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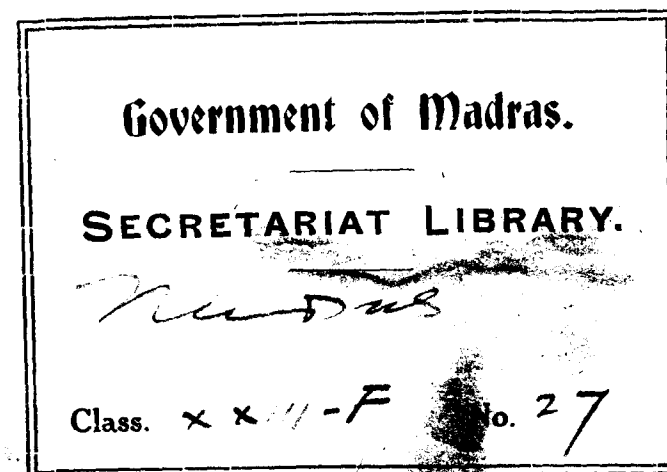
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RAILWAYS (INDIA).



RETURN to an Order of the Honourable The House of Commons,
dated 20 August 1853 ;—for,

COPY " of MEMORANDUM by Major *Kennedy*, late Consulting Engineer
of the Government of *India*, on the Question of a general System of
RAILWAYS for *India*, referred to in the MINUTE by the Governor-General
in Council of the 20th day of April 1853, relative to Railway Undertakings
in that Country."



Ch. S. V. 1-5,000-17-10-24.

Eas India House,
31 January 1854.

JAMES C. MELVILL.

(*Mr. French.*)



Ordered, by The House of Commons, to be Printed,
27 March 1854.

C O N T E N T S.

	Paragraphs.
Saving which Railways would produce in the Military Establishment of India, 2,332,482 <i>l.</i> per annum - - - - -	1 to 22.
Saving would produce a capital of 77,749,400 <i>l.</i> , which would construct 15,549 miles of Railway, at a cost of 5,000 <i>l.</i> per mile - - - - -	23 to 28.
Erroneous project now in progress in the Presidency of Bombay - - - - -	29 to 35.
General Rules proposed for construction, &c., of Railways, to prevent error. - - -	36 to 38.
Indian Government occupies the position of General Land Proprietor as well as Government, and is therefore the only source from which the development of the country resources can emanate - - - - -	39 to 50.
Peculiarities in the physical structure of India affecting Railway projects - - -	51 to 54.
General project for construction of Railways in India - - - - -	55 to 58.

A P P E N D I X.

	Page.
No. I.—Maps of Projects, recommended by Major Kennedy - - - - -	14 to 16
No. II.—Proximate Sections, showing errors in progress in Bombay Presidency.	
No. III.—Suggestions by Major Kennedy, for opening Railway intercourse between Bombay and the Table-land, passing over the Syhadree Ghats, on a principle to admit of locomotive engines carrying loads due to a level road - - -	17
No. IV.—Table and Section of Impulsive Inclines, explanatory of new method proposed by Major Kennedy, to enable locomotive engines to convey loads due to a level up ascents - - - - -	19
No. V.—Sketch Plan and Sections to illustrate errors in project sent home by East India Railway Company's Engineer, in reference to that portion of the Bengal line between the Colliery Junction and Rajmahal; with some general suggestions on principles for laying out Railway Lines - - - - -	20

COPY of MEMORANDUM by Major *Kennedy*, late Consulting Engineer of the Government of *India*, on the Question of a general System of RAILWAYS for *India*, referred to in the MINUTE by the Governor-General in Council of the 20th day of April 1853, relative to Railway Undertakings in that Country."

MEMORANDUM on INDIAN RAILWAYS.

Torrington-square, 14 September 1852.

1. It is not sufficient to be convinced, as I am, that the establishment of Railways in India is an essential preliminary to the attainment of the highest degree of efficiency of which our military and civil administrations are capable; to the prevention of local famine, and to the uniform dispersion of food; to any vigour and activity in manufacture or commerce; to the increased consumption of English goods; to the power of competing with America in furnishing to England raw cotton and other important articles; in short, to the growth of everything connected with the extension of British interests in India, as well as with the industry, the wealth, and the comfort of its vast population.

2. It is still requisite, in addition to this conviction, to be able to see how the risk of the Government guarantee which the money market requires for capital invested in Indian Railways shall be borne under the worst aspect that that risk can assume.

3. I believe that upon the Great North-western Line of Bengal, which I know better than any other, the risk would be absolutely nothing; but at the same time, when Government, or when an individual, gives a guarantee, it is a correct precaution to assume the possibility of being called upon to pay the whole amount of such guarantee, and to examine how that amount, if required, shall be forthcoming.

4. The question then is, Whether there be any direct and immediate equivalent which the Government of India can calculate upon, from the establishment of railways, which would enable them, if so called upon, to disburse the amount of the guarantee required, without any additional charge upon the revenues?

5. I feel certain that such an equivalent would be the result, at least as far as regards the one great line of railway from Calcutta to the North-west, by the enormously increased efficiency that it would produce upon the operations of the Bengal army, in facilitating the concentration of troops on any required point, and by the consequent numerical reduction of that army which it would justify. If I can show this, I am persuaded that nothing more will be required to induce the Government to adopt that immediate and vigorous activity in pressing forward the construction of railroads which they are so well aware that every interest of India demands.

6. On referring to the last Revenue Accounts furnished to Parliament by the East India Company, we find the military expenditure incurred for the last year of the return, 1848-49, to be as follows:

	<i>Co.'s Rs.</i>
Bengal - - - - -	4,99,35,384
Madras - - - - -	2,62,06,214
Bombay - - - - -	1,71,57,759
TOTAL - - - <i>Co.'s Rs.</i>	9,32,99,356

7. We may assume that of this expenditure a certain proportion, say one-fourth, would be of a nature that would not, under any circumstances, bear reduction, such as staff-pensions, officers' pay, &c.; but that increased efficiency would enable a reduction with safety to be applied to a portion of the remaining three-fourths of that expenditure.

8. To judge as to the effect which the contemplated line of railway from Calcutta to the North-west would have upon the efficiency of the Bengal army, it must be kept in mind that a regiment marching from Calcutta to Peshawar (about 1,446 miles) would occupy a period of six months, or the whole temperate or active season of one entire year, on the way; whilst by railway it could be carried the same distance in from 70 to 100 hours, and shorter distances in corresponding comparative periods respectively.

9. When the Sikhs crossed the Sutlej, on the 15th of December 1845, it was six days before the nearest troops could be congregated to meet them; and that could only be effected by leaving the adjacent stations of Loodiana, Umballa, and Meerut comparatively unprotected, whilst the small force at Ferozepore was for several days exposed to the risk of an attack from the whole Sikh army.

10. The British Commander-in-chief, Lord Gough, aided by the whole power and military experience of Lord Hardinge as Governor-general, having marched from Umballa on the 11th of December, by the utmost exertions and forced marches, met the enemy on the 18th, the greatest amount of concentration that could be effected during those seven days, by denuding the nearest stations, being under 13,000 men; and with this comparative handful of troops he was obliged to fight at Moodkee a most hazardous battle with a well-equipped army of 30,000 men, having a reserve of 30,000.

Three days later, on the 21st of December, when the British force had been increased by only 5,000 men more, making in all about 17,000, they were forced to fight at Ferozishah for two consecutive days. Thus, after ten days of concentration, only 17,000 men could be brought together from the nearest stations, leaving those stations exposed; and this out of the large and magnificent force forming the Bengal army, or I should say rather out of the united armies of British India.

11. This gallant little band was obliged to take the risk of three battles, opposed to a well-organised and well-equipped army of 60,000 men, with the enormous disadvantage of an inadequate supply of ammunition; a combination of circumstances which placed in extreme peril the British empire in India.

12. Had the proposed railway from Calcutta to the North-west been in existence, 24 hours would have enabled the Commander-in-chief to concentrate on the point attacked 60,000 men, amply furnished with artillery and stores of every kind, drafted proportionately from all the main stations, and without leaving any point or cantonment in the rear unprotected.

13. To be convinced of this, it is only requisite to refer to the Plan, showing that the line of railway would pass centrally through the great line of important military stations between Calcutta and the Sutlej; and, if we conceive a well-combined extension of the principle of trunk railways completed throughout the three Presidencies, the draft for any large field force required might with proportional facility and rapidity be concentrated from the main stations of the three armies, thereby producing a proportionably slight withdrawal of the force from any particular locality.

14. We have at this moment conflicts going on at the North-western and North-eastern extremities of our Indian frontier, points about 2,000 miles apart; either or both of which conflicts may grow into serious wars, requiring immediate and extensive reinforcements of troops and stores. The very nature of our empire in India must at all times expose us to similar conflicts, without much warning; and our stability, or even existence there, must depend on our being able to meet such conflicts with energy and rapidity, without dangerously diminishing the garrisons of other important districts, particularly of those that are nearest to the seat of war, and therefore most exposed.

15. No one will deny that the efficiency of an army is in some inverse ratio to

to the time required to concentrate such a preponderating force of well-trained troops on any given point of its lines of defence as shall secure victory over the largest hostile force that can be expected to attack it.

16. When the movements are slow, as must be the case when the troops have to concentrate by marching, each limited district must be copiously armed for its own defence and protection; but when the power of concentration is rapid, as is the case when troops can be brought together to any given point by railway from very distant stations, then a comparatively small force will suffice for each particular district.

17. What the exact ratio of increased efficiency may be, as compared with the increased power and rapidity of concentrating troops and conveying artillery and commissariat supplies to the first place of assembly for a campaign, as well as in the subsequent supply of reinforcements and provisions, it is difficult to express in precise numbers; but it would probably not be straining the argument to assume that two-thirds of any given army for the protection of British India would be much more efficient where a field force of 50,000 or 60,000 men, with ample artillery, stores, and provisions, could be congregated on any point of its vast lines of defence in 20, 40, or 60 hours, than the whole of such an army would be under the present system, requiring a mean period of three or four months to bring such a force together.

18. It is not for a moment implied, that in the subsequent manœuvres of a campaign the general can be aided by the existence of railways; their advantages, in a military point, are only assumed to apply to the first concentration of a force, and to its after reinforcement with troops, provisions, and stores. But all those acquainted with the Indian climate and practices will understand how much greater those advantages would be as applied to India, than if our consideration had reference to Europe. In India, marching or campaigning in summer is out of the question, unless at a fearful expense of life and health to our troops, whilst, from the vast extent of territory we occupy there, the ordinary dispersion of our forces may be nearly in the ratio of 1,000 miles as compared to 100 miles at home.

19. Under the foregoing views, I shall deal with the present military expenditure of Bengal as follows, that amount being - - - *Co.'s Rs.* 4,99,35,384 :

From this sum I take one-third of three-fourths, or one-fourth of the whole, as a reduction of expenditure due to the increased efficiency of the army, to be produced by railways - 1,24,83,846

Subsequent military charge for Bengal - - - 3,74,51,538

20. The reduction of expenditure in the military establishment of Bengal, which, I maintain, the construction of the railway from Calcutta to the North-west would justify, and still leave the army a much more powerful engine than it is at present, would be *Co.'s Rs.* 1,24,83,846 per annum, or taking the rupee at 2s., it would be, in British money, 1,248,384 l., which at five per cent. would enable the East India Company to raise a capital of 24,967,690 l., or at four per cent., 31,209,600 l., or at three per cent., 41,812,800 l., with which to construct railways in Bengal on Government account; or if it be considered preferable to work the railways through private companies, the Indian Government can venture to guarantee to such an amount of capital, without increasing the public charges of Bengal, even supposing the whole amount of the guaranteed interest to be annually paid by Government to the companies.

21. But if, as I firmly believe, an economically and judiciously constructed line to the North-west of India would be ample remuneration from its own resources, then the whole reduction of 1,248,384 l. annually on the Bengal military establishment, would be a clear saving upon the present expenditure; and in addition to this large saving must be considered the saving that would occur on the transport of troops in the annual reliefs; the saving upon transport of treasure and treasure parties; and, above all, the abolition of that most oppressive practice which the movement of troops now entails by the necessity of pressing the carts and animals of the country people, and carrying them hundreds of miles from their homes, in order to furnish the requisite means of military conveyance. Yet the advantages, in a military point of view,

would form only one of the numerous classes of benefits which such an undertaking would confer upon the country; nor is it easy to estimate the annually increasing prejudice to Indian produce, which the delay of applying this principle is producing, or how it is to recover the start which energy, wisdom, and activity in this respect are giving to American produce, even in our own markets.

22. Adopting the foregoing principle, as generally applicable to the three Presidencies, I shall now offer a Table, showing the annual saving on the military establishments of India generally which a well-arranged system of railways would produce; showing also the capital which that saving would enable the Government to command, either as a guarantee fund, in the event of private companies doing the work, or as a fund for actual construction by the Government itself; and, further, showing the number of miles of railway that can be made out of such capital, at different rates of cost per mile, omitting fractional parts:—

Presidency.	Col. 1. Present Cost of Military Establishments, as given in Parliamentary Return for 1843-45.	Col. 2. Annual Saving upon Military Establishments which would accrue from the introduction of Railway Interchange.	Capital which may be raised for Construction of Railways upon annual Saving in Col. 2, at			Number of Miles of Railway which may be constructed by Capital in Col. 4, at per Mile,						Col. 12. Number of Miles which may be constructed by Capital in Col. 5, at 5,000 £. per Mile.
			Col. 3. 5 per Cent. per Annum.	Col. 4. 4 per Cent. per Annum.	Col. 5. 3 per Cent. per Annum.	Col. 6. £. 5,000	Col. 7. £. 6,000	Col. 8. £. 7,000	Col. 9. £. 8,000	Col. 10. £. 9,000	Col. 11. £. 10,000	
			£.	£.	£.	Miles.	Miles.	Miles.	Miles.	Miles.	Miles.	
Bengal - -	4,933,598	1,248,384	24,907,680	31,209,600	41,612,800	6,241	5,210	4,438	3,901	3,467	3,120	8,322
Madras - -	2,020,621	655,155	13,103,100	16,378,875	21,838,500	3,275	2,729	2,339	2,047	1,819	1,637	4,367
Bombay - -	1,715,775	428,943	9,578,860	10,723,575	14,298,100	2,144	1,787	1,531	1,340	1,191	1,072	2,859
TOTAL - -	8,329,953	2,332,482	47,649,640	58,312,050	77,749,400	11,660	9,726	8,398	7,288	6,477	5,829	15,548

23. In a report which I addressed to the Government of India on the 29th of January 1851, I dwell at some length on the principles which appeared to me indispensable to ensure success and profit in this class of undertakings, and to avoid those errors, that waste, and that ruin to shareholders which have characterised similar works in England.

24. Those principles were at once approved and adopted by the Government, and one important result which may be anticipated from them is that of forcing those charged with the construction of the works in India, to adopt the most essential of all rules in engineering, which has, unfortunately, been generally disregarded in English railway practice, that of the engineer feeling his character responsible, not only for the eligible nature of his project, and the efficiency of his works, but likewise for the funds invested bringing back a remunerative return to his employers, unless he shall have clearly expressed his written opinion that such a return is not to be expected, even under the most economical system of construction that can possibly be applied. This assuredly should have been the first consideration with engineers employed by companies whose sole object was to obtain a profitable return for their investment. And had they been guided by such a consideration, they would never have allowed their works to cost 183,000 £. per mile, nor 178,000 £., nor 70,000 £., nor 60,000 £., nor 50,000 £., nor 40,000 £., nor even 30,000 £. per mile. Nor would they have constructed their lines with such defective gradients as must necessarily limit the loads of their powerful engines to a degree that must consume the profits otherwise attainable in the permanent working of the lines.

25. Had engineers kept the interests of their employers in view, they would have

have individually and collectively remonstrated against the extravagance and fraud attending the preliminary investigation of the merits of projects prior to their sanction and adoption; the frauds in valuation of property, law costs, &c.; and had they done so, Parliament would have listened to their remonstrance, and would have granted reasonable protection to the most useful class of speculators who have ever shown themselves in the British empire, and who, as matters now stand, have been pillaged by the inexcusable negligence of those in whom they confided to the extent of so many millions of pounds sterling. Happily for India, its Government have not overlooked the justice and wisdom of protecting this class of investment from the futile processes and scandalous frauds which attended the preliminary investigation, the legal chicanery, and the acquirement of the land in England.

26. But it is still imperative to adopt the most arduous and incessant scrutiny of all projects, as well as supervision in the subsequent execution, to eradicate the grave errors in the former, and the extravagance in the latter, which will otherwise assuredly emanate from those trained in the practice of England.

27. For greater security, I have given, in the above Table to para. 22, a scale showing the number of miles which might be made at different rates of cost to the amount of the capital which I assume the annual saving on the military establishment would produce in each of the Presidencies. But although, for facility of calculation and precaution sake, I have extended this scale from an average of 5,000 £. per mile to that of 10,000 £., I am nevertheless convinced that the lower average of 5,000 £. per mile ought amply to suffice for single tracks, if the engineers in charge can be forced to keep constantly in mind that the one thing needful is a remunerative return for the capital confided to them. My own experience, the results obtained on the continents of Europe and America, some few cases, even in our own country, as well as the comparative low price of labour in India, all tend to confirm this conviction. It will be safe, however, even holding this opinion, to limit, in the first instance, the authority for construction to one-half of the mileage which could be at that rate; a quantity quite sufficient to open the main lines of trunk road throughout the several Presidencies. It would give—

For Bengal - - - - -	3,120 Miles.
For Madras - - - - -	1,637 „
For Bombay - - - - -	1,072 „
	5,829 „

28. I have no doubt that the saving upon the military establishments may be fairly calculated to cover the risk of railway guarantee in the Presidencies of Madras and Bombay, as well as in Bengal. The natural formation and fall of the land, the commercial requirements as regard lines of railway, and the military points of occupation in those Presidencies sustain this view. In Bengal it must be allowed that all these matters have a singularly concurrent coincidence; whilst some peculiarities of the Bombay Presidency call for the most cautious and judicious consideration in order to secure to it the full measure of advantage of which it is susceptible.

29. In this view, I apprehend that the project now in progress at Bombay calls for some very important modification of the original design. It is to be hoped, however, that this modification may be effected without the necessity of abandoning for one object or another any of the work done. It was an error to contemplate carrying the great Northern traffic, including that of Candeish and Berar, over the Syhadree Ghats. At the same time, the portion of road made from Bombay, as far as Tannah, will probably be found suitable as the commencement of the great Northern trunk road; whilst from Tannah, on by Callian, &c., the work done may come into use as a branch towards Sholapore, &c., from the trunk line.

30. It would appear that the projectors of the works now in progress at Bombay, proposed to cross the Syhadree range by the Malsej Ghat, 2,060 feet high. They propose to surmount the precipitous portion of the Ghat, 1,170 feet

See Appendixes,
Nos. II. and III.

See Appendix,
No. II.

feet high, by a fixed engine incline of about six miles, with a gradient of about one in 18, or by an alternative incline 13 miles long, with a somewhat reduced gradient. They would then proceed through the table land due east for 20 ½ miles to Alleh, the maximum incline being so great as one in 113; at Alleh they would send off a branch to the south-eastward, in the direction of Sholapore; but the principal object appears to be the northern line from Alleh through Candeish, and crossing the Taptee and Nerbudda rivers, they would take the direction of Agra, after passing by Mow Indore, &c.; they would also throw off a branch from the Nerbudda, bearing on Allahabad. Here, then, we have gravely proposed a most erroneous project of a grand trunk road, by which the whole northern, north-western and north-eastern traffic is to approach Bombay, the important mercantile capital of Western India. Between Bombay and Agra it appears to be the intention that this great trunk line (second only to that of the Ganges, if even second to it,) should pass over no fewer than four *unnecessary* and fierce ranges of mountain, of which I imagine the aggregate amount of rise and fall would not be less than from 8,000 to 9,000 feet; whilst on the natural route by Surat and the valleys of the Mhye and Chumbul, there is but one summit to pass, at Neermuch, between Bombay and Agra; the height of this summit is 1,356 feet, which added to the fall from Neermuch to Agra, say 850 feet, would make the total rise and fall by this line only 2,206 feet, whilst the distance would be about 120 miles less than that by the hilly route through the Ghats.

31. The same reasoning which overthrows this project, as a general trunk line between Bombay and Agra, holds equally against that portion of it intended to open an intercourse between Bombay and the districts of Candeish and Berar. On this portion of it the aggregate amount of rise and fall would probably exceed considerably 4,000 feet, whilst by the coast we go level to Surat and branch off by the Taptee Valley at the slight gradient of the river, without passing any range whatever; nor would the distance by this route exceed that over the Ghats.

32. The best route harmonises with every general and local interest of India in their widest extent, whether as regarding the north, by the route I propose, with the power of throwing off branches, or as regarding the east by the valleys of Taptee, Nerbudda, Soane, Godavery, Lower Kistna, &c., or as regarding the west, by Guzerat, Kurachee, the Indus, &c. Nothing can exceed the eligibility of this mode of opening the communication of all those districts with Bombay. Nothing could be more preposterous than to think of carrying the traffic of any of them over the Ghats.

33. There is no doubt that the interests of the table-land east and south-east from Bombay call for every exertion to open a passage through the Syhadree range. But it is with this view, and this view only, that the work done to the eastward of Tannah can be made available.

34. I shall not here enter into the smaller question of, whether the Malsej or the Bhore, or any other particular Ghat, might have been the preferable one through which to reach that table-land.

See Appendix,
No. III.

35. But what I most earnestly appeal against, is the project which has for its object to approach the district of Candeish or Berar, or any other part of India, to the north, the eastward or the westward of those districts, by any line whatever passing over the Ghats. I trust that the East India Directors and the Board of Control will resist every suggestion made to them with this object, until they shall have heard from the Governor-General of India upon the subject. And I feel firmly convinced that his Lordship's experience will sustain the view which I take of this most important subject. The nature of the error is precisely similar to, though of much greater magnitude than, that which I brought under his consideration in the project of the East Indian Railway Company in Bengal. He did not hesitate in adopting the remedy I recommended in the Bengal case, nor will he now for a moment hesitate in protecting those vast districts which the Bombay project would effect from the unnecessary tax on their transport of goods that would be the inevitable effect of carrying them over several fierce ranges of hills, when a much shorter line can be had, avoiding those hills, and combining the broadest interests of Indian traffic generally.

36. The

36. The project above referred to proves, at least, the pressing necessity of laying down without delay some general and well-defined principles of action on the subject, as a protection against similar errors in future, and with a view to direct, concentrate, and combine with useful effect the efforts of well-intentioned active minds. With this object I would propose the following broad rules in respect to railways, for the adoption of the Government of India. They may somewhat startle European engineers, as aiming at a degree of perfection of which our section of the world might scarcely admit; but the more they examine the physical formation and circumstances of India, the more they will be convinced that what I propose is in strict harmony with those natural advantages which Providence has placed within our reach there, if we can but appreciate them, and exert the requisite degree of judgment in their application.

37. I propose,—

1st. That all railways constructed in India shall belong to one of two classes,—the first or the second class.

2d. That the regulating gradient of the first class or trunk railway, shall not exceed one in 2,000. By “regulating gradient” is meant the gradient which shall regulate the load of the engine.

3d. That no regulating gradient of any second class or branch railway shall exceed one in 330.

4th. 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 ½ furlongs.

See Appendix,
No. IV.

5th. That no line shall be undertaken when the estimated cost shall exceed the average rate of 5,000 £. 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.

6th. 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.

7th. That no locomotive engine shall be introduced to India for 10 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.

8th. 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.

9th. 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.

10th. 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.

11th. That, notwithstanding the tenor of Rule No. 6, 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.

12th. 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 despatch 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

131.

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three

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.

38. Although the object of the foregoing rules is sufficiently obvious, still a few observations upon them may not be considered superfluous. They seek to unite all considerations in the grand object of securing a remunerative return for the capital employed, without which it is clear that the progressive expansion of the principle involved cannot possibly be carried to the extent required by the interests of the Indian people. They keep in view the first principle of advantage possessed by railway traction over all other kinds, that of enabling the smallest power to produce the greatest result; and they tend to secure that that result, so absorbing the power, shall be as much as possible applied to the movement of effective load, and that the power shall not be absorbed either in the mere luxury of a superfluous velocity, or in contending with gravity or unnecessarily steep inclines. They seek to secure the principle of economy both in the permanent working of the lines, and in their original construction. With regard to this last consideration, there is no question that if engineers are forced to work with economy they can do so. I am about to inspect a line of single-track road that has been lately constructed at home, at an outlay of 5,000 *l.* per mile: if I find the result of any importance, I shall not fail to report it for the benefit of the Indian Government; and if a work can be produced here at that cost, there can be no question as to its sufficiency in India, where labour can be had at one-seventh of our rate.

39. It is necessary now to refer once more to the general Finance Account already alluded to. In it we find that the land revenue, or government rents of the land in India, for the year 1848-49, amounted to about 14,274,272 *l.*, whilst the charge for buildings, roads, and other public works, exclusive of repairs, was in the same year, 1848-49—

	£.
In Bengal Presidency - - - - -	53,568
In North-western Provinces - - - - -	192,780
In Madras Presidency - - - - -	23,801
In Bombay Presidency - - - - -	24,811
TOTAL - - - - -	£. 294,962

40. From this statement it would appear that nearly two-thirds of the total expenditure in public works in India for the year 1848-49 was incurred in the North-west Provinces, and probably the greater part of it for that magnificent undertaking, the Ganges Irrigation Canal, a work highly creditable to the British Administration, and one which, when completed, must prove largely remunerative in a financial point of view. The balance expended on public works, exclusive of repairs, in all other portions of India, appears to have been 102,182 *l.* for that year.

41. In considering this part of the subject, it must be kept in mind that the Government of India occupy not only the position of the Government, but likewise that of the most influential class of subjects in England, the land proprietors, a class second only in importance to the Government itself; and, therefore, as the Indian Government derive the revenues of these two classes, they will naturally feel disposed to meet the charges borne by the corresponding classes in England, without which the improvement of the country cannot proceed, nor can India compete with other countries in the general markets of the world.

42. That is to say, the Government will feel the wisdom of executing the requisite public works which should emanate from an ordinary Government, as well as the territorial improvements pertaining to the class of landed proprietors.

43. What the right proportions of revenue may be that are due to these two heads,

heads, can only be estimated by the legitimate requirements of the country; laying down, as a general maxim, that all such legitimate requirements should bring back, directly or indirectly, a corresponding return for the investments.

44. The just claims of the Indian people upon their Government, as above described, will be better understood when it is considered that the monopoly of the proprietorship of land there reserved by the Government must, to a great extent, have prevented the gradual growth of the monied and speculating classes, which in England produce the vast variety of enterprising individuals, associations, and companies who have effected such marvellous results in drawing forth the industrial resources of the country.

45. It is difficult to say what may be the ordinary average charge for the improving operations of a well-managed English estate upon its annual rental; but if we assume it to be 20 per cent., we shall not probably be guilty of exaggeration. This proportion of the Indian rental would amount to an annual outlay of 2,854,854 *l.* by the Government in its position of general land proprietor, irrespective of such further sum as it may be prudent to expend in its position of Government for public works.

46. The wisdom of the Indian Government in retaining in its own hands the rents of the land as a public revenue, cannot be overrated, and it only remains to follow up this wise principle by a liberal fulfilment of its duties as general landed capitalists in fostering the industrial resources of the country, in order to exhibit the most perfect financial administration of any government in the world. It must rapidly lead to the abolition of every existing tax or duty, for rent is not a tax; and the rent or land revenue would soon be found amply sufficient to meet all the cost of government.

47. The outlay of the Government on account of railways, or their guarantee to companies for such outlay, as well as the expenditure for construction of irrigation canals, and all other works beneficial to the occupiers of land, must be looked upon as so much money invested by Government in liquidation of the claim upon them as land proprietors of India. And the operation of those improving investments would rapidly stimulate every branch of industry, and promote the consequent accumulation of wealth in the hands of individuals.

It would, in fact, call into existence the class of private capitalists so much wanting in India, that class which in Europe originated in the first instance in the principle of the Government having given away to private persons the proprietorship of land which in India has been so wisely retained as state revenue.

48. No one, then, will deny the broad nature of the claims in this respect which the people of India have upon their Government. Nor can any one deny the broad interest which the Government must have in liquidating these claims, secured, as has been shown they are, by the certainty of deriving an immediate and ample direct as well as numerous indirect profits for all such judicious expenditure.

49. I take for granted, then, that as India has so far escaped from the errors that have attended the introduction of railways, the Indian Government will follow up their recent judicious commencement in Bengal by every possible precaution against the occurrence of the English errors. I likewise may assume that as much time has already been lost in giving to India the advantages of railways, the utmost exertions will now be used for their judicious introduction, in order that her productions may be stimulated and enabled to compete with those of other countries, and particularly of America, in the general markets. My own experience whilst employed in this department in India, has convinced me that the Government is fully impressed with the urgent necessity of these two principles; and that it is only necessary clearly to point out the precautions required, and the mode by which immediate execution can be safely accomplished, in order to ensure the utmost activity in the adoption of all these measures which shall lead to the fulfilment of what they know to be of such vital importance to their territories.

50. The first object must be to lay down the great trunk lines, with a view to the broadest future ramification, and on a principle that shall ensure the most profitable

profitable permanent working of the lines generally, bearing at once upon the internal intercourse of India itself, as well as upon the intercourse of India with Europe, &c.

51. Here we must keep in mind a few great leading features in the geographical formation of the peninsula of Hindostan; first, the great western range of hills parallel to the coast, at a medium distance of about 40 miles from it, and running south from the Taptee Valley, for 700 or 800 miles.

52. From the western range a formidable spur projects for about 400 miles to the eastward, reaching near to the centre of the peninsula from a point in the Ghat, a little to the north-east of Bombay. (a)

53. A feature of much general importance in our present consideration, is the Great Central Omrawuttee table-land. It sheds its waters in every direction; first, to the north-east by the Soane Valley, which falls into the Ganges, and passes Calcutta; second, to the south-west by the Nerbudda and Taptee, which falls into the Gulf of Cambay, on the Bombay coast; and third, to the south-eastward, by the Gunga, Godavery, Mahanuddy, &c., which flow towards the Madras coast.

54. Keeping these great geographical features in mind, (and they cannot be overlooked in any general project without fatal error), they force upon us the knowledge of what the great arteries of commerce must necessarily be; and with those arteries our trunk roads must correspond. We must remember the valleys of the Ganges and Jumna, whose waters flow from the Himalaya to the south-eastward for about 1,300 miles, passing by Calcutta and many of the richest districts in India. If we keep these leading features always in mind, and seek to accomplish the object in view without throwing away our great natural advantages, attempting to outrage scientific axioms, or fruitlessly striving to accomplish what is unadvisable merely to gratify erroneous local influences, which are taken up in total ignorance or carelessness of first principles, there will be no doubt that singularly profitable trunk lines can be selected throughout India, which shall admit of judicious ramifications to any extent that local interests can possibly demand hereafter.

55. In accordance with the principles contained in the foregoing paragraphs, as well as with those advocated in my reports, dated 29th January and 27th February 1851, I shall now proceed to consider the lines of railway, in detail, which would lead to the most perfect and comprehensive system of intercommunication that can at any future time be looked forward to for India, as exhibited in the accompanying Sketch Map.* On this map the lines coloured *Red* represent the main or trunk lines, and those marked *Yellow* represent the secondary or branch lines. It will be observed that the direction given to all railways in this project is as much as possible in the course of the valleys, and that as rarely as may be is it proposed to cross any valleys or ranges of hills transversely. Attached to this map are two Fly Sketches, marked Nos. 1 and 2; No. 1 contains the most important portions of the lines which should be first constructed, supposing the capital only procurable under a guarantee of five per cent., as set forth in column 3 of the table attached to paragraph 22, and therefore limited to about one-half of 47 millions sterling, reserving the other half as a margin to meet contingent events until extensive experience shall have given practical and certain data. Fly No. 2, contains an extension of No. 1, supposing the capital procurable on a guarantee of three per cent., which I believe it could be, as calculated in column 5, and consequently extended to about one-half of 77 millions.

56. I shall now close these memoranda, and whilst acknowledging with thanks the assistance which the Secretary to the Court of Directors of the East India Company has afforded me by free access to the maps, &c., at the India House, it will be understood that I only seek to point out a general principle, which shall be a protection against the incongruous errors of isolated action. I believe
the

(a) Since writing the above, a principle has occurred to me, as given in Appendix, No. 4, by which the engine may be enabled to surmount considerable accents with the load due to a level road.

the sketches of projects which I offer in my plans and schedules will be found to have this effect, as the basis upon which they rest and their relative bearing with each other are strictly mathematical; nor do I believe that the principle can be superseded by any other that should not have an injurious effect.

57. I should have hesitated at this distance to put forward so large a subject, necessarily connected with the minute physical structure and wants of the various particular localities of the vast continent of India, had not the evil consequences that must arise from the deficiency of some sound general plan of operations been illustrated strongly in my mind by the erroneous project now in progress at Bombay, as well as by the Bengal project, in the state in which I found it on taking charge of the Railway department under the Government of India. These are the only cases where the introduction of railways has been practically attempted in India, and they were so crude and unfitting, that had they been persevered in under the original intention, they must have not only failed as individual cases, but their failure would have blighted the principle of such works. I earnestly hope that their correction may lead to a very different conclusion. The traffic of India has no broad margin like that of England to cover grave errors. The capabilities, however, of India are numerous, and her traffic, such as it is, will suffice, provided those capabilities are turned to the best possible account, but not otherwise.

58. I shall only venture further to suggest, with a view to prevent unnecessary delay, that the Governor-General should be furnished with a power, if he does not already possess it, without reference home, to incur the requisite expenditure to investigate by reconnoissance or survey, or by reports from special officers, the merits of such railway projects as his Lordship may think fit to order. If this be conceded, much indispensable preliminary knowledge may be obtained at a small cost during the ensuing cool season. I would earnestly press the advantage of having as many projects of this nature as possible now brought up, as there is no chance of any one hereafter being placed at the head of the local Government of India, whose experience on the subject of railways could attach such value to their recommendations or decisions as that of the present Governor-General.

(signed) J. P. Kennedy,
Major.

15859.

Appendix, No. I—continued.

A P P E N D I X.

No. I.—Sketch Map of India, containing Projects for Railways, by Major J. P. Kennedy.

Table, with Fly Sketch, No. 1.

Table, with Fly Sketch, No. 2.

No. II.—Proximate Sections, to illustrate the errors in progress under the Project of the Great India Peninsula Railway Company, in the Presidency of Bombay, &c.

No. III.—Suggestions by Major Kennedy for opening Railway Intercourse between Bombay and the Table Land, passing over the Syhadree Ghats; with Sketch Map illustrating same.

No. IV.—Table and Section of Impulsive Inclines, explanatory of new method proposed by Major Kennedy, to enable Locomotive Engines to convey Loads due to a Level up ascents.

No. V.—Sketch, Plan, and Section of the Proposed Line of Railway between the Colliery Junction and Rajmahal, in Bengal, to illustrate the Method of "laying out," with a view to avoid unnecessary Gradients, and to obtain the most perfect Line with the smallest Amount of Cuttings and Embankments; with explanatory Note and References.

TABLE referring to FLY SKETCH No. 1, showing the Number of Miles of Railway in that Sketch passing through each Presidency, with the corresponding Cost, at 5,000 *l.* per Mile.

LINES OF RAILWAY.	BENGAL.		MADRAS.		BOMBAY.		TOTAL.	
	Miles.	£.	Miles.	£.	Miles.	£.	Miles.	£.
1. Calcutta to Agra, by Ganges and Jumna Valleys - -	900	4,500,000	-	-	-	-	900	4,500,000
2. Bombay to Agra, by Surat, Broach, and Valleys of Myhe and Chumbul -	409	2,045,000	-	-	309	1,545,000	718	3,590,000
3. Madras to Surat Junction, by Coasts and Valleys of Godavery and Taptee -	-	-	820	4,100,000	160	800,000	980	4,900,000
4. Madras to Malabar Coast, at Poniany, by Chingleput, Trichinopoly, and Valleys of Coleroon and Poniany -	-	-	394	1,970,000	-	-	394	1,970,000
5. Madras to Bangalore, Arcot and Tallar Valley - -	-	-	200	1,000,000	-	-	200	1,000,000
6. Bombay to Sholapore - -	-	-	-	-	350	1,750,000	350	1,750,000
7. Baroda to Kurachee, through Guzerat - - -	230	1,150,000	115	575,000	115	575,000	460	2,300,000
8. Madras Junction to Hyderabad (in Deccan), by Kistnah Valley - - -	-	-	200	1,000,000	-	-	200	1,000,000
9. Agra to Lahore, by Delhi -	385	1,925,000	-	-	-	-	385	1,925,000
10. Kurachee to Mittonkote, Indus Valley - - -	-	-	-	-	350	1,750,000	350	1,750,000
11. Rajmahal to near Darjeeling	140	700,000	-	-	-	-	140	700,000
12. From near Simla to Junction with Ganges Line, near Kurnal, by Jumna and Ghiree Valleys - -	100	500,000	-	-	-	-	100	500,000
	2,164	10,820,000	1,729	8,645,000	1,284	6,420,000	5,177	25,885,000

Appendix, No. I—continued.

TABLE referring to FLY SKETCH No. 2, showing the Number of Miles of Railway in that Sketch passing through each Presidency, with the corresponding Cost, at 5,000*l.* per Mile

LINES OF RAILWAY.	BENGAL.		MADRAS.		BOMBAY.		TOTAL.	
	Miles.	£.	Miles.	£.	Miles.	£.	Miles.	£.
Brought forward from Fly Sketch No. 1 - - -	2,164	10,820,000	1,729	8,645,000	1,284	6,420,000	5,177	25,885,000
13. Burrampooter Valley - -	650	3,250,000	-	-	-	-	650	3,250,000
14. Bombay (Ghat Junction) to Nandair, Godavery Valley	-	-	-	-	245	1,225,000	245	1,225,000
15. Poonah to Meuritch, by Satara - - - -	-	-	-	-	135	675,000	135	675,000
16. Assini to Chittigong and Arracan - - - -	540	2,700,000	-	-	-	-	540	2,700,000
17. Nerbudda Valley - - -	450	2,250,000	-	-	-	-	450	2,250,000
18. Nagpore to Junction with Bombay, Surat and Madras Line - - - -	135	675,000	-	-	-	-	135	675,000
19. Mittonkote to Lahore - -	300	1,500,000	-	-	-	-	300	1,500,000
20. Lahore to Attock - - -	200	1,000,000	-	-	-	-	200	1,000,000
	4,439	22,195,000	1,729	8,645,000	1,664	8,320,000	7,832	39,160,000

Appendix, No. III.

On Opening a RAILWAY from Bombay into the Table Land, across the *Syhadree* Range.

IN the foregoing Memorandum (paragraphs 28 to 36), I have stated the objections to any trunk line being carried over the Ghats, having for its object the northern, north-eastern, or north-western intercourse of India with Bombay. I have also stated that the interests of the extensive districts of the table land would call for the construction of one or more branch roads being made over this great range of precipitous mountain. And I now have to request the most earnest consideration as to the mode in which such an undertaking shall be effected. It is an enterprise of which the project and execution will test the resources of the railway engineers of India, and I trust that the Government will not sanction any of the objectionable schemes hitherto brought before them.

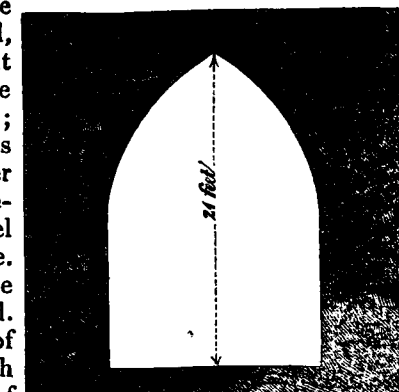
The idea of a fixed engine incline of 6 miles at 1 in 18, or of 13 miles at 1 in 40, as well as every other makeshift contrivance, should be rejected. An admirable road for a locomotive, with an ample and justifiable load, can be obtained along the face of the range. In fact the ascent can be surmounted at any required gradient, as the power exists of lengthening the base to any required extent.

This is a work in which the character of the British engineering profession is not more interested than that of the British policy and interests in India. It will prove to the nations of that country, if properly done, that their rulers are capable of overcoming every difficulty opposed to Indian progress.

Those who have already reported upon the structure of the district state, that it is most favourable for tunnelling. If this be so, it is only requisite to establish a judicious and economical principle for driving the tunnels, as well as for executing the side cutting and viaducts between adjacent tunnels; and the engineer may boldly select a first-class gradient for reaching the table land without any apprehension of an exorbitant rate of cost.

When I commenced the first tunnel in the Himalaya Mountains, on the Hindostan and Thibet road, I was influenced much more by anticipation of its effect upon the dawning subject of railway construction in India, than even of its utility as an integral portion of that particular road. It was specially important to prove that that class of work could be executed at a small cost; with that view I obtained from Mr. Edwards, the superintendent of the Hill states, the allocation to this work of a small party of convicts, who were a constant charge to the public, and had previously given very little in the way of a remunerative return for the cost of their maintenance. The party of convicts was divided into two subsections, one for each opening of the tunnel, each section being divided again into subsections or squads, relieving each other every six hours. As the law did not authorise us to employ the convicts in the night reliefs, I was obliged to get hired labourers for that duty; so that one-half of the work was executed by convict labour, and one-half by hired labour. The overseeing of the work was done by privates of a Sapper company, which was placed under my orders, and which furnished me with all the overseers I required along the whole line of road; nor were those Sappers employed on any work except as overseers. There was a Sapper overseer for each relief of the working parties at each tunnel opening, and they were particularly useful in the boring, loading, and firing off the mines. There was likewise a blacksmith's shop established for the repair of mining tools at the tunnel. Thus the work was carried on day and night. The overseers were not any additional cost to Government, as they were permanently paid military men. And one-half of the labour, exclusive of the repair of tools, was likewise without cost, as the convicts must have been maintained at the same rate of outlay, whether they had been thus employed or not. The outlay by this method, up to the time that I gave over charge of the work, was far within 6*d.* per cubic yard of excavation, exclusive of the cost of powder, which I obtained from the Government stores of captured ammunition, and was no cost to the Government, as had already been proved by large quantities of it having been blown up as useless or superfluous.

It will be observed here that I could not bring down the rate to the minimum of cost at which it may be effected, because I could not employ the convicts in the night reliefs. This, however, can be easily obviated in future works of this class by a Government rule on the subject; and no one can object that the employment of convicts for 6 hours out of 24 at this labour is a hardship, whether by night or by day. In fact, the night work is the preferable of the two, particularly in summer; and tunnel work is preferable to any other in the Indian climate. The tunnel itself, too, forms the safest and coolest place of confinement and lodging for the prisoners employed. The forms and dimensions of a tunnel for a single track of rails may be taken as in the accompanying diagram, which would require the excavation of about 30 cubic yards of rock per yard forward. This, at the rate of 6*d.* per cubic yard, would enable us to execute the tunnel for about 17*s.* 6*d.* per yard forward, exclusive of the cost of powder.



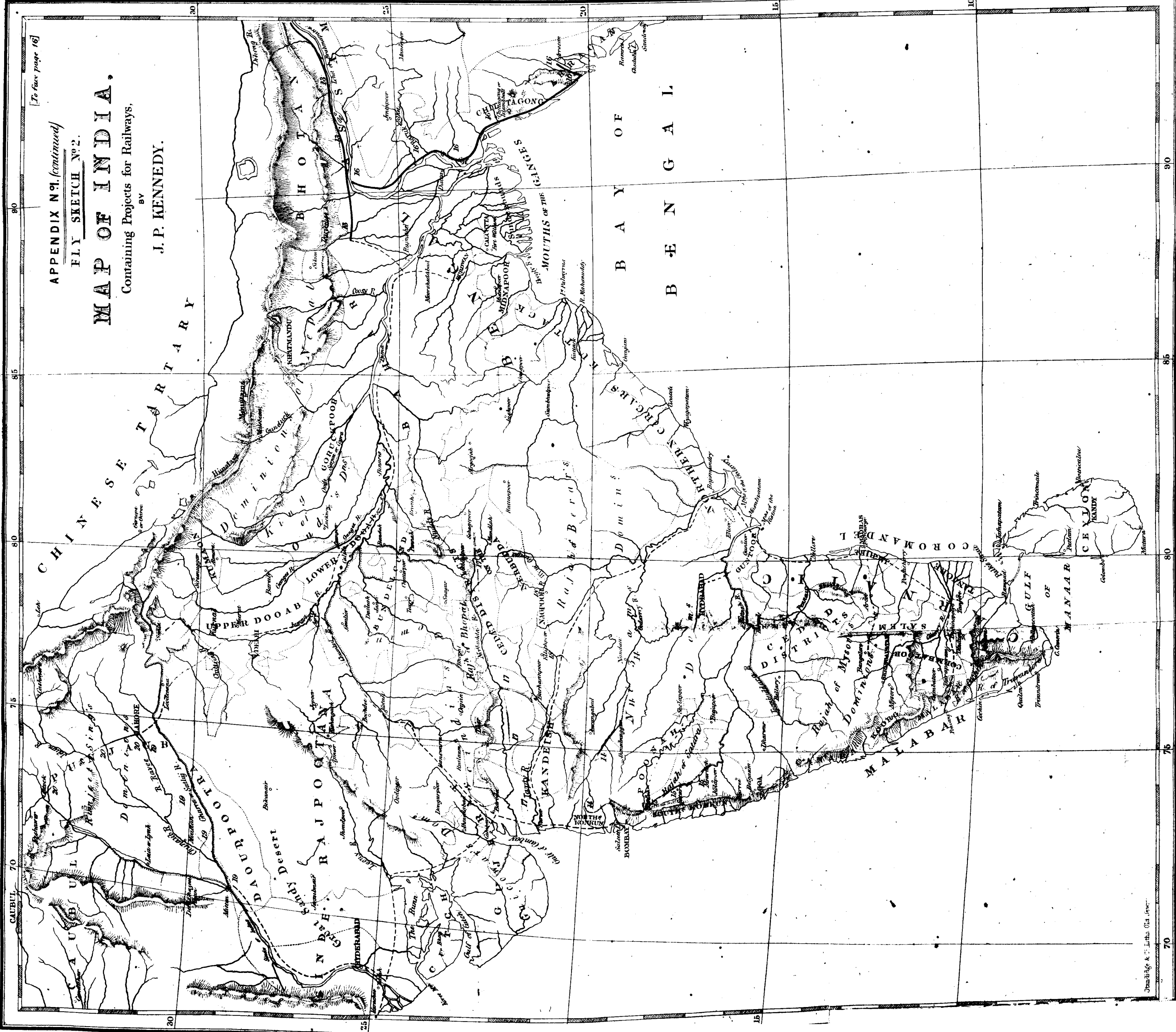
[To face page 16]

APPENDIX N^o 1. (continued)
FLY SKETCH N^o 2.

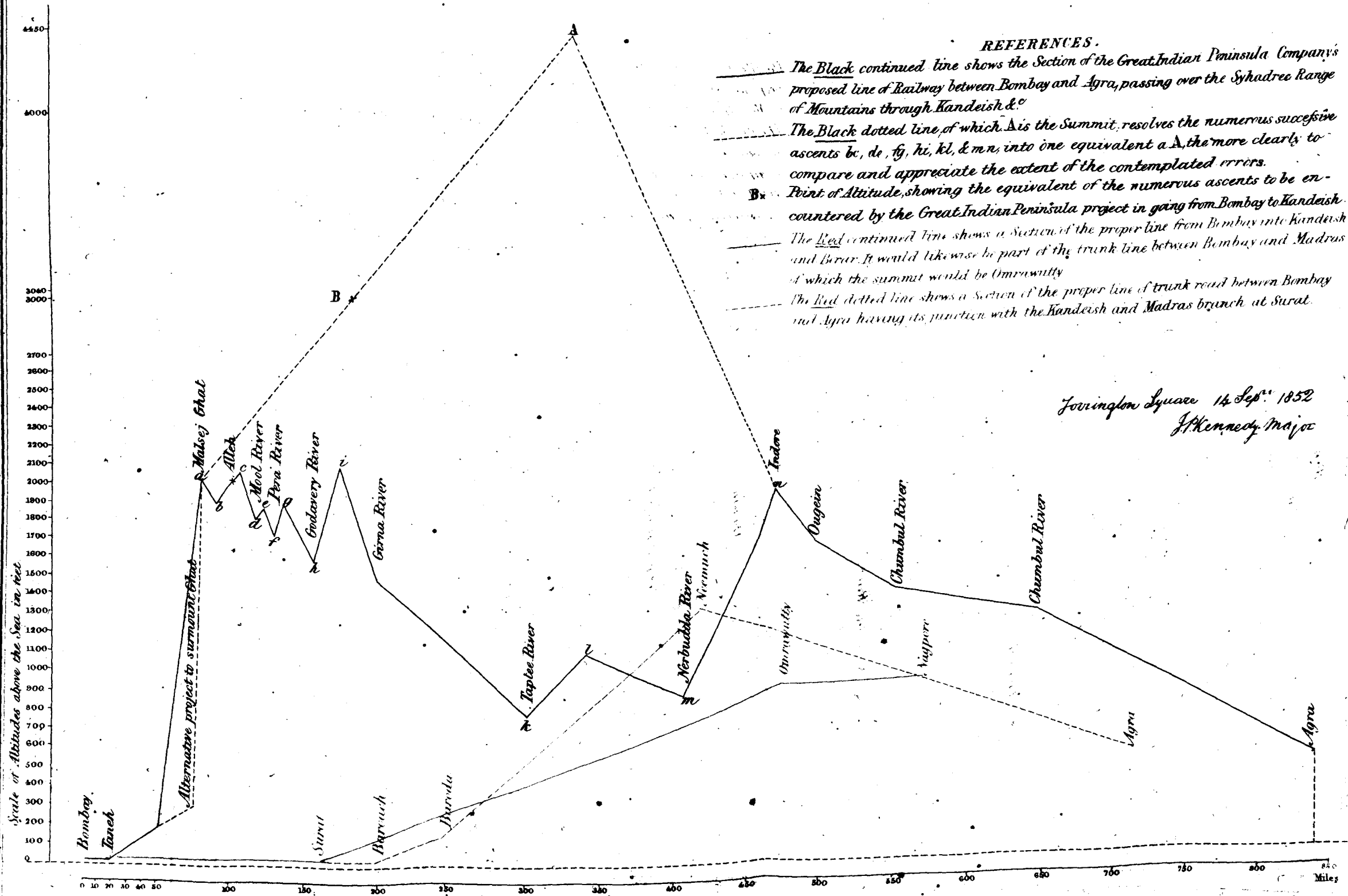
MAP OF INDIA.

Containing Projects for Railways,

BY
J. P. KENNEDY.



APPENDIX N^o. II.
PROXIMATE SECTIONS,
*to illustrate the Errors in progress under the view of the Great
India Peninsula Railway Company, in the Presidency of Bombay &c.*



The precipitous face of the Syhadree range will probably be found to average about one perpendicular to three horizontal, with an elevation of 1,500 to 1,800 feet at some of the Ghats above the more level country at its base. Its crest, for the most part offering a serrated line, with alternate salient and re-entering segments of curves of varying radii and cords, which we may assume to average somewhat less than semicircles of about half-a-mile radius; and occasionally diversified with spurs of considerable projection. The principle upon which these data should be dealt with in order to procure at the lowest cost a road fitted for a locomotive followed by a remunerative load, will be to conform as much as possible to the natural contour line of the hills, where the width can be obtained by a simple side cutting, intersecting, when necessary, such portions of the projecting segments, by cuttings or tunnels, and of the re-entering segments by embankments or viaducts, as shall bring the general line within the limits of well-considered radii of curvature.

I shall assume that the large proportion of one-half of every mile should consist of tunnels; this, at the rate above stated, of 17 s. 6 d. per yard forward, would make the cost of half a mile of tunnelling 682 l. Let us assume that the other half of each mile, consisting of cuttings, side cuttings, embankments and viaducts, would come to an equal amount of 770 l., we should thus have the gross amount of our road-way ready to lay down the rails at a cost of 1,540 l. per mile, which I believe would be found fully sufficient, as we must recollect that the tunnelling and side cutting would give an ample supply of building stone and ballasting. But to render security doubly sure, we shall add nearly 30 per cent., and say that the preparation of the road-way for the rails, including tunnelling, side cutting, embankments, viaducts and ballasting, may amount to 2,000 l. per mile. If we add to this for cost and laying of sleepers, rails, &c., per mile, 2,800 l., and road station-houses, &c. 200 l. per mile, we shall have our road finished along the Syhadree range, and ready for the engine and trains, at a total cost of 5,000 l. per mile.

With regard to the rate of ascent which it may be desirable to adopt, by inspecting the table of impulsive planes, we can regulate the length that the road should have, and thence the point at which to meet the precipice in order to reach the particular ghat by which we may propose to enter upon the table land. Taking the Bhore Ghat, which bears upon the Kistna Valleys, upon Poonah and the Shoolapore district, as our point of approach, and the height of this above the sloping ground at the foot of the precipice, to be about 1,500 feet, and choosing a rise of 16 feet in the mile, which answers to a continuous slope of one in 330, we should require a base of about 93 miles to overcome the ascent; a rise of 30 feet per mile, answering to a continuous incline of one in 76, would require 50 miles to overcome the ascent.

If it be determined to adopt the old principle of a continuous slope, I should prefer the long base of 93 miles, so as not to bring the gradient above one in 330. But if the principle I have suggested be adopted, that of using the alternate impulsive inclines, I should have no objection to the shorter base, because in that case we shall still be able to load the engine with the full weight that it can haul on a level.

To obtain a base of 50 miles terminating at the Bhore Ghat, would require us to commence the ascent of the precipice about 15 miles to the south-westward of the Malsej Ghat, or about midway between the Bhore and the Thul Ghats. And this would be a convenient point for a fork, of which one branch should bear southward by the Bhore for the southern sources of Kistna, and the other northward, by the Thul Ghat, for some source of the Godavery; a 50 miles base for an ascent of 1,500 feet would admit the adoption of the alternate impulsive planes, enabling us to give the engine a load due to a perfectly level road.

(signed) J. P. Kennedy,
Major.

See Sketch Map
annexed.

See App. No. IV.

Appendix, No. IV.

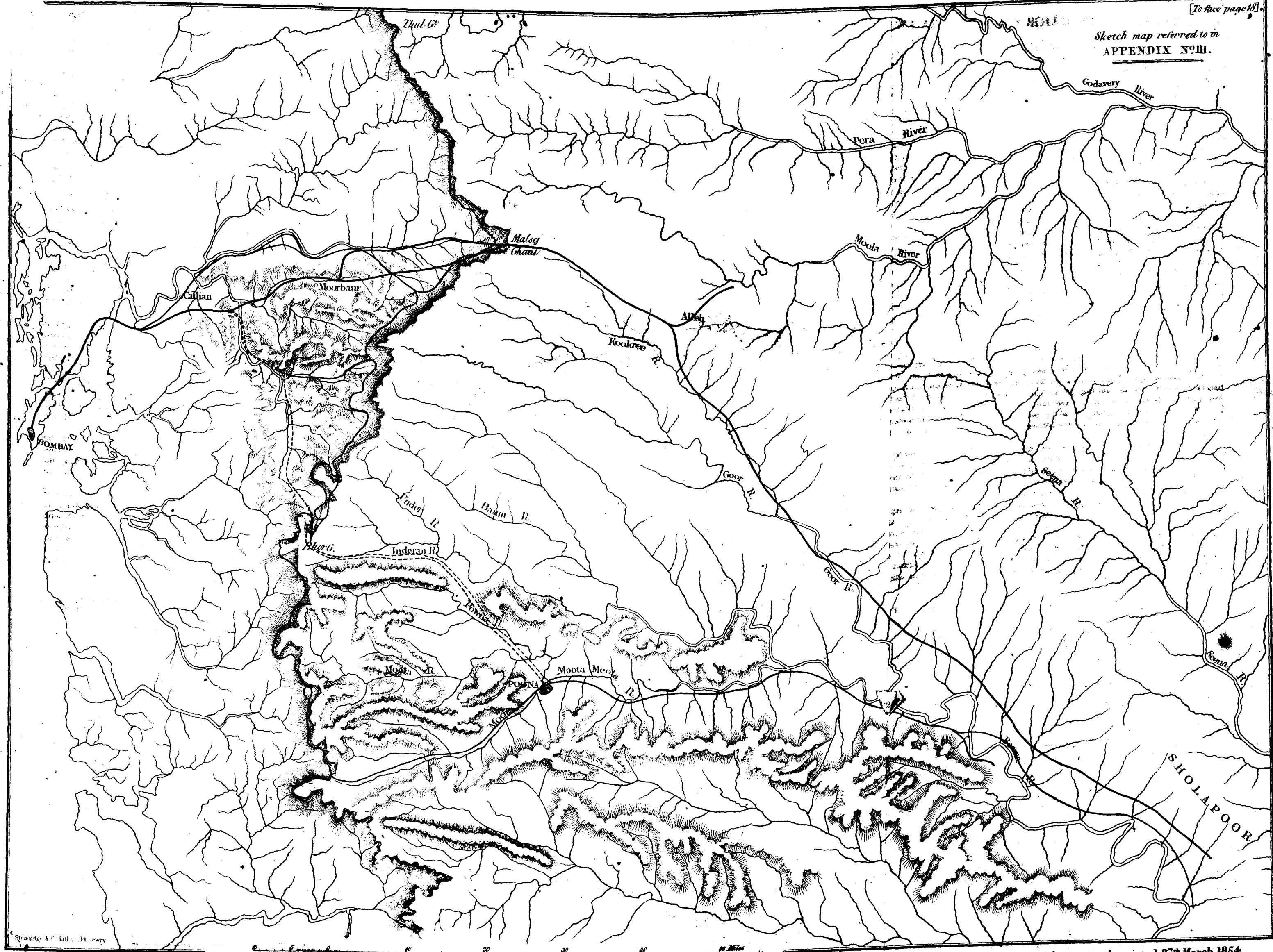
ALTERNATE IMPULSIVE PLANES.

TABLE, with Section attached, showing how Railways can be constructed, so that the Engine-power shall be economised, and applied to the Traction of effective Load, instead of absorbed unnecessarily by the gravity of Inclines. The principle consists in making all quick Inclines so short that they shall not destroy the momentum or velocity with which the Train reaches the foot of each Incline before it arrives at the top. With this view, the ascent is accomplished by means of short detached Inclines of quicker Gradient than the general rise of the Line, but not exceeding half a furlong in length, alternated with Level Planes not less than one and a half furlongs in length. Thus the Engine is enabled to overcome very considerable ascents with the Load due to a perfectly Level Road; any retardation that the Train meets with on each ascent is corrected, and the previous velocity is re-acquired on the alternate Levels.

Rise, per Mile, which may be Required on various Railroads.	Gradient or Plane which regulates the Load of the Engine, when Combined with Short Impulsive Inclines.	Alternate Impulsive Inclines, 330 Feet long each, and Four to each Mile, placed at Intervals of 990 Feet apart.		Continued Gradient Required by Usual Practice to Surmount Rise.	Tractive Power, per Ton, required To overcome Friction and Gravity on Plane which regulates Load,	
		Gradient of Short Inclines.	Obstructive Power of Gravity, per Ton, on Short Inclines, in Opposition to Engine Power.		By Using Alternate Impulsive Inclines.	By Using Method of Long-continued Inclines.
Feet per Mile.		1 In.	Lbs.	1 In.	Lbs.	Lbs.
1	Level -	1320	1-696	5280	6	6-424
2	Level -	660	3-393	2640	6	6-848
3	Level -	440	5-09	1760	6	7-27
4	Level -	330	6-787	1320	6	7-696
5	Level -	264	8-446	1056	6	8-121
6	Level -	220	10-181	881	6	8-545
7	Level -	188-57	11-878	754-28	6	8-969
8	Level -	165	13-575	660	6	9-393
9	Level -	146-66	15-273	586-63	6	9-818
10	Level -	132	16-969	528	6	10-242
11	Level -	120	18-666	480	6	10-666
12	Level -	110	20-363	440	6	11-0909
13	Level -	101-53	22-062	406-15	6	11-515
14	Level -	94-28	23-759	377-12	6	11-939
15	Level -	88	25-454	352	6	12-363
16	Level -	82-5	27-151	330	6	12-7878

I trust that the principle of Impulsive Inclines will be found as important in the correction of the regulating gradients, and the consequent increase of the engine's effective load on existing lines at home, as in the prevention of grave defects in this respect in India. It will be found peculiarly applicable on such lines as the London and Birmingham, &c., which are perilously crowded with trains that appear still inadequate to the transport required; a contingency that can only be met by increasing the present tractive power, as regards effective load, on the principle I suggest, without increased cost, or laying down additional lines of rail on which to run additional trains, at proportionally increased expenditure, both for construction and permanent working.

Sketch map referred to in
APPENDIX No. III.



APPENDIX N^o IV continued.

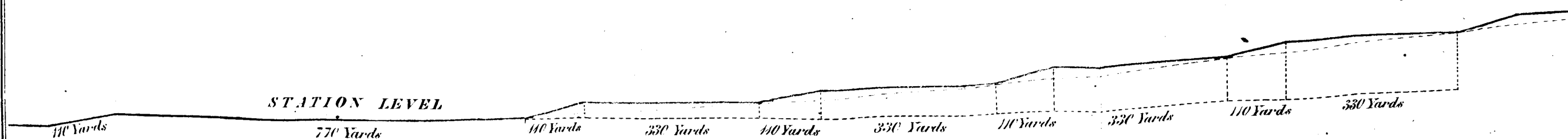
SECTION OF IMPULSIVE INCLINES.

In the Section underneath, the Red dotted line shows the usual method of rising an ascent by a continued Incline. The rise per mile in this case, is 16 feet. The gradient, 1 in 330, requiring a tractive power of 12²⁰/₁₀₀ lbs. per ton, to overcome friction and gravity for slow motion.

The Red continued line shows how the same ascent of 16 feet per mile is surmounted by the use of impulsive Inclines. The velocity of the train on arriving at the foot of each short Incline is sufficient without any aid from the Engine, to carry the train to the top, when the velocity becomes again accelerated on the level so as to carry it up the next short ascent, and so on with these alternate levels and ascents.

The tractive power required in this case to overcome friction and gravity on the regulating plane, is only 6 lbs, or less than half of that required on the continued Incline.

14 Sept. 1852 54 Torrington Square
J. H. Mansel Pleydell



Standage & Co. Litho London

EXPLANATORY NOTE and REFERENCES to the PLAN, Appendix No. V.

EXPLANATORY NOTE.

It is most surprising and most unfortunate that in their railway practice engineers appear to cast aside in a great measure the consideration that is due to the broadest rule of their professional science—that which relates to the effects of gravity on inclined planes. The case now before us exhibits a strong instance of this class of oversight. The nature of the country from Rajmahal to Calcutta would admit of a falling incline in the whole length of the line. If this result were obtained, the heaviest loads could be brought down with the smallest amount of engine power, and there would be a corresponding diminution in the consumption of fuel. But if occasional lengthy ascents are introduced in the wrong direction, and against the general fall, as proposed in the engineer's section now under consideration, the highest rate of cost for fuel must be incurred to keep the engine power at its full force on the whole journey, down as well as up; because it must be always ready to meet the occasional ascents in the wrong direction. This is a serious consideration, in addition to the still more mischievous effect of limiting the load of the engine. In the line of country now in question there can be no difficulty in avoiding this class of error. If the quantity of goods coming down exceeds much the quantity which goes up, it might be advantageous to spread over the road as much as possible the general fall, expunging every ascent in the direction of the fall, of which erroneous ascents the section contains about thirty miles. All this can be easily corrected, without much cutting or filling, by merely following a little more closely the contour line of the hills. It may be desirable to make the line on the principle of expecting equal loading both up and down. This can be effected on the admirable lines which I propose for trunk-roads, by introducing what I call the principle of alternate impulsive inclines; and the engine will thus be enabled to carry the full load in both directions which is due to a perfectly horizontal road, even although there may be considerable difference of level between the termini.—(See Appendix, No. IV.)

REFERENCES.

Like colours represent the corresponding lines in both Plan and Section.

The *broad dotted Black* lines show the direction and the levels proposed by the engineer of the East India Railway Company; from which it appears that his junction with the Colliery and Calcutta line would be 51·57 feet higher than the terminus at Rajmahal, although the latter point is more than 100 miles up the river. They show that the maximum gradient is one in 1,000, where a much better incline could be selected; and they show that he rises and falls unnecessarily 258·49, when there is the power of obtaining one uniform incline, with a difference of level of only 51·57 feet between his extreme points.

The *Red* continued lines, in Plan and Section, show how the project sent forward by the engineer could be improved in its gradients, without changing the point of junction. This, however, although a very great improvement, is not the most perfect correction that can be applied.

The *Yellow* line shows the most perfect improvement available, by the point of junction being changed to another point taken on a level with Rajmahal, and throwing the whole intervening line into one plane, which would consequently be quite level in its whole length.

The *small dotted Black* line shows what may be assumed as a horizontal contour of the hills at the surface of the ground, of which the salient and re-entering curves are cut off by yellow line, so as to reduce the curves of the railway within a desirable limit, without however any unnecessary degree of cutting or filling.

In crossing a series of rivulets and knowls, as in the present case, it is impossible without ruinous cost, and sometimes impossible, to obtain the most perfect railway in all respects on so straight a line as that proposed by the engineer's project. It must present a constant succession of easy inflexions, if perfection and economy are sought to be combined. "Laying-out" upon this principle gives some additional trouble to the engineer and his assistants, because it is easier to lay out straight lines than curves; but this additional trouble is unavoidable if we desire to keep clear of ruinous errors in our work. The question is simply whether we are to prefer a railway with vertical inflexions, which must diminish the load, or one with slight horizontal inflexions, avoiding those that are vertical. The correction which I here propose will effect a saving of 2·24 lbs. per ton of gross load in the tractive power on the whole length of this section of the work, besides a considerable saving in the cost of construction.

Torrington-square, 14 Sept. 1852.

15859

J. P. Kennedy,
Major.

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RAILWAYS (INDIA).

COPY of MEMORANDUM by Major *Kennedy*, on the
Question of a general System of RAILWAYS for
India, referred to in the MINUTE by the Governor-
General in Council of 20 April 1853, relative
to Railway Undertakings in that Country.

(*Mr. French.*)

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