduct of importance is that over the river Gunjall, which is spanned by eight wrought-iron girders of 84 feet each, resting upon masonry abutments varying in height from 40 to 61 feet. The floods of the Gunjall rise to 40 feet. A few miles further the line passes the river Towah, another affluent of the Nerbudha. During the hot season it is nearly dry, but in the rains it is liable to sudden and furious freshes, and at such time its flood channel extends to 1276 yards. The bed of the river consists of loose sand to a depth of 12 feet, but as rock is then reached, a secure foundation can be obtained. In getting them in, however, great trouble was experienced. Cofferdams had to be formed, and much pumping-power was requisite. The design for the bridge consisted of eleven 84-foot wrought-iron girders, on masonry abutments varying from 66 to 87 feet in height; but during a heavy flood in August, 1866, when the bridge was nearly ready for the girders, the large central and one of the adjoining piers were washed away. Warned by this disaster, the design has been reconsidered, and a new one consisting of much larger spans, giving more water-way, fewer piers, built of solid block in course, and oval in shape, will eventually be carried out. Besides these large bridges, there are two viaducts of seven 30-foot openings each, of four more of five 30-foot openings, and sixty-one other openings of similar dimensions, giving an aggregate total of ninety-five 30-foot openings, forty-eight of which are arched and forty-seven covered with girders. The number of culverts of 10 feet or less was sixty-seven.

From this length a branch line to Indore was pro-

jected by Mr. Berkeley. Two routes were surveyed, one by Semrolee, and the other by Baglee Ghât, both in the Vindhya range. Of the two, the latter was considered preferable. Either line would, however, be a formidable undertaking: on the Semrolee line, which was 17 miles shorter than the other, the crossing of the Nerbudha was hardly possible. The flood level was 118 feet deep, with a cold-weather channel of 154 yards and 52 feet deep; which was worse than that of Baglee, where the flood level was 175 feet deep, and the cold-weather channel only 40 feet in breadth. A maximum depth of 114 feet was measured in this channel by the surveyors in the cold season, but as a single arch or girder of ordinary size would span the gorge, the great depth and rapidity of the current was immaterial. The gradients on the Semrolee line were also inferior to those on the Baglee. The total length was $17\frac{1}{4}$ against $14\frac{1}{2}$ miles; the height 1002 feet against 678, and an average gradient of 1 in 91, instead of 1 in 112. The worst gradient on the Semrolee was 1 in 60, and that on the Baglee 1 in 100. On the Semrolee line there were five tunnels, of which two were of 550 and 572 yards, and six large viaducts; while on the Baglee there were only three tunnels, the longest being 285 yards, and no viaduct of extreme dimensions.

It seemed clear from these results that the saving of 14 miles in length on the Semrolee line would be more than absorbed by the greater cost of its heavier works. The Government of Bombay, before whom these alternative routes were laid, together with another line which had been reconnoitered by an engineer of the Bombay and Barodah Railway Company, running on the northern bank of the Nerbudha, through Chota Oodeypore, Râjpoor, the Torella Ghât, and Dhar, to Indore; had no hesitation in recommending the adoption

of the branch proposed through Baglee Ghât by the Great Indian Peninsula.

Nothing however was decided, as financial restrictions then precluded the hope of any considerable extension to guaranteed railway capital; and before a decision on the Indore branch could be formed, the large question of direct railway communication between Bombay and Agra, in the North-western Provinces, required investigation and settlement.

Returning again to the main line: the gradients on this length were easier than on most of the other sections; 121 miles were either on the level or on inclines between that and 1 in 200, leaving only about 12 miles on gradients between 1 in 176, and 1 in 150. There were no curves sharper than a mile radius, and the total length of straight was $40\frac{3}{4}$ miles. There was a good deal of heavy rock cutting near the Towah, and one short tunnel of $13\frac{1}{2}$ chains in length. About the centre of this district are situated the valuable iron mines of Poonassa, where iron-ore, limestone, and coal are found in one spot; but near the line at many points, especially to the north of the Nerbudha, iron and coal exist.

FROM SOHAGPORE TO JUBBULPORE: 119 Miles.

For about 86 miles the railway traverses ground generally of a favourable character, though much cut up at intervals by ravines, near the points where tributaries of the Nerbudha have to be passed. Of these there are several, the first being the Doodhye, requiring a viaduct of about 170 yards; the second the Sukkur, with a viaduct of the same length; and the third the Shair, with a viaduct of 213 yards. The bridges over the Shair and Sukkur were large works, and the rivers are liable to sudden and high floods—an extreme height of flood of 60 feet above the bed of the Shair, is the highest

on record. The line having thus followed the southern bank of the Nerbudha till near its source, then turns to the north, and is taken across this great river at a spot called Jhansee.

The banks of the Nerbudha at this place are high and precipitous, and the total width from bank to bank is 414 yards. During the hot weather the river, averaging 70 yards in width, contains very little water in its channel, with a depth of only 5 feet, but during the rains the floods rise from 74 to 90 feet in depth above the bed of the river. The viaduct over the Nerbudha is 387 yards in length and 100 feet in height, and the abutments are of masonry, resting upon beds of solid rock.

Out of the distance of 119 miles, about $98\frac{1}{2}$ miles were level, or with first-class gradients, and the remaining 21 miles on gradients between 1 in 196 and 1 in 100, which was the worst, and extended for $1\frac{1}{4}$ mile only. There was no curve sharper than $\frac{1}{2}$ a mile radius, and the aggregate length of straight was above 100 miles. Beyond the Nerbudha the line passes over a nearly flat country to Jubbulpore, which is $614\frac{1}{2}$ miles from Bombay, and is the point of junction of the Great Indian Peninsula with the East Indian Railway.

As soon as the survey of the line to Jubbulpore was finished, the Great Indian Peninsula Railway Company also undertook the examination of a branch line towards the Ganges Valley Railroad. The survey was made and the line selected by Mr. Graham, but Mr. Berkeley submitted a report on the subject on the 20th July, 1855. Leaving Jubbulpore, the railway gradually trends towards the north; and rising from the valley of the Nerbudha mounts to the watershed, from whence the various tributaries of the Nerbudha and of the Ganges take their rise. It then winds between the Kymoor range of hills on the south and the Bundair

hills on the north; keeping in a valley which affords the only practicable access to the Rewah plateau, until the line reaches Myhere, a town on the western borders of the state of Rewah. Thus far, even when the line was afterwards more minutely surveyed, there was no difference of opinion; but from Myhere two alternative routes were proposed. One which was favoured by Messrs. Berkeley and Graham, passed in a course nearly due east, through the heart of the Rewah territory, to the edge of the precipitous scarp forming the boundary of the Rewah table-land; and from thence, dropping suddenly to the level of the Ganges valley, was directed to Mirzapore. The other route, starting also from Myhere, passed to the westward of Rewah, to Allahabad.

During his explorations of this country, Mr. Graham discovered that the Kymore range resembled in its general geographical features the Western Ghâts, near Bombay, though the cliffs were not so forbidding. The table-land of Rewah gradually rises to the crest of the hill, and then drops at once to the level of the Ganges by an abrupt step, formed by a wall-like precipice, very similar to that of the Western Ghâts, but much lower. The height of the cliff at the Thull and Bhore is about 1000 feet, but that of the Kymore varies from 300 to 100 feet only. Mr. Graham examined the line of this precipice for a long distance from the river Tonse on the West to near the Soane on the East, but failing to find a spur or any ground suitable for a railway incline, he boldly projected a line upon the face of the rock itself, near a village called Hatta, which gave name to the scheme. The works on the Hatta incline, though practicable and easier than those on the Thull Ghât, were still very formidable. The gradients for 7 miles varied from 1 in 100 to 1 in 45, the latter severe slope being maintained for $6\frac{1}{2}$ out of 7 miles. Many curves

were less than $\frac{1}{2}$ a mile radius, and only 2 miles out of the 7 were straight. The aggregate amount of tunneling was only a few yards short of $1\frac{1}{2}$ mile, the longest tunnels being 707 and 540 yards respectively. The total length of viaduct was 693 yards, and 169,420 cubic yards of rock-cutting and 1,153,226 yards of embankment were also necessary. The average cost per mile was estimated by Mr. Berkeley at 52,340*l*.

The reconnaissance of the country as far as the Tonse satisfied Mr. Graham that no railway could be laid out in that length more advantageously than that projected at the Hatta incline, and he therefore abandoned all idea of a branch towards Allahabad; and he did so the more readily as both he and Mr. Berkeley considered that, commercially, Mirzapore was a better and more important terminus for the Great Indian Peninsula Railway than Allahabad.

About this time, however, it was decided by the Government of India that the portion of the Junction (Bombay) line, adjoining the East Indian Railway and passing through the territories under the government of the North-western Provinces, should be constructed by the East Indian Railway Company: and Mr. Berkeley's report was therefore placed in the hands of their surveyors, with instructions especially to examine the face of the ghât of the table-land of Rewah, with the view of discovering a more favourable line than that projected by Mr. Berkeley, called the Hatta incline.

The surveys were made during 1855-56; and in April, 1856, Mr. Purser submitted his report on the subject. He had confined his operations to a thorough examination of as great a length of the face of the table-land as the season would admit of, and the result obtained by their explorations was very satisfactory. Starting first from Mirzapore, and extending their researches a

few miles to the east of the Hatta incline, the engineers found that a line could be formed through the valley of the river Adh, which runs between the Kymoor hills on the left overlooking the Soane, and an escarpment of the table-land on the right. This valley varies in width from $\frac{1}{2}$ to $1\frac{1}{2}$ mile, the hills on each side being about 500 feet in height, and by its gradual rise the ghât or steep ascent was reduced to $2\frac{1}{2}$ miles only. The gradients on this length were sharp, *viz.* 1 in 50 for 2 miles, and 1 in 75 for half-a-mile; but they were superior to those on the Hatta incline. There were no tunnels and no great viaducts.

But if these results of a careful survey were satisfactory as regards the eastern or Mirzapore route, those on the western or Allahabad alternative were still more remarkably so. There, by passing well to the westward of the river Tonse, all need of climbing a ghât by exceptional gradients or extraordinary works was obviated. On the northern side of the Rewah table-land they found that there was no abrupt step or pass; but that the ascent from Allahabad on the Jumna was gradual, easy, and continuous, over rolling ground for about 20 miles; and then up a rather steeper slope for 9 miles more, on which, however, the worst gradient was only 1 in 166 for 4 miles; and thus with remarkable ease the summit near the source of the Tonse was reached.

It was clear from these considerations that the Hatta incline works were not necessary, and that a railway to Mirzapore should follow the Adh river route; but the question between the Mirzapore and Allahabad alternatives remained.

The comparative advantages of the lines may thus be summed up :—

By Allahabad, the gradients would be more favourable, the works lighter, $20\frac{1}{2}$ miles of new railway saved,

and the route from Bombay would be for all places above Allahabad 70 miles shorter than by Mirzapore. The Allahabad line, too, had the advantage of running through only a corner of the Rewah territory, while that by Mirzapore would run, and must run, through its whole breadth.

By Mirzapore, however, the distance between Bombay and Bengal would be shorter by 20 miles than by the more western road; the line would pass through an established emporium of commerce, and would abut upon a navigable part of the Ganges.

Still the preponderance of advantages was clearly on the side of the Allahabad line; and it received unanimously the preference from the railway company and from Lord Canning and his advisers, and the question was finally settled in August, 1858.

The line thus selected was 222 miles long, and was divided for purposes of supervision into three districts. But though its course was determined in 1858, its construction was delayed for some years in consequence of financial difficulties arising from the mutiny of 1857; and the line, which was let by contract to Messrs. Waring and Hunt in October, 1862, was not actually commenced till February, 1863. In the detailed description of this branch there is not much of interest to record, and the line, which was laid out by Mr. Le Mesurier, after very careful surveys and many trial sections, has been constructed well and speedily.

JUBBULPORE DIVISION: 68 Miles.

In this length the railway has to pass over a number of streams flowing into the Nerbudha, the largest being the viaducts over the river Huron, consisting of five openings of 110 feet each, and that over the Newar of three spans of 110 feet each. The beds of both rivers

are sandy, and rock foundations were not obtainable for either. Designs giving a smaller amount of waterway were at first prepared; but the engineers, guided by the experience learnt on the East Indian Railway, subsequently modified their plans so as to allow of greater space for the current. The abutments and piers were built of ashlar, and the wing walls of coarse rubble masonry; the foundations resting on wells, in the way that had been usually employed on the East Indian Railway. Besides the above large structures there was one opening of 110 feet over the Roharee, and two over the Kutnee and Pareyut, of three spans of 70 feet each. These were covered with iron girders, but the arched bridges were also numerous. There were altogether in this division six arches of 30 feet span each, four of 25 feet, and twenty-eight of 20 feet: two bridges of the last dimensions containing five arches each. The bridges and culverts of smaller dimensions than 20 feet were numerous—the total amount of masonry in the division being $30\frac{1}{4}$ millions of cubic feet. The embankments and rock cutting were also heavy, giving a total of $127\frac{3}{4}$ millions of cubic feet in the former, and $8\frac{1}{2}$ millions of the latter. The gradients and curves were both first-class.

MYHERE AND ALLAHABAD DIVISION: 154 Miles.

In this section also there are no large rivers, but the streams are numerous, which, however, now no longer flow in a westerly direction towards the Nerbudha, but have a northerly course, and belong to the great Ganges river-system. Leaving the valley of the Nerbudha, the railway gradually ascends the Kymore hills, with fair gradients, the steepest being 1 in 166 for a length of about 4 miles; while all the remaining gradients and all the curves without exception were of a first-class character. The only works of any magnitude are three

openings of 110 feet each, over the Sutnah, and two of 110 over the Semroul, iron girders being in each case used. The Goozree was crossed by three arches of 65 feet each, and the Barooah by five of 40 feet.

The minor bridges were numerous, and in the aggregate amounted to fourteen spans of 28 feet, covered by girders, twenty-three openings of 30 feet, one of 25 feet, and fifty-five of 20 feet. Among those of 28 feet span, there were two bridges of five openings each; of the 30 feet, one of seven openings, one of five, and five of three; of the 25 feet, two of five openings, and two of three; and of the 20 feet, one of twelve openings, one of ten, one of eight, two of five, and nine of three.

The amount of earthwork in bank and rock cutting was large, the former amounting in all to $259\frac{1}{2}$ millions of cubic feet, the latter to $9\frac{1}{2}$, the masonry being $6\frac{3}{4}$ millions.

The foundations rest as usual on wells, the piers and abutments being generally of stone in ashlar or rubble, and the arches of brick.

The whole of this line was laid with rails weighing 74 lbs. to the yard run; and the railway was opened for public traffic during the summer of 1867.

CHAPTER XIV.

THE GREAT INDIAN PENINSULA RAILWAY.—BOMBAY
AND MADRAS.

Mr. Berkeley's Report on the Bhore Ghât—The Kusoor Ghât—Captain Crawford's Views—Surveys ordered—Submitted in 1854—Comparative Advantages—The Sawlee Incline—The Bhore Ghât made practicable for Locomotives—Callian—Description of the Bhore Ghât—Reversing Station—Line Beyond the Ghâts—Point of Junction with the Madras System of Railways—Much discussed—Finally decided in 1854—Mogdul—Hyderabad—Opinion of the Bombay Government—Line *viâ* Cuddapore—Line *viâ* Raichore—Relative Advantages—Final Decision in favour of a Railway through Sholapore and Kulberga to Raichore—Works on the Line—The Kangunnee—The Kistnah—Raichore—The Madras Line—The Toongabudra—Pennair—The Town of Cuddapah—River Cheyair—The Ghâts near Tripputtee—Arconum.

A SCHEME for connecting Madras with Bombay by a railroad was among those of imperial importance which had been reviewed by Lord Dalhousie; and the Malsej Ghât plan, together with the coast line to Paulghât having been absolutely rejected; an approval of Mr. Berkeley's design, to make the junction over the Syhadree range, had been given, conditional upon proof being submitted that the point selected, *viz.* the Bhore Ghât, was the most eligible in all respects for the construction of a railway in that direction. This decision was communicated to Mr. Berkeley in April, 1853, and he was desired to certify that the Syhadree range nowhere afforded a pass in a south-easterly direction of more easy access than the Bhore Ghât.

As soon as the weather permitted the range was personally examined by Mr. Berkeley; and in December in the same year he forwarded a further report. He explored the Syhadree range from the Malsej Ghât on

the north to the Koombha Ghât, near the river Savitree, on the south, a distance of about 80 miles, both below in the Concan and above in the Deccan; and certified that to the best of his professional judgment, the Syhadree range afforded no place of ascent so eligible for the South Eastern Railway as the Bhore Ghât. In submitting this report, however, he mentioned that an incline of 1 in 33 could be laid out on the Kussoor Ghât by which the distance between Bombay and Poonah, would be shortened by 6 miles, and on considering this Capt. Crawford thought that this line deserved further examination.

Captain Crawford, however, concurred with Mr. Berkeley in his opinion that to the southward of the Bhore Ghât the difficult features of the range increased and became more and more forbidding and impracticable; while it could only be the occurrence of a particularly favourable ascent, that could in any way compensate for the increased length of line that the *détour* southward would cause, more particularly as it would have to pass through a difficult portion of the Concan. Practically, therefore, the choice for the south-eastern extension lay between the Kussoor and the Bhore ghâts. Everywhere else either the spurs of the range were too short to admit an incline practical for locomotives to be laid out, or a river with steep banks barred the foot of the ghâts, or terrific ravines high up on the mountains required bridging economically beyond the powers of engineering skill. Beyond was the precipice; and that being surmounted, then the valleys of the Deccan system of rivers had to be studied; and an examination of them proved that the formation of a railway to Poonah, in any direction but one of those followed by the river Moola or its tributaries, would encounter great and expensive works. These

facts all tended to prove that the railway must be taken to the Deccan by one of the two ghâts named.

Captain Crawford recommended, therefore, that the line on the Concan should be staked out to some point near them, and that an extension to Poonah should also be at once laid out from the top of the Bhore Ghât. He suggested also, as the exact line up the ghâts to be traversed by the railway would require long study, while the facts that had been ascertained had reduced the space for this study within narrow limits; that lines both below and above the ghâts should in his opinion be safely staked out and constructed, pending the final resolution of the question of the incline: as any alteration that might eventually be proved to be requisite, would be of no moment.

Lord Elphinstone so far acted on this advice as to direct a careful survey of the Kusoor Ghât, and to sanction the extension of the line from Callian to Narell, a point which would be common to either ghât; but he protested against any postponement of the construction of the incline beyond the time absolutely necessary to determine which ghât afforded the better line.

These directions were given in February, 1854, and work upon the Kusoor was recommenced on the 28th April, completed in June, and in August, 1854, Mr. Berkeley submitted the result of the survey.

Taking the Bhore Ghât incline, as laid out in 1852, as a standard, the survey showed that the Kusoor Ghât had a height of 1728 feet against 1796 at the Bhore, a length of incline of 11 miles instead of 13 miles 46 chains, and an uniform rate of inclination of 1 in 33 in lieu of 1 in 40.

Although the Kusoor thus was proved to be in itself 68 feet lower than the Bhore, yet as the approach to it from the existing line involved heavier works and

steeper gradients, little real advantage was thus gained. Comparing the height of these passes with the level of high-water mark at Bombay, it was found that the Kussoor was 2149 feet high, and the Bhore 2016, giving a difference in level of 133 feet in favour of the Bhore. If a stationary-engine plane, similar to that first proposed for the Bhore, were applied to the Kussoor incline, the result would be equally unfavourable. The comparison would be:—

KUSSOOR GHÂT INCLINE.

1 in 20 for 1 mile 68 chains; 1 in 39 for 9 miles 12 chains.

BHORE GHÂT INCLINE.

1 in 20 for 1 mile 68 chains; 1 in 47 for 11 miles 58 chains.

The Kussoor line would therefore have been very inferior to the Bhore, unless its base could have been lengthened, but that the survey proved to be impracticable.

Again, as 1 in 33 was then considered too steep for the effective use of locomotive power, a stationary-engine incline would have been compulsory; but the local features of the Kussoor Ghât were such as to prevent its establishment. Mr. Berkeley stated that the incline could not be put at the top of the ghât; because it would have had to descend through one continuous tunnel, $1\frac{1}{2}$ mile long, through the angle of the ghât-verge, and then emerging on the ghât-escarpment, 409 feet below its crest, it would fall along the precipitous margin of a very deep ravine, and would terminate in a tunnel. The curves also would be very sharp, and it was therefore clear that the stationary-engine plane could not be placed near the summit of the ghât; but if not placed there, the gradients on the remainder of the incline would be impracticable for locomotives. In short, he ascertained that a stationary-engine plane could not be constructed in that part of the ghât where it was essentially necessary to establish it; and it was evident,

therefore, beyond all question, that the Kussoor Ghât was not only ineligible but impracticable for a railway.

Mr. Berkeley also tried another alternative route up the same spur, which he called the Sawlee incline, but with no better success. Its summit was 2228 feet above high-water mark at Bombay, and was therefore 212 feet higher than the Bhore. The distance to Poonah would be shortened by 2 miles only; but the height of the actual incline at the Sawlee was 1980 feet against 1796 at the Bhore; its length 15 miles, instead of 13 miles 68 chains—the uniform rate of inclination being in either case 1 in 40. The increase in length of the incline, which was obligatory for the purpose of obtaining a like gradient, was a disadvantage, for which a saving of 2 miles in the entire distance was no equivalent.

But the works would have been enormous. There were twelve tunnels, amounting in length in all to 3 miles 80 yards, the longest being 850 and 895 yards respectively, with only one shaft; and there would have been six viaducts, in length aggregating 2089 yards, one with an extreme height of 470 feet, and two others of 370 feet each. On another line, modified with the hope of reducing the works; there would have been eleven tunnels amounting in length to 3 miles 10 chains, one 1159 yards long, with no shafts; but then the number of viaducts would have been increased to nine, of an aggregate length of 2362 yards, with an extreme height for four of them of from 320 to 357 feet. It was evident, therefore, that the Sawlee line was also impracticable: as the works requisite exceeded the limits of experience and of reasonable economy; while when attempts were made to reduce the height of the viaducts, the tunnels were increased to such length as to condemn the line; and, on the other hand, if the tunnels were shortened, the ravine-crossings became practically impossible.

This minute examination of the Kussoor Ghât necessarily resulted in its condemnation, and the Bhore Ghât was therefore accepted by the Government of Bombay as the pass for the south-eastern extension; and directions were given in October, 1854, to that effect, as well as for the completion of the laying out of the lines both below and above the ghât.

Three seasons had been expended in a close examination of the Syhadree range, with a result which proved conclusively that the objectionable features of the Bhore Ghât incline could not be avoided; and that in selecting that route the Government were not entailing permanently upon the traffic between Bombay and Madras any needless tax or barrier.

Mr. Berkeley next devoted his talents and energy to devising plans for removing the main objections to the Bhore Ghât, and especially to making it practicable for locomotives. To the attainment of this object his labour was chiefly directed, from the fact of Mr. Stephenson having advised that the stationary-engine plan should, if possible, be avoided, even though its omission were attended with a considerable augmentation of the cost of the works.

Having now completed the relation of the preliminary investigations and discussion regarding the direction of the south-eastern line, it will be convenient to describe the works upon the railway that has been actually executed.

Returning then to Callian, the point from whence the lines from Bombay towards Calcutta and Madras diverge, the first section was from Callian to Padushurree, with a temporary branch to Campoollee, at the foot of the mail-road up the Bhore Ghât.

CALLIAN TO PADUSHURREE: $30\frac{1}{4}$ Miles.

On leaving Callian the railway follows the valley of the river Oolassa, encountering no works of any special difficulty. The information obtainable regarding this length is slight, but the small bridges and culverts were numerous, and had to be constructed with care, so as to enable them to resist the fury of the floods, which at times rush over the ghâts, and in a few hours raise streams into rapid torrents. The ruling gradient of this section was 1 in 115, and it had no curve sharper than half-a-mile radius. This portion was laid out in two lengths, first as far as Narell, 20 miles from Callian, and subsequently to the foot of the ghât, and it was executed by a native contractor, Mr. Jamsetjee Dorabjee, satisfactorily and with rapidity. It took rather more than two years to execute, and was opened on the 12th May, 1856. In addition to this permanent length of railway, as soon as the route by the Bhore Ghât was fixed, a temporary line $7\frac{1}{2}$ miles long was formed from Padushurree, at the foot of the spur up which the railway climbed to the Bhore, to Campoollee, the village at the bottom of the mail-road. This temporary line was made on a sanction given by the Bombay Government in October, 1854, as the construction of the Bhore Ghât would necessarily take some years.

THE BHOKE GHÂT: 15 Miles 68 Chains.

The incline when first laid out was 13 miles 68 chains long, with a stationary-engine plane; but it was subsequently modified several times in accordance with the information obtained by a more intimate study of its characteristics, and it was not till the expiration of a fourth season that its direction was finally settled. Such improvements were then made in its gradients, without

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entailing an extravagant increase in the extent of the works, as justified Mr. Berkeley in unreservedly recommending the adoption of a locomotive incline—a proposition gladly accepted and sanctioned by Government in 1855. The works were let on contract to Mr. Faviell in January, 1856.

The incline, as it has been actually constructed, commences at the head of the river Oolassa near the village of Padushurree, where a small station, called Kurjut, has been placed on a piece of level ground, on which descending trains will stop. This station is 29 miles from, and 196 feet above high-water level, at Bombay, while the top of the Bhore is 2027 feet; so the actual height surmounted at the incline itself is 1831, the average gradient being therefore 1 in 46. The total length of 15 miles is broken into four portions, at each of which there is a certain distance level and 2 chains or so on an ascending gradient of 1 in 50, so that any train, which from any cause may be descending too rapidly, can easily be brought to a standstill. This gradient and level are also an assistance to trains in starting up the ascent.

The first station is about 4 miles from the bottom, where safety sidings are provided, into which any train can be turned and stopped if requisite; the next is at the reversing station at the 11th mile, where, by means of a siding and turntable, the engine is brought from the front to the rear of the train, which leaves the station in a direction opposite to that by which it entered. This plan at this particular point is very advantageous, in allowing the line to be laid in the best direction as regards gradients and works, and in raising its level just as the steepest part of the precipice is reached. The third station is at Khandalla at the 13th mile, and that at the summit is called Lanowlee.

On leaving Padushurree, or Dhyolee, or Kurjut (three names are given to this spot), the line keeps to the western flank of the great spur, here called the Soangiri Hill, and for the first 4 miles it has to encounter very heavy works, which, on the second survey of the hill, were found to be necessary in order to reduce the steep gradients first laid out to others which would be more practicable for locomotives. By some heavy embankments the line reaches the first mile, and then keeping round the Soangiri Hill passes on its course through six tunnels of 66, 132, 121, 29, 136, and 143 yards respectively. Bending then towards the north the line ascends round the Mhow-ke-Mullee and Khummee hills to the station at Thakoor-wada, at $5\frac{1}{2}$ miles, meeting on its way enormous works. In this distance of only 2 miles there are no less than eight tunnels and five viaducts, and yet this was ascertained after many trials to be the best direction for a railway that could be selected. The tunnels were 286, 291, 282, 49, 140, 50, 437, and 105 yards respectively, and the five viaducts, though not remarkable in length, were very lofty. They were all of masonry, with 50-foot arches, two viaducts having eight,* one six, and two four openings. The least height of pier was 77 feet, while two others were 98, one 129, and the fifth 143 feet in height.

On emerging from this succession of tunnels beyond the Khummee Hill, the line for 2 miles farther follows the direction of a natural terrace or cress in the rock, running nearly on the surface of the ground, without

* One of these called the Mhow-ke-Mullee, fell down, and had, together with many others on the inclines and along the lines, to be rebuilt. Failure was caused either by inefficient foundations, bad dry mortar, neglect of bond, or at times by the unequal settlement of a hard casing of ashlar or block in course, and of a soft hearting of rubble. There was also much laxity in supervision.

any obstacles, as far as Gamba Nath, where two precipitous rocky ravines cut the terrace in twain. Crossing these by two small viaducts, one with six 40-foot and the other with four 30-foot arches, with piers of 48 and 88 feet in height, the line continues along the same cess for 2 miles farther, to the bold projecting rock called Nath Ka Dongur; but no longer without heavy works. In this length of 2 miles there are nine tunnels of 81, 198, 55, 63, 126, 79, 71, 280, and 121 yards respectively.

Beyond this the railway enters upon the long and tolerably level neck, forming the link, between the spur up which the line has been travelling, and the main ghât itself. At the end of this neck, at $11\frac{1}{2}$ miles, was the reversing station, which has been before described, and which was the plan finally settled upon as the best for surmounting the last great difficulty on the incline, *viz.* the escarpment of the main ghât. By means of it the railway is finally taken up the last 5 miles to the top by gradients of 1 in 37, 1 in 40, and 1 in 50, with two tunnels, one of 346 and the other of 62 yards; and with only one viaduct of ten 40-foot arches and one of 60 feet.

By this course the railway, leaving the reversing station by a curve of 15 chains on a gradient of 1 in 75, pierces Elphinstone Point by the long tunnel of 346 yards, before mentioned; then keeping along the edge of the great ravine called Khandalla, passes the station of that name; and so following the course of the main stream of the ghât, reaches the crest of the Bhore at the village of Lanowlee.

On the incline, besides the viaducts named, there are twenty-two bridges of various spans, from 7 to 30 feet; and eighty-one culverts, from 2 to 6 feet.

The total quantity of cutting, which is principally

through rock, is 2 millions of cubic yards; and the greatest depth on the central line is 76 feet, but on the faces of the tunnel through Elphinstone Point the depth is 150 feet. The cubic content of the embankment is a little more, amounting to $2\frac{1}{4}$ millions of cubic yards, the maximum height of bank on the central line being 75 feet, though many of the outer slopes are 150, and some of them as much as 300 feet.

There are in all twenty-five tunnels, of a total aggregate length of 3986 yards, or more than $2\frac{1}{4}$ miles, six of them being more or less lined with masonry for a length altogether of 312 yards. The viaducts are eight in number.

The length of the incline is 15 miles 68 chains, of which 5 miles 34 chains are straight, and 10 miles 34 chains curved. The sharpest curves are one of 15 chains radius for a length of 22 chains, and another of 20 chains radius for 10 chains. Between radii of 20 and 30 chains there are curves of a total length of 1 mile and 48 chains, and the remainder are with radii between 33 and 80 chains. The steepest gradients are 1 in 37 for 1 mile and 38 chains, and 1 in 40 for 8 miles and 4 chains, the remainder being between 1 in 42 and 1 in 75; the only exceptions being 1 in 330 for 23 chains, and a level of 1 mile and 15 chains.

The line is double throughout the incline, and has cost 68,750*l.* per mile, or in all about 1,100,000*l.* The tunnels are the works which presented the greatest difficulties to the contractors, as they nearly all contain trap rock, usually of a very hard character. From the precipitous forms of the hills it was generally impossible to sink shafts, and the drifts had therefore to be driven solely from the ends, much skill and care being requisite in setting out the work on the sharply-curved inclines, so as to ensure perfectly true junctions.

The viaducts are partly of block in course masonry, an abundance of admirable building stone being everywhere procurable; but the building has not been of a good description, and consequently there have been some failures, among which the Mhow-ke-Mullee viaduct is included, which had to be rebuilt.

Another cause of danger and trouble was the slips which are liable to happen, when the boulders with which the mountain sides are covered lose their support by excavations in cuttings below, or are loosened by the action of the rains and roll down towards the valleys. All these boulders had to be removed from the flanks of the mountain above the railway, so as to ensure the safety of the line. Mr. Berkeley, from whose account, and that of Lieutenant J. D. Swiney, R.E., the above description has been compiled, thus describes another peculiarity:—"The ground along the flanks of the Ghât mountains is often of so precipitous a character that we have met with frequent cases where, on the upper side, we have only a low embankment, while on the other side the bottom of the slope would be of an impracticable depth unless it were retained by a strong wall of masonry. In some situations we met with the extraordinary circumstance of one-half of the line being upon rock benching, and the other half consisting of a very lofty embankment, or of a high embankment retained by a wall of masonry. In other places, again, we have found the mountain sides so steep as to render it unadvisable to encounter the difficulty of embanking the line or building battering walls, because they would be of enormous height above the surface of the ground, and would have to be carried down to a great depth beneath it before a secure foundation could be obtained for them. Under this peculiar state of things we have determined to place the line

upon arches or vaults. These will sometimes be of a novel description, for we shall have here and there to place one-half of the width of the railway upon rock benching, while the other half will stand upon vaulted arches."

The landslips were particularly troublesome in the lower portion of the incline, and shortly after an engine first passed up it on the 30th March, 1862, the whole of one of the open cuttings near the foot of the incline was thus filled in. This unexpected accident necessitated the driving of a tunnel of arched masonry through the *débris* which had fallen, a work which delayed for some time longer the final opening of the incline.

The work took seven years and a quarter to complete, and was executed entirely by contract. It was first let to Mr. Faviell in the autumn of 1855, and the works were commenced on the 24th January, 1856. In June, 1858, 2 miles of the upper part of the incline, from Khandalla to Lanowlee were opened for traffic. In March, 1859, Mr. Faviell gave up his contract; and for a short time the engineers of the railway company carried on the works themselves. In the same year it was re-let for contract to Mr. Tredwell, who, however, died within fifteen days of landing in India; and the work was actually completed by Messrs. Adamson and Clowser, the managers of the contractor, Mrs. Tredwell. These gentlemen carried on their arduous undertaking with the greatest assiduity and ability. Their good and liberal management collected and retained on the work an immense force of labour of all kinds, the average number of workmen for two seasons being 25,000, and in 1861 more than 42,000 men were employed upon the works.

The rails used on the incline weigh 85 lbs. to the yard, and were manufactured with special care so as to

secure hardness and flexibility; and under the fish-joints a cast-iron chair, spiked to longitudinal timber bearers, is so fixed as to support the bottom of the rail and to give additional strength and security to the joint. The incline is worked by pairs of double-tank engines of great size and power.

After reaching the summit of the Syhadree range the railway is carried over a rough country by the river Indrownee to Poonah; and then in a south-easterly direction, in the valley of, and parallel to, the river Nurah, to the spot where it joins the Bheemah, flowing from the northward. Crossing the river Bheemah, the railway is continued down its course to Mohol, on the river Seenah, a large tributary of the Bheemah, and so on to Sholapore, where a temporary terminus was formed pending the decision upon the various routes proposed for the junction with the Madras line.

There are no details on record regarding the works on this length, and the general paucity of minute information is as great as is the case on the North-western line of the Great Indian Peninsula Railway. The length of the district from Khandalla to Sholapore is $205\frac{1}{4}$ miles, and it was opened for traffic in sections. From Khandalla to Poonah, $41\frac{3}{4}$ miles, on the 14th of June, 1858; from Poonah to Duhsal, at $64\frac{1}{4}$ miles, on the 15th of December of the same year; from Duhsal to Barsee road, $50\frac{1}{2}$ miles, on the 24th of October, 1859; from Barsee road to Mohol, $28\frac{1}{2}$ miles, on the 2nd of January, 1860; and from Mohol to Sholapore in June of the same year.

The ruling gradient is 1 in 131, as severe as it is on other portions of the Great Indian Peninsula Railway, and the radius of its sharpest curve is half-a-mile.

The principal works on the length are the viaducts over the rivers Bheemah and Seenah. That over the

Bheemah consists of twenty-eight segmental arches of masonry, of 40 feet each. The piers are 60 feet in height, with foundations resting on rock, its flood stream being 46 feet in depth. The viaduct over the Seenah is not so large, consisting of twelve arches similar to those over the Bheemah, with piers 54 feet in height, resting on foundations partly of rock and partly of clay. The flood stream is 41 feet in depth. There are besides in all 22 viaducts, 359 bridges, and 454 culverts, all of masonry; but beyond this fact no detailed information regarding them has been obtainable, the works being of an ordinary description, and not possessing much interest for engineers.

In consequence of financial difficulties arising from the mutiny, several sections of railway were for a time postponed, in order that money might be available for those portions which were being constructed. The junction line between Madras and Bombay was one of these deferred sections, and the various alternative routes were not even surveyed till 1863, although a trunk line between these cities had been one of the plans originally contemplated and sanctioned as part of the comprehensive scheme of railway intercommunication for India.

The question when reviewed, was first laid before the Government of India in March, 1864, but a decision upon the point was not arrived at until the December of that year. In the original plan, which had received a general approval, the trunk line from Bombay was intended to be taken *via* Sholapore, Mogdul, Bellary, and Cuddapah, to Madras; but subsequently, on again considering the subject, the governments of Bombay and Madras conjointly advocated that the line should pass through Hyderabad, and from thence to Cuddapah.

At Bombay the opinion in favour of the Hyderabad route was, on all accounts, strongly urged. That Govern-

ment represented that though it was admitted that this line *viâ* Hyderabad was sensibly longer, yet, as there would be practically no through-traffic by Mogdul, the argument that a direct line is better than a circuitous one had no force. Traffic north of Mogdul would tend to Bombay, and south of it to Madras. That the direct line, passing through a poor, thinly populated, and impoverished district, and terminating in an obscure village called Mogdul, would probably cause a drain upon the profits of the railway company; while the longer one *viâ* Hyderabad, traversing a fertile and densely populated country, would have for its terminus an important and populous city, an unfailing source of large and profitable traffic. That it was of greater importance to put Hyderabad in direct railway communication with Madras and Bombay than Bellary; though taking the main line through the former city did not necessarily imply that Bellary must not have a railroad, as there was nothing to prevent a branch being made to it from Cuddapah.

The Bombay Government and the Resident* at Hyderabad strongly recommended the formation of a railroad to that city for military and political reasons. Hyderabad, they urged, is the largest military station in Southern India; it is the place of all others where an outbreak may be most expected, and therefore it is of much importance to be able by means of a railroad to reinforce the garrison quickly in the event of disturbances, and to have the troops available for dispatch elsewhere should their aid be needed.

As the line from Cuddapah to Hyderabad would have to pass through a difficult and unproductive country, the Madras Government, on commercial grounds, preferred the line *viâ* Mogdul to that by Hyderabad; but

* The British representative at the Court of the Nizam.

though conscious of the disadvantages inherent to the latter route, yet, for political and military reasons, they thought that it ought to be selected.

For the direct line two routes had been suggested and surveyed—the original line from Sholapore, *viâ* Mogdul and Bellary, to Cuddapah; and an alternative route also from Sholapore, but taken by Kulberga and Raichore to Cuddapah. The entire case being laid before the Government of India in an exhaustive note by Colonel Strachey, R.E., the Secretary in the Public Works Department, they decided after a careful consideration of all the arguments, that the guaranteed main trunk line of communication between Bombay and Madras should follow the second of the direct alternative routes which had been surveyed, *viz.* that by Kulberga and Raichore; that a guaranteed branch line should be constructed from some junction near Gooty to Bellary; and that if any company should be formed to make a branch from Kulberga to Hyderabad, it should receive a subsidy. It was also decided that Raichore should be the point of junction for the Bombay and Madras railways.

The distances on the several proposed routes are as follows :—

	Miles.
1. Main Line, <i>viâ</i> Hyderabad	556
(Branch from Cuddapah to Bellary.)	
2. Main Line, <i>viâ</i> Mogdul	517
(Branch from Sholapore to Hyderabad.)	
3. Main Line, <i>viâ</i> Raichore	504
(Branch from Kulberga to Hyderabad; and branch from Gooty to Bellary.)	

These figures showed that the Hyderabad line would involve 50 miles more of railway to construct; would require 75 more of main line to be made before the through communication was completed, and would bring 140 miles more of Madras, and nearly 30 miles more of Bombay railway under guarantee than if the main line

were taken *viâ* Raichore. By adopting the Raichore route in preference to that by Hyderabad, the through line between Bombay and Madras would be shortened by 75 miles: an advantage which the Government of India considered to outbalance entirely the increase of distance between Madras and Hyderabad, while the convenience of the traffic between Bombay and Hyderabad would be equally well consulted by either of the proposed lines.

The gravest objection, however, to a through line, on which military communications between the east and west coasts and the north and south of the peninsula of India had to depend, passing close to and round the capital of a foreign State, was, that in the case of an outbreak the railway connection would be very easily cut off. The inhabitants of Hyderabad are known to be hostile to us, and there is much reason to anticipate internal commotions and changes in the condition of society in the city. But the influences that might produce danger to a railway near the capital of the Nizam would be, it was thought, far more feeble, if not quite inappreciable, in the remote agricultural districts through which a line *viâ* Raichore would pass; and therefore, on the whole, the Government of India felt no hesitation in selecting that route as the one for the main trunk line of communication between Bombay and Madras.

SHOLAPORE TO KULBERGA: 72 Miles.

The line thus chosen runs for 72 miles in a direction nearly due east to the town of Kulberga, keeping parallel to the river Bheemah, and between it and a range of hills, which also at a distance of from 20 to 40 miles follows its course. From the hills flow several streams, which the line has to cross, and from the same range some ridges also project towards the Bheemah, over

which the railroad has to climb. Kulberga is situated in the dominions of the Nizam, and was formerly a place of much wealth and great strength, and though now decayed, is still of considerable importance.

The railway, skirting as it does the river Bheemah, has to pass the entire drainage of the district, every stream and river eastward of Sholapore discharging itself into that river. The masonry works, therefore, were numerous, but not difficult, the largest bridges being those over the rivers Baree and Murrigeehulla, over which viaducts of fifteen and twelve 30-foot arches respectively were required.

The gradients were severe, from the railway being obliged to pass the three summits that have been mentioned by inclines of 1 in 100; but not more so than those on other parts of the Great Indian Peninsula lines.

KULBERGA TO RAICHORE: 88 Miles.

After passing the town of Kulberga, from whence the branch to Hyderabad is projected, the line turns southward, still clinging closely to the Bheemah, passing all its tributaries flowing from the east, and following, through districts liable to floods and inundations, its course till the line meets the Kistnah, just beyond the point at which the Bheemah flows into it. Crossing the Kistnah, a heavy work, the railroad runs through a level, cotton-producing district to Raichore, which is 160 miles from Sholapore, and there unites with the Madras system of railways.

The gradients on this length are easy; but the district traversed requires a large provision of waterway, and the river Kangunnee, which is crossed by the railway 24 miles from Kulberga, needs a work of first-class magnitude. A viaduct of twenty-two 60-foot openings, covered by girders, takes the line over the

Kangunnée river; while another viaduct of still larger dimensions, containing thirty-eight openings, each of 60 feet, spans the Kistnah.* Stone and lime were abundant, and there was no difficulty about the foundations of these large viaducts, as they rest on rock; and the works, therefore, though sure to be costly, were not otherwise formidable.

The line was in direction unexceptional, there being only one curve of half-a-mile radius, and a length of $63\frac{1}{2}$ miles straight.

The line from Sholapore to Raichore is still under construction, but is being rapidly carried on to completion under the management of energetic contractors.

Raichore is in the territories of the Nizam, through which the railway has been running for more than 100 miles; but shortly after leaving the junction the line enters the boundaries of the Madras Presidency.

RAICHORE TO CUDDAPAH: 177 Miles.

Raichore is situated in the Doab or level tract between the rivers Kistnah and Toongabudra, which is covered throughout by a black, cotton-producing soil. Over this plain, which is highly fertile and bears luxuriant crops, the railway is carried without any works of importance to the river Toongabudra, which requires a large viaduct. The width of the river from bank to bank is about 3200 feet, and the flood-rise above the general bed of the river is 17 feet 6 inches. The banks of this river are bold and well-defined; and as rocks exist at a short distance below the surface, there was little difficulty in obtaining a good foundation. A large viaduct of fifty-eight openings of 64 feet, spanned by

* It has recently been determined to substitute iron cylinders filled with concrete for the masonry piers at first designed for the Kistnah viaduct.

wrought-iron girders, is being erected at this point, which is $290\frac{1}{2}$ miles from Arconum. After passing this river, the line, still running nearly due south, is carried through a district, fertile though not cotton-producing, studded with populous villages, to the town of Advani, from whence to Gooty the country is hilly and sterile. The gradients for a length of 20 miles near Gooty are rather severe, and there is a good deal of rock cutting.

From the town of Gooty, or rather from a junction adjacent, called Goondagul, a branch-line 35 miles in length is taken to the important military station of Bellary, crossing on its way the river Huggry, measuring 2970 feet in width, and spanned by thirty-four openings of a similar description to those used at the Toongabudra, *i.e.* 64 feet each. The banks of the Huggry, being low and irregular, are ill-defined.

Returning again to the main line at Gooty, the railway now bends towards the east, and passing through a hilly and rather a difficult country for 25 miles, approaches the river Pennair; from whence to Cuddapah the ground is very favourable, the country being level and rich, producing both cotton and indigo in abundance. The whole plain is highly cultivated, and dotted with populous villages, though probably not more likely to yield a paying traffic than the districts traversed by the line between Madras and Beypore. The only, but serious, obstacle to the construction of a cheap railway through this part of the country is the number and formidable character of the rivers which have to be crossed.

The Pennair is the main river, into which the others flow, and a bridge 1800 feet in length was at first designed across it, at a point just below the confluence of the Chittravutty. In laying out the railway, however,

this was modified, and two bridges, one over each river separately, have actually been constructed. The Pennair is spanned by a wrought-iron viaduct containing twenty-four openings of 64-feet each, and the river Chittravutty by forty openings of 70 feet each. Another small tributary stream, called Jastoor, requires a bridge of four 64-feet spans. In the next few miles several small bridges are necessary, one needing seven girders of 50 feet, and another five of similar dimensions; and then beyond, at a distance of 14 miles from the town of Cuddapah, the large river Paupugnee is met with. Its width is about 2400 feet, and its banks are very low and irregular, constantly changing their shape. The channel itself often shifts its position, the bed of the river consisting of fine sand, which, under the heavy floods, rising at times as much as 14 feet above the general level of the country, is continually moving. The only other bridge that was required to reach Cuddapah was a skew of nine wrought-iron girders of 52 feet each over the Rolla Vonka Nullah.

Cuddapah is a populous and thriving place, the centre of an important district, from whence flows a considerable traffic towards Madras, which was estimated some years ago at an annual value of twenty-five lakhs. This town was one of the points to which the Madras Railway looked for a revenue, and it was for some years a temporary terminus of the North-western line. After passing the town of Cuddapah, and a small river of that name, by eight openings covered with wrought-iron girders 60 feet in length each, the railway for a distance of 27 miles passes over an easy country in an easterly direction, with no works of any consequence until the river Cheyair is reached, which is the third work in order of magnitude on the railway. The bridge over the Toongabudra is the

largest, and that over the Chittravutty the second. The Cheyair is crossed by thirty-eight wrought-iron girders of 64 feet each, the piers being of masonry. It is 92 miles distant from Arconum, and between the Cheyair and the junction there are no bridges of any size. The country indeed is quite altered in character, being hilly and covered with ravines, through and among which the railway has been traced.

The works most deserving mention are the bridges over the Condoor and the Naggery, the former being crossed by five wrought-iron girders at a skew of 70° of 47 feet span each, and the latter by thirteen arches of 40 feet. The remainder are of 30 and 40 feet arches, of the character and dimensions usually used on the Madras lines. The rivers Poolunga and Loonamookey are crossed by viaducts of nine 30-feet arches each. Between Cuddapah and Arconum the obstacles encountered by the railway are no longer great rivers, but the heavy works required at the ghâts near Tripputtee, where a high embankment had to be constructed at a spot called Ballâpillay, and a deep rock-cutting excavated at Naggery. On leaving Naggery the railway enters upon a comparatively level country, and passes in nearly a due southerly direction to Arconum, the junction with the Madras and Beypore line, distant 42 miles from Madras. Part of the north-western Madras line is still under construction, but the works are rapidly advancing towards completion, and it will no doubt soon be opened throughout its length—thus uniting the city of Madras with Bombay and Europe.

CHAPTER XV.

THE BOMBAY, BARODAH, AND CENTRAL INDIA RAILWAY.

Portion of a larger Project — Intended Terminus in Delhi or Agra — Lieutenant-Colonel Kennedy — Easy Gradients — Coast-line to Barodah — Peculiar Difficulties caused by Rivers and Swamps — Departmental as opposed to Contract System of Construction — Description of the Line — Surat as a Port and Terminus — Colonel Kennedy's Method of Bridging — Pile and Cylinder Piers — Warren's Girders — Bridge over the Taptee — Terminus at Bombay — Mahim and Bassien Creeks — The Nerbudha — Town of Baroach — The Mhye — Ahmadabad — Great Cost of the Line.

THE Bombay and Barodah Railway was one of the first lines brought to the notice of the Government of India; and as a local scheme it, at an early period, obtained the encouragement of a guarantee. The directors of the company, however, did not intend merely to unite the port of Bombay with the richest province of that presidency, Gujerat, but, as its designation implies, contemplated also extensions of their railway through Central India, with the object of eventually placing their terminus either in Delhi or Agra.

This, the more extended portion of their project, was reviewed when the competing plans of the Great Indian Peninsula and this railway were considered in a former chapter; and the present account will be confined therefore to the description of the line which has been actually sanctioned and completed.

Lieut.-Col. J. Pitt Kennedy was the Consulting Engineer to the company, and was from the first the main promoter of the scheme and the designer of its plans and modes of operation. He had always held strong

views on the subject of the great eventual economy in working a railway obtainable by the use of easy gradients, and the line advocated by him was admirably selected as an example of what the theory could effect.

A railway from Bombay to Barodah could only be traced in one direction, along the narrow strip of level land which lies between the Syhadree range of mountains and the Indian Ocean. It was intersected by no ridges, and no choice had to be made between the comparative advantages of passes over hills. The line must be formed over the rough and rocky ground near the hills, or parallel and close to the sea. It is true that this latter plan required the execution of most difficult and costly works, as the railway must cross at right-angles the entire drainage of a vast central area at its widest part near the ocean. Every stream on its way from the mountains to the sea had to be spanned by a bridge; and besides these small but very numerous obstacles, three immense rivers, flowing from the central regions of India, barred its course. Large tracts of swamp and inundation had also to be encountered, as well as two arms of the sea near Bassein. The rivers are nearly all tidal, with deep sandy beds or alluvial drift, extending to a depth of 20, 30, and 40 feet, and then terminating in clay or shale. All of them are subject to rapid and sudden floods, raising streams to raging torrents, and causing the larger rivers to rise 30 and 40 feet in a single night with a current running at the rate of 10 or 11 miles an hour. Indeed, it was admitted that the country through which the Bombay and Barodah Railway must run was so intersected with tidal rivers that it was doubted by many whether it would be practicable even to construct a railway in the direction.

Undeterred, however, by these difficulties, vast as

they were allowed to be, Colonel Kennedy, after careful consideration, designed a style of bridging specially adapted to the flat, alluvial districts crossed by his railway, and with skill and courage deserving of all commendation overcame all the impediments in his path, and has completed this railroad successfully, if not as cheaply as he had too sanguinely anticipated.

Colonel Kennedy also had always been much impressed with the belief that the construction of a railway on the departmental system ought to cause much economy in first cost; and with reason, if he could have always ensured as his agents thoroughly conscientious, able, and zealous engineers. Taking, however, men on the average, this is impossible; and in practice it is found that there is no saving on the whole by adopting a departmental method of construction as opposed to that by contractors. A length of 100 miles or so may, under the special management of a selected officer, show most satisfactory results both in economy, speed, and character of work performed; but this will not be maintained throughout a length of 400 or 500 miles, in which the evils of inefficiency and want of energy in individuals are sure also to be manifested. Indian experience seems clearly to prove that if a contractor of ability and wealth be secured at remunerative rates, he will construct a railroad at a cost which will not much, if at all, exceed the expense which a railway company must incur when making a line directly by means of its own engineers. The only exception to this general rule appears to be the Madras railway, and that for various reasons cannot be pronounced conclusive.

Returning now to the more detailed account of the line, the great disadvantage under which it has laboured has been the determination, maintained for several years, that the line should commence from Surat

instead of Bombay—thus leaving a link of the chain wanting, and that, too, the one which was the most important. The idea that Surat could be turned into a harbour has proved illusory. As Lord Dalhousie happily observes in one of his Minutes—"During one season of the year Surat is wholly inaccessible to shipping. Its situation must make it at all times more perilous, and by no exertions of science or art can it ever be rendered comparable with the harbour at Bombay. How inferior it now is, and how little hope there can be of ever making it a successful harbour, except at an enormous expenditure of time and money, appears to me manifest from Colonel Kennedy's own report; which, in support of his railway scheme, contains two collateral schemes for the improvement of Surat: the one of which has for its object to remove from the town the inundations which annually accumulate where there ought to be dry ground; while the other is designed to remove from the harbour the ground which annually accumulates where there ought to be deep water."

Colonel Kennedy himself was quickly convinced that his first views regarding the capabilities of Surat as a port were too sanguine; and he subsequently urged repeatedly and strongly the necessity, if the railway were to have a fair chance of success, of completing the length between Surat and Bombay. This was at length conceded in February, 1859; and it will be convenient to treat the undertaking as a whole, as it was eventually authorized, instead of dealing with it in the sections in which it was constructed.

The decision of the Honourable Court of Directors to permit the Bombay and Barodah Railway Company to make a line from Surat to Ahmadabad was given in April, 1855, and operations were at once commenced.

The difficulty of the line was the enormous quantity of bridging requisite, which, in the aggregate, amounted to 6 miles in length. Colonel Kennedy considered that piers and abutments of masonry would be quite inapplicable to bridges over the rivers crossed by his line flowing through alluvial plains or inundated districts. He, therefore, determined to use an adaptation of Mitchell's hollow screw piles for piers and abutments, and a girder of one uniform span of 60 feet.

The following description is based on various accounts of the bridges which have from time to time appeared in reports by Colonel Kennedy in papers in the 'Civil Engineers' and Architects' Journal:—The piers are formed by a row of three cast-iron hollow cylindrical piles of 1 inch thickness and 2 feet 6 inches outside diameter—cast in 9-foot lengths, weighing $1\frac{1}{2}$ ton each. To the bottom length is cast a screw, projecting 1 foot 3 inches, giving a total diameter of 4 feet 6 inches, by which the pile is screwed into the ground, sometimes by manual power, with capstans, and sometimes by bullock power, applied directly to the cap of the pile. The latter plan was found to answer best when the piles had to be screwed to a great depth, as at the Nerbudha. With capstans a pile could hardly be turned once in half-an-hour with four levers secured to a pile, but with eight bullocks yoked to each lever, it could always be turned' once in two minutes.

While the cylinders were thus being sunk, men were continually clearing and removing the core of sand or clay from the inside, which, in most cases, was a work of considerable trouble. The water usually at once rushed in and then the men had to work with scoops, which proved a tedious mode of operation. The piles being screwed down to the proper depth and entirely emptied, were filled with good concrete and surmounted by a cast-

iron cap, which supported the wrought-iron standards of the girder. The three piles of which each pier was formed were 14 feet apart, centre to centre, and where the height was great and the stream rapid, strut piles, sloping at an angle of 30° from the vertical piles, were added on both sides of the pier in tidal, and on one side only in other rivers.

The piles above the ground have flanges on the outside for bolting them together by twelve 1-inch bolts, but those underground have their flanges inside bolted together by ten 1-inch bolts, so that the outside surface of the piles, being flush, may present no resistance to the descent of the pier. The oblique strut piles are precisely the same in construction as the ordinary piles, and are joined to them by caps cast at the proper angle, so as to clip the body of the upright pile. All the piles above ground are connected together by horizontal and diagonal wrought-iron bracing attached to lugs cast on the piles at the flanges. The horizontal struts are of T iron, the diagonal bracing being of angle-iron placed back to back and rivetted at their intersection. This bracing answers alternatively as struts or ties, in accordance with the direction of the current, and has therefore to be fitted with great accuracy. It is secured to the lugs by a pin at one end and by a gib and cottar at the other. All the fitting work of the bracing and other operations required under water were performed by men equipped with a diving helmet and dress.

The girders used were constructed on Warren's triangular principle. Each span for a single line of railway consisted of a pair of wrought-iron girders 62 feet 5 inches long on the top flange, 7 feet 9 inches deep, and 13 feet apart from centre to centre. One end of each girder is bolted to the cast-iron piers, and the other end is left free to slide upon rollers. Each girder is

divided into eight equilateral triangles, 7 feet 6 inches each, and each pair of girders is connected together by wrought-iron transverse girders, 12 feet deep, cross-braced. The clear span is 60 feet. The bolts were required to fit their holes with great accuracy, no error of more than $\frac{1}{100}$ th of an inch being allowed. The entire superstructure of the ninety-five bridges on the line, comprising 477 spans of 60 feet each, was all made of component parts, and each span being an exact duplicate of its fellow, each set of holes being cut from the same template, and each screw from the same thread, the greatest facility in packing, distributing, and arranging the bridge-work at the ports of embarkation and delivery was secured; while native workmen after erecting one span had no difficulty in putting up any number of others. The bridge over the Taptee, of thirty of the above units, with a height of 80 feet from bottom of screw to the under-side of the girder, which was elevated 40 feet above low water, and with strut piles on both sides, was commenced, erected, and opened for traffic in eight working months, the time that elapsed from sinking the first pier to completion being exactly one year.

Had not Colonel Kennedy adopted, on the portion of the line first constructed, *viz.* that from Surat to Barodah, a plan apparently so well suited for bridging the great extent of water crossed by his railway, it is improbable that he would have obtained permission to bring the extension from Surat directly to Bombay, as in the straight course lay Bassien Creek, and some others nearly as formidable in character.

In addition to the physical obstacles, the Great Indian Peninsula Railway having been made as far as Callian, in a direction generally northerly, there was a great inducement to make a junction somewhere on that

line, and so save the cost of an extra railroad and the value of the land for another terminus in the city of Bombay, where sites were difficult to find and very costly to purchase. Still there was much to be advanced in favour of a separate line. The ruling gradient of the Bombay and Barodah Railway was 1 in 500, which had been obtained with much trouble and at a great cost: while that advantage would to a great extent have been sacrificed if the line after all had been taken to Callian, which it could only have reached by passing through a very rough country, requiring severer gradients than existed on the Barodah line. The traffic too would have had a circuit of 16 miles, would be required to travel over the Great Indian Peninsula line, with a ruling gradient of 1 in 100; and at Bombay itself, the extensive operations of two railway companies would have to be cramped into the limits of one terminus, already so small as hardly to be sufficient for one. After much discussion and protracted deliberation, it was* decided that the Bombay and Barodah Railway Company should have its own direct approach to Bombay, with a station at Grant Road, not far from the Byculla club and racecourse, with the intention of eventually extending its line through reclaimed land in Back Bay to a permanent terminus at Colaba. The station at Grant Road is conveniently situated for the town of Bombay, and has a short junction with the Great Indian Peninsula Railway terminus, though it has not the advantage of direct communication with the harbour and shipping.

* The question of site has again been recently reopened, and it is now proposed to place the terminus of the Bombay, Barodah, and Central India, and that of the Great Indian Peninsula Railway in one place, on land reclaimed from the sea by the Elphinstone Land Company.

BOMBAY TO SURAT: 183 Miles.

The railroad, on leaving Grant Road Station, passes up the island of Bombay, keeping near the western shore to the town of Mahim, at its northern extremity. At Mahim there is a heavy embankment, and the line then crosses the creek of that name by three spans of 60 feet each to the island of Salsette, through which it runs, still following closely the direction of the coast to the arm of the sea called Bassein, by which Salsette is separated from the mainland of India. The water in the Bassein Strait is not deep, nor, excepting the tide, is there any current in it. The greatest depth is about 16 feet, but the width was great and its bed was of the usual sandy, treacherous description. It was crossed by four viaducts, separated a little from one another by banks, having an aggregate length of 7780 feet, or about $1\frac{1}{2}$ mile. There are 129 spans of the common unit of 60 feet each, which are divided into four parts containing 20, 66, 23, and 20 spans respectively.

But even after passing this Strait, the difficulties in the line were by no means overcome. Between the northern shore of the Bassein Creek and the southern bank of the Taptee, there are bridges over a width of water amounting in all to 9010 feet, or nearly 2 miles, for which 149 spans had to be erected. The piers of two of the larger viaducts, *viz.* those over the rivers Damaun of fifteen spans, and Sunjad of nine spans, are of stone masonry; but all the remainder are supported on screw piles. The principal ones among them are two bridges of fourteen spans each, over the rivers Umbeska and Omnya; one of thirteen over the Poorna; and one of twelve over the Mendola river. Besides these, there are twelve other bridges of various dimensions, containing less than twelve spans each; all the openings being 60 feet in length.

SURAT TO AHMADABAD: 142 Miles.

Between these points the bridges were not nearly so numerous as between Bombay and Surat; but though in the number of rivers and estuaries to be crossed there was a diminution, yet in magnitude and natural difficulties the rivers to the north of Surat far exceed those to the south of that city. The rivers Taptee and Nerbudha receive the drainage of the Indyhadree and Satpoora ranges of mountains, and are, too, the receptacles of the floods of many hundreds of square miles in their long and varied course. The length of the Nerbudha may be taken as 600, and that of the Taptee at 400 miles, while their tributaries drain basins of great size, making altogether an area of enormous extent. The river Mhye also, though it has not nearly so long a course as the Taptee, is very broad, bringing down an amount of water nearly as great in volume as that conveyed by the latter.

The river Taptee, on which Surat stands, is 2000 feet in width, and is spanned by a bridge 1891 feet in length, composed of thirty spans. The floods in this river are often known to rise 30 feet and more in one night, and the floods in their fury bring with them masses of floating trees and other matter, which are liable to endanger the safety of any bridge. It was also exposed to the influence of a rapid tide, against the effects of which, as well as of ordinary floods, peculiar precautions had to be taken. Strut piles, protected by wooden fenders, were fixed on both sides of the bridge.

Between the Taptee and Nerbudha there are two small bridges of three and four spans over the Keen and Amma, and then the railway passes over the great engineering work of the line—the viaduct of sixty

spans over the Nerbudha. Contrary, however, to what might have been expected, the structure of this bridge exactly corresponds with those over the smaller rivers, the only peculiarity being the great depth to which the piles are screwed. The bottoms of some of the screws are 40 or 45 feet below the level of the bed of the river, and the difficulty of reaching such a depth may be estimated, when it is considered that the depth of water is 30 to 40 feet, rising in times of floods to 60 feet, with a current of about 10 miles an hour. Excepting, however, the time and cost, there is nothing in the bridge calling for peculiar remark;* and it has successfully resisted the attacks of many very heavy and high floods. The bridge over the Taptee is said to have cost 40,000*l.*, and that over the Nerbudha 110,000*l.*—sums that in themselves are remarkably moderate.

Beyond the Nerbudha the railway, passing through the town of Baroach, keeps a little more inland than has hitherto been the case, and crossing three small rivers with bridges of three spans each, reaches, at the 80th mile from Surat, the town of Barodah. Leaving this place, which is of considerable size and importance, the line bends westward round the head of the Gulf of Cambay, and soon meets the large river called the Mhye. This the railway crosses by a bridge of the same size and dimensions as that over the Taptee, *viz.* thirty spans of 60 feet; the only difference between it and other bridges on the line being that the roadway rests on the upper member of the girder, instead of being suspended from it by standards. The vertical piles were screwed to a maximum depth of 32 feet into hard clay with speed and facility, and they are strengthened by the addition of oblique piles on both

* A portion of this bridge has failed in the centre of the river during the floods of the past year.

the up and down stream sides. The height from the top of the rail to the bed of the river is 75 feet; and the whole viaduct was constructed in little more than a year.

Considering their size, the difficulty of obtaining foundations in tidal estuaries, the rapid current, and alluvial soil, the speed with which the bridges over the Taptee, Nerbudha, and Mhye were constructed, without any accidents or mishaps of any consequence, is surprising. The principle of screw piles for piers and abutments has subsequently been much adopted in India, and has been found to supply a want in the peculiar exigencies of roads in alluvial districts which no other class of bridge has met equally well.

Beyond the Mhye there are four other large streams to be crossed before Ahmadabad is reached, forming together after their confluence, the great river known as the Sauhermuttee, which enters the Indian Ocean at the northern extremity of the Gulf of Cambay. Two of them are wide enough to require viaducts of ten and seven spans, while the others are much smaller, taking only three. At Ahmadabad is the present terminus of the Bombay and Barodah line; but should it be eventually prolonged towards Delhi, a different system of gradients will probably have to be adopted.

As from the position of the line, its bank forms a dam across the natural outlet of the drainage of the country, the railway has, in times of extraordinary floods, which in India occur at periodical intervals with much certainty, suffered very much. During the monsoon of 1866 the violence of the floods was very great, and appeared unprecedented in depth; an effect produced, no doubt, by the existence of the railway itself. Some twenty breaches, varying in length from 25 to 100 feet, were made in the bank near the rivers Veturne

and Dhanoo, and additional waterway had to be provided in the repaired line at a large outlay.

In fact, from these and other causes, the hopes of great cheapness in the construction of the Bombay and Barodah line, which were entertained and confidently asserted by its projector, Colonel Kennedy, have proved delusive; as the actual cost of the finished line will be more than 20,000*l.* a-mile; and it will therefore be one of the most expensive railways in India.

CHAPTER XVI.

THE SCINDE AND PUNJAUB RAILWAYS.

The River Indus as a Channel of Communication — Sir Charles Napier — Kurachee — Project for uniting Delhi, Agra, and Lahore with Kurachee — Five Companies with distinct Names established — Really, however, one Enterprise, and will be so treated — The different Links commenced at different Times — Scinde Railway Terminus at Kurachee — Gradients of Line easy — Railway subject to Inundation — Rivers Mulleer and Bahrun — Wharf Accommodation at Kotree opposite Hydrabad — The Indus Flotilla — Not a Success — Projected Railway — Mooltan to Lahore — Remarkable from an absence of Works and Difficulties — Cost and Delay of internal Transport — Sher Shah Ghât near Moulton — The Ravee Doab — Fortified Station at Lahore — Lahore to Umritser — Bridge over the Ravee Doab Canal — Umritser to Delhi — Preliminary Discussions and Surveys — Route *viâ* Seharunpore selected — Let in Contract to Messrs. Brassey — Still under Construction — To be finished in 1870 — Formidable Obstacles — The Rivers Beas, Sutlej, Guggur, Jumna, and Markundah — Design of an uniform Character for all — Well Foundations — Small Spans for Iron Girders used — Cheapness thus secured — Jullunder — Sirhind — The Sutlej — The Markundah — The Guggur — The River Jumna — Mozuffernuggur — Ghazeeabad — Wooden Sleepers Burnettized employed — Rails of Steel Iron — Terminus at Delhi.

AN examination of the map of India will at once indicate that the whole of the northern provinces of the continent are dependent upon the two natural channels of communication, the river Ganges and the river Indus. From various causes, but mainly in consequence of the existence of a convenient port for shipping at or near Calcutta, there has been from time immemorial a constant stream of commerce on the river Ganges. From this flow of traffic, populous and wealthy cities sprang up on its banks, and the districts generally were fertilized and benefited. Such, however, was not the case with the Indus. In the river itself, the navigable channels were rather more shallow and shifting

than those of the Ganges, and some rapids near Sukkur usually required a portorage for some miles. Its mouths, too, were much obstructed with banks, and the creeks between them were tortuous and difficult to navigate; while, even when the dangers of the river were successfully passed, the mariner reached no commodious or safe anchorage, but an open ocean, where, on the sand bars at the entrances of the hundred mouths of the Indus, the waves were during the south-west monsoon always breaking.

Still the great commercial and political advantages which the Indus was capable of presenting, could it be rendered easily navigable, and could a port for shipping be made near its mouth, were so manifest, that the facilities the river was calculated to afford were dwelt upon by every Indian statesman who of late years has had to conduct the administration of any of the Western Provinces of India, or hold diplomatic relations with the princes of neighbouring states.

To Sir Charles Napier, however, is the credit due of first giving a practical turn to the various recommendations and suggestions on the subject which from time to time had been made. He selected Kurachee, as a place which by means of artificial additions might be formed into a harbour. It was then a mere fishing village, possessing some natural advantages as a port, situated at some distance to the north of the main exits of the Indus, but still communicating with it by means of the Gharrah Creek. Sir Charles Napier also commenced the mole which bears his name, for the purpose of improving the approach to the port of Kurachee; an improvement which has been since prolonged by a groyne running out to Manora Point, where the bar at the mouth exists.

The plan and skill with which these works were laid

out have been much questioned and doubted, yet they have certainly deepened the water on the bar and improved the harbour generally, so that ships drawing 18, 19, or 20 feet, can now enter or leave the port with ease and safety. The great desideratum of a tolerably commodious port near the mouth of the Indus, having been thus secured about the time when railways were first being introduced into India, the great project of uniting the capitals of the North-western Provinces of Hindustan, Delhi, Agra, and Lahore, with Kurachee by means of the Indus was speedily set on foot, and was favourably received and accepted by the Governors of India. The plan was not, however, put forward at first as a whole, but on the contrary has been advanced in a peculiar and disjointed manner.

There are no less than four different undertakings, with distinct capital, accounts, and local agents; all, however, having the common object of forming a good and convenient through communication between the upper districts of India and the Indian Ocean. These undertakings, though kept separate as regards accounts, are under one management at home; and are all equally under one guarantee of interest, but they have distinct titles and are called "The Scinde Railway Company," "The Indus Flotilla Company," "The Punjab Railway Company," and "The Delhi Railway Company." There will be no advantage in retaining these distinctions in this account, and it will be more convenient to consider the enterprises as one concern, as in objects and designs they really are.

The original promoters of the undertaking, among whom Mr. W. P. Andrews was the most conspicuous, at first advocated a short line, 114 miles only in length, from Kurachee to the banks of the Indus, opposite the town of Hydrabad. From Hydrabad a fleet of steamers

was to carry on the communication to Moulton, and from Moulton a railroad up the Baree Doab was to complete the junction between Lahore and Umritser, the political and religious capitals of the Punjaub; whilst the final link between Umritser and Delhi was eventually to be formed by a railroad between those cities.

The plans for the Scinde line were formed in the early part of 1855, and in the month of December of that year the Scinde Railway Company formed a contract with the East India Company to construct a railroad from Kurachee to Kotree, on the right bank of the Indus, opposite to Hyderabad. Shortly after, on the Court of Directors entering upon a more extended plan of supplying railway communication to India, this agreement was superseded by another, which gave effect to the larger views and the more comprehensive plan of operations which have been sketched. Two contracts, dated respectively February and March, 1859, were signed; one for the establishment of a steam flotilla on the Indus between Hyderabad and Moulton; and the other for the Punjaub Railway, *viz.* a line from Moulton to Umritser. The further extension to Delhi was granted to the Scinde Railway Company in the same year, although from the pressure of financial difficulties its construction was postponed till 1864, when a tender from Messrs. Brassey, Wythes, and Henfrey, for the formation of the entire line from Umritser, to a point opposite to Delhi, including the provision of rolling stock and stations, was accepted. The rate at which this contract was made was 14,630*l.* per mile.

Returning now to the consideration of the main enterprise, the first part which has to be described is the railway in the Province of Scinde. This great undertaking, as a whole, is in truth second in magnitude to none in India, though, from being known under

various names, it is rather dwarfed and diminished in importance in public estimation, when compared with its great contemporaries, the E. I. and G. I. P. Railways.

KURACHEE TO HYDRABAD: 108 Miles.

At Kurachee the terminal arrangements are more extensive and complete than the length of the line would warrant, had it not been necessary to provide not only for its own wants, but for all the traffic coming down the Indus. The main terminus for passengers is now at the McLeod Road Station, conveniently situated near the old town of Kurachee, and from this it was intended that the line should be carried on by a viaduct of ten spans of 100 feet each, over the Chinnee Creek to the island Keamaree, so as to have a convenient access for the goods traffic of the railway to the shipping of the harbour.

Passing from the McLeod Road Station, the line proceeds to a spot 3 miles from Kurachee, where the workshops of the line have been erected; and from whence a short branch of 3 miles long has been constructed to Ghizree, on the Gharra Creek, for the purpose of accommodating the traffic coming directly from the Indus and the eastern districts of its delta, near the once flourishing, but now decaying town of Tatta. From Ghizree the line passes throughout its length through a rather barren and sparsely-populated district, crossing in its course the drainage of a mountainous region, called generally the Kara Hills. In these hills a limestone, easily worked, but hardening with exposure, and forming an admirable building stone, was found, and was largely used in the masonry works of the railway.

From the line having been traced across the natural fall of the country, in the low ground at the foot of the hills, the gradients are easy and the works generally are

light, bridges alone being excepted. As might be inferred, however, its position has required the provision of a large amount of waterway, and the line is still subjected at times to be submerged by inundations, caused by the furious downpours, which at long intervals fall upon the usually rainless province of Scinde. During the construction of the railway works, great inconvenience was experienced from the want of good water for the workmen to drink. If the bad, brackish water usually found in the wells of the country was used, cholera, dysentery, and fever were sure to follow; so arrangements at a great cost had to be made to obtain pure water from the Indus, or from wells sunk in the beds of the minor rivers. Trains of water-carts from the rivers Mulleer, Bahrūn, or Indus were at first organized; and subsequently, as the line advanced towards completion, water-trains were regularly despatched to the workmen along the line, as it was found impossible by other means to keep them together and in health.

At about the 16th mile from Kurachee the railway has to cross a wide river called Mulleer, which is formed by the confluence of several streams. The viaduct over it consists of twenty-one spans of 80-foot iron girders, on Warren's triangular principle, resting on stone piers. This was the principal work on the line; the next largest being the viaduct over the Bahrūn river, at the 100th mile from Kurachee. This river was not, however, spanned by iron girders; but by thirty-two segmental arches of 45 feet each. Its total length was 1728 feet, and its average height, measuring from the bed of the river to the rails, was 25 feet 6 inches. Besides these works there was a viaduct of eight spans of 80-foot girders over the Loyach, and one of six similar spans over the Runnipithiani river. The Guggur and Rhooch rivers required bridges of

three spans of 80 feet each, and the Dorbagi two spans.

Of minor bridges there were five, with arches varying from 45 to 30 feet in span, having an aggregate of seventeen arches; and nineteen, containing forty-eight arches each of 20-feet span. There were twenty bridges of spans between 12 and 15 feet, with a total of fifty-five openings, and 533 culverts, each less than 10 feet. The ruling gradient of the line is 1 in 200, and, out of the entire distance of 108 miles, $32\frac{1}{2}$ miles are on the level; and for a distance of $74\frac{1}{4}$ miles the line is straight. There is no curve with a radius shorter than half-a-mile.

One feature in the construction of this railway which deserves attention is, that as rain in Scinde is rare, but the fall, when it does happen, extremely heavy and sudden, the engineer who designed the railway, Mr. Brunton, considered it wiser, in the large plains which are annually liable to inundation for a few days, to allow the flood-water to flow over the line instead of under it. The expedient, though devised to suit the peculiarities of a railway formed in a country with a climate like that of Scinde, does not appear to have produced the economy in cost which had been anticipated; for the injuries done by floods have been very great, and the cost of working and maintenance extraordinary, amounting in the year ending 30th June, 1862, to 86 per cent. of the gross receipts, and to 93 per cent. in 1864.

Considerable additions to the strength of the wing-walls of bridges and culverts were proved by the floods to be required, and increased waterway had in many instances to be provided in embankments. At Kotree, on the Indus, 2000 feet in length of wharf-accommodation was constructed, both at a high and low level, so

as to suit the convenience of steamers and barges as well as that of native craft; and from Kotree the Indus flotilla maintained the communication as far as Moultan. A steam ferry was also established at Kotree for the accommodation of the passenger and goods traffic of Hyderabad.

THE INDUS FLOTILLA.

A description of this fleet hardly falls within the scope of this book, and it will suffice to say that the difficulties in the navigation of the Indus have proved much greater than had been expected. A model-steamer called the 'Stanley,' was built in London, but on trial in the Indus, her engines were found defective and wanting in power. Even when altered and improved, she was unable satisfactorily to stem the current of the Indus, and six other steamers contracted for, similar to her, have proved unsuited for the work they are required to perform. There have been consequently great delays in organizing a regular trade, but the company having bought five steamers formerly employed by Government on the Indus, have completed their arrangements, and as more experience is gained, further improvements will no doubt be made. But at the best, steam communication on a river like the Indus, so shallow, and yet with a strong current, must be tedious and liable to delays and serious derangement; and the plan therefore of joining Hyderabad with Moultan by a railway, has been pressed upon the Government of India, which has so far encouraged the project as to allow surveys to be made on both banks of the Indus with that object.

MOULTAN TO LAHORE: 219 Miles.

This railway is a most remarkable work in an engineering point of view; not, however, on account

of the difficulties the line has to overcome, but from the extraordinary facilities which the contour of the country and the direction of the line present, for the construction of a railroad. In very few other parts of India, and probably even of the world, could a line run for 219 miles in nearly a straight course (for 114 continuous miles the line is perfectly straight), or practically on the level, without having to cross a river, without passing over one hill, or anything approaching the character of a hill, and without meeting with a ravine or hollow. The worst gradient is 1 in 600, and even that gentle slope is but seldom required. The whole district, however, is liable to periodical inundation to the depth of about 2 feet, rendering an embankment necessary, and the railway has to cross several irrigation canals, and to provide culverts for many water-courses and drainage channels, which are intercepted by its course.

The line was commenced in 1859, Sir John Lawrence, then Lieutenant-Governor of the Punjaub, formally turning the first sod in February in that year; but though the works were so light, labour for what was required even was hard to get, and great delay was caused by disputes between the agent and chief engineer, who were both eventually removed. The failure of native contractors to perform the task undertaken by them also caused much delay; while, when the works were taken over by the railway company, and their execution departmentally was determined upon, the engineers, new to their work, were unable at first to cope with the natural difficulties in their way.

The comparative failure also of the Indus flotilla prevented the speedy and exact delivery of permanent way, iron girders, and other stores from England; and eventually the great bulk of the iron work was brought

up the Indus in native craft, through the agency of Mr. Coates, an Englishman, who accepted and successfully carried out a contract for the transport of these materials from Kurachee.

The traffic terminus of the southern extremity of the line is at the steamboat wharf on the Chenaub, at a spot called "Sher Shāh Ghât," where facilities for the accommodation of the traffic were made as far as the nature of the ground and river would allow. As, however, the river overflows its banks annually to a considerable depth, while the deep-water channel of the cold season is continually fluctuating, it was determined to erect the permanent station on high ground at some distance from the banks, and that nothing but open platform, which could be easily shifted and would not be very expensive, should be constructed near the river. Fourteen miles from this wharf, the railway passes the large town of Moulton, near which there are several culverts, and small arched bridges of no importance over two native canals called Secunderabad and Wulle Mahommed.

After leaving Moulton, the line passes up the centre of the plain or doab between the rivers Ravee and Sutlej, keeping near the summit of the ridge which forms the watershed between these two rivers; and running also generally parallel to the line of the Baree Doab Canal. The district at present is dry and barren, and very thinly inhabited, but it only needs the water which the canal will supply to make it fertile and flourishing, and to procure for it a prosperous and adequate population, which will no doubt eventually cluster round the railway stations, that will thus become nuclei of thriving villages and towns. When the line was traced, however, there were no places of sufficient importance to require a railway to be taken to them, and the line therefore

ran in a direct course towards Lahore, without stations or works requiring description or remark.

Between Moulton and Lahore there were in all nine small bridges, six of which were within five miles of Lahore. The two largest were over branches of the Baree Doab Canal, and consisted of girders on Warren's principle of 80-foot span each, resting upon brick piers; but there was of course no difficulty about foundations, and the works were of a very ordinary character. At Lahore it was considered desirable to make the passenger station easily defensible, and in external appearance it resembles a fort. The interior, however, is commodious, containing both arrival and departure platforms, with the usual offices. The rail exits can, if necessary, be closed with heavy sliding doors; and the station itself is so planned with reference to the other buildings in the terminus, as to have a command of fire over them to some extent, so that if an emergency should arise it might be occupied as a citadel. It is situated about 400 yards distant from the Delhi Gate of Lahore, and is built entirely of the best brickwork. The line from Moulton to Lahore was opened for traffic in April, 1865.

LAHORE TO UMRITSER: 32 Miles.

This section of the line, connecting the two most important cities in the Punjab by railway, was pushed on with greater celerity than that between Moulton and Lahore just described; and although the country was not quite so easy, there were no engineering difficulties. The largest bridge was one on the skew, of two spans of 80 feet each, composed of iron girders on Warren's principle, over the Baree Doab Canal, and another one of 60 feet over a drainage channel. Excepting these and a short viaduct of eight 12-foot arches, there were neither bridges nor any other works of im-

portance upon this portion. The station at Umritser, like that at Lahore, has been designed with the intention that it may be readily defensible. It is situated on the northern side of the city, in a position to accommodate both the through traffic and the wants of the city and cantonment.

UMRITSER TO GHAZEEABAD (DELHI JUNCTION):
303 Miles.

It had always been contemplated that this length of railway, the final link connecting Lahore with Calcutta, should be made as soon as the preliminary lines had progressed sufficiently to render its construction advisable; and in pursuance of this view the Government of India had entered into an agreement with the Scinde and Punjaub Railway Company, in the year 1859, to make a line from Umritser to Delhi. Shortly afterwards, however, great financial difficulties arose in India, and under the pressure of them the construction of this line and of several others also was allowed to remain in abeyance.

The plans of the originators of the East Indian Railway Company had intended that Lahore, instead of Delhi, should be the terminus of their line, and engineers in their employ had made some reconnoitering surveys of this country, directing their explorations mainly to the river Sutlej. The direct line, from Delhi through Paniput and Kurnal to Umballa, was the direction which was then supposed the most eligible for a railway; and the engineers at that time proposed to take it from Umballa across the Sutlej, at or near Ferozepore, below its confluence with the Beas. This was, however, at an early stage in the progress of this railway, and when the question was again revived in 1862-63, it had been determined that the East Indian Railway should

terminate at Delhi, and that the Scinde and Punjaub Railway Company should be entrusted with the completion of the railway communication with Lahore.

The Government of India also, on reviewing the question, decided that the advantages of a railway formed along the established route of communication (*viâ* Seharunpore), and connecting Umballa and Meerut directly with one another, and with Allahabad, would, on military considerations, be far preferable to the direct route. The country on the east side of the Jumna was richer and more productive than that on the western bank; more densely populated, and more likely, therefore, to be able to support a railway, and to relieve the Government from the burden of paying the interest guaranteed upon the capital that may be required for the construction of the line. All reasons, indeed, conduced to the conclusion, that a railway following a course *viâ* Meerut, Seharunpore, and Loodhianah, would not only be more generally useful, but also far more remunerative, than the direct line *viâ* Paniput and Kurnal.

This recommendation of the Indian Government having been accepted by the Secretary of State for India, and the direction having thus been finally determined on, the actual route was selected and approved in the course of 1863. During the next year the Delhi and Umritser Railway was commenced by some small contracts for earthwork being let to contractors in India. In the meanwhile negotiations had been in progress in England between the directors of the Railway Company and Messrs. Brassey, and on the 3rd May, 1865, that firm signed a contract, providing for the construction, within five years from that date, of the whole length of railway between Umritser and Ghazeeabad, a distance of 303 miles, at 12,630*l.* per mile, exclusive of rolling-stock.

Although the Umritser and Delhi Railway was not

long, yet from the number and size of the rivers it had to cross, the difficulties that had to be encountered were formidable, and quite out of proportion to its length. Five great rivers, the Beas, Sutlej, Guggur, Jumna, and Markundah, all required bridges of a large and expensive character; and though the country traversed by the railway was flat, yet it was intersected by numerous branches and channels belonging to the Jumna and Baree Doab systems of irrigating canals.

On leaving Umritser the line runs for 27 miles through a flat country to the river Beas, and crossing it passes to the north of the Jullunder cantonments; then turning south it meets the river Sutlej, which is bridged near the fort of Phillour, and after traversing a good deal of low ground and inundation it reaches the military station and town of Loodhianah, and is then carried across the plains of Sirhind, near the old decaying city of that name. Crossing then the rivers Markundah and Guggur the railway passes the cantonments of Umballa, and soon after, crossing the river Jumna and canals derived from it, it reaches the civil station and town of Seharunpore; near which the line is carried over the river Hindun, and from thence runs, still in a southerly course, to Meerut, the largest military cantonment in the North-western Provinces.

A few miles beyond Meerut the line unites with the East Indian Railway at Ghazeeabad Junction, communicating by a short branch of 11 miles in length, with its terminus in the city of Delhi.

This line, resembling in these and other respects the East Indian Railway, had all its curves and gradients of an unexceptional class, and the uniformly level character of the country which it traversed, rendered any high embankments, except at the passage of rivers, unnecessary. The banks on an average did

not exceed a height of from 4 to 6 feet; but differing from other Indian lines in this particular, they were only 23 feet wide at formation level, and adapted for the reception of a single line of rails. The great feature of the railway was the number and size of the bridges, which in both respects far exceeded the usual average for such a length of line. There was much similarity in their general design; but they can be most conveniently described by taking the line section by section in order.

UMRITSER TO THE RIVER BEAS: 27 Miles.

The great work on this length was the bridge over the river Beas. In width it was 3221 feet, which was divided into twenty-nine spans of $111\frac{1}{2}$ feet each, giving a clear waterway of $29 \times 99 = 2871$ feet, or about half-a-mile in length. Each pier rests on a single well of brickwork, $12\frac{1}{2}$ feet external diameter, and $6\frac{1}{2}$ feet internal, which has been sunk to a depth of 42 feet or more, through layers of sand and gravel, below the cold weather water-level of the river. This great depth has been found necessary in order that the piers may be supported by the friction on the sides of the wells, as good foundation is seldom obtainable, even at that or at greater distances below the surface.

The wells are shod with a wrought-iron curb of a wedge-shaped section, of the same dimensions as the brick walls of the well, 4 feet in height, weighing about 6 tons each. Armed with this, the wells are sunk by native divers, in the same way that has already been described, as far as they can be made to go, or as water will allow; and then a plan similar in principle to that used to sink the wells on the Eastern Bengal Railway was employed. A wrought-iron tube 6 feet in diameter was inserted into the brick well, and fastened to the

projecting rim of the curb ; and on this the bell, which is described in the account of the bridges on the Eastern Bengal Railway, and is used for working under atmospheric pressure, is secured. Air being pumped into the tube, such a pressure is obtained as will expel the water, and workmen are then able to continue their excavations at the bottom of the well, and the whole pier, being heavily weighted, is sunk to the depth desired, and the wells are then hearted with concrete. The superstructure of the piers and abutments consists of brickwork.

The river Beas runs, as may be inferred from the character of the strata through which the wells are sunk, through a very soft and treacherous soil, which is liable to be washed away by any flood or sudden inundation ; and as by the mere existence of a bridge some current and scour would be created, great and extraordinary precautions were thought necessary to keep the main current in its present channel, and to prevent any cutting away of the bank approaches. Rows of wells, forming a curtain, are sunk across the mouths of some overflow streams above the site of the bridge, so as to counteract any tendency to deepen which their channels might show ; spurs are formed high up the course of the river for the purpose of guiding the main stream straight to the bridge ; and long wing-walls, resting on lines of wells, in shape sometimes circular and sometimes elliptical, with an external major axis of 14 feet, and minor axis of $6\frac{1}{2}$, with walls $1\frac{1}{2}$ foot thick, have been formed on the right bank to an extent of 600 feet in length, and on the left to a distance of no less than 3960 feet.

The distance between the piers from centre to centre is $111\frac{1}{2}$ feet, or 99 feet clear between the piers, and is spanned by iron lattice girders ; and this plan of having

piers resting on a single well with comparatively small spans, and consequently, light iron-girders, effected considerable economy in the total cost of the bridge, as compared with the piers* containing many wells, and the large girders used on the main line of the East Indian Railway.

Some of the wells forming the piers of the bridge after being sunk to a depth of 43 feet, reached a satisfactory foundation, consisting of boulders of kunkur, limestone, and of sandstone of considerable size. Besides the great viaduct over the Beas, there were the following bridges of considerable size: one bridge of one span of 139 feet, one of 79 feet, and one of 72 feet; and two smaller, consisting of two viaducts, each of three 30-foot spans; one of which rests on piers of screw piles. The other bridges have all their piers and abutments of brickwork.

JULLUNDER SECTION : 50 Miles.

From the Beas to the river Sullej.

Besides the usual average of culverts and small bridges, there are only three bridges of any magnitude: two of two spans of 80 feet each, and one of three spans of 30 feet each, all covered by iron girders and resting on brick piers and abutments.

SIRHIND SECTION : 114 Miles.

From the Sullej to the river Jumna.

The works on this length are of greater magnitude than on any other;—the railway, skirting the line of the Himalayah mountains in a direction generally parallel to their alignment, crosses the natural drainage, which runs off by a number of streams and torrents.

* The piers of bridges on the East Indian Railway were founded to receive eventually a double track.

The width of the Sutlej when in flood at the point where the railway crosses is above $1\frac{1}{2}$ mile, but about 5 miles above this spot the width is reduced to 4200 feet; and as the waters of the floods pass through this channel, a bridge of 4224 feet, consisting of thirty-eight spans of $111\frac{1}{2}$ feet each, and giving a clear waterway of 3762 feet, has been constructed in the centre of the wide bed.

The design for the piers and girders was similar to that of the Beas bridge, but as a bed of clay extended across the river channel, at a depth varying from 40 to 50 feet below the low-water level of the river, the piers were sunk into that, thus obtaining a secure foundation. On the right bank, the wing wall was to be carried on wells, to the high firm ground on which the fort of Phillour stands, a distance of 2900 feet; but on the left bank, which is low, the wing wall also on wells, was to be more than $1\frac{1}{4}$ mile in length. Extensive precautionary measures, by forming spurs to direct the current, and by sinking curtains of wells across the beds of existing nullahs near, so as to guard against any inclination to deepen their channels, were also taken.

Between the rivers Sutlej and Jumna the principal bridges are the following:—

The iron girder bridge over the Markundah river, of eleven spans of $111\frac{1}{2}$ feet each, with a clear waterway of $11 \times 99 = 1089$ feet.

The design for this bridge is identical with that which has already been described, but the wells supporting the piers and abutments, were not sunk so deep as those at the Beas. At a few feet below the surface of the bed of the river, a stratum of clay was found, and into it, to depths varying from 34 feet to 18 feet, the wells were sunk, and a very satisfactory foundation was thus obtained.

Over the West Jumna Canal two spans of 105 feet

each were required; and for the remaining rivers a uniform span of 80 feet, in viaducts proportionate to their width was chosen.

The Guggur river required eight spans of 80 feet.

The Tangree river required six spans of 80 feet.

The Boodher, Loodhianah, and Chittery rivers required three spans of 80 feet each.

The Sursuthe, and another nameless stream, required two spans of 80 feet each.

Three other nullahs had bridges of a single span of 80 feet each; two more, girders of 55 feet; and over the Chua river, a bridge of two spans of 30 feet was erected; thus giving a total, in the length between the rivers Sutlej and Jumna, of thirty spans of 80 feet each. Besides the bridges which have been mentioned, small bridges and culverts were very numerous. The foundations of the abutments, piers, and wing walls of all the viaducts rest upon wells; and generally speaking, they have been sunk into stiff clay, beds of which have been usually found at depths varying from 20 to 25 feet below the low-water mark of the cold season of the year.

Wherever stiff clay existed, the wells when sunk deeply into it were firm and stable, and resisted successfully the action of the current; but if, from miscalculation, or from the unexpected rise of floods, the wells were allowed to remain during the wet season with their curbs in sand or only resting upon the clay, the scour of the river, increased as it was sure to be by the mere fact of the existence of the wells, was nearly certain to undermine and cause them to tumble over. This happened at the Tangree river, where long wing walls, of about 250 feet in length, resting on thirty wells of 8 feet in diameter on the right bank, and of about 125 feet in length, resting on fifteen

wells of like dimensions on the left bank, were constructed.

The wrought-iron girders for the bridges were tested by dead weights before erection, in the following way:—

For spans exceeding 80 feet, by a weight of 1 ton per foot run of single line of way.

For spans between 50 and 8 feet, by a weight of $1\frac{1}{4}$ ton per foot run for a single line of way.

For spans up to 50 feet, by a weight of $1\frac{1}{2}$ ton per foot run of single line of way.

Cross girders being all tested with 10 tons in the centre.

FROM THE RIVER JUMNA TO MOZUFERNUGGUR:
54 Miles.

The chief engineer of the line, anxious to have as few dissimilar parts as possible, adopted for the large bridge over the river Jumna the same design as for those over the Beas and Sultej. The bridge consists of twenty-four spans of $111\frac{1}{2}$ feet, each giving a clear waterway of 2376 feet, nearly the same as the waterway of the bridge over the Jumna at Delhi, which is 2424 feet. The piers will be similar to those already described, but as clay was not obtainable, the wells were sunk to a depth of 42 feet or more below low-water level, a depth supposed to give safety from the action of all floods, while it was known to be sufficient to give stability by friction. The wing walls were not so long as at the other large bridges, but on the left bank especially, they had to be continued to several hundred feet, to prevent the cutting away of the bank by the annual floods, though at first it had been hoped that this would not have been necessary.

After this great work, the next largest bridge is

one of 100 feet span over the Eastern Jumna Canal; while for the others the uniform span of 80 feet has been retained.

The Hindun river, requires a bridge of five spans of 80 feet.

The Nalah and Dhumnoulah rivers, need bridges of three spans of 80 feet each.

Another nullah is bridged by a single span of 80 feet; and the Boodhee, with two spans of 30 feet. Besides these larger structures there is the usual provision of small bridges and culverts for minor watercourses.

FROM MOZUFERNUGGUR TO GHAZEEABAD : 58 Miles.

The only bridges on this section are those over the Ganges Canal. One of them crosses the canal on the skew by three girders of 93 ft. 6 in., resting on piers formed by pairs of iron cylinders of 6 feet in diameter, sunk 20 feet below the bottom of the canal, and built up solid with brickwork; and the other is similar in design though differing somewhat in dimensions.

Wooden sleepers, carefully Burnettized, were used for half the length of the line, and Greave's iron-pot sleepers for the other half. The specification stipulated that the solution of chloride of zinc, as prepared by the patentees, should be diluted to a strength of 1 in 40, and that the sleepers should be treated in one of the following ways :—by soaking ten to eighteen days in the cold solution in open tanks, or by soaking for three or five hours in the solution heated to 160° or 180° Fah., or by the pneumatic apparatus :—the timber being placed in a wrought-iron cylinder, the air exhausted and the solution admitted, force-pumps are to be worked until a pressure of 150 lbs. on the square inch is produced and maintained for sleepers half-an-hour, and for timber an hour-and-a-half. But whatever process be adopted, the saturation

was to be so effectually done that the timber should take up 6 pints of the concentrated solution (containing 16 oz. to the pint) to the load* of 50 cubic feet.

The rails are of steel-iron, and most carefully manufactured of the very best metal, puddled, thoroughly worked by a steam-hammer of 3 tons weight or more, and then rolled to size. Test-rails from each day's manufacture being placed upon bearings 3 ft. 6 in. apart, were tested with weights first of 20 then of 25 tons in the centre, and were not to be passed without deflecting more than $\frac{3}{4}$ or $1\frac{1}{2}$ respectively. The test-rails were also required to bear 40 tons without breaking. The rails weighed 60 lbs. per yard, and the chairs 21 lbs. 10 oz. each. Galvanized iron-fencing was provided for the whole of the line.

Exclusive of the termini, there were twenty-two intermediate stations, which were also to be constructed by the contractors, and a separate terminus in the city of Delhi. In the contract a certain sum was allowed for the erection of the termini and stations; but if this amount in execution were exceeded, the extra work was to be paid for at fixed schedule rates.

* Taking 15 sleepers to the load, then each sleeper should take up $6\frac{1}{2}$ oz. of the salt.

CHAPTER XVII.

MADRAS RAILROADS.

Early Struggles—First Designed from Madras to Arcot or Wallajanuggur—Mr. Simms' Views and Recommendations—The Company dissolved—Scheme revived in 1849—Receives the Support of the Court of Directors—Opposed by the Board of Control—Again strongly recommended by the Court—Board of Control again Declines—Major Pears appointed Consulting Engineer to the Government of Madras—Report by Major Pears—Memorandum—Various Routes up the Ghâts—Very low Estimate—Recommends that the Railway be made by Government directly, without the agency of a Joint-stock Company—Report adopted and recommended by the Court—Rejected by the Board of Control—Question of Railways in India generally referred to Lord Dalhousie—Opinions and Report by Mr. John Peter Grant—Government of India decide to commence a Line and to carry it from Madras to Menil.

THE European residents at Madras were not slower than those at Calcutta and Bombay in recognizing the advantages which a railway would give to their city and Presidency. As early as the 8th of July, 1845, the Madras Railway Company was formed in London, and the first general meeting of the shareholders took place in February, 1846. The object of the promoters of that company was the construction of a railway from Madras to a commercial town called Wallajanuggur, which under its military cognomen of Arcot is well known. An estimate was framed, and a general scheme prepared, which in 1847 was submitted to the judgment of Mr. Simms, C.E., the First Director of the Indian Government Railway Department. The scheme was favourably entertained, and, indeed, it could hardly fail to be so.

Madras, though not deserving the name of a port, is yet the only existing outlet for the produce of the Presidency, and contains at least 600,000 souls. Wallajanuggur lies nearly due west of it; and through it flows all the traffic from the north-west and south-east. Trade in Madras has two main directions, one from the northern districts of Bellary and Cuddapah, the other from Coimbatore and Salem, receiving as affluents streams of commerce from Mysore. These lines converge and meet at Wallajanuggur; and it was therefore not surprising that projectors should in the first place fix upon it as an entrepôt of trade, suited to be either a terminus or a point from which future railway lines might start. In Madras there are no natural water-communications, and the only competition was that of pack-cattle and of bullock-bandies, or carts drawn by bullocks. Railway communication being so vastly superior to these methods, it is no wonder that both projectors, the official advisers of Government, and Government itself, urged most strongly the claims of this railway, and entertained sanguine views of its financial success.

Mr. Simms' first report upon any definite railway was on that proposed between Madras and Wallajanuggur, and his views expressed in 1845 have a singular interest when read in the light of experience in 1868. After disposing of its expediency, its practicability, and its bearing upon a general system of railways for India, to all which points no exception could be taken, Mr. Simms, anticipating the advice shortly after given more formally to the Government of India, recommended that the mode of construction should not be left to the opinion of any engineer who may chance to be employed by a railway company; but thinking that the lines which may now be constructed by private companies will eventually become the property of Govern-

ment, he considered it essential that they should be made in a permanent and substantial way and on one general system. With this object he proposed to draw up a general specification which should be applicable to all railways in India, and be binding on all railway companies or other contracting parties, and not be liable to alteration without the sanction of Government.

Mr. Simms evidently estimated very highly the commercial success railways in India would be sure to obtain, as well as the advantage which would be secured by a connection with Government, for the terms and conditions proposed are stringent, compared with the small aid that he conceived Government should grant.

The terms upon which the concession of the privilege of making a railway in India should be granted, ought to have reference, Mr. Simms considered, to the line being part of a general system of railroads, intersecting India in all directions, and to its ultimately becoming the property of Government. With these views, not only was the railway to be constructed on a Government specification, and in a specified manner, but as much as possible a duplicate system should be introduced into all the details of the railway; and the whole working and book-keeping of the lines should be subject to the control and supervision of Government. Besides this the railway company was to furnish any returns, statistical or otherwise, which the Government might desire.

These stipulations, it will be noticed, do not differ much from those which have been actually made by Government with the various railway companies, but the advantages which Mr. Simms recommended to be granted were small and few compared with those which have been conceded. There was to be *no guarantee of interest, no gift of land free of all cost*; but on the contrary, the railway company were to be allowed to make a

line on a lease, the period of which was to be determined after ten years' experience of the result of the opened line, on the basis of the profit of the three past years. This peculiar arrangement was suggested as there was great uncertainty about the return upon the capital that may be expended. The duration of the lease, however, was to be so fixed as to provide a fair percentage of profit on the capital, and a redemption of the capital itself. At the expiration of the lease, *the whole of the railway and its appurtenances were to become the property of Government without any payment, except perhaps for the plant, which might be taken at a valuation.*

Assuming, as of course Mr. Simms did, that the profit on the railway would be large and certain, the general scope of the suggestions was perhaps judicious; as, although the control which Mr. Simms proposed that Government should exercise, was at once supreme and minute to a degree, yet it was to be exercised for the good of the shareholders of the company which might carry out the undertaking. The railway company were, in his view, to be employed merely as agents and contractors to supply money and works.

Such a proposal, so one-sided in its purport, and resting upon the assumption that the railway would certainly be highly remunerative, while in truth this was very uncertain, was not likely to meet with much favour; and beyond the estimate, which was at 5000*l.* a-mile, nothing further at this time occurred. Mr. Simms mentions also, that the estimate in his opinion was too low, and that a rate of 8500*l.* per mile would be more likely to be near the truth. The company being unable to obtain any pecuniary concession from the Honourable Court of Directors, was shortly after dissolved, and it was not until after experimental lines had been sanctioned in Bengal and Bombay, with a

guarantee of interest on the capital paid up, that the subject of a railway in Madras was revived.

In 1849, Mr. Arbuthnot, as chairman of two meetings held in London regarding a railway in Madras, addressed the Court upon the subject, and subsequently Colonel Sim by letter asked for an assurance from the Honourable Court that they were prepared to grant the same terms and encouragement to Madras as they had to Bengal and Bombay. Simultaneously with this movement, the residents in Madras held a public meeting, the Right Honourable the Governor being in the chair, for the purpose of digesting and preparing a scheme for a joint-stock company to make a railway from Madras to the interior towards Arcot.

Captain Collyer, of the Madras Engineers, offered to make a survey and estimate, and Majors Pears and Smith, and Captain Bell, all of the same regiment, were requested to consult with Captain Collyer to determine the direction of a line, and generally to complete all the information that could be obtained on the subject.

The Honourable Court received the proposal favourably, and passed the following resolution on the subject:—"Resolved that the Court, continuing to entertain the opinion that it would be just and expedient to extend the experimental introduction of railways in India to the Madras Presidency, recommend that terms corresponding with those which have been offered to the East Indian and Great Indian Peninsula Railway Companies, be granted to the Madras Railway Company in respect of a capital of 600,000*l*." This resolution was submitted to the Board of Control for the affairs of India, on the 1st June, 1849, but it was not till the 17th August, 1849, that a reply, signed by the late James Wilson, was sent. Its terms were decidedly opposed to the wishes of the Honourable Court

of Directors; and sanction to the proposal was refused because the conditions on which experimental lines are being made in Bengal and Bombay, place the whole risk of the undertaking on Government; and because as regards a railway in Madras, there was an entire absence of information, whether the undertaking combined the great political and commercial objects, which a careful scrutiny of the ground itself and of the reports by a competent officer of Government, had proved that the Bengal and Bombay schemes would do. The reasons for deferring approval to the construction of a railway in Madras were thus summed up: 1st. "Because much more exact information is required as to the merits of the particular line proposed, not only as to its engineering facilities, but more especially as to its position in relation to the great political and commercial objects, which a railway in Madras should possess, as well as to any general system of railways in India, of which it should hereafter become a part; and 2nd, Because at least some experience should be obtained of the working of this new system of performing public works in India, before it is further embarked in; and the Board feel that it can adopt this course without inflicting any hardship or cause of complaint on the individuals constituting this new company."

On the 30th August, 1849, the directors of the East India Company again urged the claims of the Madras Presidency, as they were unable to admit that the reasons adduced by the Board of Control constituted a valid objection to their wish to extend to Madras the benefits which have been conceded to the other Presidencies. They reminded the Board that a survey had been made of a line from Madras to Wallajanuggur (Arcot), and that Mr. Simms had reported favourably on the documents submitted to him; that knowing that

a railway from Madras would as a matter of necessity have a direction westward, the directors did not propose to approve of this specific line, but merely to sanction the undertaking generally, leaving the exact alignment, position of termini, and all details to the local government, who would, if requisite, have further exact surveys made.

Further, that as the result of an experimental line constructed in one Presidency would be no criterion whatever regarding the probable success of a similar trial in another, it would be useless to await the completion of the railways authorized for Bengal and Bombay before according sanction to a line in Madras. That a line in the last-named Presidency would be cheaper and made more easily; and inasmuch as Madras had no means of transport by inland channel or canal, would be a greater boon to the inhabitants, and would be more likely to be a commercial success than a railroad in either of the other two provinces. The Board, however, remained obdurate; and in a letter dated 17th September, 1849, signed by Mr. James Wilson, declined for the reasons previously explained, to allow an extension of guarantee to capital for a railroad in Madras.

On this refusal being communicated to the directors of the Madras Railway Company, they drew up an able document, containing in a lucid statement all the reasons that could be urged in favour of the project.

After repeating that the two sections of railways sanctioned in Bengal and Bombay could only be taken as trial-experiments of railroads in their own localities, they ask, if an experiment be still required, where is there a line possessing greater advantages in that respect than that which they advocate.

An experimental line should be of moderate length. That from Madras and Wallajanuggur will be 72 miles.

It should have well-established termini, and a considerable traffic should exist between them. Madras is the chief or rather sole port of Southern India ; it is the seat of Government and the centre of commerce. Its population is 600,000. Wallajanuggur, or Arcot, is at once a military station, a populous town, and an entrepôt of traffic between the western provinces and Madras. The engineering difficulties should not be great ; and the cost should be moderate. The survey proves that the country presents every facility for cheap construction : no ghâts to tunnel or surmount, no river of any magnitude to cross ; no extensive alluvial plains, subject to inundation, to traverse. The cost per mile must be, and will be moderate when compared with that of others.

There should be, too, an absence of competing water-carriage. In Madras, on the line proposed there is and never can be any. The alignment of an experimental railway should be fitted for a prolongation to a great arterial line. Although the section from Madras to Arcot has been shown to be complete in itself, yet, in fact, it is only the first link in a chain to connect the coast of Malabar with Coromandel, thus opening up the rich districts of Cauvery, Tanjore, Trinchinopoly, and Coimbatore. However future lines may radiate, the traffic from inland to Madras must flow over the line from Arcot to Madras. In short, its advantages were so great that a guarantee was merely a nominal support.

The Court of Directors, in forwarding this letter, again pressed the subject upon the consideration of the Board of Control. But as no additional reasons were now brought forward, it is not surprising the Board in reply merely referred to their previous letters, and adhered to their opinion before expressed.

The question was thus shelved for the present ; and

the next thing that occurred was the appointment of Major Pears, of the Madras Engineers, to make a report on railways in Madras, not with reference to an experimental line only, but to the ulterior destination of railways, which would facilitate communication for political and commercial purposes and effect more ready intercourse with other Presidencies.

With great promptitude Major Pears submitted during the course of 1850 a series of reports, admirable for their clearness and completeness. Difference of opinion must exist regarding his recommendations and the conclusions drawn, but none regarding the ability with which his views are advanced.

Omitting any consideration of the commerce along the coast, north and south of Madras, as it would not affect the prospects of a railway, the great bulk of the traffic of the Presidency flows towards Madras from the Bellary and Cuddapah districts in the north-west, or from Coimbatore, Salem, and Mysore in the south-west. Both streams unite near Wallajanuggur, or Arcot; and that place was therefore selected as the natural terminus of a short line of railway from Madras.

But Major Pears having been directed not only to consider local advantages but also imperial requirements regarding railways, was obliged to take larger views than the directors of the original proposal. From much careful investigation he came to the conclusion that one trunk-line should run from Madras to the Malabar coast, *viâ* Vaniambady, Salem, Paulghât—that solitary and remarkable gap in the Western Ghâts: and the other should diverge from the first line at a point about 70 miles due west of Madras, should climb the Eastern Ghâts near Palmanair, and should be carried, *viâ* Bangalore, to Bellary, and from thence to Poonah and Bombay.

On the above as a basis, Major Pears felt unable to recommend Wallajanuggur as a terminus, as it was not in the direct line, being situated on the left, or northern side of the river Palar, which divides it from the cantonments of Raneepett and Arcot. Wallajanuggur also is but a small place of business, and although the entire population of the three towns, Wallajanuggur, Raneepett, and Arcot, is 54,000 ; yet the first, which alone is a trading community, contains only 20,000 inhabitants, and is not a central point, but merely a town through which the traffic coming from the west passes. It was evidently dubious whether traders would transfer their goods from carts to the railway, at a spot within three days' march along a good road from Madras, after having accomplished their journey over the difficulties of the road, and having crossed all the rivers. Major Pears's judgment on the point was in the negative, and it met with the entire concurrence of the Madras Government.

Discarding, then, Wallajanuggur as a terminus, Major Pears advanced several reasons why Vaniambady, 130 miles from Madras, should be adopted ; while one member of the Madras Government wished for Vellore, and another for a place called Goriattum. But, though the *pros* and *cons* of these proposals are discussed at length, yet a relation of them would have no interest now, as no experimental line of railway was made in Madras ; but instead, two through lines were eventually decided on.

In the meanwhile, a survey of the country with levels had been undertaken ; and in December, 1851, Major Pears submitted a definite proposal, with plans and estimates for a railway from Madras, in a direction nearly due west, to an unimportant place called Menil. Beyond that point, which he considered as fixed, the

course of the line was to be guided by the ease or difficulties of the passes up the ghâts.

These hills are very remarkable, both in position and character. Their crest is about 2000 feet, on an average above sea-level, and the line of hills, which is about 110 or 120 miles distant from Madras, resembles a natural retaining-wall for the high table-land of Mysore. For the most part, except where at long intervals passes are to be found, they present to the view either abrupt cliffs or steep and rugged slopes.

At the time these preliminary reports were written, it was considered that the two lines which the Madras Presidency needed, should be carried, the one from Madras, *viâ* Vaniambady, to the western coast; the other to Bombay, *viâ* Bangalore and Bellary. This latter course being selected, as the country between Madras and Cuddapah was known to be very difficult, and was then believed to be practically almost impassable for a railway. It is of course also evident, that in mounting from the coast to such a height as the table-land of Central India, two methods might be adopted. A line might gradually rise from the sea, so as to lift the railway to the level of the crest of the ghât, leaving the steep incline short; or the railway might be constructed with favourable gradients to the base of the hills, leaving them to be climbed by an abrupt slope. The latter course was, however, clearly preferable, both on account of first cost of construction and of subsequent working. Examining the ghâts with these views, Major Pears found that there was a pass, nearly in a direct line between Madras and Bangalore, near Palmanair, which could be approached along a ridge forming the watershed between the Palar and Poiney rivers, so as to leave a total rise of 400 feet only to be overcome at the ghât.

At Palmanair, a railway could be formed up the ghâts, with a maximum gradient of 1 in 37, and with no curves sharper than 1 mile radius.

Under these circumstances, and being apparently nearly entirely influenced by facilities in construction, and subsequent economy in working, Major Pears recommended that the railway should be carried away from Arcot and Vellore, and other centres of population, upon a line that was eminently favourable in a purely engineering point of view, through Menil and Sholinghur to Palmanair; and so on *viâ* Bangalore to Bellary and Bombay, with a branch *viâ* Amboor to Vaniambady.

He thus sums up to the advantage of the line: "The character of the country is most favourable, there are no costly or difficult works—the greater part of the land is of small value, much of it of no value at all—while the line would not only monopolize the entire traffic proper to the direction it takes, but from its great superiority over other existing modes of transport, would attract largely from all directions. Under any circumstances, therefore, the line to Menil appears the best for a trunk line."

The estimated cost of the Madras and Wallajanuggur line was 3450*l.* per mile including stock; that of the Madras and Menil line, 3384*l.* per mile.

The amount of waste land through which the railway was to pass is remarkable, as indicating the desolate country through which for the sake of gradients the railway was traced. Of the total amount of land estimated to be necessary, more than half was waste and uncultivated; and the total estimated value of the land requisite was only 42*l.* per mile.

In thus selecting a course away from towns on the score of economy in construction and working, a grave

error was committed, as experience year by year proves more clearly that railways ought to be conveyed if possible to the very heart of centres of commerce; and that to place a terminus distant from them is to neglect a revenue which proximity would be sure to obtain.

The opinions propounded, however, were indorsed by the Government of Madras, with the exception of Mr. Thomas, and adopted by Lord Dalhousie's government; and a line to Menil, passing at a distance of some miles from Arcot, was sanctioned. Mr. Thomas alone opposed this direction. "I will further add," he writes, "that it appears to me that the line should run direct through Wallajanuggur (Arcot), and not leave a large and commercial town out of its immediate line; and take a less thickly inhabited and less wealthy line of country, as that to Sholinghur would be. I do not think it probable that the warehouses at Wallajanuggur, or its trade would be transferred to another locality to meet the rail. The only result, therefore, of thus passing by Arcot would be, I fear, to continue the cart-traffic indefinitely." He also wished that the railway should go to Vellore.

But besides a full discussion of the merits of the suggested directions for the first experimental line of railway in Madras, Major Pears in his exhaustive preliminary reports, strongly advocated a single line, and a moderate rapidity; but he thought that railways should not be constructed on such a refined system of economy as to render them unsuited to a higher speed than 10 or 12 miles an hour. Kept within the limits of safety, speed is a mere question of expense, and up to 20 or 25 miles an hour, not of much importance. If, however, the public required speed, it must of course be paid for. As regards the mode of construction, he opposed the systems adopted in Bengal and Bombay; and strongly

urged that the railway should be made by Government through its own servants. He thus writes:—"I should hope that in this Presidency (Madras) the Government might see fit to make the first railway experimental in another sense, and to try to what extent the people may be benefited by making the line a national work. By the above conditions (*i.e.* those granted to Joint-stock Companies in Bengal and Bombay) it seems that the risk of ultimate failure falls on the country; while on the other hand, should it prove successful, a tax, amounting to 5 or 6 per cent. on the capital invested, will be levied in favour of the shareholders in the shape of tolls, beyond that which is required to meet the ordinary interest of the capital. It appears at first sight that such a dividend can only be reasonably expected as a return for the risk incurred; and it would appear also in this case clearly the interest of Government to raise the money and to take the work into its own hands."

* * * * *

"With a Board of Directors seated in London, and all the chief executive officers appointed from thence, it is to be feared that the control exercised by a Government officer would be little more than nominal, or if called into active exercise, would prove in too many cases a source of dissatisfaction and embarrassment. Under such circumstances, every question relating to the amount of expenditure, or to the proceedings of individual servants of the company, would become the subject of reference at home; and it seems not too much to prognosticate that arrangements of this nature, for the exercise of authority on the part of Government, would become almost if not altogether inoperative."

These first reports are dated 5th March and the 15th December, 1851; and his recommendations were adopted by the Government of Madras, who in a dispatch to the

Court of Directors, dated June, 1851, state that they fully concur in the views expressed by Major Pears that the proposed railway should be a Government undertaking.

It would seem also that these opinions found favour at home, for in April, 1852, we find the Court of Directors requesting the permission of the Board of Control to give instructions to the Government of Madras to execute this work, saying, that as they, the Honourable Court, contemplate a great extension of the railway system in India, they wished to adopt the present opportunity of testing the cheapest and most efficient mode of conducting such works, by taking the present work on themselves.

The Board of Control, however, who, it must be said, seemed never willing to adopt the views of the Court of Directors, were indisposed to accede to the wishes of the Court: because as it must ever be an object of very high importance to attract the investment of British capital, skill, and enterprise, to undertakings for the improvement of our empire in India, the system of contract is the more eligible, as being eminently conducive to that end. They also felt doubts "whether an equally effective control over the expenses of such works could be maintained in India under general instruction from the Home Authorities, as that which is now exercised through the railway boards meeting in London under the constant and immediate supervision of the Court." The Court of Directors, though unconvinced, were unwilling to cause delay by continuing the controversy, and at once proceeded to make arrangements for entering into a contract with the Madras Railway Company, actually completing them shortly afterwards, in June, 1852.

Whether the experiment of constructing a railway

by engineers directly under the orders of Government had ended in failure or success, it must be regretted that a trial of the plan was not made; for competition would at all events have led to increased efforts, and, probably, to greater economy and efficiency.

While, however, this correspondence between the authorities in England was taking place, events were occurring in India which finally settled the question of trunk railways there. The whole subject of railway communication had been referred by the Court of Directors to Lord Dalhousie, the then Governor-General, to whom also was committed the decision regarding the direction which the railway in Madras should follow; and to the solution of the general question, which is considered in a previous chapter, that of the local railway in Madras was of necessity subordinated.

On the transmission of Major Pears' Reports to the Supreme Government, Mr. (now Sir) John Peter Grant, the then Home Secretary to the Government of India, wrote, in laying them before Government, a brief but able digest of the various schemes. The Madras Government had approved, he remarked, of both lines selected by Major Pears:—

1. One direct to Palmanair, and *viâ* Bangalore to Bellary;
2. Another from a point on the first line about 60 miles from Madras, *viâ* Vaniambady to the Malabar coast; .

But had recommended that the first-named line should have the precedence in point of execution.

Now it so happens that the trade from Bellary to Madras was estimated at $2\frac{1}{2}$ lacs annually; but that from Cuddapah to Madras at $25\frac{1}{2}$ lacs.

The distance by road from Madras to Bellary by

Cuddapah is 316 miles; but by Bangalore it would be about 100 miles more. Cuddapah is 400 feet above the sea, Bellary 1600, Palmanair 2100, and Bangalore 3000 feet. It was, therefore, evident that a railway from Madras to Bellary, *viâ* Bangalore, would be nearly 100 miles longer than by a direct road, would mount at least 500 feet, only to fall again, while it would miss the entire existing trade from Cuddapah, estimated to be eight times greater than that from Bellary.

Consequently Mr. Grant strongly condemned the proposed direction by Palmanair, until a survey of the Cuddapah districts had been made. The country between Madras and Cuddapah was known to be difficult for a railway, but was not known to be impracticable; and unless that was ascertained it was argued that a line in a north-westerly direction through Cuddapah was without doubt by far the best. Bangalore could, moreover, be reached with facility from the south-western line, by the remarkably easy pass up the ghâts to the Mysore table-land at Coopum, not far from Vaniambady, which Major Pears had lately discovered.

Finally, Mr. Grant sums up his opinions of the requirements of the Madras Presidency, as regards railways, in the following way:—

1. A line from Madras to Cuddapah and Bellary.
2. A line from Madras by Vaniambady and Salem to the west coast of India.
3. A branch from Vaniambady to Bangalore.
4. A branch from Coimbatore to the foot of the Neilgherry Hills.

There is no doubt that these views were sound; his recommendations were eventually, though not immediately acted on, and the Madras Presidency now possesses the lines then suggested by him.

As regards the first section of the line to Menil, his sentiments were decided. If there is not to be a railway to Palmanair, then a railway to Menil is unquestionably a bad plan, as it takes the rail quite off the existing line of the south-west traffic, and away from the large towns on that line.

His opinion, however, did not receive attention, and an agent from the Madras Railway Company having reached Madras in January, 1853, and it being desirable to decide something at once so that a commencement might be made; the Government of India directed in a letter, dated 4th March, 1853, that a line from Madras as far as Menil be at once constructed, as the best line for an extension of the railway system in the Madras Presidency, in any direction that further surveys would determine to be desirable.

CHAPTER XVIII.

MADRAS TO BEYPORE.

Terminus at Madras — General Direction of the Line — Beypore as a Terminus —
 Mr. Bruce — System of Construction — Average Cost — Commenced in 1853
 — The River Cortillaur — Poiney — Most of the Viaducts of 30 ft. opening —
 The Palar — The Pennaar — Works generally Inexpensive — Branch to
 Bangalore — The Cauvery — Paulghât — The Kuddelhoondy — Beypore
 Harbour — Callicut — Cochin.

As soon as the proposal to have railways at Madras had been set on foot, two main lines of existing traffic had been discovered, which indicated to the Government of Madras the general direction which lines in that Presidency should follow. One was that from Cuddapah to Madras, which the junction-line with Bombay would accommodate; and the other the trade flowing in a south-westerly course from the Malabar coast, through Coimbatore and Salem, to Madras. The first line has been described; but the South-western Railway, usually known as the Madras and Beypore line, has now to be considered.

The terminus at Madras was on the sea-beach, at a spot called Royapooram, and was conveniently situated for the mercantile part of the town, which is built parallel to the beach; while any trade which the bad and inhospitable roadstead would allow would be carried on from the terminus with all the facilities that were obtainable. The Madras Station is a prominent object from the shipping, and is near to the new pier which has lately been erected through the surf. The railway, on leaving Madras, is carried in a westerly

direction as far as Goriattum, passing on its way Arcotum (42 miles from Madras), the junction for the Bombay line, and near the military cantonments of Arcot and Vellore: though the railway is not taken close to these latter towns, but is kept at a distance of three or four miles from them with the purpose of securing the easiest possible gradients and works. Passing the town of Goriattum, the railway runs south to Jaularapett, near Vaniambady, the junction of the branch to Bangalore; and then to the city of Salem, where, again bending westerly, it is carried on to Erode, the junction with the Great Southern Railway, running to Trichinopoly and Negapatam; and so on to Coimbatore, and then following the course of the river Ponany, passes through a gap of the Western Ghâts, called Paulghât, to Beypore, which is 406 miles distant from Madras.

Beypore is a place where it was thought possible that a port might be formed, and where it is hoped a flourishing commercial town may still spring up. In itself, however, it was of no importance; and up to the present the sanguine anticipations of those who selected Beypore as the terminus of the South-western line have been disappointed.

At the commencement of the construction of railroads in Bengal, a system of contracts was tried, and after a short time abandoned as productive of much trouble and little result. In Bombay, large contractors had done all the work entrusted to them, and as far as the contracts were concerned, there had been few failures; but in Madras the plan of doing work by contract was not tried. Mr. Bruce, the first Chief Engineer of the line, had had in Bengal experience of the annoyance caused by feeble and incompetent contractors, and at once determined to execute the Madras

line by the direct agency of the engineers of the company.

This seems to have been judicious. For though the price of labour is undoubtedly cheaper in Madras than in the other Presidencies, which has had its due effect; yet still, as far as economy is concerned, the result of doing work without the aid of contractors has in Madras been satisfactory. The average cost per mile of railways with a single tract in Madras has been from 8000*l.* to 9000*l.*, instead of from 15,000*l.* to 20,000*l.* as in other parts of India.

The ghâts on the eastern coast of India near Madras did not present such great difficulties as those on the Bombay side; and the South-western main line, running from coast to coast, went round the eastern line of mountains, and passed through the Western Ghâts at Paulghât, which is only 800 feet above the level of the sea. The rivers to be passed were numerous, but, the Cauvery excepted, required no extraordinary extent of bridging. The beds of the rivers consisted usually of pure fine sand, in which foundations could be obtained only by wells, giving support by means of friction on their sides.

The entire distance from Madras to Beypore is 406 miles, which for the purposes of construction was divided into seventeen districts; but there will be no object in retaining such a minute division in the present description. The first portion of the line sanctioned was from Madras to Menil, a distance of 50 miles, which was authorized as an experiment, and as a line that would be common to all railways in Madras, in whatever way the extensions might be directed. The first sod was turned on the 9th of June, 1853; but before much progress had been made the Court of Directors determined upon carrying out a comprehensive scheme of railways

in India, in furtherance of which a line from Madras to the western coast was authorized, and the contract was signed in December, 1855.

MADRAS TO GORIATTUM: 96 Miles.

The line is absolutely deficient in works of engineering interest in every respect but the bridges, and even these are of the simplest kind. The gradients are unexceptional, and the works extremely light.

Shortly after leaving Madras, the railway passes the river Cortillaur by a handsome and substantial stone bridge of twenty-six arches of 30 feet each; and near Arcot the river Poiney is crossed by a similar viaduct of fifty-six openings. The arches are segmental, and of the same size as those over the Cortillaur,—the superstructure being of granite, roughly dressed, the piers resting on high walls protected by massive stone invert. After passing the city and port of Vellore, but at some distance from it, the railway meets the river Goriattum, and over two of its separate channels the railway is carried by viaducts similar to those over the Cortillaur and Poiney, the first containing twenty-four openings and the second five.

This length was opened in sections—the first, from Madras to Arcot, a distance of 64 miles, on the 1st of July, 1856; the second, of 17 miles, on the 7th of May of the following year; and the third, of 15 miles more, on the 11th of May, 1858.

GORIATTUM TO SALEM: 110 Miles.

After passing Goriattum, the ground becomes rather more difficult, but easy gradients are still maintained. The line, however, instead of running parallel to the general drainage of the country, now crosses it; and the number of bridges is therefore much increased.

There are in this distance ninety-five bridges and numerous culverts, but the largest are those over the Palar and Pennair rivers. A viaduct of fourteen openings of 30-foot arches, and five of 64 feet, spanned by iron girders, carries the railroad over the former; and another of eighteen openings, all of 30-foot arches, over the latter. Besides these viaducts, the tributaries to these rivers required bridges of some size; but the uniform dimension of 30 feet was retained in every instance but two, *i. e.* over the Juniteporan, which was crossed by five arches of 15 feet each, and the Godar, which had a bridge of twelve openings of 20 feet each.

The remaining viaducts between the Palar and Pennair rivers consisted of five openings over the Cotar, three over another crossing of the Godar, seven over the Pimperpnuth, or Palamode river, and seven over the Moorunaputty, or Muttoer, all of 30-foot arches. Beyond the Pennair, and between that river and Salem, there were two more viaducts, one, of seven openings, over the Ahtoor, and the other, of four openings, over the Shevoroy, the same span of 30 feet being retained. The foundations were usually on brick wells, and the superstructure was sometimes of the same material. Much difficulty was experienced in getting flat bedded stones for masonry; and boulders, which are to be found everywhere, were therefore used largely both in foundation and superstructure. Where the piers were made of brick, the cutwaters and angles were protected with quoins of stone.

The works, on this line are peculiarly simple and inexpensive; and the masonry structures, though suitable and substantial, are of a very ordinary character, and do not call for any particular description.

From near Vaniambady, a branch, 84 miles in length, has been constructed by an easy incline up the ghâts

discovered by Major Pears, to Bangalore, so as to bring that important military port into railway communication with Madras, but there are no works on it of any engineering interest.

SALEM TO BEYPORE: 209 Miles.

Beyond Salem the country is flat and level for some distance, and the railway meets with no obstacle until it reaches the Cauvery, at Erode, the bridge over which is the most important work on the South-western line.

Here wrought-iron girders have been adopted in lieu of the ordinary 30-foot arch, and there are twenty-two openings of 64 feet each. The piers are of stone, which was obtained in the district, of an admirable quality and with flat beds, which produced masonry of a substantial character. There is comparatively little water in the Cauvery during the dry season of the year, and advantage was taken of this circumstance in getting in the foundations of the piers. Dams were run out from either bank, enclosing on the left a space for nine piers and on the right for eight piers, the middle space, *viz.* that for four piers, being left open for the flow of the current of the river.

Between Erode and Coimbatore, the line is carried over a level country, with no works of greater importance than twenty small bridges. Beyond Coimbatore the character of the country changes, becoming more hilly and broken by ravines. The jungles near Walliar proved peculiarly unhealthy and deadly both to Europeans and Natives. The Western Ghâts were crossed at the remarkable gap in the range called Paulghât; and then the line, following the duration of the Ponany as far as the town of Tirtalla, bends at that point to the north, and runs in a straight course to Beypore. Between Coimbatore and the ghâts the rivers Walliar (Noyel)

and Kolegad (Purley) are crossed by viaducts of five and fifteen openings of 30 feet each—the height of the former, *viz.* 33 feet from the bed of the river to the soffit of the arch, being, among the ordinary very low bridges of this line, remarkable. There are besides two bridges of one 30-foot arch each, and twenty-three others of small dimensions, varying from 20 to 9 feet.

Beyond Paulghât the difficulties in the line were above the average, as many torrents, taking their rise in the Syhadree range, rush across the low strip of the Malabar coast to the sea. As laterite abounds in this district, the smaller bridges were usually built of it, the quoins being of gneiss. Over the river Wattlepolliam, a masonry bridge of three openings of 30 feet each is erected; but over the Thotha, which was about 960 feet in width, a temporary wooden structure, at a skew of 45°, was at first formed. But the wooden bridge has been taken down, and wrought-iron girders, twelve 60-foot openings, have been substituted for it.

The Kuddelhoondy is a much more troublesome river to deal with, as it is 2370 feet in width, with a bottom of mud to a great depth. A wooden viaduct, consisting of sixteen openings of 24 feet and sixty-eight spans of 12 feet, was put up, as a temporary measure, in the first instance; but this is to be replaced by an ordinary iron girder bridge. The foundation was to have been obtained by screw-piles; but as the depth of mud proved very great, cast-iron cylinders, 6 feet in diameter, at 70-foot intervals from centre to centre, leaving clear openings of 64 feet each, have been sunk, and hearted in the usual way. The girders are 139 ft. 10 in. long, in five lengths: two of 21 ft. 4 in., two of 30 ft., and one of 37 ft. 2 in., in the middle. They are supported in the centre, and are so constructed, it will be observed, as to pass over two clear spaces of 64 feet

each, which is an unusual arrangement. The width of the bridge altogether is 26 feet, the distance between the two cylinders forming each pier, from centre to centre, being 24 feet. A smaller stream, called the Terroor, 330 feet in breadth, was the only other stream of any size passed by the railway; and over it a bridge of a similar character is to be erected.

The Madras Railway is fortunate in not having to encounter any serious engineering obstacles requiring costly works or expedients to overcome them; but having this advantage financially, the structures on the line necessarily possess little interest in an engineering point of view.

Bey pore, chosen as a terminus in the lack of any good harbour upon the coast, has proved unsatisfactory, and having no natural advantages as a port, the railway has not yielded that amount of through traffic which a line stretching from coast to coast across the peninsula might have been expected to obtain. Inquiries have therefore been set on foot with a view of finding a more suitable port and terminal station. Callicut, a few miles farther to the north, has been thought of, but it would be but little, if any, better than Bey pore; and Cochin, the capital of the small state of the Rajah of Cochin, which has a small natural harbour and a rather convenient roadstead, has also been examined. It has the drawback of being situated in a foreign territory; but this objection may perhaps be overcome by treaty arrangements with the Rajah. The question, however, remains for the present undecided, but it is dubious whether a change will be advantageous or will yield more revenue. In the absence of any central and flourishing place of trade of decided prominence, the district of Malabar, its towns and population, is in truth the terminus of the line.

CHAPTER XIX.

GREAT SOUTHERN RAILWAY OF INDIA.

Traced through the Districts watered by the Cauvery — Negapatam as a Port — Returns as yet unsatisfactory — Erode as a Terminus — Mode of Construction — Works very Light — Bridges usually of 30-ft. Arches — Very cheaply made — Cost only 7700*l.* per Mile.

THE company, which assumed this designation, had for its object the improvement of the means of intercommunication between the rich and populous districts watered by the river Cauvery and the port of Negapatam. Several plans have been projected, and the promoters of the line were sanguine in their anticipation of a large and remunerative traffic; but up to the present time their expectations have been disappointed. The line which has been eventually sanctioned is one running from Negapatam to Erode, the point at which the Madras and Beypore Railway passes the Cauvery. There are no works of difficulty on the line, as it runs for the most part over a level and very productive district, in which provision has alone to be made for the passage of many tributaries to the Cauvery, and of numerous irrigation channels. The works being so light, it was determined to make the railway without the aid of contractors; and the entire line has been constructed without difficulty or delay.

NEGAPATAM TO TRICHINOPOLY: 78½ Miles.

For 40 miles the line runs through rice-fields, and for the remaining 38 over inundated cultivation or waste land. The rails are so raised as to be above the

floods and inundation on a bank, of an average height of 6 feet. In the 80 miles there are eighty-nine bridges of various sizes, twelve of which have openings of 30 feet, spanned either by girders or arched; and the rest are all of smaller dimensions. The largest viaduct is one of fifteen arches of 30 feet each, over the river Moothalay; the foundations of which rest on clay 14 feet below the surface, instead of on brick wells as usual. The only other bridge of any importance is a girder bridge of ten 30-foot spans, over a stream called the Rajah's Nullah, which has a rapid current during the wet season. There are 250 culverts, and $2\frac{3}{4}$ millions cubic yards of earthwork in bank and cutting. Most of the bridges are of brickwork; but in some, laterite has been used.

The first sod of the railway was turned on the 5th May, 1859; and the line from Negapatam to Tanjore was opened for traffic in 1861; and to Trichinopoly in March, 1862.

TRICHINOPOLY TO ERODE: $88\frac{1}{2}$ Miles.

The railway, after passing near the town and cantonments of Trichinopoly, and avoiding the undulating land in the interior, as well as the valuable rice-fields adjacent, keeps parallel and very near to the river Cauvery. It is traced, like a part of the East Indian Railway between Colgong and Patna, on the raised margin, which always forms the boundary of a river like the Cauvery, subject to annual inundations. About 4 miles from Trichinopoly it crosses a considerable stream called the Codamooty, just at its confluence with the Cauvery, and then, without any bridges of consequence, it is carried to the town of Caroor, on the river Ambamootay, which is 1000 feet in breadth, with foundations in deep fine sand. Beyond this river the

line still skirts the Cauvery; but has rather severer gradients to encounter, as a ridge 181 feet higher than the level of the town of Caroor runs down to the Cauvery, at right-angles to the direct course which the railway must take.

Surmounting this obstacle the railway falls with a gradual slope to the river Noyel, which is a considerable stream of rather less width than the Ambamootay.

Beyond the Noyel to Erode junction the ground still rises, and the line, for the purpose of avoiding valuable rice-land, is taken over stony undulating ground, with rock near the surface for nearly the whole distance. The gradients used are rather severe, though 1 in 100 is the worst; but to obtain even this a very considerable amount of earthwork in bank and cutting has been found to be requisite. Throughout the entire length of this short railway there are no bridges of any magnitude or of special importance, and this railroad has been constructed and finished at a less cost than any other line in India, the single track not having exceeded 7700*l.* per mile.

CHAPTER XX.

CONCLUSION.

Railway Capital as an Investment—Responsibility of Engineers—Indian Railways under the Supervision required by the Guarantee—Cost of Lines in India and in England—Unwillingness of Natives to invest Money in Railways—Capital Raised in London—The Debt for Interest—The Rate of Exchange—Receipts by various Companies—Tables—The promising Financial Prospects of the East Indian, the Great Indian Peninsula, and the Eastern Bengal Railways—The Position of the Bombay and Barodah, Madras and Punjab Railways—The Failure of the South-Eastern—Unguaranteed Schemes a Failure—The Oude and Rohilcund—Branch from Nulhattee—The Indian Tramway Company—Lengths of Line under Guarantee—Projected Extensions—Summary.

ALTHOUGH the works of railways possess in themselves much of interest, and an account of them can hardly fail to secure a certain degree of attention from intelligent observers of material progress, and from all who recognize their importance in promoting civilization and social advancement, yet there is another and a not less important phase of a railway system to which the general public, and especially intending shareholders, look with earnest eyes. Will it pay? is always the question anxiously put, and upon the reply depends the credit which the proposal will obtain. The plan may evidently be desirable on public grounds, much may hinge upon its immediate prosecution; but all will avail little with the capitalist unless the answer to the question, Will it pay? is perfectly satisfactory.

Engineers have often been accused, and sometimes it is to be feared with justice, of being so absorbed in their enthusiasm for the execution of magnificent works of skill or of difficulty, as to be too oblivious of the

interests of shareholders; in fact, to treat the construction of the works of a railway too much as a mere exhibition for their skill, and as abiding monuments of their genius and constructive ability, instead of remembering that economy and simplicity are essential requisites to obtain satisfactory financial results, and good returns for the money capitalists may entrust to them to spend.

Without presuming to advance that the engineers employed on Indian lines are constituted differently from other men, yet it may be confidently asserted that there has been comparatively little of mere engineering display on the lines of India. Several reasons have combined to produce this result. In the first place, engineers have remembered the unfortunate position of English railways, caused often, as the public assert, by the extravagance of the design for their works; and on being commissioned to undertake a new system, have been anxious to avoid the errors into which their brethren had fallen, and against which it was well known that both Government and the Board of Directors were especially on their guard. A salutary impression was also produced upon the minds of the designers for the works of Indian railways, by the knowledge that their plans would be professionally examined by perfectly independent men, who were ready to exercise a watchful vigilance over excess or mere display; and not simply submitted to a Board of Directors, often supine or negligent, or if individually active and energetic, easily made tractable by the plea of overbearing professional and technical necessity. This is a line of argument which it is difficult for a layman, however unconvinced, to withstand, without removing responsibility from the shoulders that ought to bear it, and himself undertaking a burden which he is not profes-

sionally competent to sustain. It is, indeed, certain that the plan of check and reference which was originated by the system of guarantee, and consequent supervision, had, with many drawbacks, this advantage, that it rendered extravagance in design less likely than under the more unrestricted administration of a joint-stock company.

It may then be stated as a broad fact, though there are some few exceptions of little comparative moment, that the railways of India have been designed on principles of economy, and have been constructed without much waste or unnecessary expense, though with due care, with one exception, to secure stability and permanence. Although this has been the case, yet the sanguine expectation of great cheapness which some of the projectors of Indian lines had originally entertained, have been signally disappointed. The great cost of freight from England and of the inland transport of iron work, the difficulty and expense of procuring sleepers, the high rates of salaries and wages of European superintendents and artizans, have counterbalanced in a great degree the cheapness of labour, the freedom from Parliamentary expenses, and the free gift of land by Government. Without the grant of land, indeed, it seems unlikely that any railways in India would have been earning a dividend repaying the interest of 5 per cent. guaranteed, and still more, a sum additionally remunerative to shareholders.

It was originally estimated that the cost of Indian railways with a double track would not exceed 14,000*l.* or 15,000*l.* per mile, and for a single line 8000*l.* or 9000*l.*; but though the capital accounts of these railways for construction are not now, and will not for some years to come even be provisionally closed, yet still fairly reliable data exist from which it may be

inferred that the various railways when completed will have been made at the following average rates:—

	Double Line per Mile. £	Single Line per Mile. £	
East Indian Railway ..	22,000	15,000	
Great Indian Peninsula ..	16,000*	13,000	
Madras	..	12,000	} Short lengths of these lines are laid with a double track.
Bombay and Barodah ..	..	20,000	
Punjab	..	10,000	
Scinde	..	19,000	} 41 miles double, and an expensive terminus.
Calcutta and South- eastern }	..	20,000	
Eastern Bengal	..	17,000	} Short lengths of these lines are laid with a double track.
Great Southern	..	7,700	

The most expensive line is the Bombay, Barodah, and Central Indian Railway, and the cheapest the Great Southern; but the rates at which all have been constructed contrast most favourably with the outlay for the long and metropolitan lines of Great Britain, but rather exceed the average cost of railways recently made in the rural districts of England and Ireland, as will be seen from the subjoined Table:—

	Double Line per Mile. £	Single Line per Mile. £
The London and Blackwall	290,000	
London and Greenwich	264,000	
London and North-western	62,000	
Great Western	51,000	
North British	29,000	
Caledonian	24,000	
Somerset Central	7,000	
Preston and Longridge	..	7,800
Killarney Junction	..	6,100
Hereford and Gloucester	14,500	
Dublin and Drogheda	15,700	

The amount of capital required by the railways of

* Ghât lines excepted. Many failures arising in some degree from in-different work have recently come to light, and the reconstruction consequently necessary will probably swell the first cost of the Great Indian Peninsula Railway per mile, to the figure given for the East Indian Railway.

India was very large, and could not possibly have been raised by joint-stock companies without the aid of a guarantee of interest by Government; but that having been conceded, it is curious to notice the want of appreciation of its value by the natives of India, who are generally so keen in availing themselves of Government securities.

If the issue of an ordinary loan by Government at 4 or 5 per cent. were announced at Calcutta and Bombay, there would be eager competition for it among wealthy native bankers and landholders, and all would be taken up in a few days. But the case was very different with regard to railway guaranteed capital, though in fact the security is precisely the same in either case; while the capital of the railway companies has the advantage of the possible contingency of an additional dividend, should the returns of the traffic exceed the 5 per cent. interest guaranteed.

The management, however, of mercantile concerns in Calcutta had so often proved reckless and bad, and ruin had so frequently overtaken those who had embarked in business speculations supported and advocated by English merchants, that the native mind had become very suspicious of all management but that of Government. When, therefore, railway companies, though in truth but differing slightly from Government agencies for carrying out a great and improved system of inter-communication, appeared in the great capitals of India as quasi-independent bodies, their wealthy men could not divest themselves of the suspicion which would have inevitably attached itself to any similar joint-stock undertaking that might have commenced business in India without the support and supervision of Government. This suspicion took the practical turn of declining to invest their money in railway stock, although

guaranteed; and out of the 76 millions of pounds sterling which had been raised as capital for Indian railways up to April, 1868, only three-fourths of a million had been subscribed in India; and even of that small sum a large portion had come not from natives of India, but from Europeans residing there.

On the 1st of January, 1868, there were 49,690 shareholders of Indian railway stock, and out of this number 40,221 were in England, leaving 819 for India, of which 397 only were natives. The stake, therefore, that England has in the success of Indian railways is very great; for the money sunk in their construction has been raised almost exclusively from Great Britain.

It is now estimated that a capital of 90,000,000*l.* sterling will be required to finish all the railways that have up to the present received a guarantee; but, considering that it is almost impossible to foresee at the commencement of an undertaking all the ramifications in which expenditure will be necessary, and that consequently such preliminary estimates are nearly always insufficient, it is probable that this sum will be considerably exceeded before all the lines now guaranteed are completely finished and properly stocked.

The greater portion of the present amount of capital, *viz.* 76 millions, has been raised by the issue of shares amounting in all to 59¼ millions, and the remainder by convertible or unconvertible debentures to the extent of 16¾ millions; but it is probable that the latter plan of obtaining funds will not for the future be resorted to, since recent legal decisions having thrown discredit upon that class of securities, it has been found exceedingly troublesome to meet the demands of debenture-holders to have their bonds paid off. As long as holders of debentures were willing to have them renewed when they fell due, or as long as new debentures,

if issued, were readily absorbed by the market, no difficulty was experienced; but the case became widely different when they were no longer in favour with the public, and railway companies became obliged to pay off out of income the amount of debentures as they became due. The position of debenture-holders of Indian railways is, however, distinct from that of proprietors of similar securities on English lines, as the former had the security of India and the Indian Government for both principal and interest, while the latter had only that of a joint-stock company. But even though this was the case, yet it might be very inconvenient to the Governors of India to have to make arrangements to meet the payment of some millions of debentures in any one particular year; and it has no doubt been wisely determined that the raising of capital by their means shall not be employed for the future.

The interest on the capital which has been guaranteed by Government is at the rate of 5 per cent., with two trifling exceptions of one million of Madras stock at $4\frac{3}{4}$, and half-a-million at $4\frac{1}{2}$ per cent.; and of course during the time occupied in the construction of railways the whole of the interest had to be paid by Government. But as the railways began to earn revenue the payments from the Indian treasury became proportionally reduced; and of late years this diminution has been advancing in a rapid and satisfactory ratio. The total sum advanced on account of interest up to April, 1868, was nearly $22\frac{1}{4}$ millions sterling, from which, however, has to be deducted $9\frac{1}{2}$ millions which has been repaid by railway companies out of their earnings, leaving a balance of about 12 millions of debt by railway companies to Government on account of interest.

Here it may be remarked that a very large additional contribution to the funds of Indian railways has

been made by Government, somewhat unintentionally, by the rate of exchange having been in the first instance, in 1840, fixed at 1s. 10d. per rupee; but as since then silver has become dearer, the rate of exchange has risen to 2s. or upwards per rupee, and as nearly the whole of the capital of Indian lines is raised in London, it follows that for every 100*l.* which railway companies pay into the Bank of England to the credit of the Secretary of State for India, the treasury in India has to pay to the agents of the companies there a value in rupees equivalent to about 109*l.* This difference on a capital of 70 or 80 millions amounts to a very large sum; and though if the rate of exchange remains at its present high figure, and the railways are profitable, this advance will be repaid by the corresponding payment, in crediting revenues earned in India, to the reduction of debt of railway companies for guaranteed interest; still for the present, there can be no question that the large additional advance by Government towards the cost of constructing Indian railways which the agreement of 1s. 10d. as the rate of exchange has involved, is a great boon to railway companies—a greater boon, in fact, than had been at all contemplated. In agreements more recently entered into, the rate of exchange has been fixed at 2s. the rupee, an arrangement which will be a relief to Indian Finance Ministers, who have been sorely vexed at having to make the large advances needed during late years by railway companies, at a rate so inconvenient to them in their dealings with a chronic deficit in revenue.

The receipts of the various railway companies have as a rule been progressing year by year, as will be seen from the following Tables which have been constructed on information given by Juland Danvers, Esq., the Government Director of Indian Railways, in his annual reports :—

TABLE SHOWING the RECEIPTS and PROFITS of INDIAN RAILWAYS.

YEAR.	East Indian Railway.		Great Indian Peninsula.		Madras.	
	Gross Receipts.	Net Profits.	Gross Receipts.	Net Profits.	Gross Receipts.	Net Profits.
	£.	£.	£.	£.	£.	£.
Year ending June 30, 1854 ..	..	..	35 miles open. 14,261	7,122		
" " 1855 ..	121 miles open. 31,453	10,631	48 14,566	3,771		
" " 1856 ..	121 82,178	48,413	88 23,443	11,413		
" " 1857 ..	121 113,646	69,484	90 58,165	33,823		
" " 1858 ..	142 150,233	87,725	105 75,033	42,561		
" " 1859 ..	202 330,267	179,591	194 147,431	82,940	66 miles open. 45,543	15,387
" " 1860 ..	272 318,808	172,173	277 181,677	74,881	137 67,436	25,905
" " 1861 ..	602 408,474	214,580	437 228,689	69,779	201 83,678	19,746
" " 1862 ..	539 553,206	281,000	437 279,268	86,548	332 123,778	32,180
" " 1863 ..	537 800,552	380,999	542 387,627	143,048	444 194,119	52,024
" " 1864 ..	517 1,119,482	490,727	553 532,877	154,817	448 270,636	118,998
" " 1865 ..	1030 1,674,441	928,752	700 1,175,090	480,494	598 405,000	269,452
" " 1866 ..	1030 2,012,680	1,119,315	812 1,252,962	536,334	611 438,787	249,372

YEAR.	Bombay and Barodah.		Scinde.		Panjab.	
	Gross Receipts.	Net Profits.	Gross Receipts.	Net Profits.	Gross Receipts.	Net Profits.
	£.	£.	£.	£.	£.	£.
Year ending June 30, 1860 ..	60 miles open. 3,472	1,203				
" " 1861 ..	130 19,043	7,261	105 miles open. 15,037	104.		
" " 1862 ..	130 46,933	20,778	105 25,036	5,338		
" " 1863 ..	168 102,918	62,831	105 89,913	18,994	45 miles open. 12,715	4,372
" " 1864 ..	185 141,779	..	105 98,811	6,657	45 17,166	4,763
" " 1865 ..	306 321,816	112,833	105 82,493	3,507	253 25,250	6,008
" " 1866 ..	306 407,688	114,455	109 53,166	10,083	353 90,269	25,395

YEAR.	Eastern Bengal.		Calcutta and South-eastern.		Great Southern.	
	Gross Receipts.	Net Profits.	Gross Receipts.	Net Profits.	Gross Receipts.	Net Profits.
	£.	£.	£.	£.	£.	£.
Year ending June 30, 1862 ..	..	..	..	..	47 miles open. 12,154	6,550
" " 1863 ..	45 miles open. 76,351	34,338	28 miles open. 2844	..	79 26,447	14,196
" " 1864 ..	110 88,548	41,025	28 6559	..	79 27,340	13,717
" " 1865 ..	110 123,374	62,111	28 8367	..	79 35,236	17,785
" " 1866 ..	110 129,347	62,246	28 ..	..	79 45,582	24,694

TABLE showing TOTAL LENGTH OF UNDERTAKINGS, ESTIMATED COST, AVERAGE COST per MILE, AMOUNT OF GROSS RECEIPTS, and AVERAGE WEEKLY RECEIPTS. (Prepared by JULAND DANVERS, Esq.)

RAILWAY.	Total length of undertaking.	Estimated ultimate cost when finished, with a certain extent of Double Line.	Average cost per Mile when finished, with a certain extent of Double Line.	Amount of gross receipts per Mile per week required (50 per cent. being calculated for working and maintenance) to produce			Average weekly Receipts during 1865-66.
				5 per cent.	6 per cent.	7 per cent.	
	Miles.	£	£	£ s.	£ s.	£ s.	£ s.
East Indian, Main Line ..	1275	28,000,000	22,000	42 6	50 15	59 0	89 0
Great Indian Peninsula ..	1266	18,380,000	*14,510	27 18	33 10	39 0	55 5
Madras, South-west Line ..	492	5,904,000	12,000	23 0	27 13	32 6	14 0
Bombay and Barodah ..	312	7,488,000	24,000	46 3	55 3	64 12	13 8
Scinde	109	2,180,000	20,000	38 9	46 3	53 17	19 8
Punjab	253	2,530,000	10,000	19 5	23 5	26 18	8 6
Eastern Bengal	160	2,720,000	17,000	32 13	39 12	45 15	28 7
Great Southern	160	1,600,000	10,000	19 5	23 5	26 18	8 10
Calcutta and South-eastern	29	609,000	21,000	40 7	48 10	56 10	9 0

The East Indian, the Great Indian Peninsula, and the Eastern Bengal Railways are by far the most profitable concerns, and all promise to more than repay the 5 per cent. interest guaranteed upon their capital. The position of each of the companies is good and satisfactory, and it is impossible to foresee which railway may in the end pay best; but there are peculiarities in the local position of each, which are interesting to notice. The gross earnings of the Great Indian Peninsula are, considering the mileage opened, the largest, but the profits are diminished by the great cost of working, caused by the want of coal in the neighbourhood of Bombay, and the consequent large outlay required for fuel for locomotives. The cost of coal per train mile on the Great Indian Peninsula during 1866 was 1s. 6¼d., instead of 3¼d. as on the East Indian Railway, or nearly six times more. As soon, however, as the Great Indian Peninsula Railway is completed to the

* It is certain that this rate will be much exceeded. A cost of 20,000£ per mile will probably be nearer the truth.

coal-field on the Nerbudha, this outlay will be greatly diminished; and it is then probable that this will pay the largest dividends of any Indian line.

But close to it, even if it prove indeed to be behind it at all, will be the East Indian Railway. This line is now in the possession of an immense revenue, and both it and the Great Indian Peninsula have already earned money enabling them to declare for one half-year a dividend of $\frac{1}{2}$ per cent. over and above the guaranteed interest of 5 per cent. The cost of the East Indian Railway has been large; a drawback which is, however, compensated for by the cheapness and abundance of the fuel obtainable in the valuable coal-fields of Raneegunge, Barrakur, and Kurhurballee. The single line is already choked with traffic, and the immediate construction of a double line having been proved to be imperative, has been commenced. This will enhance the cost of the line; but still there is almost a certainty that the East Indian Railway, if wisely administered and thriftily worked, will be a highly profitable undertaking. To obtain this desirable result, however, a very strict watch over the administrative and traffic departments will be essential, so as to resist the tendency to expansion in expense and size, which such departments always evince.

The Eastern Bengal Railway, though a diminutive undertaking when compared with its gigantic contemporaries above named, has yet from the first proved itself to be a line likely to be highly remunerative. From the first year that it was opened its income has been large, and in the course of only four years the profit has nearly doubled; and its net receipts have already very nearly covered the outlay for guaranteed interest. The railway stretches away into a district previously quite closed to traffic or commerce on any

large scale. When extended to Goalundo, the junction of the rivers Ganges and Burrampooter, it will probably obtain a large access of traffic from Assam and the regions to the north-east of Dacca; and it bids fair to yield a return which will be satisfactory both to Government and the shareholders.

After these three concerns, but at a long interval, follow the Madras, the Scinde, Punjaub, and the Bombay and Barodah Railways; all of which are distinguished by the promising feature of a continually increasing business, though their earnings have, up to the present, fallen very far short of a sum that would yield 5 per cent. on the capital expended in their construction. In these railways also there are local peculiarities deserving notice. The traffic on the Bombay, Barodah, and Central India compared with its length is large, and continually increasing; but the cost of making the line has been so excessive, that the prospects of dividends beyond 5 per cent. are remote. The Madras and Punjaub Railways on the other hand are not able to obtain much work, the country being poor and without great commercial activity; but then such has been the economy in their construction, that there is a better probability of their being paying concerns, though not for some years to come. The Scinde Railway labours under the disadvantage, which has been previously noticed, of being the funnel through which the traffic of a large undertaking must pass, requiring costly terminal accommodation disproportionate to its length; while it only obtains the through traffic of the Indus Railway system, the local being absorbed by the other links from which in capital the Scinde line is disconnected. The only line, however, which must be pronounced a failure is that called the Calcutta and South-eastern. It is very short, being only 28 miles in length, and has hitherto

been always worked at a heavy loss, while its cost has been excessive—over 20,000*l.* a mile. Port Canning has up to the present time been unable to secure any trade, and the line therefore, though nominally running to a port, in reality ends, in railway parlance, “no-where,” while the country through which it passes, though fertile, is thinly populated. The enterprise was never viewed with favour by the Governments of Bengal and India; and judging from the existing position of Port Canning, it seems to have been a pity that a guarantee was ever given to it. The Directors have lately given notice of their intention to abandon any further prosecution of the scheme.

Besides the railways which have been named and described in the foregoing pages, there are also two other undertakings in India which are only commencing their operations upon that continent. One of them, the Indian Branch Railway, better known now as the Oude and Rohilcund Railway Company, having secured a Government guarantee, will no doubt successfully prosecute the works that have been designed. The other, the Indian Tramway Company, has also recently obtained a guarantee of 3 per cent. for a short line from Arconum to Conjeveram. Their works, however, are not so far advanced as to require a detailed account; but the companies deserve notice as undertakings which have been set on foot and commenced with capital raised without the aid of Government, but which have been unable to continue to carry on their works, much less to complete them, on their own resources.

The public would not subscribe money to any plan for a railway in India on the faith of a joint-stock company merely; for though the guarantee system has certainly enabled the directors of the various Indian railways, which have obtained that aid, to raise the

capital required for the construction of the lines with an ease and facility almost unexampled ; yet one bad result has followed from the concession of this advantage. As the interest upon the capital of certain Indian lines is guaranteed, and as these companies have hitherto been obliged annually to come into the English Stock Exchange to raise funds for the purpose of completing their railways, it has naturally been found impossible to induce the capitalists of London to come forward and subscribe to any Indian schemes, however sound, unless assisted by similar security.

The Indian Branch Railway Company was formed with the legitimate object of making branches from the great trunk-lines to large towns and marts of commerce; but, though granted a subsidy per mile, was only with the greatest difficulty able to find money enough to finish a short light line from Nulhattee, on the main line of the East Indian railway, to the bank of the Bhagaruttee opposite Moorshedabad; but unable to complete another short branch, 42 miles in length, also undertaken by it from Cawnpore to Lucknow, without obtaining a loan from the treasury of Government.

On the Nulhattee branch-line, which was made on an existing common road and has a narrow gauge, Mr. Wilson, the Chief Engineer, introduced many ingenious contrivances both in the permanent way and in the rolling-stock; but there has not been much opportunity of testing their use and permanency, as the traffic on the line has not answered the expectations of those who had projected the railway.

The Indian Branch Railway Company were more successful with their Cawnpore line which has the standard gauge; but being anxious to extend their operations into Rohilcund, and having proved the impossibility of raising capital without the direct guarantee of Govern-

ment, applied for this assistance, and it has during the past year been granted. The lines projected are to run through the fertile provinces of Oude and Rohilcund from some point near Benares to Bareilly, with branches to Cawnpore, Delhi, Fyzabad, and Nynce Tal.

The only other company which has now any footing in India is the Indian Tramway; but being unable to raise money for the prosecution of its project, *viz.* the making a line of railway from Arconum to Pondicherry, it also has obtained like aid.

The following Table gives the total length of Indian railways which, having received a guarantee, are now under construction, and will a few years hence be finished :—

RAILWAYS.										Total length as at present sanctioned (given ap- proximately).
										Miles.
East Indian	{	Main line	..	..	..	..	..	..	..	1276½
		Jubbulpore line	..	..	..	..	..	..	..	225
Great Indian Peninsula	..	..	..	..	..	..	..	..	..	1266½
Madras	{	South-west line, including Bangalore Branch								492
		North-west line	..	..	..	..	..	..	..	333
Bombay, Barodah, and Central India	..	..	..	..	..	..	..	..	..	312½
Scinde	..	..	..	..	..	..	..	..	..	109
Punjaub	..	..	..	..	..	..	..	..	..	246
.. Delhi	..	..	..	..	..	..	..	..	..	320
Eastern Bengal	..	..	..	..	..	..	..	..	..	159
Great Southern	..	..	..	..	..	..	..	..	..	168
Calcutta and South-eastern	..	..	..	..	..	..	..	..	..	29
Indian branch	..	..	..	..	..	..	..	..	..	672
Total										5609

Having thus completed a review of the operations of railway companies in India, it seems right to consider briefly the advance which has been made, and the position now occupied.

The capitals of India will shortly be connected, the peoples of the land will have been brought into closer

social intercourse than had hitherto been conceived possible, the prophecies of financial disaster and of physical impossibilities have been proved to be groundless, commerce has been stimulated, and India is at last awake.

British rule has been strengthened, the members of the vast but rather disjointed fabric have been knit together with a network of iron sinew, and consolidated. The empire is now in a far better position than it has hitherto ever been to resist invasion from without or insurrection from within. If war be the fate of British India, she has now a power of concentration, and an unity of vigour and energy, which will give her a force unknown before. If peace be her lot, she bids fair soon to take that place in the commonwealth of nations to which her magnitude and her fertility entitle her.

And if railways, even while confined to trunk lines only, have so far conduced to this, the statesman may well ponder, whether a further step onwards may now be desirable, or whether it would be better to pause awhile and rest. Moved by such considerations, Sir Stafford Northcote has, in a recent dispatch, requested the Government of India to advise him on the subject, desiring that their attention may be directed to two classes of railways.

First. Those required mainly for political or military considerations, the advancement of a backward district, or the welfare of a neglected race, though not ignoring commercial opportunities or requirements.

Second. Those principally needed to further the interests of trade.

The replies from India have not yet been received; but in the interval, promoters and directors of railway companies at home have not been idle in advocating

extensions and branches which would in their opinion enhance the value of their respective lines. In doing this they profess to be guided only by the belief that the lines recommended by them will pay; and while admitting this, yet it must be conceded that the judgment of directors of joint-stock companies on such matters is by no means unerring.

The East Indian Railway having obtained a chord line, seems anxious to rest, and to improve the capabilities of its valuable property: in this it is wise. It is the highway of Hindustan, and if traffic be fostered and economically managed, the line has a promising future of prosperity.

For the Great Indian Peninsula Railway a line on the table-land of the Deccan, uniting the existing North and South-western Railways, has been projected.* It is so evidently undesirable to burden traffic by needlessly going up and down the ghât inclines, that the idea has found much favour; and if there be traffic ready to come upon the lines, it would manifestly pay to construct it. But this seems to need proof, for the common movement of trade is from the interior to a port, and not in transverse directions, unless the lines are drawn between centres of manufacturing industry, which can hardly be said to exist at present in the Deccan.

The Eastern Bengal Railway longs for an extension northward to Darjeeling, and eastward to Assam. It is most natural that a short but prosperous line should wish to get the more prominent position that size would give; but the claims of the prolongations demanded seem difficult to establish. A line to Darjeeling would run through an agricultural district, passing no towns

* This line was first proposed by Government. The Great Indian Peninsula also desire to make a railway from near Boorhanpoor to Agra *viâ* Indore, as mentioned previously.

of any size, and would terminate on a mountain range. It would be parallel to and have to compete with the boat-trade on the Teesta, and many other rivers flowing from the Himalayah to the Ganges, which on the road to the metropolis bars direct communication. Unless, indeed, Darjeeling becomes the seat of the Government of India, as some advocate, it is difficult to conceive that such a line would be a commercial success. Assam, too, is so well provided with admirable and perennial water communication, that steamers seem more suited to its wants than railroads. Still it is a rising province, with a flourishing and increasing tea-cultivation, and the time may come when a railway there may be a necessity.

A glance at the map will show that Malwah and Rajpootana, lying between Barodah and Delhi, have not as yet been in any way opened out by railway advantages. But the districts are productive and important, and, both politically and commercially, the execution of the proposed extension of the Bombay, Barodah, and Central India Railway to Delhi seems demanded, as soon as funds can be raised for the purpose.

The prolongation of a railway from Lahore* to Peshawur is a pressing State necessity, but the construction of the line must, from the hilly nature of the country and from the width and rapidity of the rivers to be crossed, be costly, while it offers but slight prospect of pecuniary return on the capital that will be required.

Along one of the banks of the Indus, too, from Kurachee to Moultan, a railway is desired; but the want does not appear urgent except perhaps on political grounds. The steamers of the Indus flotilla maintain a communication, somewhat tedious and uncertain it

* A portion of this line from Lahore to Rawul Pundee is being constructed by Government agency.

is true, but still complete; and the revenues of the Scinde and Punjaub Railways are not so buoyant as to give much encouragement to the project on the plea of pecuniary return for the outlay.

The Great Southern Railway Company wish to carry out their original* intention of making a line from Trichinopoly to the port of Tuticorin, close to Cape Comorin, at the southern extremity of India; but it does not seem to be likely that the anticipations of profit on this prolongation will be realized more certainly, than those which were formed regarding the finished line, where it is proved that they were far too sanguine.

Various short branches, or feeders as they are called, are also desired, and no doubt plausible reasons can be adduced on behalf of each. But in England *feeders* have too often turned out to be *suckers*; and in judging the claims of such lines it should always be remembered, that in an agricultural district a station on a railway will certainly secure all traffic within a radius of 10 miles, and probably even more; and that though a branch to a small town may be a great local convenience, yet it may often not materially increase the work or the revenues of a railway. But though this be so, and though railway directors should not view such proposals so favourably as they are frequently inclined to do, yet other motives may well influence a Government like that of India. "Will it pay?" should not, will not, be their only spring of action. The welfare and advancement of India, the safety of its population from famine, and the stability of British rule, will justly have great weight in considering the projects that may be laid before them, and encouraged by what

* A survey of this extension has been sanctioned.

has been effected, they will take further steps to open out districts and to promote the well-being of the empire.

But although the financial position of railways in India is thus, on the whole, satisfactory now, while promising far larger results in the future, yet the return from their construction to which the Government have mainly looked, has always been the material and social advancement which facility of communication produces. In this respect, nothing remains to be desired. Commerce is annually increasing, wages are rising, manufactories are springing up, skilful and intelligent artisans are being educated, and the social barriers of caste and prejudice seem gradually yielding; and there is a hope that, combined with the prosperity, wealth, and civilization which have been created and fostered by the railways of India, the blessings also of a spiritual Christianity, based on the truth of God's Word, may ere long spread extensively over the length and breadth of that land, which has for so many ages remained covered with the pall of apathy and vice that false religions of every kind invariably throw over the countries in which they exist.

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