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FRIDAY, FEBRUARY 23, 1877.

All communications for the Society should be addressed to the Secretary, John-street, Adelphi, London, W.C.

PROCEEDINGS OF THE SOCIETY.

PATENT LAW REFORM.

A Conference will be held on Monday, the 6th March, by the Society of Arts, for the purpose of discussing the provisions of the Patent Law Amendment Bill, now before the House of Commons. The subject will be introduced in a short paper by Mr. H. Trueman Wood, the Assistant-Secretary of the Society, and Resolutions will be proposed to the meeting for adoption.

INDIAN SECTION.

Friday, February 16th, 1877; the Right Hon. the Earl of NORTHBROOK, G.C.S.I., in the chair.

The Chairman said—The subject of Indian railways is not only one of great consequence to the administration of India, alike in its commercial, political, and military aspects, but it is also one of great interest to the people of this country, because 90 millions of English money have been invested in these railways. Mr. Juland Danvers, twenty years ago, succeeded a man of great ability, Sir James Cosmo Melvill, as the Government Director of Indian Railways. That office is one which requires considerable knowledge of business and great tact, and I can say, from what I know and what I have heard, that Mr. Danvers has performed his duties to the entire satisfaction both of the Government and of the companies. Some eighteen months ago he most properly thought it would add to his usefulness if he made a personal inspection of the railways. He, therefore, went out to India, and traversed and examined, in conjunction with Mr. Rendel, all or nearly all the railways which were either constructed or under construction. Therefore I think there is no man who, from his acquaintance with the subject, and from his personal knowledge, is more capable of giving information upon the subject of Indian railways than Mr. Danvers.

The paper read was :—

INDIAN RAILWAYS.

By Juland Danvers, India Office.

In addressing the members of the Society of Arts, it is needless to dwell upon the importance of applying to every country that most necessary of all practical arts, the formation of communications. It may be laid down as an axiom that the nation which has been best provided with the most suitable means of conveyance, within and without its territory, has made the greatest advance in civilisation and prosperity. There are two ways by which communications may be carried on, viz., by land and by water. In many places, and for many purposes, rivers and canals afford the readiest and cheapest mode of internal transit; but the former are only available, and then only when navigable, for places situated on or near their banks; the latter can only be constructed when the water is at hand to fill them, and where the gradients of the country favour its flow. The great advantage of land communication is that it can be formed wherever it is wanted; that it can unite towns and military posts by the *shortest* routes; that it ensures speed and punctuality, and that it is more free from interruptions.

There should, however, be no rivalry between land and water, between canals and railways, in India. On the contrary, there should be close alliance and well-arranged co-operation. The one will fertilise the land, the other will convey the produce where the river or canal cannot take it. Many important towns and many districts, rich in mineral and agricultural produce, would be cut off from each other, and from their nearest port, if they depended upon water. Even where rivers exist it has been found necessary to construct railways. In England no new canals have been cut since railways were introduced, and some canals have been converted into railways. The establishment of flotillas of steamers on the navigable parts of the Thames, Rhine, Seine, and other rivers, did not prevent the necessity for constructing railways along their banks. In India we have the example of the Indus. For some time it was attempted to carry on the traffic between the port of Kurrachee in Scinde, and Lahore in the Punjab, by the joint instrumentality of the two railways in those provinces, and the flotilla on the river between Kotree and Moultan, but the navigation was difficult, slow, and perilous, and the service was inadequately performed. It has, therefore, been superseded by a railway.

The object of these prefatory remarks is simply to point out that India would have been deprived of an important and necessary aid to advancement if she had not been supplied with railways. I do not for a moment wish to imply that canals are not equally important and necessary in their proper place. I would only say that by the judicious combination of the two the future resources of the country would be found incalculable. An enormous amount of virgin soil might be brought into cultivation; the failures of crops would not be of such common occurrence as they are now, and, if scarcity were to prevail in any districts, the products of more favoured parts of the country could be conveyed to them. Famines, in fact, would not be known, and the general wealth, prosperity, and comfort of the people would be promoted. We have already had instances where canals and railways have gone hand in hand to avert suffering and famine. The scarcity which followed the drought in the North-West Provinces, in 1860, and in Bengal in 1874, would certainly have been accompanied by famine if it had not been for the joint action of canals and railways.

Before describing the railways of India and their effects, it may be useful to take a glance at the country anterior to their establishment. Any history of the material progress of India may well be divided into a pre-railway and a post-railway period. Since their introduction India has made great strides, partly through their instrumentality and partly through contemporaneous causes. For some time after British supremacy had been acknowledged, little was done in the shape of forming good and reliable communications. Fifty years ago the highway from Calcutta to the North-West Provinces was the river. The interesting journals of Bishop Heber and other travellers of those days describe the time occupied and the dangers and difficulties encountered on the journey. Any attempt to go from Southern India to Delhi or Lahore by land was not thought of. It would have occupied an ordinary traveller months, nay more than a year, for he could only move with comfort and safety to health in the cool season. Now it could be accomplished with ease in a week. The physical features of the country offered difficulties which were insurmountable by the ordinary traveller. Within the period I have mentioned—viz., in 1830—Sir John Malcolm, then Governor of Bombay, was opening for the first time a cart road which had been made up the Bhore Ghât, and spoke of it as a work which was "to break down the wall between the Concan and the Deccan." It was regarded as a magnificent engineering feat. What would have been thought by those who rejoiced on this occasion of the railway which, within the period of a generation after, was taken over the same barrier and opened by Malcolm's worthy successor, Sir Bartle Frere, amidst a similar flourish of trumpets? There were obvious reasons why we were backward in prosecuting public works in India. Wars, internal commotions, our political relations with native states, the settlement of newly-acquired territory, occupied and engrossed the attention of the Government and its officers. The want of money also, and the absence of suitable materials for road making, especially in the Bengal Presidency, were serious impediments. It must, moreover, be admitted that there was wanting that recognition and due appreciation of the importance and value of well-chosen public works which characterises our administrators of the present day. It was not unnatural, therefore, nor without some cause, that, in answer to observations which were made on the scarcity of communications, the authorities dwelt upon the fact that, for a third of the year, the whole country might be regarded as a road, that they made the most of the few hundred miles of pucka road which existed, and argued that for the general use of the country fair weather tracks only were required.

As the political atmosphere became clearer and quieter, a stronger sense of the necessity for extended communication was entertained, and a systematic commencement was made with roads and with works of irrigation. Just as railways were on the eve of being introduced, several well-constructed highways had been established, and canals had been cut. In 1850 about 3,200 miles of metalled trunk roads, and 1,800 miles of canal, were in existence. This, of course, was a mere scintilla of what was required, and was by no means commensurate with the social and commercial wants of the community.

Up to this time the question of introducing railways into India had only formed the subject of discussion and controversy. Railways, after all, are nothing more than the best known means of carrying on communication by land. But what with prejudice, timidity, and a dread of spending money beyond the usual limits of military and naval establishments, civil administration and jails, there was considerable difficulty in persuading some even to believe that railways were good for India. The first serious proposal to introduce them was, curiously enough, treated almost with derision by some of those who were, or who were thought to be, the best judges of the country and people. "The railways," said they, "might possibly be made; but the natives will not use them." Then came the bugbear of physical obstructions, and after that the money difficulty. All this may appear to us frivolous and weak, but the irresistable force of facts and examples, used by men of energy and perseverance like Macdonald Stephenson, John Chapman, W. P. Andrew, and others, as well as by some in the service of Government who were fully alive to the importance of the work, were required to bring the matter to a point.

When at last it was decided that railways should be made in India, it is not to be wondered, after all that had occurred, that the first step was a cautious and tentative one. It was a question whether the lines decided upon should be taken in hand by the State itself or by joint-stock companies. The latter agency involved the necessity for State assistance and control, and all the inconveniences and complications of a double system. It, nevertheless, had its advantages. The chief reasons for preferring it were that Government was doubtful of its own power to undertake works of this character; that objections were entertained in those days to the raising by the East India Company of money for such purposes in England; that it was desirable to introduce into India private enterprise in some shape, even although its spirit might be damped by the guarantee of a certain return on the capital embarked; and that a permanent body like a London company could be better depended on for the appropriation of funds specially raised for a railway than the Government itself. The Board of Control were very strongly in favour of employing companies; the Court of Directors were not so. But it was plain that more delay would occur if some agreement was not come to, and all were now anxious to see a commencement made. It was accordingly settled, after a prolonged negociation with the East Indian Railway Company and the Great Indian Peninsula Railway Company, that an experimental line of about 100 miles in Bengal should be committed to the former, and of 50 miles in Bombay to the latter. Interest at the rate of 5 per cent. per annum was guaranteed on £1,000,000 for the line from Calcutta, and on £500,000 for that starting from Bombay. A complete Government control over the proceedings of the companies was provided, and such provisions made for giving a share of profits to the shareholders in the event of successful management, as, it was hoped, would counteract the enervating effects of an

assured minimum rate of interest. I do not propose to discuss at any length the merits or demerits of this arrangement. I know that the policy which dictated it has been objected to; that the guarantee system is regarded by some with aversion, and that it has been condemned. I rejoice that the necessity no longer exists for resorting to it, but, with all its objections, it was on the whole the most practicable one at the time. The delays and failures which had occurred in operations undertaken by the Public Works Department, the habits which had been acquired of commencing works and making no provision for completing them, the reversal by one superintendent or commissioner of a district of the policy of his predecessor, all concurred to show that the organisation of the department was not such as qualified it to take in hand the railways of the country. The financial difficulty was greater still. The only sure way of raising money as it was wanted, and of securing its application to the object in view, was through the instrumentality of companies. This alone was an immeasurable advantage, and has been acknowledged as such by many who are most opposed to the system. I have only further to say that Lord Dalhousie, who, besides his powers of administration, was not a man to do anything without good reasons and without much reflection and deliberation, recommended the employment of guaranteed companies for carrying out the scheme of main lines over the country which he submitted, and which I believe would not have been brought to its present state of completion under any other plan. After Lord Dalhousie's recommendations arrived in Leadenhall-street, much remained to be done. I happened to be behind the scenes, and witnessed the difficulties as they cropped up one after another, and it was fortunate for India that there were men at hand like Lord Broughton and Sir Charles Wood,* Sir James Melvill, Sir James Hogg, and Mr. James Wilson, who, with willingness to drop minor points of difference, had the practical sagacity to arrive at conclusions by which the object they all had at heart should be accomplished.

The trunk railways proposed by Lord Dalhousie were selected with the view of securing the greatest political and commercial advantages. Commencing in the south at the port of Beypoor, on the western coast, a line stretches across to Madras, with branches to the foot of the Neilgherries and to Bangalore. A line proceeds thence in a north-westerly direction to Bombay, and from that city crosses the central provinces of India viâ Jabbalpur to Allahabad, throwing out a branch to Nagpur. At Allahabad it meets the great line which extends from Calcutta to the north-west frontier, *viâ* Agra, Delhi, and Lahore. A line was also laid out commencing from Bombay and going north, its ultimate terminus being Delhi. This latter line has only proceeded at present so far as Ahmedabad in a northerly direction, but a metre gauge State line has been brought down to Ajmere from Agra and Delhi, the important gap between Ajmere and Ahmedabad being in the category of those which have been sanctioned, and will be commenced when money is forthcoming. Lord Dalhousie described this line as of the "greatest political and commercial value" more than twenty years ago. It certainly has not diminished in value since that time, and in addition to the objects just mentioned, the prevention of a repetition of famine in the districts through which it will pass may well be borne in mind. Famines have cost, and one at this moment is unhappily costing, the country millions. Money disbursed on these occasions is necessarily spent hurriedly, lavishly, and perhaps wastefully, whereas, if applied to canals, irrigation works, and railways, well chosen and economically constructed, it would afford better means of relief when scarcity occurred, and would produce revenue to the State out of the increased traffic receipts. As an illustration of this, I have only to refer to the traffic on the East Indian Railway for the years preceding and following the scarcity of 1874. The total amount received in 1873 and 1875 together, from the class embracing grain, was £1,331,400. In 1874 it was £1,385,000, or more than double the average of the other two years. The amount of grain moved to the famine-stricken districts, was 800,000 tons.

The gauge fixed upon for the original trunk lines was five feet six inches. It is easy to be wise after the event and to be critical when experience has been gained. It does not, therefore, show any particular sagacity to say of Lord Dalhousie's grand scheme that, in some cases, the alignment might have been more suitable, and that it would have been better if the gauge of English lines, as was proposed by the Court of Directors, had been adopted. Lord Dalhousie himself would probably have said the same if he were now alive. At that time the Court of Directors were thought to be rather behind the age in proposing so old fashioned a gauge as the four feet eight inch; and in India the question was, not whether five feet six inches was wide enough, but whether six feet would not be better. The five feet six inches was, in fact, a compromise.

A decided and determined commencement was thus made in the work of constructing a comprehensive scheme of railways, which should provide India with main lines of communication, and form a basis for future ramifications. With the exception of the larger rivers and the Western Ghâts, the natural features of the country did not present very serious difficulties. The course of the lines was chiefly across extensive plains and through valleys. The obstacles just referred to were, however, of no ordinary character. I have already alluded to the lines which were taken over the mountain barrier separating Bombay from the Deccan, the first running parallel with, although at an average of some fifty miles from, the coast for many miles. The works on these ascents are magnificent monuments of engineering skill and perseverance. The crossing by the Thull Ghât on the North-Eastern line of the Great Indian Peninsula Railway is 1,912 ft. above the level of the sea; that by the Bhore Ghât, on the South-Eastern line, is at an elevation of 2,037 ft. The Thull Ghât incline is nine miles in length; the steepest gradient is 1 in 37, for upwards of four miles; the sharpest curve is 15 chains radius, for 20 chains 50 links; the length of tunnelling is 1,962 yards. The Bhore Ghât incline is fourteen miles in length; its average gradient, 1 in 48; its

* Now Lord Halifax.

steepest gradient is 1 in 37 for 1 mile 38 chains, and 1 in 40 for 8 miles 6 chains; its sharpest curves, one of 15 and two of 20 chains radius; its length of tunnelling, 1 mile 44 chains. The cost has been at the rate of from £50,000 to £60,000 a mile. These were formidable and expensive works; but the rivers of India are what have puzzled and thwarted the engineer, and upset his calculations, more than anything else. Bridges have been broken down and swept away by the floods, and their foundations, even when laid sixty feet below the bed of the river, have been undermined by the water. We have very little idea, in this country, of such tremendous forces, and they were scarcely expected in India; at any rate, they were not understood. The shifting character of these streams has also been a source of expense and trouble. While the bridge over the Sutlej was being constructed, the river, which had been flowing for eighty years along the north side of the valley, changed its course to the south, and the length of the bridge had to be increased in consequence from 4,000 ft. to 6,200 ft. At Goalundo, also, the terminus of the Eastern Bengal Railway, notwithstanding that £100,000 had been expended on protective works, the ground on which the station buildings stood disappeared in the course of a week, and was carried down by the two great rivers which here meet, to be added to the deposits at their delta. The bridges which carry the East Indian Railway over the Jumna, at Allahabad and Delhi, and over the Soane, are magnificent structures, and have remained firm and safe since they were put up. A list of the principal bridges and their dimensions is given in a table appended to this paper. They are constructed generally of iron girders placed on well foundations made of stone, brick, or iron cylinders. The railroads are constructed generally with a single line only. Out of a length of 6,760 miles now open, about 800 miles only are double. The original gauge was, as I have already stated, five feet six inches. A narrower gauge of the width of a metre has since been introduced, and many of the State lines, as well as the South Indian Railway Company's system, are made on the smaller scale. I will only venture to say one word on this very controversial point. The object of adopting the narrower gauge was to ensure economy, and to enable India to be supplied with an extended system of railways at the cheapest possible rate, it being a question in some cases whether there should be light narrower gauge lines or none at all. I may be allowed to add in passing, that the narrow gauge lines over which I travelled in India, were as steady and smooth as the others, and there need be no apprehension as to their not being easy and comfortable if properly worked. The rails vary in weight from 84 lbs. to 40 lbs. to the yard. Latterly, in consequence of the cheapness of steel, many rails have been sent out of that material. Iron is used for sleepers where the soil is suitable for packing. Incredible as it may seem, India failed to supply wood for its own sleepers, and it has been found necessary and more economical to send out Baltic wood creosoted than to use that grown in the country. The materials sent from this country to India for the railways include all the iron and machinery, as well as stores of every description. Even grease for lubricating purposes has been sent out; but country oil is now universally used. The weight of these materials had reached to about 5,250,000 tons, and their value amounted to £35,000,000, up to the end of last year. All this had been sent out since 1850. In the early stage of operations, one great difficulty was the inland transport of this mass of dead weight, and a large outlay was incurred in the process. The ease with which this is now performed is an enormous aid to the progress of future lines.

The first railway in India was opened in April, 1853, the last by H.R.H. the Prince of Wales, the President of this Society, in December, 1875, when at Madura, in Southern India. The line first opened started from Bombay, and went to Tannah, a distance of 22 miles. The next year it was extended a length of 13 miles to Callian, near which place the line bifurcates, and proceeds over the two ghâts in south-east and north-east directions. In the same year, the first thirty-seven miles of the East Indian Railway, extending from Calcutta to Raneegunj, were opened. In 1855, a length of 171 miles had been completed, 120½ in Bengal, and 50½ in Bombay. The next year Madras contributed 65 miles. Five years afterwards (in 1860) 836 were open, including 368 of the East Indian, 297 of the Great Indian Peninsula, 35 of the Bombay and Baroda, and 136 of the Madras. In 1861, the Scinde line from Kurrachee to Kotree (105 miles) was opened, as well as 49 miles of the South Indian, and in the following year 110 miles of the Eastern Bengal, and 15 of the line from Calcutta towards the Mutlah were finished. In 1862, the first narrow gauge and lightly constructed line was opened, joining Moorshedabad with the East Indian Railway at Nalhati. By this time, the East Indian Railway Company had completed upwards of 830 miles, the Great Indian Peninsula 495, the Madras 447, and the Bombay and Baroda 185, making altogether 2,352 miles. Progress for the next five years proceeded at the rate of about 200 miles a year, and, in 1865, 3,368 miles were open for traffic. Many of the lines were still disjointed, and through communication between the principal cities and the seats of the various Governments had yet to be completed. The year just mentioned was, however, memorable for the completion of the splendid bridge over the Jumna, at Allahabad, and through it of a continuous line of 1,020 miles from Calcutta to the left bank of the Jumna at Delhi. In the following year that city was connected with the railway by the bridge across the river. In the year 1870, the completion of the last section of the North-Eastern line of the Great Indian Railway enabled the whole line between Bombay and Calcutta to be opened for traffic. The distance by the route then established was 1,470 miles. This was reduced to 1,400 in the following year, when the Chord line of the East Indian Railway was finished. In 1871, the line across the southern part of the peninsula joining Bombay with Madras was completed. The opening of the last section on the Punjab and Delhi line also established uninterrupted railway communication between Calcutta and Lahore and Moultan, and thus was the system of trunk lines laid down by Lord Dalhousie carried to completion. Upwards of 5,000 miles of railway were at this time open in

India. In the five years which have followed, that length has been increased to 6,760, principally by the system of lines in the provinces of Oude and Rohilkund, 542 miles, on the standard gauge; the lines from Delhi and Agra going south through Rajpootana by Ajmere, which have been constructed on the metre gauge, and are worked by the State; and by 520 miles belonging to the South Indian Railway Company, whose system, also constructed on the metre gauge, will extend from Madras to Tuticorin, and include the line formerly called the Great Southern of India Railway, going from Errode, on the Madras Railway, *vid* Trichinopoly, to Negapatam.

Subjoined is a list of all the railways, small and great. [A sketch map on the wall exhibited their course.]

	Gauge.	Length of Line sanctioned.	Total length opened.	Portion laid with Double Line.	Length remaining to be finished.	Capital Cost.
	ft. in					£.
GUARANTEED.						
East India:—						
Main line	5 6	1,280	1,280	414¾	...	27,200,000
Jubbulpur'n		223¾	22·¾	...	...	3,300,000
Great Indian Peninsula	5 6	1,278¾	1,278¾	327	...	23,500,000
Madras	5 6	856½	856½	...	...	10,250,000
Bombay, Baroda and Central India	5 6	408	408	21½	...	7,750,000
Scinde, Punjab, and Delhi	5 6	663¾	663¾	4½	...	11,000,000
South Indian	3 3⅜	617½	527½	...	90	3,700,000
Eastern Bengal	5 6	159¾	157½	...	...	3,000,000
Oudh and Rohilkund	5 6	711	542¾	...	168¼	5,500,000
STATE.						
Nalhati	4 0	27½	27½	...	...	30,000
Calcutta and South-Eastern	5 6	28	28	...	...	690,000
Northern Bengal	3 3⅜	358½	...	...	358½	Unfinished
Punjab Northern	5 6	267½	62	...	267½	
Indus Valley	5 6	508	..	...	508	
Rajputana (Agra and Delhi to Nasirabad)	3 3⅜	402	402	...	...	2,500,000
Neemuch (Indore to Neemuch)	3 3⅜	302½	...	...	302½	Unfinished
Indore to Khandwa (Holkar's)	3 3⅜	85½	57	...	28½	
Patri branch of Bombay, Baroda, and Central India Railway	5 6	22½	22½	...	...	
Wurdha Valley	5 6	76	18	...	58	
Tirhut	3 3⅜	93	44	...	49	Unfinished
Rangoon and Irrawaddy Valley	3 3⅜	371	...	...	371	
Sindia (Agra to Gwalior)	5 6	72	...	...	72	
West Rajputana	3 3⅜	314¾	...	...	314¾	
Nagpur and Chattisgarh	3 3⅜	123½	...	...	123½	
BERAR.						
Khamgaon	5 6	7½	7½	...	...	48,600
Amraoti	5 6	5½	7½	...	...	30,600
NIZAM'S GOVERNMENT.						
Wadi to Hyderabad and Secunderabad	5 6	121	121	...	...	1,150,000
PROVINCIAL.						
Muttra and Hathras	3 3⅜	30	30	...	...	93,000
Total	...	9,415¾	6,764	768	2,651	

It is well known that, under the contracts with the companies, the Government have the power to purchase the undertakings on certain specified terms, the amount to be paid being regulated by the average price of the stock during three preceding years, and the sum so arrived at being payable at the option of the Government in a lump sum or in the shape of an annuity. The following are the dates at which the different railways come under the operation of this provision:—

The East Indian main line	15th February, 1879.
" " Jabbalpur line	21st April, 1883.
Great Indian Peninsula	17th August, 1899.
Madras	1st April, 1907.
Bombay, Baroda, and Central India	1st May, 1905.
Scinde, Punjab, and Delhi	1st January, 1885.
Eastern Bengal	30th July, 1883.
South Indian	1st March, 1890.
Oudh and Rohilkund	2nd August, 1887

It will be easily understood that all the great undertakings have not been carried out without much human exertion, both of mind and body, and without a large expenditure of money. The professional work done by the engineer, both civil and military, has not been light. He not only had to overcome the natural physical difficulties of the country, to which allusion has already been made, but he had to submit to a hostile climate and to the pestiferous vapours of the jungle. The labour at his command was inferior to what he had been accustomed, and at first difficult to manage. Separated sometimes hundreds of miles from head-quarters, and frequently 30 or 40 miles from the nearest European habitation, he had to depend on his own resources in a great measure and to make the best of poor materials. The wayside graves bear evidence to the loss of many a valuable life. The Mutiny overtook many more while helplessly engaged in the execution of their work, and on a single tablet in the Memorial Church at Cawnpore I counted the names of 19 engineers who had fallen by the hands of the mutineers. I could not help thinking that these men died as nobly as if they had fallen in the field of battle. Some indeed did good service. It will not soon be forgotten how, at the famous defence of Arrah, Boyle and others connected with the staff of the East Indian Railway, in company with Wake and his companions, succeeded in keeping the enemy at bay until relieved by Sir Vincent Eyre.

Besides the well-known names of Berkly, Bruce, Brereton, Brunton, Campbell, Graham, Harrison, LeMessurier, Bradford-Leslie, Logan, Manning, Mathew, Prestage, Purdon, Purcell, Rendel, Sibley, Turnbull, Hardy Wells, and Barton-Wright, who were in the service of the companies, the distinguished corps of Royal Indian Engineers contributed some of its most able men to the work. There were Baker, Beadle, Chesney, Crawford, De Bourbel, Dickens, Drummond, Greathead, Hancock, Johnson, Luard, Kennedy, Pears, Peile, Pollard, Killow-Pye, Rivers, Stanton, Shaw-Stewart, Strachey, Taylor, Trevor, Yule, and White, all of whom have been some time or other engaged in railway work or administration. It may be safely said that India will never cease to feel the effects of their labours.

We now come to the cost, the capital cost of these 6,760 miles of railway, with their 700 stations, 1,400 locomotives, and 30,000 vehicles of all

kinds. It will be convenient, first of all, to define what the capital is which I propose to take as representing expenditure on this head. I do not include in it the guaranteed interest which has yet been unpaid by the companies; nor the loss incurred by Government by the fixed rate of exchange; nor the price of the land; although I must admit that the two latter have formed a real part of the cost borne by the State. The loss by exchange has been a contribution by the Government, and has amounted altogether, after making deductions for gains, to something like £2,000,000. It came to pass in this way. When the contracts were entered into, the rate of exchange for the rupee was 1s. 10d., and it was stipulated that for every 1s. 10d. received by the Government in England they should advance to the companies a rupee in India. The value of the rupee gradually rose, however, as the railways advanced, and at length the Government found themselves giving a rupee, which was equal to 2s., for the 1s. 10d. they received. Some consolation for this sacrifice was then felt in the expectation that the turn of the Government would come when the railway receipts were paid into their treasuries, for then would the Government, in the same way, receive rupees worth 2s. in India and credit the companies with 1s. 10d. in England; but the Government were doomed to be unfortunate. No sooner did the railways begin to earn respectable revenues than the exchange again fell, not only to 1s. 10d., but far below that rate, incurring further loss by the very operation through which the Government expected gain. The Government have, however, gained to the extent of about £500,000, through the higher rates of 1s. 11d. and 2s. having been fixed upon with some companies. Whether their losses in the end will be wholly recovered it is impossible to say, and it would certainly be unsafe to predict.

The value of the land is, of course, an essential part of the first cost of the railway, and ordinarily would be a capital charge. It is not, however, included in the capital accounts of the companies, as one of the conditions of the contracts is that the land is granted free. The exclusion of the sums representing these items will not, perhaps, be considered as giving so very unfair an advantage to the railways as would appear to be the case, if it is borne in mind, when making up the accounts, that the companies are not credited with what might have been earned from mails and troops, had not the former been carried free, and the latter at reduced charges, for the Government.

The unrepaid guaranteed interest should not, I think, be regarded as capital. True, it is not interest earned, and it is a gift, *pro re ratâ*, to the shareholder; but the capital of a railway, or any work, is, I take it, the actual amount which, on its completion, has been expended on it. If railways had been made by Government with borrowed money, their capital accounts would not have been charged with the interest accruing on the loans which fell short of the receipts. And if a man builds a house, and finds that the rent gives him two instead of five per cent., he does not year by year look upon his house as having cost the amount of the difference in addition to the original outlay. I propose, therefore, to take as the capital cost of the railways only what I find entered as such in the accounts.

These show that the guaranteed lines now open have cost in round numbers £94,000,000, and the State lines about £12,000,000. This gives an average of about £15,600 a mile. But some have cost much less than others. The cheapest line hitherto has been the Rajpootana, a metre gauge line, which has cost so far about £6,000 a mile; the most expensive, the Bombay and Baroda, which will be upwards of £20,000, although portions of this line have recently been constructed at the lowest figure yet reached, viz., £1,000. The outlay on the East Indian has been about £20,000; on the Great Indian Peninsula, £17,800; and on the Madras, £12,000 per mile. The Oude and Rohilkund will have cost about £11,000 per mile, and the Sinde, Punjab, and Delhi, £16,000. The South Indian, also a metre gauge line, when finished, will probably have cost about £6,500. The expenditure on the trunk lines has been much larger than was expected. Some of it could not have been foreseen; some could not have been prevented by any skill or forethought; some may be ascribed to imperfect calculations; and some to mistakes and mismanagement. A general spirit of recklessness and extravagance has been laid at the door of the guarantee system, because a certain dividend was assured to the companies; but opinions differ on this point. A more efficient system of co-operation and control might, I think, have been established by the Government and the companies from the first, whereby costly mistakes might have been avoided and delay prevented; but they were not errors consequent on the payments of interest to shareholders, and it is only necessary to point to the experience of railways in the rest of the world, whether England, the Continent, or America (with the cost of which those of India will not compare unfavourably) to show that the absence of the guarantee did not encourage or enable shareholders to prevent waste, extravagance, and even ruin.

Amongst the sources of expense not foreseen may be included the Sonthal rebellion in 1855, and the Mutiny in 1858, both of which events produced destructive effects upon the works of the East Indian Railway, besides costly delays and alterations. The actual amount of loss incurred by these calamities has not been positively ascertained, but it has been estimated at between three and four millions sterling.

Then the difficulty of transporting materials from the ports to the interior was much greater than was expected. So great was the necessity felt for pushing on the works, that the lines were not constructed "telescopically" (by which means the rails themselves as laid down become available for the conveyance of materials), but were commenced at various places at the same time. The ordinary carrying service of the country, both by road and river, broke down, and it was thought worth while for the East Indian Railway Company alone to provide steamers, at a cost of half a million, for taking their stores up country on their arrival at Calcutta. The river crossings were also a source of unexpected expense. They were, as I have before observed, sometimes beyond the grasp of the engineer, who had miscalculated or been misinformed on the volume and force of the floods

in the monsoon, and the repairs and additional works which became necessary greatly added to their original cost. Mistakes, and worse than mistakes, have also been made in the mode of executing portions of the lines, which have failed from sheer mis-construction.

It would, of course, have been much more satisfactory if railways had cost less. We can only now make the most of the experience which we have gained, and take care that in future past errors will be avoided, and suitable lines constructed at a much smaller outlay.

Before leaving the subject of capital, I should mention that the whole of the guaranteed stock has practically been raised in England. Scarcely 1 per cent. is held in India, and not half that by natives. It consists of £85,000,000 share capital, of which £82,225,000 receive 5 per cent.; £1,275,000, 4¾ per cent.; £500,000, 4½ per cent. This is held by 56,400 shareholders, of whom 800 are in India, 390 of these being natives. In addition to this, £4,766,300 has been raised by debentures, with rates of interest varying from 4½ to 4 per cent.; £5,786,300 by debenture stock at 4 and 4½ per cent. There is also a sum of £562,000 not bearing interest, consisting of premiums on stock, &c. The capital for the State lines has been raised by Government loans, principally in India, at from 4 to 4½ per cent.

One gratifying feature in the present position of railway finance is that more money is being obtained in India for the purpose of extending railway communication. Some native States have come forward, and undertaken, with the assistance and under the guarantee of the Government, to provide the necessary capital. This has been done by the Nizam, Holkar, Scindia, and the Guicowar. Provincial revenues are being also devoted to meet local wants, and natives interested in the agriculture and commerce of their neighbourhood have come forward with their subscriptions. A line constructed under an arrangement of this kind was laid down between Hathras, a station on the East Indian Railway, and Muttra, on the River Jumna. It is about thirty miles in length, and cost about nine lacs, six of which were provided from provincial funds and three from local subscribers. And another case has just occurred, where the whole of the sum required for a railway, twelve miles in length, between Deldanagur, a station on the East Indian Railway, and Ghazeepore has been subscribed by natives in the neighbourhood.

We have now to consider the various effects which railways have produced upon the country. These may be regarded in their social and political, as well as in their commercial and financial, aspects.

The first effect which railways had upon the lower strata of society in India was to improve the wages of the labourer, and to open his eyes to the fact that he possessed a property, the value of which was regulated by natural laws, and not, as was often the case before, by the will and caprice of his employer. The railways will also improve the condition of the people by enabling them to be supplied with cheaper food and raiment, and by helping to educate them. As they go to and fro, they will see and learn much that they never thought of before. There will also be more intercourse and friction. The power of caste has also been shaken. Rather than pay more for his fare, a high caste Hindoo travels in the same carriage with a fellow creature whose presence in the same room would be considered pollution. At first natives hesitated to travel for fear of the mysterious motive force which he could not understand. His dread has been converted into admiration. The pilgrim was doubtful of the propriety of travelling by railway, but an authoritative opinion being obtained from the great Sanhedrim of Hindoos that railways might be used by devotees without impairing the efficacy of their pilgrimage, hundreds of thousands use them annually. As "trifles make the sum of human things" it may be worth while to mention that, in the early days of railways, the lower classes attempted the game, to which they are very partial, of bargaining, and tried to beat down the prices of their tickets at the booking office; I need not say that they soon learnt to discontinue this practice. The higher classes have also been taught a lesson. A petty rajah, at first, would come up to a station breathing out "threatenings and slaughter" upon the station master for allowing a train to go before his arrival. Now he finds that even a rajah in his own territory must submit to the "imperative call" of the railway bell. Thus in many indirect ways are railways producing a salutary effect upon the social condition and habits of the population at large, and aiding the approach of that social improvement and regeneration which we all hope to see. Direct advantage may be better measured by the numbers who actually use the railway. It is quite clear that the natives are not deficient in that desire to move about which is attributed to the whole human family, and that the number travelling will be in proportion to the facilities given. Fifteen years ago the passengers numbered about 12½ millions; ten years ago they amounted to 18¼ millions, and in 1875 they rose to 26¾ millions in the year. When it is stated that the population of the lower class passengers is generally about 97 per cent., the second class being about 2·25, and the first less than one per cent., it will be seen that it is the mass of the people who travel. The fares must be low to attract them. On some lines the lowest class is about a farthing a mile, so that a passenger may travel nearly 50 miles for a shilling. Nor in enumerating the social effects of railways should the advantages which they bring to Europeans be omitted. They contribute enormously to their health and comfort, and are the means of saving the life of many a sufferer and invalid, who is now conveyed easily and rapidly to a port, over distances which before involved weeks of distressing fatigue and exposure.

Regarded from a political point of view, the value of railways in India can hardly be exaggerated. It is scarcely necessary to point out that whatever, in a country of such extent, unites the various seats of Government; whatever enables the military force to be moved with ease and expedition, must be a source of strength to the Government and a means of preserving peace and security to the country. Railways do this at a large saving of money besides, and bring home, moreover, to the native observer, whether within or without our territory, the wonderful energy, power, and resources of the governing race.

Nothing, perhaps, shows the effect of our rule upon India more than the railways. It is visible, tangible, and felt by all. Liberty, security, justice, irrigation might, in some modified forms or other, have been attained without us, but if the superfluous capital of England had not been available for her railways, India would have been as China is now, with nothing but a toy line.

On their importance as engines of commerce I need not enlarge. They have already become the chief instruments for carrying on internal trade, and have greatly contributed to its development. They have also been the means of increasing external commerce. New markets have been opened to places previously shut out from commercial communication with the rest of the world. Commodities have been supplied from sources before unknown to dealers in them. Energy has been aroused, and the desire to exchange and barter goods has been increased. The native trader is quick and calculating. I was surprised to find, in remote parts of India, how familiar he was with the prices which prevailed in distant markets. He does not fail to take into account every anna which he has to pay for the transport of commodities, but he attaches a value to greater certainty and celerity of despatch than he has been accustomed to, as well as to the absence of waste in transit. We met with an interesting example of the union of ingenuity and submissiveness in the native character, when travelling last year in the Punjab. At a station between Lahore and Moultan, heaps of wool were waiting to be taken on, but were delayed in consequence of the inability of the flotilla to convey them down the river Indus. The poor consignors, who had remained day after day with their merchandise, were in a great state of perplexity and excitement, and were at first ready to demolish the traffic manager. They not only wished to avoid disappointing their correspondents at Kurrachee, but feared lest rain should come and spoil their goods. The traffic manager, unfortunately, could not help them, but promised to do his best, and with considerable tact, checked their complaints, and pacified them by reminding them that it was the will of Providence that the vessels could not convey more goods than they could contain, and that if the rain did come they must remember who sent it.

The amount of goods carried by the railways is in a great measure dependent on trade, and is affected by the same influences, being increased or diminished by good and bad seasons, confidence and distrust, peace and war, high and low prices, and so forth. The following figures show the increase of traffic during the last fifteen years. In 1860, the tonnage was 553,857; in 1865, it was 1,628,970; in 1870, it was 3,435,269; and in 1875, it was 4,388,649. The mileage open in these respective years was, 840, 3,000, 5,000, and 6,500. For last year I am not able to give the sum total, but I know that a great stride was made, especially on those lines where the rates were lowered, and where an enlightened management has been pursued. This was particularly the case on the East Indian Railway, and to the course followed by that company may be attributed the chief part of their prosperity. In consequence of the low rates, combined with other circumstances, viz., the removal of the export duty, the price of silver and the facilities afforded by the Suez Canal, large quantities of grain have found their way to this country at a price which left a good margin for profit. During the eight months between March and December of last year, 3,864,780 cwt. of wheat were exported from India. In the same period of 1875 and 1874 the amounts were 1,835,000 and 835,518 respectively. There has also been a large increase in seeds. In 1874, the quantity of linseed exported in the above-mentioned period was 2,420,973 cwt.; in 1875, it was 3,892,206, and in 1876 it rose to 4,755,741. This is something for railways to have helped to accomplish. Who would have expected, twenty years ago, that a granary for England would be found in the valleys of the Jumna, the Ganges, and the Sutlej? Or that, by the influence of steam, America and Russia would find in the far East a competitor for supplying us with food?

The goods are generally divided into five classes, the rates varying from 4d. a ton per mile for the highest to ½d. a ton for the lowest class, this last being exceptionally low, and only adopted by the East Indian Railway for grain and coal.

The financial results, as a whole, have hitherto disappointed expectations. Many thought, and I include myself amongst the number, that the railways would have paid better before this. Our opinions were, it is true, founded upon estimates of a smaller capital outlay, but our hopes rested upon a larger increase of revenue. Besides the large original cost, the causes of this disappointment may be found principally in the slower development of traffic than was expected, and, to a certain extent, in the high charges for working and maintenance. Let us see what the deficiency is which we lament. Some of us may think that, after all, what India now pays for her railways is not so ruinous, and that she either directly or indirectly receives compensation for the burden imposed upon her. This may be true. But the absence of the burden would nevertheless be a more satisfactory state of things. The deficit falls upon a people who cannot afford to bear it. What is first desired is, that the receipts from the railways should cover the amount of guaranteed interest annually paid on the capital. During the last twenty-six years the State has paid to the companies a sum of about £61,500,000.* Up to the end of last year, about £34,736,000 had been earned by the railways, so that there has been an average annual deficiency of rather more than £1,000,000. In some years it has approached £1,500,000. It must be borne in mind that for a long time a large portion of the capital was unproductive. Extensive works have been going on all over the country, and of course it was only open lines that were able to contribute to the revenue. It was not until 1871 that the system of trunk lines was completed, so that time has hardly yet been given to develop their capabilities. Time, however, is not only required to bring out the actual productiveness of the railways, but the powers and abilities of managers, and the due appreciation by customers of the value of this novel mode of conveyance. The total net revenue earned by the railways in 1875 was £3,647,868. The amount paid for guaranteed interest was

* See Appended Table.

£4,650,346. The deficiency was thus rather more than one million. Last year's results will I expect be more satisfactory. I am in hopes that it will be found that the deficiency will be reduced to half a million.

Again, taking the results of the same five years which have before been selected for purposes of comparison, we find that in 1860 the net revenue from the railways was £276,800. In 1865 it amounted to £1,434,000; in 1870, £2,805,188; in 1875, £3,576,514. In 1876 I estimate that it will be £4,200,000. The gross receipts from passengers were £1,188,000 in 1865; in 1875 they were £2,341,000. The gross receipts from goods in 1865 were £2,000,000; in 1875 they were £4,773,000.

I have been referring hitherto to the guaranteed railway in the aggregate, but this appearance of average mediocrity conveys anything but a clear or correct notion of some of the undertakings. Although it may not be in railways "to command success" while they may deserve it, results, for our present purpose, must be the test of superiority, all due allowance being made for disadvantages attendant on age and position. The East Indian Railway stands out pre-eminently as a valuable, well conducted, and prosperous line. Its advantages are great, and the company is now making the most of them. The results of last year show that it yielded nearly 7 per cent. on a capital of £30,500,000. The gross receipts were upwards of £3,000,000; the working expenses about a third of that sum. The East Indian Railway has thus beaten all the English lines, some of which, by dint of debentures and debenture stock, guaranteed and preference stock, raised on favourable terms, have been able to squeeze out a dividend at the same rate, or sometimes a higher rate than the above, to the holders of a third of the whole capital expended. If the capital of the East Indian Railway had been divided in the same proportion of ordinary stock, preference stock, and loans, as the average of English lines is, the dividend to the shareholder would probably have been about 11 per cent., and this too, be it remembered, with average charges for conveyance, taking goods and passengers together, one half those in England.

Next comes the Great Indian Peninsular Railway, the expended capital of which is about £23,500,000. The gross earnings last year were £2,230,000, and the expenses will probably amount to £1,050,000. The net receipts will thus produce a dividend of 5 per cent.

The Eastern Bengal Railway, with a capital of £3,000,000 will yield about 4½ per cent.; the Bombay, Baroda, and Central India Railway will produce 3¾ per cent. on a capital of £7,750,000; the Madras 2½ per cent. on a capital of £10,250,000; the Scinde, Punjab, and Delhi 2¼ per cent. on a capital of £11,000,000; and the Oude and Rohilkund 2¼ per cent. on £5,500,000; the South Indian yielded 2½ per cent. on the capital of £3,700,000: but nearly 4 per cent. on a capital of £2,560,000, which is the amount expended on the open line.

These figures are approximate, but they are sufficiently accurate to serve our present purpose. It thus appears that out of a capital of £94,200,000, expended on the guaranteed lines, the Government have been exonerated from the payment of any interest on £54,000,000 which earned more than 5 per cent., and that last year's deficiency is derived from certain lines, representing a capital of £4,200,000, of which £3,000,000 yielded 4½ per cent., £7,750,000, 3¾ per cent. and £30,000,000 between 2 and 3 per cent. With regard to these last, it may observed that they are for the most part labouring under disadvantages which, in the case of the Scinde, Punjab, and Delhi, will be removed when the Indus Valley Railway brings the Punjab into connection with its natural port, Kurrachee; and in the case of the South Indian, which already shows strong signs of life and vigour, when the important link connecting Madras with the southern portion of the line is finished. It should be remembered also that the Oude and Rohilkund is still in its infancy, and also disconnected at its extremities with other lines of railway.

The State lines which constitute the rest of the system now open are, with the exception of the Rajputana railways, not favourable specimens; they are either cripples or dwarfs. The line I have just mentioned does, however, furnish a good example of a well constructed and well managed undertaking, and the results are already satisfactory. It starts from Delhi and Agra by two separate lines, which form a junction at Bandikui, whence it proceeds to Ajmere and the cantonment of Nasirabad. From thence it will go south to Indore and join the Great Indian Peninsula Railway at Khandwa, and south-west to Ahmedabad, where it will meet the Bombay and Baroda line. At present it is only open to Nasirabad from Delhi and Agra, with a branch to the Sambhur Salt Lake, and it is this portion with which we have now to do. It is a single line, and has been constructed on the metre gauge. Its length is about 400 miles. It has cost £2,500,000, or about £6,000 a mile; but it is estimated that another £500,000 will be required to complete and equip it properly, bringing its total cost to £3,000,000, or about £7,200 a mile. This includes a bridge over the Jumna at Agra and minor bridges. It was opened for traffic in 1875. The total earnings for the half-year ending 30th June last (the half it must be admitted when most traffic takes place) were Rs. 1,321,535; the expenses Rs. 749,248, leaving Rs. 572,260 as the net receipts, being at the rate of 2·27 per cent. for the half-year, and more than 4½ per cent. for the year. Considering that the result has been attained in a single year, it cannot but be regarded as very satisfactory, and as furnishing good ground for hope in the future.

The revenue of all lines, whatever their cost, must depend not only on the traffic attracted to them, but on the cost of working and maintaining them. Different undertakings vary much in this respect. One from its position may naturally command a large traffic; one may be able to obtain fuel at a cheap rate; another may have easy gradients: another may be a good serviceable length, and have an equal stream of traffic each way; and another may be connected with a port where the freights for goods from England are comparatively low. All these would possess advantages which would promote economical working; but skilful management will overcome, or at any rate diminish, most impediments, and more than counterbalance the favourable circumstances of a neglected undertaking. As with men, the better

trained and more cultivated will surpass their more gifted competitors, so with railways economy of working and correct principles of management will ensure success more than natural advantages. I do not mean that natural advantages are to be despised. They should certainly be made the most of, and not made the excuse for folded arms, while adverse circumstances should be regarded as a stimulus to extra care and exertion.

There can hardly be a better specimen of a line which at present combines the twofold advantages of favourable position and good management, than the East Indian Railway, and yet its direct competition with the river was at one time thought to be a serious drawback. It is this very competition which has helped to make it what it is. The proof of the economical arrangements which characterise it may be seen in the working expenses, which, for the half-year ending June last, were only 33 per cent. of the gross receipts. Those of the Great Indian Peninsula for the same period were 46; the Madras, 72·75; the Bombay, Baroda, and Central India Railway, 43·56; the Scinde Punjab, and Delhi, 63·69; the Eastern Bengal, the Rajputana, 56·69; Oude and Rohilkund, 58·28 per cent. The proportion per cent. of expenditure to receipts for the year 1875, on English and Irish lines, was 55, and on Scotch, 52.

The expenses peculiar to Indian Railways are not, as was first expected, so much those which are produced by a tropical climate or by the ravages of insects, but are those which arise from the damage done to bridges and other works in the vicinity of rivers by the force of the floods, and those also which follow the necessary employment of European agency. Both these causes will in time become less. Our engineers will, no doubt, in the end vanquish the rivers, and by degrees natives will take a larger share in the working of the lines. It is at present requisite to send out not only engineers, managers, superintendents, and foremen, but to employ Europeans as accountants and engine-drivers, as well as a certain proportion of inspectors, pointsmen, and guards. Their wages are three or four times what they earn in England, and ten times more than those of natives. The latter, however, are apt learners in mechanical art, and have been trained to very useful work in the locomotive shops. It will take time to qualify them for the more arduous duties of locomotive drivers, which require coolness, courage, and decision, but some have already shown themselves to be equal to such employment, and I have known a case where the European driver was drunk, and the native fireman took charge of the engine as well as of his companion. On the other hand there are examples of the pusillanimity of the native in an emergency. In an accident which occurred from a collision, the native stoker threw himself off the engine and was killed, a fakir jumped from his carriage and met the same fate, and the station-master was never seen again. Educated natives fill the offices of station masters, accountants, assistants to traffic managers, clerks, and guards. But a certain proportion of European officers and servants will always be necessary. At various selected places on the lines, provision is made for the Europeans and their families, and railway towns have sprung up, with their churches, schools, institutes, baths, co-operative stores, and libraries. Cricket, fives, and billiards are played with the same energy as in this country. The children are educated, and the sons are growing up to take part in the work their fathers have been engaged in. It is wise to attend to the health and amusements of these communities, and also to rouse a spirit of interest in the work among all the *employés*, by allowing them to participate in the success of the line they are connected with. This principle is carried out on some of the lines, contributions out of any excess profits over 6 per cent. being made to provident funds, which belong to all who subscribe a regulated proportion of their pay. The amount added by this means to the fund of the East Indian Railway last year was about £20,000. The principle is also applied, in another way, to the working of the Oude and Rohilkund Railway, where, instead of maintaining permanent staffs at the station for the purpose, contracts are made with the station masters to load and unload the goods on terms which give them a small profit, and consequently an interest in the increase of traffic.

The only accidents *peculiar* to Indian railways are those produced by the violence of the elements. I have already mentioned how viaducts have been carried away. It has happened that, no notice having been received of the sudden destruction of a portion of a bridge, a train was plunged into the gap. On one occasion in Scinde, a village on the banks of a nullah was swept away and brought down a railway bridge in its ruin. There has also been an instance of a train being blown over by a hurricane. Wild animals are sometimes the cause of accidents. An elephant has been known to charge a train, and a buffalo has been the means of throwing a train off the line. But these are of rare occurrence, and railway travelling in India is quite as safe as in this country. Poor people sometimes die in the carriages from heat and fatigue, but they are almost always cases of those who should not have attempted a journey, being worn-out creatures, who perhaps are making a last attempt to reach some favourite shrine. The "line-clear" system is applied to the working of the traffic; but as necessity arises the block system is gradually introduced.

It now only remains to consider the policy which should guide the administration of these great undertakings. As political, or strategical, works they should, of course, be made capable of rendering such service as may be required of them whenever the occasion may arise. But it is in their other capacity—as carriers of men and merchandise—that they have to be chiefly regarded when we are concerned with their remunerative powers. It appears to me that, in every sense, their commercial character should be preserved and developed, and that the broadest view should be taken of their aims and capabilities in this respect. I believe that a policy dictated by such a view of their position, would enable the railways to confer the greatest advantages to all concerned. In the first place, whether in the hands of companies or of the Government, they should be allowed to earn the full fruits of a careful and liberal management. I know that some would limit the profits to an amount sufficient only to cover the interest on the capital, and would

Give the customer the benefit of any excess. The vicissitudes of traffic might interpose a difficulty in the way of this arrangement; but supposing it feasible, would it be fair to the community at large who have furnished the means of obtaining the money to deprive them of a participation in the benefits? The more legitimate mode of dealing with the excess would be to spend it on extending the railway system. I have just advocated a liberal policy as being the most likely to pay. By this I mean one that brings the railways down to the wants and capacities of the people, which considers carefully the peculiar circumstances of the country, encourages the growth of its agricultural produce, and stimulates fresh industries. The policy which would strive for high returns from a contracted traffic is not the policy suited to India; if, indeed, it be suited to any country. As I believe some of the most successful commercial enterprises have been conducted so as to secure a large aggregate profit by numerous small gains, so should railways be managed as to produce large receipts from the small earnings of a multitude of transactions. The people of India are poor, and the distances are great. Fares for the low classes of passengers, and charges for the staple commodities of the country, must be very low in order to secure the traffic which may reasonably be expected. I do not forget that, to enable this to be done, thrift and skilful management is necessary, and we have seen on the East Indian Railway how it is possible for an Indian line, by these means, to carry its freight cheaper than any English railway. Besides the usual obvious measures for attracting traffic by good accommodation, punctuality, and all reasonable conveniences, care in the selection and economy in the use of materials must be exercised, and every effort should be made to reduce the dead weight and unprofitable work, by running as few trains as possible, and filling them up to the brim; in other words, by reducing the train mileage and increasing the train loads. There is nothing so objectionable in railway returns as "a beggarly account of empty boxes." Lessons may be continually learnt by a careful study of statistics. The very word I am afraid brings to some minds the idea of mystifying doubts and suspicions, but however much a mass of ill-arranged figures may confuse and deceive, properly prepared statements furnish the most instructive information for future guidance. Rates and fares, for instance, should be regulated chiefly by the cost of transport, and as such charges are made by the ton, and for the passengers per mile, it is most important that the cost of conveying a passenger and a ton a mile's length should be ascertained. This has been done by Mr. Rendel, who, by an intelligent analysis of the traffic returns, has from time to time prepared tables which show not only the cost but the amount earned from each passenger and each ton of goods carried one mile. The East Indian Railway Board were thus enabled to explain, in their last report, that the average sum received for carrying a passenger one mile was ·38d., the average cost ·14d., and consequently, that the profit on each passenger was ·24d.; that the average sum received for carrying one ton a mile was ·91d., the average cost ·26d. and the profit ·65d. This is turning statistics to good account, for a unit of great value is arrived at, and the secret of success is revealed. I have already given the results of this line. Mr. Crawford, the chairman of the Company, was able to point out to the shareholders that its present prosperous position had been attained by thrift, enterprise, and liberality, and he spoke in a confident tone of the success of the policy which he recommended, and which was explained in the last report of the Board.

After alluding to the economy exercised by the staff in India, the report goes on to say:—"It was this which prompted and justified the policy of the Board in regard to reduction of rates, and it is this reduction of rates which has conduced so much to the late development of traffic. The action and re-action of these three influences—that is to say, economy of cost, low charges, and increase of traffic—upon each other have operated, and are still operating, to produce not only financial prosperity in the line itself, considered as a property, hardly surpassed by any line in England, but, what is of still more importance, a commercial activity in India in some of the most important products of the soil, which will have a marked effect on the welfare of that country at large."

It is gratifying to see so high and at the same time so just a view taken of the duties and obligations of a guaranteed Indian railway company. Satisfactory as this account is, I cannot but think that, if the principles here advocated are formed into a settled policy by the administrators of our railways in India, we shall see yet more favourable results. The prosperity of these great works and the improvements of the country should go hand in hand together. Any system of management which does not promote the due development of the produce of the soil, and stimulate the various rising industries of the country, cannot be a proper one for adoption. We have already seen how, in the case of wheat and seeds last year, the agricultural riches of the country "derived from benignant skies and a prolific soil" received an impulse from low rates. Other products will be acted upon in the same way. The growers of cotton find it difficult to compete with America, but India is now spinning much of her own produce, and will soon go a step further. Along the western coast, at Bombay, Surat, and Broach, large mills are at work. When visiting one of these in company with Mr. Rendel last year, I spoke to the owner on the subject of the import duty on manufactured goods. His remark was, "Whether the duty is kept on or taken off, we intend to beat Manchester." In Calcutta mills for working up jute—which, as an article of commerce, has only been heard of in India within the last twenty years—have been established. There is great activity in the coal producing districts of Bengal and Central India, and supplies of coal are being taken many hundred, and even more than a thousand miles up country for the use of the railways. Tea has already become an important article of commerce, and now rivals that of China in quality. There is no reason why tobacco should not be more extensively cultivated and prepared for European consumption. There are probably other articles which in time, and with proper facilities for reaching a market, will

Railway.	1860. Receipts. Passengers.	Goods, &c.	Total.	Working and Maintenance Expenses.	Net Receipts.	1865. Receipts. Passengers.	Goods, &c.	Total.	Working and Maintenance Expenses.	Net Receipts.
	£	£	£	£	£	£	£	£	£	£
East Indian.—Main Line	131,798	202,584	334,382	165,543	168,839	525,660	916,435	1,442,104	670,005	772,099
Do. Jabalpur	..	..	Not	opened.	..	..	..	Not	opened.	..
Great Indian Peninsula	88,343	108,206	196,549	119,795	76,754	241,469	628,827	870,296	555,670	314,626
Madras	39,913	36,487	76,100	46,979	29,421	149,449	200,007	349,456	177,817	171,639
Bombay, Baroda, and Central India (opened on 10th February, 1860)	..	..	6,090	4,268	1,822	154,630	41,805	196,435	123,365	73,070
Scinde, Punjab, and Delhi (including Indus steam flotillas)	..	..	Not	opened.	..	36,330	145,371	181,701	155,636	26,065
South Indian { Amalgamated Gt. Southern of India and Carnatic Railway Companies }	Not	opened.	{ Great Sout Carnatic	hern of Ind Railway ..	ia Railway	19,127	16,109	35,236	17,451	17,785
Eastern Bengal	..	..	Not	opened.	..	..	..	Not	opened.	..
Oude and Rohilkund	62,158	50,682	112,840	54,094	58,746	..	..	Not	opened.	..
Totals.....	260,054	347,277	613,421	336,585	276,836	1,188,832	1,999,236	3,188,068	1,754,038	1,434,030

Railway.	1870. Receipts. Passengers.	Goods, &c.	Total.	Working and Maintenance Expenses	Net Receipts.	1875. Receipts. Passengers.	Goods, &c.	Total.	Working and Maintenance Expenses.	Net Receipts.
	£	£	£	£	£	£	£	£	£	£
East Indian.—Main Line	722,510	1,908,959	2,631,469	1,099,459	1,532,010	801,311	1,708,352	2,509,663	963,054	1,546,609
Do. Jabalpur	62,846	59,617	122,463	104,846	17,617	77,300	107,748	185,048	107,326	77,722
Great Indian Peninsula	434,276	1,225,671	1,659,947	1,032,630	627,317	478,530	1,494,554	1,973,084	932,786	1,040,298
Madras	187,112	306,101	493,213	259,693	233,520	226,049	363,343	589,392	414,204	175,188
Bombay, Baroda, and Central India (opened on 10th February, 1860)	189,578	303,520	493,098	288,526	194,572	228,348	357,106	585,454	318,543	266,911
Scinde, Punjab, and Delhi (including Indus steam flotillas)	182,589	236,938	419,527	333,125	86,402	227,275	369,619	596,964	397,443	199,621
South Indian { Amalgamated Gt. Southern of India and Carnatic Railway Companies }	39,318 3,054	31,644 464	70,962 3,518	42,646 3,967	28,316 Loss 449	54,228	49,125	103,353	49,774	53,579
Eastern Bengal	70,553	107,539	178,092	99,187	78,905	110,298	185,520	295,818	190,081	105,737
Oude and Rohilkund	16,329	8,254	24,583	17,605	6,978	137,585	137,587	275,122	164,273	110,849
Totals.....	1,908,165	4,188,707	6,096,872	3,291,684	2,805,188	2,340,994	4,772,904	7,113,898	3,537,484	3,576,514

Statement of Cost, and of some of the Dimensions of the largest Bridges on Railways in India.

Railway.	Name of Bridge.	No. of Spans.	Length of Bridge.	Depth of foundation below Low Water.	Height from Low Water Level to under side of Girders.	Total Cost.
			Feet.	Feet.	Feet.	Rs
East Indian	Jumna (Allahabad) ..	14	3,080	40	60	40,75,800
,, ...	Soane	28	4,536	32	37·6	26,10,167
,, ...	Jumna (Delhi) ..	12	2,640	7 to 39	23·5	16,60,354
Scinde, Punjab, and Delhi	Sutlej (Loodianah) ..	59	6,456	40 to 50	17·5	31,06,076
,, ...	Beas	34	8,820	43 to 70	21	22,90,366
Eastern Bengal	Goraie Bridge ..	7	1,295	78 to 98	51	16,95,009
*Oude and Rohilkund..	Ganges (Cawnpore)	25	2,750	50 to 65	31·66	19,40,000
,, ...	Ganges (Rajghât).	33	3,040	55	24·39	9,63,580
Madras	Chittrawutty	40	2,800	12 and 30 ft. deep	20	3,54,705
Great Indian Peninsula.	Kistna.....	36	3,865	Average 15·69	†46·51	12,80,001
,, ...	Taptee (Bhosawul)	33	2,556	,, 17·30	†57·88	13,64,900
,, ...	Toongabudra ..	58	4,060	Shallow on rock	37	7,55,756
Bombay, Baroda, and Central India	Taptee (Surat) ..	30	1,875	Average 14	†53	8,95,260
,, ...	Nerbudda (Broach) ..	67	4,187	,, 37	†48·5	46,93,490
Rajpootana (State)....	Jumna (Agra) ..	16	2,272	,, 70	31·66	16,54,203
Punjab Northern	Chenab	64	9,088	,, 75	20	46,78,924
,, ...	Sutlej (Bhaulwulpoor) ..	16	4,224	,, 100	Minimum of 30	38,85,780

* The figures for the bridges on the Oude and Rohilkund Railway are only approximate, and subject to revision.
† Height of railway above low water.

appear on the list of exports. All these are encouraging features in the material prospects of India, and all are being helped by railways. For these and for other reasons which have appeared in the course of this paper, their judicious extension is, I submit, to be desired.

DISCUSSION.

Mr. Crawford (the Chairman of the East Indian Railway) remarked that people who took any interest in Indian railways were very much indebted to Mr. Danvers for his clear and comprehensive paper. What these railways were capable of doing for the country was only now appearing, and the prosperity on which some of them had embarked only now commencing. A very different state of things existed now from what there had been, and this was mainly owing to the extremely accurate and exhaustive statistics which had been prepared by Mr. Rendel, and the method which the companies now had of ascertaining the exact cost of doing every item of their work. Formerly it had been thought impossible to bring grain from the upper parts of India, where large quantities where known to be stored, to Calcutta, at a profit; but this had been done, and recently grain had been brought from Cawnpore to Calcutta, a distance of 684 miles, at a cost of 6s. 4d. per quarter; and arrangements had recently been made by which a large quantity of wheat, which was raised in more distant parts of Delhi and Lahore, would be brought to Calcutta, for 12s. 6d. per quarter. Was there any railway in England which could afford to carry a commodity like that such a distance, at such a cost, with profit to it? But for Mr. Rendel's method of ascertaining the cost of working, and what they could really afford to carry their goods for, these things could not be carried on successfully. It was this which made the difference between the English and Indian railways. Rates of a halfpenny per mile were unheard of in this country, and there was no limit to the amount of profit which would be opened up in time to come. It would surprise people who knew India in former days, and who were accustomed to the jog-trot way of travelling, when the cost was so enormous, and three months' time was required to bring goods from the interior to the coast, to see the change that had been effected, and that the superabundance of produce which existed in some districts of India was available for our own requirements. It was deeply interesting to the people of this country to know now, that even if the great granary of South Russia might possibly be jeopardised, there existed in India a vast source of supply, which could be brought to this country with profit to all. Upwards of 200,000 tons of wheat were last year exported from India, 170,000 tons of which left the port of Calcutta, and the greater part of which came here. Taking the produce as being four or five quarters to the acre, that quantity would not require more than about 200,000 acres of land to produce it, and the extent of country was enormous where grain could be grown. There was another enormous trade which had recently sprung up in India, for which they were indebted to the railways, and that was the growth of linseed and rapeseed. The quantity of linseed alone exported from India in 1876 represented £4,000,000, though it was not to railways alone that this was owing. One of the principal things which gave an impetus to the trade was the measure, of which Lord Northbrook was the father, for the abolition of the export duties. The amount of the duty in the case of wheat was nearly 1s. per quarter; in the case of linseed it was more. When they remembered that represented about two per cent., and that in these times that was considered a mercantile profit, they could understand the great advantage of the abolition. Then there came the depreciation of silver; and, then, again, the enormous advantage in

having commodities which it was possible to export to England, to the extent of some six or seven millions, was at once seen. He seriously hoped Mr. Danvers' paper would not lie buried in some report, but that it might be spread abroad to enlighten the public mind upon the subject of Indian railways. It would show that Indian railways had not been the extravagant and ill-considered enterprises they were thought to be by many people. Only on Tuesday evening, in the House of Commons, they had heard on high authority that it was in consequence of the extravagance connected with Indian railways that the State railways had been introduced. He entirely differed from that statement, and he hoped an opportunity would offer when this view could be tested by those who were interested in the matter, and who could prove that, all things considered, Indian railways had been as economically constructed as any vast series of railways in Europe, or the world. It was all very well for other countries to trade upon the experience gained in England. People said Continental railways had been constructed more cheaply than those in India, but who, he would ask, had bought the experience that enabled them thus to construct them at less cost? Why England had bought the experience and paid dearly for it too, and it was after we had learned in the school of experience how railways were best made, that other countries were able to avoid the errors which had led to the extravagance and enormous cost which marked the construction of the railway lines. The companies had to introduce works of a character hitherto unknown in India, and had to resort to expedients wholly novel to the country. True, some mistakes had occurred, but they were of an unimportant character really, and it was this experience which enabled other people to be so wise after the event, and make such boasts of how much better they could do. The statement of Mr. Danvers was a very proper sequel and a very proper commentary on much which had been said in the House of Commons at the debate on Tuesday, and he (Mr. Crawford) believed if there had been any member of the House present who was thoroughly acquainted with the matter, a vast amount of misapprehension and misunderstanding would have been prevented.

Mr. Scott Russell, F.R.S., said although he had never been in India, he was well acquainted with all that had taken place there in regard to railways, as he had known many engineers and others connected with those undertakings. He had watched their progress with very great interest, and as an engineer he had frequently had occasion to advise other countries upon their public works. And what he had generally recommended was that they should imitate England as little as possible in what had been done in regard to its railways, but should imitate as much as possible what Englishmen had done for railways in India. There was much in the administration and utilisation of railways in India which might be followed with great advantage in England, if in nothing more than in knowing the exact cost of carriage of, and the profit and loss on each item of goods. One thing, however, in connection with Indian railways he deeply regretted, and that was that a uniform gauge had not been adopted. He did not care whether the gauge was wide or narrow, but a difference of gauge was certainly a great evil. In saying this he did not mean to indulge any crotchet, though he had his crochets, but he was merely giving utterance to a view into which he had been disciplined, for one of the earliest duties of his life as an engineer was to do some work in connection with a railway of an exceptional gauge, which after doing much useful work, had to be pulled up and relaid merely because its narrow gauge prevented its getting into the general traffic of the railway system. He strongly regretted that any consideration should have permitted, either the Government or anybody else, to indulge themselves in any other than one uniform gauge for the Indian Empire; and he predicted that if the administrators of India would indulge in exceptional railways, the day would come when in some state of war they would have to regret that the material of their army could not avail itself of the railways because of their exceptional character. In England they had not now any great amount of exceptional railway. At great cost they had got rid of that, and now had an uniform narrow gauge, which not only enabled them to carry everything over the country, but would enable them to assist any of their continental neighbours. It was a mere fallacy to think that the breadth of gauge made a difference in the cost of a railway. He would also urge the importance of uniformity of pattern being adopted in India in respect to locomotives and carriages. If they would organise their railway material, so as to reduce the great variety now existing in engines and carriages, to perfect mathematical uniformity, such as Sir Joseph Whitworth had, and the London and North-Western Company were introducing, that forced uniformity would effect an immense saving in their current expenses. The locomotives so made would only cost two-thirds of their present cost of maintenance, and wear and tear would only be half what it now was.

Mr. J. T. Wood considered that the time had not arrived for making any reduction in the rates charged by the guaranteed railways, but on the contrary, if those railways were to be self-supporting, it would be necessary to increase the rates charged on some of them. He ventured to doubt whether the export of wheat and seeds, consequent on the opening of the Suez Canal, would have been less in the aggregate if the railway charges had even been somewhat higher than those actually in force. He would, as briefly as possible, explain his views on these points, and also offer some observations on the question of surplus profits. He was under the impression that the original guarantees were granted, and the rates fixed, with regard to estimates of traffic actually existing in the districts through which the railways were to pass, and that the idea of development of non-existing traffic by charging low rates was, if entertained at all, considered of very minor importance. As matters now stand, the bill for guaranteed interest must be paid every year. The question was—Whether the practice was to be continued of charging a portion of the bill against the tax-paying community of India, or whether the whole of the bill was in future to be discharged by the persons using the railway? At present the scale of charges on the different railways was not uniform. If the policy be correct and adopted of carrying nothing on the guaranteed railways below cost price, and of so adjusting the rates that each article should bear its full quota, not only of the working expenses, but also of the guaranteed interest, it would be necessary (taking the returns of 1875 as the basis of the calculation) to raise the rates of six of the guaranteed companies to an extent varying from 11 to 55 per cent. The highest rate then chargeable for third-class passengers on any of the guaranteed lines would be ·54 of a penny, and the highest rate charged for the lowest class of merchandise would be 1·8 of a penny, which rates in England would be considered very moderate. It was impossible to tell, except by experiment, extended over a sufficiently long period, whether the increase of rates within moderate limits would have the effect of diminishing the quantity of traffic brought to the railways, or of diminishing the net receipts, but he did not see why the same kind of traffic in different parts of India similarly situated would not bear the same charges of transport. He would give an example. The districts traversed by the Oude and Rohilcund Railway were, for many years, contiguous to the districts traversed by the East Indian Railway. It could be proved, beyond doubt, from the statements given in the report of the former company for the half-year ending June last, that if that company had been allowed by the Government to charge,

and been able to obtain the same fares from their passengers as those charged on the East Indian Railway, and been allowed to charge and been able to obtain the same rates for their goods as those charged on other railways, they would have more than covered the guarantee instead of showing a deficit. The imports of wheat into the United Kingdom during the year 1875 from all countries amounted to 2,593,825 tons, of which 27,000 tons came from Bombay and Scinde, and 38,000 tons from Bengal and Burmah. The imports from India during 1876 may be larger. Even assuming that India could undersell the rest of the world and gain the whole of this export trade, the quantity of land required to grow that amount of wheat, in a country where rotation of crops is not necessary, would, at the rate of 30 bushels per acre, be under 6,000 square miles, a tract about the size of Yorkshire; and if the necessary amount of land were available for the cultivation of wheat within a nearer lead by rail or water to Bombay and Kurrachee than to Calcutta, the former ports would be able to beat the latter in the competition for the traffic. The returns for the year 1875 show that the tonnage of goods, exclusive of minerals, carried on the Great Indian Peninsula and Bombay and Baroda lines, which have their termini at Bombay, in that year were 110 and 135 per cent. respectively greater than in the year before the Suez Canal was opened; but the tonnage of goods, exclusive of minerals, moved on the East Indian Railway was only 10 per cent. greater than in the year 1869, the money receipts being £185,000 less. This, he thought, was conclusive that the export trade from India created by the opening of the Suez Canal would ultimately take the shortest and most direct route, and that the cultivation of wheat and other produce would be regulated accordingly. Calcutta was at present competing with Bombay and Kurrachee for the export trade in wheat. Wheat was said to have been selling at Cawnpore for £4 per ton, at the time that the price in London was £11, thus leaving a margin of £7 for the purposes of trade. Wheat was being brought to Calcutta by two railway companies at ·654 of a penny per ton per mile. This, according to the tables of the Blue-book of 1875, would give to one of the companies a profit of ·043 of a penny—say, $\frac{1}{25}$ of a penny per ton mile, and to the other company a profit of ·33 of a penny per ton mile. The railway company received 28s. 6d. for freight, the steamers 50s., out of which they had to pay 8s. for the toll of the Suez Canal, and the remaining 61s. 6d., less charges, went to the merchants for profit. Perhaps the railway company did not make the most of the opportunity, and accepted a smaller share of the £7 than they might have obtained. They would, however, according to the tables in the Blue-book, have obtained a profit of $\frac{1}{3}$ of a penny per ton mile on the rate charged. Another company is, however, now bringing wheat from Umritser to the East Indian Railway at the same rate as that charged by the latter company, namely, ·654 of a penny. But, according to the Blue-bock, the Punjab line will only make a profit of $\frac{1}{25}$ of a penny per ton mile on the transaction, and will thus have to carry ten tons of wheat 600 miles to earn a profit of £1 sterling. He was glad to say that there was now a prospect of surplus profits being the rule instead of the exception, at any rate as regards one half of the year. Hitherto the guarantee system had been an excellent school for training shareholders into indifference to the management of their affairs. As long as any guaranteed railway was considered safe to pay its working expenses, the price of its stock on the share-lists would be the same, whether the earnings were £9 per mile per week, or £25 per mile per week, for the shareholders had been so often disappointed in their expectation of surplus profits that they made their investments on the basis of the guarantee only, instead of on the basis of the reecipts. But now every florin of surplus profits expected to be permanently paid would raise the value of the stock by 20s. at least. The shareholders had been already recommended by a late member of Council for India to look more closely after their own affairs. It seemed to him that the position of the shareholders of the canal was very analagous to that of the shareholders of the guaranteed railways. It was not necessary for him to discuss whether the two undertakings had or had not materially contributed to the welfare of large communities. The shareholders in both undertakings had vested interests in contracts which were becoming valuable every year. Vested interests were always liable to the attack of classes who would benefit by their demolition. M. de Lesseps had successfully resisted the pressure put upon him to reduce the tolls of the canal by the representatives of steamer property, which had cost more than the canal itself; by the representatives of traders, who every year consigned merchandise through the canal, which aggregated in value more than the canal itself, and by representatives of most powerful political interests; and it was to be hoped that the directors of the guaranteed railways would follow so good an example, and not be persuaded, with or without consulting their shareholders, into consenting to any reduction of rates until the 10 per cent. contemplated by the contracts had been earned, or the lines taken over by the Government in the meanwhile at their full value.

Mr. Conybeare, in a few brief observations, drew attention to the great purity that had been displayed in the management of the Indian railways, in comparison with the way in which railway enterprises had been conducted in other countries. India owed a great deal to the *savoir faire* which had characterised the management of her railways, and, whatever might happen, England would have a noble monument of her rule in India by educating that country, and by giving a good code of laws, and a magnificent system of eternal communication.

Mr. Maitland, speaking as one who had been a merchant in India for some years, bore strong testimony to the immense benefits conferred on the commerce of India by railways, and said there could be but one opinion as to the great value of the principle laid down by the ruling companies, of reducing the traffic rates for bulky merchandise, so as to increase the volume of the exports of India. He referred specially to the immense increase in the exports of oil seeds, and, to what was practically a new trade, the trade in wheat, which India could supply to any extent, so as to make us independent of both Russia and America. Again, great credit was due, and especially to the East Indian Railway Company, for the reduction made in their expenses, which the last report showed had been brought down from 38 to 33 per cent. on the gross receipts, and this, of course, greatly aided them in carrying cheaply. He alluded, also, to the great importance of feeder-roads in connection with the railways, and said a tribute was due to Lord Dalhousie, to whom India owed her great railway system.

Mr. Crawford, remarking on the price of coal, said that the East Indian Railway Company raised their own coal, at a cost of 4s. 7d. per ton (at the pit's mouth), obtained from deposits discovered by the engineers in the early history of the railway. They were now raising 300,000 tons in the year, but they only had a very small coal bill—unlike many housekeepers in England.

Mr. Ward said he was very much interested in communications with Darjeeling, and asked whether a line to that point existed.

Mr. Danvers replied that the line was being made.

Mr. Ward expressed a fear that the line would stop short at Jullipigoree, and urged that it was very essential to have complete communication between Darjeeling and Calcutta, in order that the district where tea was grown might have the advantage of a railway communication.

Mr. Fleming, C.S.I., observed that under the present system of constructing railways by the direct action of the Government, whenever there was the slightest financial difficulty, the works were stopped, and he mentioned as a conspicuous instance of this, that the Western Rajpootana line had been postponed indefinitely because of the financial difficulty connected with the scarcity in the Deccan and Madras. One of the good results effected for India by the guarantee system was that there was a third party with whom the Government made contracts, and that through good or bad times the work went on. Mr. Fleming also remarked upon the effects of railway communications upon famines in India, and urged that for this reason, and also to give an outlet to the productions of the country, and encourage the people to produce, these communications should be extended as far as possible.

The Chairman, in closing the discussion, touched upon the chief points referred to in the paper. He thought the paper which had been read by Mr. Danvers, and the discussion which had followed, could not but be considered by those who were interested both in the prosperity of India, and the success of the railways there, as highly satisfactory. Looking at the broad results of what had been done, it seemed that they had now in that country a very widely extended system of railroads, which had been completed within the last twenty-five years. While the Government of India had paid year by year out of the revenue the whole of the interest of the money expended in constructing those lines, and, as was the case in other countries, had put the interest to the capital account, at present while there still remained some railways unfinished to be made out of guarantee capital, the charge upon the revenue was in the last financial year only one million. They had heard from the author of the paper that it would be only half a million next year. That was the broad result. Now, he did not think anyone who had any knowledge of India could doubt that that was one of the most profitable investments that ever was made by a great nation. He agreed with one of the speakers that the greatest credit was due to those who encouraged that system, and had carried it through to the present time, and especially to Lord Dalhousie, the eminent Governor-General of India. He had a thorough knowledge of the railroad system in this country, and he applied his great abilities to the subject on his arrival in India with, to his mind, great success. Something had been said upon the question as to whether "guaranteed" railroads or railroads made by the State were the best system. He thought there was no man in England—he was going to say or out of it—who would doubt that the best system for a Government was that the railways should be made by private capital. That undoubtedly agreed with our English ideas, which ideas he himself had not changed by the experience he had gained in India. At the same time every one who knew something of the subject would understand that it would have been quite impossible to raise money in India unless a guarantee had been given. Doubtless, it was obvious that in a system of guarantee one of the greatest inducements for economy in the management, viz., an uncertainty of any return on the part of those who invested their money, was absent. The shareholder knew that he would get his five per cent. whatever might be the way in which the business of the railroad was conducted. No one could deny that; but at the same time those railroads had been conducted by men of honour and ability, and during the time of their construction, although doubtless mistakes had been made—not more, perhaps, than were to be expected under the circumstances—he did not believe that any unnecessary expenditure had been incurred. Referring to the subject of tariffs, as far as he knew, the opinion held by those in India who had gone into the question was that, not only for the development of the resources of the country, but for the profit of the railroads themselves, it was a judicious measure that was taken by the East Indian Railway Company in reducing their rates, and that it might be followed with advantage by other companies. It had been remarked that, in regard to dealing with famine in India, the extension of railways there was the most effective means of guarding against any such calamity. It had also been mentioned by Mr. Danvers that, during the time of the scarcity in Bengal in 1873-4, there were no less than 800,000 tons of food grain brought into the famine districts by means of railroads. That was perfectly accurate, and what he had simply to add was that it was only the existence of railroads in India that had made it possible for any Government, with any exertions and at the expenditure of any sums of money, to meet these calamities. They had heard of famines that had taken place in former times in which there had been great mortality, such as the one in Rajpootana, where the scenes were perfectly heartrending, It was impossible at that time in any manner to have met that calamity. The distance from the parts of India in which there was plenty, and the difficulties of transport, were so great, that he did not believe any foresight would have met that famine in Rajpootana then. On the other hand, at the present time he thoroughly believed, from what he had heard elsewhere, that the measures which the Indian Government and the governments of Madras and Bombay were now adopting, to meet the scarcity in these districts, would be successful. They would be successful mainly, in his opinion, because of the railroads, which now traversed almost the whole area of scarcity, and enabled the enormous quantity of food grain now produced in India to be conveyed to those parts of the country which required it. What he would say was that railways were very good things, and the extension of trade in India very desirable. They were all glad to see those things progress, but there was one matter which signified more than all, viz., the soundness of Indian finance, which the Government of India must have first and foremost in their minds. India was a poor country compared to England, although its exports are so great, and it would not stand any extraordinary taxation. In his opinion the finances of India were in a perfectly sound condition. The finances had been so sound during the past four or five years that, although the cost of the famine in Bengal amounted to some six millions sterling, the surplus of three years was sufficient to produce a sum equal to the whole of that expenditure. In his opinion, so long as the expenditure was properly controlled, and, most important of all, so long as peace was preserved, the natural expansion of the railways of the country would enable the Government not only to meet the expenditure for such calamities, but in the course of years, would be ample to provide for the steady extension of the means of communication there. Moreover, it seemed to him that something like the prospect of a fair profit would be shown in railroad-making in India, and that they would see before very long natives—for he thought the capital was more likely to come from India than from this country—coming forward to make some inexpensive railroads, which would become feeders to the main lines. He thought that was an object very much to be desired, and any encouragement which could be given to the construction of such lines would be well bestowed. In conclusion, he was sure that they would all join with him in offering their most sincere thanks to Mr. Danvers for his paper, and in expressing a hope that the present successful position of some of the principal railway companies in India was only the beginning of a condition of things which would show that those undertakings would not only be useful to the country, but would really show a very large commercial profit.

A vote of thanks to the Chairman concluded the proceedings.

Mr. Hyde Clarke writes:—The protracted discussion did not give me the opportunity of speaking on the

paper of Mr. Danvers. It was marked by its liberal tone, but its most important feature—its bearing upon railway extension in India—did not receive due notice. As Lord Northbrook said, "India is a poor country," but assuredly the way to keep it poor is to deprive it of railway extension, the great necessity for its development. This subject requires more consideration than it could receive in one desultory debate. The first thing to which attention should be directed is the existing amount of railway accommodation in India. Taking the figures of Mr. Danvers, 25,000,000 passengers means that one in eight of the population travels once in a year on the railways, and that it would take eight years for each man, woman, and child in India to go once upon a railway. The amount of goods conveyed is possibly a carpet-bagful, or 20 lbs. per head for food, fish, salt, fuel, clothing, implements, seed, manure, building materials, and exchangeable produce, produced and distributed or received. It is absolutely certain that upwards of one hundred millions of people have never been on a railway, nor are likely to do so as matters stand. The provision made by the Government to supply their wants, and to provide each member of the population with an outfit of railways and public works, is 2s. per head. These appalling figures in some degree represent the way in which the development of India, so powerfully portrayed by Mr. Danvers, is to be dealt with. The paltry pittance provided is made dependent on the condition of the finances of India, the maintenance of which in good condition is, as Lord Northbrook says, of great value; but this is not a condition precedent to railway development, but dependent upon it and subsequent to it. Mr. Danvers has given the key to it. One of the first effects of railways felt by the population was, he says, the rise in wages. India is a poor country, but in regard to this question of transport provision it is relatively poorer, because the material has to be found on a European standard of prices, and the return has to be obtained on an Indian standard. As I have more than once pointed out, at the time railways were introduced wages were in many places a rupee a month or a penny a day, and they have since doubled, trebled, and quadrupled. Wheat, as referred to by Mr. Crawford, is 4s. per quarter in the north-west. When the same effect has been produced in India as in Europe, the shores of Western Asia, in Egypt, of raising the price of commodities to the commercial market standard, less the cost of transport, then India will in so far cease to be a poor country, and will be able to pay railway fares and rates and further taxes on a European scale. The effect of the rise of prices of cotton during the cotton famine is an exemplification of the wider and general effects. It is under the influence of this gradual advance that, notwithstanding the land revenue settlement in Bengal, the revenues in India have advanced, notwithstanding the paltry cost of railway guarantees, and it is by such operation that they will advance. Consequently, railway extension has to provide for increased revenues, and to make a provision for famines, as referred to by Mr. Danvers and Lord Northbrook, and not for railways to be dependent on famine deficiencies, and the good or ill administration of the revenue. It could not fail to strike me that no reference was made to railways in America, where population is more sparse than in India, and where grain has to be conveyed by railway enormous distances, and where parallels will be found to those low charges for freight looked upon by Mr. Crawford as exceptional, and which are so necessary for India. It was gratifying to me to find Mr. Danvers enforcing—as I have done so often, and for so many years—the importance of the statistical study of the traffic, which is so well attended to in France, and so ill attended to in this country. It is also acceptable to find the acknowledgment of the confirmation by experience of the influence on the rates for goods of expedition in conveyance, and safety from damage (see my "Practical and Theoretical Considerations on the Management of Railways in India," 1846, pp. 6, 7, 11, &c.). Turning back to those older times, it is useful to say that one reason why Indian railways have been so long in reaching a remunerative return is the neglect of the Government, as in Turkey, in providing the branch communications; and another, the same neglect in delaying the requisite extensions. Another cause is that ingenuously intimated by my friend Mr. Crawford, that it was only four years ago that his administrators or the government found out the right way of determining the rates. This demands none the less notice, because, although the East Indian Railway is now so far in the right way, the principles enunciated in the discussion were calculated to convey erroneous ideas. The principles on which the rates of charge for weight depend do not chiefly rest, as assumed, on Mr. Rendel's calculation of what the goods can be carried for; such an assumption would not be admitted by any French administrator. The first thing is to ascertain what margin there is between the price in the place of production and that at the place of sale or consumption, and the nature and quantity of the goods, and then to determine whether they can be conveyed at a gross profit more or less. It is evident, with regard to a crop of grain, that it can only be moved when the market price will afford the margin for transport, and that unless it be removed at such period it cannot be moved at all. The profit must be on the bulk. It might even, for that matter, be worth while to remove a grain crop at a nominal rate to avoid the risk of its being wasted, and so decrease the price for the district, for the total and continual traffic depends on the greater or less prosperity of the railway district. All these questions can only be decided, as Mr. Danvers has laid down, by statistical investigation, and it is of great importance that establishments for this purpose, which cost little money, should be adequately organised. It is to be trusted that the result of the paper of Mr. Danvers, when it comes to be discussed in England and India, through the wide circulation of the *Journal of the Society of Arts*, will be to place railway extension, and the provisions of irrigation and public works likewise, on a proper basis, by making them independent of the experimental budgets of Indian financial administrators, and of the casual development of a country for which no adequate provision is made.

TWELFTH ORDINARY MEETING.

Wednesday, February 21st, 1877; Lord ALFRED S. CHURCHILL, Chairman of Council, in the chair.

The following candidates were proposed for election as members of the Society:—

Cohen, Mrs., 6, Holland-park, Notting-hill, W.
Copland, William Robertson, 83, West Regent-street, Glasgow.
Eve, Henry Weston, 37, Gordon-square, W.C.
Garnett, George, The Friars, Monkton-street, Ryde, Isle of Wight.
Hildebrandt, John Albert Rheinhold, A.I.C.E., M.I.M.E., Bow-chambers, 55, Cross street, Manchester.
Morris, Joseph, Stopford-road, Jersey.
Morton, Robert, 22, The Chase, Clapham-common, S.W.
Nathan, J., 38, Elgin-road, St. Peter's-park, W.
Peto, Henry, 10, Stafford-terrace, Kensington, W.
Steet, G. Carrick, Medical Department, General Post-office, E.C.
Strongitharm, Augustus Horace, Barrow-in-Furness.
Volckman, William, 43, Victoria-road, Kensington, W., and Buckingham Club, Waterloo-place, S.W.
Wigner, George William, F.C.S., 79, Great Tower-street, E.C.

The following candidates were balloted for, and duly elected members of the Society:—

Arnot, William, F.C.S., St. Margaret's, Kirkintilloch.
Baker, Francis Henry, 24, Portsdown-road, Maida-vale, W.
Beresford, Lieut. Claudius, R.E., Learmount-park, Londonderry, Ireland.
Byas, Edward Higley, 25, Belsize-park, Hampstead, N.W.
Chadburn, William, 71, Lord-street, Liverpool.
Dellagana, James, junr., 106 and 107, Shoe-lane, Fleet-street, E.C.
Fuller, Thomas C., 2, St. Mary's-villas, The Elms, Ramsgate.
Haworth, W, 80, Warwick-gardens, Kensington, W.
Keates, Thomas William, The Acacias, East Dulwich, S.E.
Litting, George, M.A., LL.B. (London), Grammar, school, Stevenage.
Lowe, Charles Harlowe, A.I.C.E., Vestry-hall, Hampstead, N.W.
Lundie, George Archibald, Tweed-lodge, Charles-street, Cardiff.
Pope, William, 89, Cold Harbour-lane, Camberwell, S.E.
Rowley, Captain Charles J., R.N., H.M.S. *Iron Duke*, Kingstown, Ireland.
Shepherd, H. H. B., 24, Victoria-road, Kentish Town, N.W.
Tappley, Rev. Frederick, 18, Victoria-grove, Folkestone.

A lecture was delivered on—

CERTAIN RELATIONS BETWEEN PLANTS AND INSECTS.

By Sir John Lubbock.

The Council of our Society have determined this session to have a certain number of evening lectures, and have done me the honour of asking me to deliver the first. Your Secretary has, moreover, suggested that I should take for my subject a continuation of the lecture which I delivered before the British Association at Belfast, and which I have since expanded into a little book, on the "Relations of Flowers and Insects," and especially on the fertilisation of flowers by insects. It would, no doubt, have been easy to occupy not only a single evening, but even the whole time of the course, by descriptions of the various ingenious contrivances through which this is effected. I propose, however, on the present occasion, to ask you to look at the question from a somewhat different point of view, and have taken for my title, "Certain Relations Between Plants and Insects." This will include not only the modes of attraction, but the means of defence, which have been elaborated by plants, and also the influence exercised by plants on insects.

Neither plants nor insects, indeed, would be what they are, but for the influence which each has exercised on the other. We know now, for instance, that certain plants produce no seeds at all unless visited by insects. Thus, in some of our colonies, the common red clover sets no seeds on account of the absence of humble bees; for the proboscis of the hive bee is not long enough to affect the object. According to Mr. Belt, the same is the case for the same reason in Nicaragua with the scarlet-runner.

But even in those cases in which it is not absolutely necessary, it is a great advantage that the flowers should be fertilised by pollen brought from a different plant, and, with this object in view, insects are tempted to visit flowers for the sake of the honey and pollen; while the colours and scents are useful in making the flowers more easy to find.

The real use of honey, indeed, now seems so obvious that it is remarkable to see the various theories which were entertained on the subject. Patrick Blair thought it absorbed the pollen, and then fertilised the ovary. Pontedera thought it kept the ovary in a moist condition. Linnæus confessed his inability to solve the question. Other botanists considered that it was useless material, thrown off in the process of growth. Krünitz even observed that in meadows much visited by bees the plants were more healthy, but the inference he drew was that the honey, unless removed, was very injurious, that the bees were of use in carrying it off. Sprengel was the first to show that the real office of the honey is to attract insects, but his views was far from meeting with general consent, and even so lately as 1833 were altogether rejected by Kurr, who came to the conclusion that the secretion of honey is the result of developmental energy, which afterwards concentrates itself on the ovary.

One reason why the earlier botanists missed the true explanation was, perhaps, that some plants secrete honey on other parts besides the flowers. Belt and Delpino have, I think, suggested the true function of these extra floral nectaries. The former of these excellent observers describes a South American species of acacia, which, if unprotected, is apt to be stripped of the leaves by a leaf-cutting ant, which uses the leaves, not directly for food, but, according to Mr. Belt, to grow mushrooms on. The acacia, however, bears hollow thorns, and each leaflet produces honey in a crate-formed gland at the base, and a small, sweet, pear-shaped body at the tip. In consequence, it is inhabited by myriads of a small ant, *Pseudomyrma bicolor*, which nests in the hollow thorns, and thus finds meat, drink, and lodging all provided for it. These ants are continually roaming over the plant, and constitute a most efficient body guard, not only driving off the leaf-cutting ants, but in Mr. Belt's opinion, rendering the leaves less liable to be eaten by herbivorous mammalia.

Delpino mentions that on one occasion he was gathering a flower of *Clerodendron fragrans*, when he was suddenly attacked by a whole army of small ants.

I am not aware that any of our English plants are protected in this manner from the browsing quadrupeds, but not the less do our ants perform for them a very similar function, by keeping down the number of small insects, which would otherwise rob them of their sap and strip them of their leaves.

Mr. Forel watched, from this point of view, a nest of *Formica pratensis*. He found that the ants brought in dead insects, small caterpillars, grasshoppers, cercopis, &c., at the rate of about 28 a minute, or more than 1,600 in an hour. When it is considered that the ants work not only all day, but in warm weather often all night too, it is easy to see how important a function they fulfil in keeping down the numbers of small insects.

Some of the most mischievous, indeed—certain species, for instance, of aphis and coccus—have turned the tables on the plants, and converted the ants from enemies into friends, by themselves developing nectaries, and secreting honey, which the

ants love. We have all seen the little brown garden ant, for instance, assiduously running up the stems of plants, to milk their curious little cattle. By this ingenious idea, not only do the aphides and cocci secure immunity from the attacks of the ants, but even turn them from foes into friends. They are subject to the attacks of a species of ichneumon, which lays its eggs in them, and Delpino has seen the ants watching over them with truly maternal vigilance, and driving off the ichneumons whenever they attempted to approach.

But though ants are in some respects very useful to plants, they are not wanted in the flowers. The great object is to secure cross fertilisation; but for this purpose winged insects are almost necessary, because they fly readily from one plant to another, and generally confine themselves for a certain time to the same species. Creeping insects, on the other hand, naturally would pass from each floret to the next; and, as Mr. Darwin has shown in his last work, it is of little use to bring pollen from a different flower of the same plant; it must be from a different plant altogether. Moreover, when they quitted a plant they would naturally creep up another close by without any regard to species. Hence, even to small flowers (such as many cruciferæ, compositæ, saxifrages, &c.), which, as far as size is concerned might well be fertilised by ants, the visits of flying insects are much more advantageous. Moreover, if larger flowers were visited by ants, not only would they deprive the flowers of their honey without fulfilling any useful function in return, but they would probably prevent the really useful visits of bees. If you touch an ant with a needle or a bristle, she is almost sure to seize it in her jaws, and if bees when visiting any particular plant were liable to have the delicate tip of their proboscis seized on by the horny jaws of an ant, we may be sure that such a species would soon cease to be visited.

On the other hand, we know how fond ants are of honey, and how zealously and unremittingly they search for food. How is it, then, that they do not anticipate the bees and secure the honey for themselves? Kerner has recently published a most interesting memoir on this subject, and pointed out a number of ingenious contrivances by which flowers protect themselves from the unwelcome visits of such intruders.

The most frequent are by the interposition of *chevaux de frise*, which ants cannot penetrate, glutinous parts which they cannot traverse, slippery slopes which they cannot climb, or barriers which close the way.

Firstly, then as regard *chevaux de frise*.

In some respects they are the most effectual protection, since they exclude not only creeping insects, but also other creatures, such as slugs.

With this object it will be observed that the hairs which cover the stalks of so many herbs, usually point downwards. A good example of this is afforded, for instance, by a plant allied to our common blue scabious, *Knautia dipsacifolia*. The heads of the common carline (*Carlina vulgaris*), again, present a sort of thicket, which must offer an impenetrable barrier to ants. Some species of plants are quite smooth, excepting just below the flowers. The common but beautiful cornflower (*Centauria cyanus*) is quite smooth, but the involucres forming the flower head are bordered with recurved teeth.

In this case neither the stem nor the leaves show a trace of such prickles. In this species the stigma projects about 1-5th inch above the flower, so that if ants could obtain access, they would steal the honey without fertilising the flower; a flying insect, on the contrary, alighting on the flower, could scarcely fail to touch the stigma.

Kerner has called attention to very interesting illustration afforded by the *Polygonum amphibium*. The beautiful rosy flowers of this species are rich in nectar; the stamens are short; the pistil, on the contrary, projects considerably above the corolla. The nectar is not protected by any special arrangement of the flower itself, and is accessible even to very small insects. The stamens ripen before the pistil, and any flying insect, however small, coming from above, would assist in cross-fertilisation. Creeping insects, on the contrary, which in most cases would enter from below, would rob the honey without benefiting the plant. *P. amphibium*, as its name denotes, grows sometimes in water, sometimes on land. So long, of course, however, as it grows in water, it is thoroughly protected, and the stem is smooth, while, on the other hand, those specimens which live on land throw out certain hairs which terminate in sticky glands, and thus prevent small insects from creeping up to the flowers. In this case, therefore, the plant is not sticky, except just when this condition is useful.

All these viscous plants, as far as I know, have upright or horizontal flowers. On the other hand, where the same object is effected by slippery surfaces, the flowers are often pendulous; creeping creatures being thus kept out of them, just as the pendulous nests of the weaver bird are a protection from snakes and other enemies. As instances of this kind, I may mention the common snowdrop, or the Cyclamen.

I have elsewhere ventured to suggest that the so-called "sleep" of flowers had reference to the habits of insects, on the ground that flowers which are fertilised by night-flying insects would derive no advantage by being open in the day; while, on the other hand, those which are fertilised by bees would gain nothing by being open at night. I confess that I suggested this with much diffidence, but it may now, I think, be regarded as well established.

Silene nutans, the Nottingham catchfly, is a very instructive species from this point of view, and indeed illustrates a number of interesting points in the relations between plants and insects. Its life history has recently been well described by Kerner. The upper part of the flowering stem is viscid, from which it has derived its local name, the Nottingham catchfly. This prevents the access of ants and other small creeping insects. Each flower lasts three days, or rather three nights. The stamens are ten in number, arranged in two sets, the one set standing in front of the sepals, the other in front of the petals. Like other night flowers, it is white, and opens towards evening, when it also becomes extremely fragrant. The first evening, towards dusk, the stamens in front of the sepals grow very rapidly for about two hours, so that they emerge from the flower; the pollen ripens, and is exposed by the bursting of the anther. So the flower remains through the night, very attractive to and much visited by moths.

Towards three in the morning the scent ceases, the anthers begin to shrivel up or drop off, the filaments turn themselves outwards, so as to be out of the way, while the petals, on the contrary, begin to roll themselves up, so that by daylight they close the aperture of the flower, and present only their brownish-green undersides to view, which, moreover, are thrown into numerous wrinkles. Thus, by the morning's light, the flower has all the appearance of being faded. It has no smell, and the honey is covered over by the petals. So it remains all day. Towards evening, however, everything is changed. The petals unfold themselves, by eight o'clock the flower is as fragrant as before, the second set of stamens have rapidly grown, their anthers are open, and the pollen again exposed. By morning the plant is again asleep, the anthers are shrivelled, the scent has ceased, and the petals rolled up as before. The third evening again the same process, but this time it is the pistil which grows, and the long spiral stigmas on the third evening take the position which on the previous two had been occupied by the anthers, and can hardly fail to be dusted by the moths with pollen brought from another flower.

An objection to the view that the sleep of flowers is regulated by the visits of insects, might be derived from the cases of those flowers which close early in the day, the well-known *Tragopogon pratense*, or "John Go-to-bed at Noon," for instance; still more, such species as *Lapsana communis*, or *Crepis pulchra*, which open before six and close again before ten in the morning. Bees, however, are very early risers, while ants come out much later, when the dew is off the grass; so that it might well be an advantage to a flower which was quite unprotected to open early for the bees, and close again before the ants were out, thus preserving its honey for another day.

So much for the first part of my subject. I must now pass to the second—the action of plants on insects. It would here, perhaps, be most natural to discuss the modifications which have been produced in insects by the search after honey and pollen, especially the gradual lengthening of the proboscis in butterflies, moths, and bees, to enable them to suck the honey, and the adaptation of the legs of bees to enable them to carry off the more or less dry and dusty pollen. Having, however, already treated of them elsewhere, it will be better for me to take other illustrations, and fortunately there is no lack or difficulty.

Many of the cases in which certain insects escape danger by their similarity to plants are well known; the leaf insect and the walking-stick insect are familiar and most remarkable cases.

The larvæ of insects afford, also, many interesting examples.

I will not, however, refer to isolated cases—however interesting in themselves—on the present occasion, but will take a group and see how far we can explain its various colours and markings, and what are the lessons which they teach us. For this purpose I think I cannot do better than select the larvæ of the *Sphingidæ*, which has just been the subject of a masterly monograph by Dr. Weissmann, the learned professor of Frieburg.

Let me ask you, then, to glance at the diagrams of caterpillars behind me. They are very different in colour—green, white, yellow, brown, sometimes even gaudy, varied with spots, patches, streaks, and lines. Now, are these merely casual and accidental, or have they a meaning and a purpose?

In many, perhaps in most cases, the markings serve for the purpose of concealment. When, indeed, we see caterpillars represented on a white sheet of paper, or if we put them on a plain table, and focus the eye on them, the colours and markings would seem, if possible, to render them even more conspicuous, as, for instance, in this diagram of *D. galii*; but amongst the intricate lines and varied colours of foliage and flowers, and if the insect is a little out of focus, the effect is very different.

Let us begin with the *Chœrocampa elpenor*, the elephant hawk moth. The caterpillars, as represented in most entomological works, are of two varieties, most of them brown, but some green, Both have a white line on the three first segments; two remarkable eye-like spots* on the fourth and fifth, a very faint median line, and another more than four inches long. I will direct your attention specially, for the moment, to three points:—What mean the eye-spots and the faint lateral line; and why are some green and some brown, offering thus such a marked contrast to the leaves of the *Epilobium parvum*, on which they feed? Other questions will suggest themselves later, for I must now call your attention to the fact that, when they first quit the egg, and come into the world, they are quite different in appearance, being, like so many other small caterpillars, bright green, and almost exactly the colour of the leaves on which they feed. That this colour is not a necessary or direct consequence of the food, we see from the case of quadrupeds, which, as I need not say, are never green. It is, however, so obviously a protection to them, that the explanation of the green colour of small caterpillars suggests itself to everyone. After five or six days, and when they are about $\frac{1}{4}$-inch in length, they go through their first moult. In their second stage they have a white subdorsal line stretching along the body, from the horn to the head; and after a few days, but not at first, traces of the eye-spots appear on the fourth and fifth segments. There is also a second pale line running along the side. Please remark these two lines. After another five or six days, and when about $\frac{1}{2}$-inch in length, our caterpillars moult again. In their third stage, the commencement of the eye-spots is more marked, while, on the contrary, the lower longitudinal line has disappeared. After another moult, the eye-spots are still more distinct, the white gradually becomes surrounded by a black line, while the centre becomes somewhat violet. The subdorsal line has almost, or entirely, disappeared, and in some specimens faint diagonal lines make their appearance. Some few assume a brownish tint, but not many. A fourth moult takes place in seven or eight days, and when the caterpillars are about an inch and a half in length. Now, the difference shows itself still more between the two varieties, some remaining green, while the majority become brown. The eye-spots are more marked and the

* The shaded portions, which replace the eye-spots on the other segments, are an instance of the general rule that a character which appears on every two segments, has a tendency to develop itself on every other segment.

pupil more distinct, the diagonal lines plainer, while the subdorsal line is only indicated on the first three and the eleventh segments. The last stage has been already described.

Now, the principal points to which I desire to draw your attention are (1) the green colour, (2) the longitudinal lines, (3) the diagonal lines, (4), the brown colour, and (5) the eye-spots. There are, however, some other very instructive points to which I should like to draw your attention presently, because they throw much light on this group of insects.

But to return to my five points. As regards the first—the green colour—I think I need say no more. The value to the young insect, the protection it affords, is obvious. We must all have observed how difficult it is to distinguish small green caterpillars from the leaves on which they feed. When, however, they become somewhat larger their form betrays them, and it is important that there should be certain marks to direct the eye from the outlines of the body. This is effected, and much protection given, by longitudinal lines, such as those occurring in the second stage of our larvæ. These lines, both in colour and thickness, much resemble some of the lines on leaves (especially those, for instance, of grasses), and also the streaks of shadow which occur among foliage. If, however, this is the explanation of them, then they ought to be wanting, as a general rule, in very small caterpillars, and to prevail most among those which feed on, or among grasses. Now, similar lines occur on a great number of caterpillars belonging to most different groups of butterflies and moths, as you may see by turning over the illustrations of any monograph of the lepidoptera. We have seen that they exist among the hawk moths, as, for instance, in *Ch. Elpenor;* they occur in many butterflies, as, for instance, in *Arge galathea*, which feeds on the cat's-tail grass; and among moths, as, for instance, in *Pyrophila tragopoginis*, which feeds on the leaves of the "John go-to-bed at Noon" (*Tragopogon*). Now you will find that the smallest caterpillars rarely possess these white streaks. As regards the second point also, the streaks are generally wanting in caterpillars which feed on large-leaved plants. The *Satyridæ*, on the contrary, all possess them, and all live on grass. In fact we may say, as a general rule, that these longitudinal streaks only occur on caterpillars which live on or among narrow-leaved plants. We have seen that in a later stage these lines disappear on certain segments, and are replaced by diagonal lines. In this particular species these diagonal lines are faint, but in a great many other caterpillars belonging to the most distinct families of butterflies and moths, they are conspicuous and no doubt important. Now these diagonal lines come off just at the angle of the ribs of leaves, and resemble them very much in general effect. They occur also especially in species which feed on large-leaved plants, and I believe I may say that though a great many species of caterpillars present these lines, they are rarely if ever present in species which live on grass. In this diagram are represented three of such caterpillars, one belonging to each of the three great divisions of lepidoptera, namely, that of the purple emperor (*Apetura iris*) which feeds on the oak, as representing the butterflies; that of the privet hawk-moth; and lastly, that of a moth, the Kentish glory (*Endromis versicolor*), which feed on larged-leaved plants, and I believe I may say that, though very frequent, they rarely occur in species which live on grass. It might at first be objected to the view that there are many cases, as indeed in our elephant hawk-moth, in which caterpillars have both. A little consideration however will explain this. In small caterpillars these oblique lines would be useless, because they must have some relation, not only in colour, but in their distances apart, to the ribs of the leaves. Hence, while there are a great many species which have longitudinal lines when young, and diagonal ones when they are older and larger, there is not, I believe, a single one which begins with diagonal lines and then replaces them with longitudinal ones. You will also observe that the longitudinal lines still remain in our caterpillar on those segments which have no diagonal ones. This also often occurs, and it is striking where the lines are marked. This is also an advantage, because white lines crossing one another at such an angle have no relation to anything which occurs in plants, and would make the creature more conspicuous. It is an advantage therefore that when the diagonal lines are developed, the longitudinal ones should disappear. There is one other point in connection with these diagonal lines to which I must call your attention. In our species they are white, but in some cases, as for instance in the beautiful green caterpillar of the privet hawk-moth, the white streak is accompanied by a coloured one—in that case lilac. At first we might think that this would be a disadvantage, as tending to make the caterpillar more conspicuous; and in fact if we put one in full view out, for instance, on a table, the coloured lines are very striking. But we must remember that the habit of the insect is to sit on the inside of the leaf, generally near the midrib, and in the subdued light of such a situation the coloured lines beautifully simulate a line of soft shadow, such as must always accompany a strong rib, and I need not tell any artist that the shadows of yellowish green must be purplish. Moreover any one who has ever found one of these large caterpillars, will, I am sure, agree with me that it is surprising, when we consider their size and conspicuous colouring, how difficult they are to see.

The next point is the colour of the mature caterpillars. We have seen that some are green and others brown; and the green ones are obviously merely those which have retained their original colour.

Now for the brown colour. It is evident that this makes the caterpillar even more conspicuous among the green leaves than would otherwise be the case. Let us see then whether the habits of the insects will throw any light upon the riddle. What would you do if you were a big caterpillar? Why, like most other defenceless creatures, you would feed by night and lie concealed by day. So do these caterpillars. When the morning light comes they creep down the stem of the food plant, and lie concealed among the thick herbage and dry sticks and leaves near the ground, and it is obvious that under such circumstances the brown colour really becomes a protection. It might indeed be said that the caterpillars having become brown, concealed themselves on the ground; that in fact we were reversing the state of things. But

this is not so, because while we may say, as a general rule, that (with some exceptions due to obvious causes) large caterpillars feed by night and lie concealed by day, it is by no means always the case that they are brown, some of them still retaining the green colour. We may then conclude that the habit of concealing themselves by day came first, and that the brown colour is a later adaptation. It is, moreover, interesting that while the caterpillars which live on plants often go down to the ground and turn brown, those which feed on large trees or plants remain on the underside of the leaves, and retain their green colour.

Thus, in *Smerinthus ocellatus*, which feeds on the willow and sallow; *S. populi*, which feeds on the poplar; and *S. tiliæ*, which frequents the lime, the caterpillars all remain green; while in the convolvulus hawkmoth, which frequents the convolvulus, *Chærocampa nerii*, which feeds in this country on the periwinkle; *Chærocampa celeris*, *Ch. elpenor*, and *Ch. porcellus*, which feed on galium, most of the caterpillars turn brown.

There are, indeed, some caterpillars which are brown, and yet do not go down to the ground, as for instance, those of *Aspilatis aspersaria*, and indeed of the *geometridæ* generally. These caterpillars. however, place themselves in peculiar attitudes, which, combined with their brown colour, make them look almost exactly like bits of stick or dead twigs.

The last of the five points to which I called your attention was the eye-spots. In some cases spots may serve for concealment, by resembling the marks on dead leaves. In *Deilephila hippophaæ*, which feeds on the hippophae, or sea buckthorn, a very grey-green plant; the caterpillar, also, is a very similar grey-green, and has, when full grown, a single red spot on each side, which, as Weissmann suggests, at first sight much resembles in colour and size one of the berries of hippophae, which, moreover, are present, though not ripe, at the same period of the year. Again, in *Chærocampa tersa*, there is an eye-spot on each segment, which mimics the flower of the plant on which it feeds (*Spermacoce hyssopifolia*). White spots, in some cases, also resemble the spots of light which penetrate foliage. In other cases, however, and at any rate in our elephant hawk-moth, the eye-spots certainly render the insect more conspicuous. Now in some cases, as Wallace has pointed out, this is an advantage rather than a drawback. Suppose that from the nature of its food, or any other cause, as for instance from being covered with hair, a small green caterpillar was very bitter, or in any way disagreeable or dangerous as food, still in the number of small green caterpillars which birds love, it would be continually swallowed by mistake. If on the other hand it had a conspicuous and peculiar colour, its evil taste would serve to protect it, because the birds would soon recognise and avoid it, as Weir and others have proved experimentally. We have a striking case of this among the hawk-moths in *Deilephila euphorbiæ*, which feeding on the Euphorbia with its bitter milky juice, is very distasteful to birds, and is thus actually protected by its bold and striking colours. The spots on our elephant hawkmoth caterpillar do not admit of this explanation, because the insect is quite good to eat, I mean for birds; we must, therefore, if possible, account for them in some other way. There can, however, I think be little doubt that Weissmann is right when he suggests that they actually protect the caterpillar by frightening its foes.

Everyone must have observed that these large caterpillars have a sort of uncanny, poisonous appearance; that they suggest a small thick snake or other evil beast, and the eyes do much to increase the deception. Moreover, the segment on which they are placed is swollen, and the insect when in danger has the habit of retracting its head and front segments, which gives it an additional resemblance to some small reptile. That small birds are, as a matter of fact, afraid of these caterpillars (which, however, I need not say are in reality altogether harmless) Weissmann has proved by actual experiment. He put a caterpillar in a tray in which he was accustomed to place seed for birds. Soon a little flock of sparrows and other small birds assembled to feed as usual. One of them lit on the edge of this tray, and was just going to hop in, when she spied the caterpillar. Immediately, she began bobbing her head up and down, but was afraid to go nearer. Another joined her, and then another, until at last there was a little company of ten or twelve birds, all looking on in astonishment, but not one ventured into the tray, while one which lit in it unsuspectingly, beat a hasty retreat in evident alarm as soon as she perceived the caterpillar. After watching for some time, Weissmann removed the caterpillar, when the birds soon attacked the seeds.

Other caterpillars also probably, of nearly allied species, are protected by their curious resemblance to spotted snakes.

There are many—very many—other points connected with the colouring of sphinx caterpillars, to which I might refer if time permitted. I will only allude to two. The peculiar hues of the death's-head hawk-moth caterpillar, which feeds on the potato, and unites so beautifully the brown of the earth, the yellow and green of the leaves, and the blue of the flowers, that, in spite of its size, it can scarcely be perceived unless the eye be focussed exactly upon it. The other is the anceryx. The caterpillars of this genus differ in style of colouring from all other sphinx larvæ, having longitudinal bands of brown and green. Why is this? Their *habitat* is different. They feed on the leaves of the pinaster, and their peculiar colouring offers a general similarity to the brown twigs and narrow green leaves of a conifer. There are not many species of lepidoptera which feed on the pine, but there are a few, and I have here diagrams of two, *Achatia spreta* and *Dendrobinus pini*, both of which, as you will see, have a very analogous style of colouring, while the latter has also tufts of blueish green hair which singularly mimic the leaves of the pine. I have added also the larvæ of a species of saw-fly (one of the hymenoptera), which also attacks the pine, and you will see that here also the colouring is curiously similar (*Lophyrus socia*).

But, as Wiessmann points out, we may learn another very interesting lesson from these caterpillars. They leave the egg, as we have seen, a plain green, like so many other caterpillars, and gradually acquire a succession of markings, the

utility of which I have just attempted to explain. The young larva, in fact, represents an old form, and the species in the lapse of ages has gone through the stage which each individual now passes through in a few weeks. Thus the caterpillar of *Chœrocampa porcellus*, the small elephant hawk-moth, a species very nearly allied to *Ch. elpenor*, passes through almost exactly the same stages as that of *Ch. elpenor*. But it leaves the egg with a subdorsal line. No one can doubt, however, that there was a time when the new-born caterpillars of *Ch. porcellus* were plain green, like those of *Ch. elpenor*. In this respect, then, *Ch. porcellus* is a newer specific form than *Ch. elpenor*. Again, if we compare the mature caterpillars of *Chœrocampa* we shall find that there are some forms, such as *Ch. myron* and *Ch. chœrilus* which never develop eye-spots, but correspond to the second stage of *Ch. elpenor*. Here then we seem to have a species still in the stage which *Ch. elpenor* must have passed through long ago.

The genus Deilephila, of which we have in England three species—the euphorbia hawk-moth, the galium hawk-moth, and the rayed hawk-moth, is also very instructive. The caterpillar of the euphorbia hawk-moth begins life of a clear green colour, without a trace of the subsequent markings. After the first moult, however, it has a number of black patches, a white line, and a series of white dots, and has, therefore, at one bound, acquired characters, which in *Ch. elpenor*, as we have seen, were only very gradually assumed. In the third stage the line has disappeared, leaving the white spots. In the fourth the caterpillars have become very variable, but are generally much darker than before, and have a number of white dots under the spots. In the fifth stage there is a second row of white spots under the first. The caterpillars not being good to eat, there is, as has been already pointed out, no need for, nor attempt at, concealment. Now, if we compare the mature caterpillars of other species of the genus, we shall find that they represent phases in the development of *D. euphorbiæ*. *D. hippophae*, for instance, even when full grown, is a plain green, with only a trace of the line, and corresponds, therefore, with a very early stage of *D. euphorbiæ; D. zygophylli*, of South Russia, has the line, and represents the second stage of *D. euphorbiæ;* another Deiliphila has the line and row of spots, and the third stage; lastly, *D. vespertilio* and *D. galii* have progressed further, and lost the longitudinal line, but they never acquire the second row of spots which characterise the last stage of *D. euphorbiæ*.

The larvæ of insects teach us, indeed, many instructive lessons. It would be a great mistake to regard them as merely preparatory stages in the development of the perfect insect. They are much more than this, for the external circumstances act on the larvæ as well as on the perfect insect, and both, therefore, are liable to adaptation. In fact, the modifications which insect larvæ undergo may be divided into two kinds—developmental, or those which tend to approximation to the mature form; and adaptational or adaptive—those which tend to suit it to its own mode of life.

It is a remarkable fact, and except on those principles with which the name of our great countryman, Mr. Darwin, are justly united, I do not see how it can be accounted for, that the forms of larvæ do not depend on that of the mature insect. In these diagrams, for instance, are represented some very similar larvæ, and the very dissimilar perfect forms which they ultimately assume. In other cases similar, or comparatively similar, perfect insects have very dissimilar larvæ. Indeed, a classification of insects founded on larvæ would be quite different from that founded on the perfect insects. The *Hymenoptera*, for instance, which, so far as the perfect insects are concerned, form a very homogeneous group, would be divided into two—or rather one portion of them, namely, the saw-flies, would be united to the butterflies and moths. Now, why do the larvæ of saw-flies differ from those of other *Hymenoptera* and resemble those of butterflies and moths? It is because their habits differ from those of other *Hymenoptera*, and they feed on leaves like ordinary caterpillars.

From this point of view the transformations of the genus Sitaris, which has been very carefully investigated by M. Fabre, are peculiarly interesting.

The genus Sitaris (a small beetle allied to *Cantharis*, the blister-fly, and to the oil-beetle) is parasitic to a kind of bee (*Anthophora*) which excavates subterranean galleries, each leading to a cell. The eggs of the sitaris, which are deposited at the entrance of the galleries, are hatched at the end of September or beginning of October, and M. Fabre not unnaturally expected that the young larvæ, which are active little creatures with six serviceable legs would at once eat their way into the cells of the anthophora. No such thing: till the month of April following they remain without leaving their birthplace, and consequently without food; nor do they in this long time change either in form or size. M. Fabre ascertained this, not only by examining the burrow of the anthophoras, but also by direct observations of some young larvæ kept in captivity. In April, however, his captives at last awoke from their long lethargy, and hurried anxiously about their prisons. Naturally inferring that they were in search of food, M. Fabre supposed that this would consist either of the larvæ or pupæ of the anthophora, or of the honey with which it stores its cell. All three were tried without success. The first two were neglected, and the larvæ, when placed on the latter, either hurried away or perished in the attempt, being evidently unable to deal with the sticky substance. M. Fabre was in despair: "Jamais expérience," he says, "n'a éprouvé pareille déconfiture. Larves, nymphes, cellules, miel, je vous ai tous offert; que voulez-vous, donc, bestioles maudites?" The first ray of light came to him from our countryman, Newport, who ascertained that a small parasite found by Léon Dufour on one of the wild bees, was, in fact, the larva of the oil beetle. The larvæ of sitaris much resembled Dufour's larvæ; acting on this hint M. Fabre examined many specimens of anthophora, and found on them at last the larvæ of his sitaris. The males of anthophora emerge from the the pupæ sooner than the females, and M. Fabre ascertained that, as they come out of their galleries, the little sitaris larvæ fasten upon them. Not, however, for long: instinct teaches

them that they are not yet in the straight paths of development; and, watching their opportunity, they pass from the male to the female bee. Guided by these indications, M. Fabre examined several cells of the anthophora; in some, the egg of the anthophora floated by itself on the surface of the honey, in others, on the egg as on a raft, sat the still more minute larva of the sitaris. The mystery was solved. At the moment when the egg is laid the sitaris larvæ springs upon it. Even while the poor mother is carefully fastening up her cell, her mortal enemy is beginning to devour her offspring; for the egg of the anthophora serves not only as a raft, but as a repast. The honey which is enough for either, would be too little for both; and the sitaris, therefore, at its first meal, relieves itself from its only rival. After eight days the egg is consumed, and on the empty shell the sitaris undergoes its first transformation, and makes its appearance in a very different form.

The honey, which was fatal before, is now necessary, the activity, which before was necessary, is now useless; consequently, with the change of skin, the active, slim larvæ changes into a white, fleshy grub, so organised as to float on the surface of the honey, with the mouth beneath and the spiracles above the surface: "grâce à l'embonpoint du ventre," says M. Fabre, "la larve est à l'abre de l'asphyxie." In this state it remains until the honey is consumed; then the animal contracts, and detaches itself from its skin, within which the further transformations take place. In the next stage, which M. Fabre calls the pseudo-chrysalis, the larva has a solid corneous envelope and an oval shape, and in its colour, consistency, and immobility reminds one of a *Dipterous pupa*. The time passed in this condition varies much. When it has elapsed the animal moulds again, again changes its form; after this it becomes a pupa, without any remarkable peculiarities. Finally, after these wonderful changes and adventures, in the month of August the perfect sitaris makes its appearance.

In fact, whenever in any group we find differences in form, or colour, we shall always find them associated with differences in habit.

To return, however, to my principal subject, the sphinx caterpillars. For such an enquiry as this, the larvæ of Lepidoptera are particularly suitable, because they live an exposed life; the different species even of the same genus often feed on different plants, and are therefore exposed to different conditions, and last, not least, because we know more about the larvæ of the Lepidoptera than of any other insects. The larvæ of ants all live in the wet; they are fed by the perfect ants, and being therefore all subject to very similar conditions are all very much alike. It would puzzle even a good naturalist to determine the species of an ant larva, while, as we all know, the caterpillars of butterflies and moths are as easy to distinguish as the butterflies and moths; they differ from one another as much as, sometimes more than the perfect insect.

There are five principal types of colouring among caterpillars. Those which live inside wood, or leaves, or underground, are generally of a uniform pale line; the small leaf-eating caterpillars are green, like the leaves on which they feed. The other three types may, *si parva licet componere magnis*, be compared with the three types of colouring among cats. There are the ground cats, such as the lion or puma, which are brownish or sand colour, like the open places they frequent. So also caterpillars which conceal themselves by day at the roots of their food-plant tend, as we have seen, even if originally green, to assume the colour of earth. The spotted or eyed cats, such as the leopard, live among trees; and their peculiar colouring renders them less conspicuous by mimicking spots of light which penetrate through foliage. Lastly, there are the jungle cats, of which the tiger is the typical species, and which have stripes, rendering them very difficult to see among the brown grass which they frequent. It may, perhaps, be said that this comparison fails, because the stripes of tigers are perpendicular, while those of caterpillars are either longitudinal or oblique. This, however, so far from constituting a real difference, confirms the explanation, because in each case the direction of the lines follows those of the foliage. The tiger, that walks horizontally on the ground, has transverse bars; the caterpillar, which clings to the grass in a vertical position, has longitudinal lines, while those which live on large veined leaves have oblique lines like the oblique ribs of the leaves.

Thus then, I think, we see reasons for many at any rate of the variations of colour and markings in caterpillars, which at first sight seem so fantastic and inexplicable. I should, however, produce an impression very different from that which I wish to convey, were I to lead you to suppose that all these varieties have been explained or are understood. Far from it, they still offer a large field for study; nevertheless I venture to think the evidence brought before you to-day, however imperfectly, is at least sufficient to justify the conclusion that there is not a hair, or a line, not a spot or a colour, for which there is not a reason, which has not a purpose and a function in the economy of Nature.

MISCELLANEOUS.

WATER SUPPLY OF THE METROPOLIS.

The following letter has been addressed to the Right Hon. Richard A. Cross, Secretary of State for the Home Department:—

Sir,—On behalf of the Executive Committee of the National Health Society, I am to crave your pardon for reminding you at this time of your promise made to a deputation of the society, that you would do your best to prepare a measure for the better supply of water to the metropolis, and to submit to you some suggestions and points of information therein.

Without dwelling on the grievous injuries and losses that have occurred from the delay in the realisation of the promise of the Premier to Colonel Beresford, of support to his excellent Bill, made before the change of government took place, I am to state that the society have derived much encouragement as to your disposition to promote remedial measures for the metropolis, by the fact of your having moved the extension of the inquiries of the grievances of some men of the Fire Brigade, to

the grievances of four millions of population in the insecurity of their lives and property from fire arising from the defective conditions of the distribution of water for its prompt extinction. Already has that inquiry elucidated evidence of the most important character. Our committee are further encouraged, by your recent expression, at Birmingham, of your admiration of the local administration of that and other municipal institutions,—because, as the committee are anxious to point out, you will find in the legislation and administration of that municipality, and of Glasgow, Manchester, Liverpool, and other municipalities, most important precedents in principle and working, for the primary measure now prayed for, of placing the entire water supplies of the metropolis under unity of responsible public management. You will find that in those cities, when the water supplies were taken out of the hands of trading companies, the change was effected without difficulty from the intermittent system which occasions the stagnant detention of water in butts and cisterns—which extensively makes good supplies bad and bad supplies worse—to the system of constant and direct delivery of water fresh and well aerated. You will also find from the evidence obtained under the extended inquiry you have initiated, as to the means for better protection of life and property from fire, that in Manchester, Liverpool, and in Glasgow, by the use of hydrants on the constant supply system, and by unity of public management under the police force, the use of horse or steam engines is now only required in some 3 or 4 per cent. of cases, thus diminishing proportionally the need of the brigade force (which here it has been proposed to augment, at a great expense), and occasioning a reduction by two-thirds there of the rates of losses of life and property by fire, and proving that all delay of relief to the metropolis is at the expense of at least two-thirds of the present ordinary losses, as also of proportionate dangers of extraordinary conflagrations. The attainment of a constant supply of water for that one object, is it to be understood, would be the attainment of a constant supply for the sanitary objects so pressingly needed.

For dealing with the sanitary condition of this metropolis by the use of hydrants, also for the improvement of its sanitary condition by surface cleansing, you may be commended to the example of the metropolis of France, where by the adoption of the measures recommended by the first general board of health in England, the distinction has been obtained for that metropolis of "clean-streeted Paris," a distinction in contrast with "filthy-streeted London." The same efficient method of cleaning has been adopted in the metropolis of Austria, and even the metropolis of Spain, and there can be no doubt, from such examples as reported by a special committee of the Society of Arts, "the time and expense of the surface cleaning of the streets may be reduced more than one-half, and injuries to roads and furniture and clothes, as well as excessive dirt on the person, and serious injuries to the health from breathing dust and pulverised dung dust, and its filth on the skin, and injuries to clothes and furniture in dry weather, and from the evaporation of liquefied dung in wet weather may be prevented, and the streets be kept in all weathers in the like states of cleanliness and freshness, to those experienced after the cleansing of heavy thunder-showers."

As to the expenses at which the changes requisite for sanitary purposes as well as for security may be effected, it has been put about by adverse interests, that large sums of money will have to be raised, and great expenses will have to be incurred which must be ultimately borne by the already heavily oppressed ratepayers.

It is on these allegations the committee solicit your especial attention, to the experience of the municipalities of Manchester, Birmingham, and others. And first, as to the expense of the change of system from the intermittent to the constant system of supply; instead of necessitating an entire change of the house fittings, and an expenditure of five or six pounds per house, or of several millions, it is shown in evidence, given before the Fire Brigade Committee, that at Manchester the change was effected at a cost of between ten and eleven shillings per house only, or at an expense, with some attendant economies it would achieve, it were economical to defray from the water-rates. The cost of the hydrants in use in Manchester, and elsewhere, are from a fourth to a third of the expense which has been assumed as an objection to the change.

Your particular attention is solicited to the evidence obtained from competent sources by a committee of the Society of Arts, in which you will see that by a consolidation of the eight separate water companies on a public footing, a saving may be made of upwards of £100,000 per annum, a sum which, if capitalised, will suffice to effect gratis the primary sanitary changes required, after making full compensation on accustomed terms to the directors, officers, and to the shareholders; which, the precedents I am to adduce will show, may be effected mainly by a financial change of securities. For if you will consult the recent experience in this matter of the last municipality you visited and expressed your admiration of what it was doing—Birmingham—you will find that in taking the supply out of the hands of the trading companies and placing it on a public footing, as has recently been done there, not one penny of money need be borrowed, but only the financial change effected, as it was done there, and has been done in many other cities, of giving the shareholders a public security for their dividends, from which they will, without any cost whatever to the ratepayers, obtain a large and important addition to the saleable value of their shares.

It is proper to observe that the chief obstruction to the change of system, recommended by commission after commission, as requisite for the sanitary improvement of the metropolis, has arisen from the office-bearers, directors, and law officers, deriving emoluments from law and parliamentary expenses. Of the foremost in opposition have been those of the New River Company. There have recently been public sales of shares in this company, when the auctioneer dilated on their great value as a permanent investment, especially from the powerful interest there was in Parliament for the support of the property. In June last, on sale, what are called new shares of £100 each, on which £60 had been paid, fetched £285 to £295 each. At another sale, on the 1st ultimo, twenty-nine of the £100 new shares, in what was descanted on as "this most flourishing and successful trading corporation in the world," on which £70 had been paid, and on which the dividend and proportion of rental at Midsummer last was at the rate of £10 3s. 1d. per cent. per annum, were all sold at £310 and £315 per share. It is proper to state that a proportion of these shares is in real property belonging to the company, but it is to be observed that it was not that proportion on which parliamentary influence was, as it were, put up as part of the saleable value. It was stated in the particulars of sale that the income of the company "has never retrograded, and it must continually advance, as the company has the monopoly of the water-supply over a large area, including the City of London and the northern districts of the metropolis, where building speculations are proceeding rapidly."

I am to beg your particular attention to the report of the River Pollution Commissioners, on the quality of the supply of water in which a monopoly is thus claimed. The Commissioners state, in their sixth report, that, "the New River Company supplies 20 to 22 millions of gallons daily to 104,637 houses and about 675,000 people, including in that number 2,000 meter supplies, about 5,000,000 gallons daily, is to trade and manufacturers, the remaining 16,000,000 being for domestic purposes. The whole of this enormous quantity of water is taken

from the Lee at Ponder's End." The Commissioners show that the water at the intake at Walthamstow "is charged to a high degree with previous sewage contamination."

The Commissioners further state, "that sewage and other disgusting matters reach the intake of the metropolitan water companies drawing from the River Lee, and that the soluble portions of such matters are not wholly eliminated by the efficient filtration to which the water is subjected before delivery; that the water of the Lee, though less impure than that of the Thames, is slowly though irregularly deteriorating from year to year, and that there is no hope of effectually purifying it to such an extent as to render it at all times safe for domestic use."

After showing the increase of organic impurity from year to year they conclude, "That the Lee should, therefore, be abandoned as a source of potable water; but that this measure is not so urgent as the relinquishment of the Thames water."

If you could yourself see the way in which the water of the quality stated by the Commissioners is delivered and kept stagnant in water-butts for the lower classes, as described in a report by Dr. Sutton, the medical officer of Shoreditch, you would see how the bad supplies are made worse, and why water, as a rule, is not drunk by them, and how drinking habits are induced and confirmed amongst them.

At a recent meeting of the Common Council, the chairman of a committee for examining the condition of the Mansion House, stated that "when the members of his committee and himself were discharging the duty which devolved annually on the committee, they found three-quarters of an inch of fungi-scrub floating on the top of the largest cisterns in the Mansion House, and which supplied all the other cisterns used for domestic purposes in the establishment. Moreover at the bottom of the same cistern there were three-eighths of an inch of mud, and in a bottle of water placed on the Lord Mayor's table could be seen hundreds of nematoid worms." He added "that Dr. Saunders, the medical officer of health, was so struck with the condition of the particular cistern referred to, that he would not allow his inspector to touch or look into it until two other witnesses were brought to look at it." Whether the impurities described were due in any degree to the original impurities of the water at the company's intake, as described by the River Pollution Commissioners, or to the effects of stagnant detention in cisterns, which the constant system would abolish with all care for cisternage, it were unnecessary to ask. The Government have now the supervision, and it is to be hoped will shortly have the direct charge of the county and the borough prisons. The county prisons yield instances of the best known sanitation, by which their criminal populations have an almost entire immunity from the ravages of epidemic and preventable disease; an immunity which, by the exercise of the like care and sympathy, it is hoped may ultimately be obtained for the honest and industrious population of this country. As showing what may be done by the improvement of the water-supplies, particular attention is solicited to the following extract from the last published report of the medical officer of Millbank prison, displaying the improvement made in the health of the prisoners, by such a change of the sewage-tainted river supplies (that have been condemned by the River Pollution Commissioners) to spring sources, as it is hoped by your promised measure may be gained for the general population of the metropolis.

"The prison," he says, "continues to be almost free from diseases of the miasmatic order, and this is equivalent to stating that diarrhœa and dysentery, small-pox and erysipelas, typhus and typhoid fever, are all but extinct as causes of mortality. With regard to the mortality from typhoid or enteric fever, the contrast between the ten years 1845-54 and the four following years, is very remarkable. During the first period there were fifty seven deaths from that disease; during the second only three. The improvement supply, which was effected in August, 1854, explains the great difference, and constitutes the separating line between the two periods. Prior to that date, the prison had been supplied with Thames water, pumped from the river immediately opposite the gates, and afterwards filtered. This supply was cut off, and water from the artesian well in Trafalgar-square took its place, with immediate benefit to the health of the inmates of the prison, and a large reduction in the rate of sickness and mortality. Fifteen years have now elapsed since a case of typhoid fever originated here, and it may therefore be said that in this prison the disease is extinct. Millbank, however, by no means stands alone among the government prisons in this respect. An enviable security is enjoyed, but it is not monopolised. On looking through the annual medical statistics of these prisons for the twenty years 1855-74, I find only eight deaths are ascribed to enteric fever, or 40 per annum in a population, male and female, averaging 7,013. During the five years, 1870-4, only two deaths were caused by the disease in an average population of 9,509. If the sanitary securities enjoyed by the inmates of the convict prisons could be extended to the general population of the country, many thousands of lives would every year be saved."

In all prisons great care is taken of the water-supplies, for it is found that accidental pollutions of them are attended by marked disturbance of the health of the inmates. Subjoined is an account, by a distinguished physician, of the state of the river supply on the south of the Thames.

"1. I pay £10 a-year for water-rate.

"2. I have never had a drop of water for it fit to drink, and as filtration cannot remove the soluble transparent foul matter in it I boil all my drinking water, or else buy it as aerated water.

"3. The foulness shows itself in the following manner:

"(*a*) Unless the house cisterns are frequently cleansed, which of course adds to the water-rate, it would be unsafe to use the water for culinary purposes.

"(*b*) This condition of the water shows itself by distinct putrescence in all the water whether boiled or not, if only it be allowed to stand in a jug or bottle for a certain number of days, and in a moderate house temperature. It is sensible to smell by a strong sewer odour, and to taste as putrid.

"(*c*) The result may be to a certain extent prevented by continued care in scalding and cleansing bottles and jugs, precautions which never should be necessary.

"(*d*) You know all about Dr. Hassel's microscopic investigations, but now-a-days I do not require to use his subsidence vessels.

"After getting your note I had a microscope at hand, and took a drop of water from a water-bottle filled eight hours before, with a clean glass rod, and under the microscope it contained hundreds of paramecia.

"Some time ago I did the same in order to obtain a drop of water for an immersion microscopic lens. But instead of seeing the object under it, I found the water-disk crowded with paramecia, and with numerous specimens of euglenias and bacteroids, the last denoting putridity. I had all the cisterns and water-vessels in the house cleansed in consequence.

"The filtration humbug is played out. The source must be pure and no filtration needed. It does no real good."

It may be proper to call your attention to the manner in which the exceptional functions charged upon the Government as respects the metropolis of the examination of the companies supplies, and of an audit of their expenditure, and of their charges, upon the consumers. It would appear, however, to follow from the enactments for the exercise of those functions, that the position of the companies is that of responsible contractors, as to the qualities and prices of their supplies, instead of their

being practically irresponsible monopolists, as the recited unqualified conditions of sale would lead to be supposed.

Your attention is earnestly solicited to our municipal experience, as aiding to an important extent to the solution of the sanitary and economical questions in issue for the improvement of the supplies of water to the metropolis.

The sanitary engineers in the Government service, who are conversant with the subject of the water-supply of the metropolis, will inform you that probably one-half of it is on the intermittent system pumped in to waste. The evil is not alone the waste of money or the mere waste of water, but is in its permeation through bad sewers and permeable drains, foul and tainted water, to the creation of "excrement-sodden," and marshy conditions of the sites of the ill-drained lower districts.

The Manchester municipality on getting possession of the waterworks and changing the system of the supply from the intermittent to the constant system, effected a most important reduction of the like previous waste of water. The rate of supply had been 33 gallons per head of the population, the same as it is now in London, and with such care as a public authority may take it was brought down to 20 gallons per head per diem. In Liverpool a similar or even a greater reduction has been reported to have been effected on the constant system. In those cities, the proportion of large consumers for manufacturing and other purposes, is reported to be greater than in the metropolis, and here, therefore, the saving may, under competent management, be expected to be greater or to the extent of about one-half; but taking the reduction to be the same as in Manchester, from thirty-three to twenty gallons per head of the population, that on the daily quantity last pumped into the metropolis of upwards of 117,000,000 gallons, would effect a saving of some 40,000,000 per diem of water pumped to pernicious waste, that is to say, a waste of nearly double the quantity supplied by the New River Company, which might all be dispensed with, or the greater proportion of the water derived from the more sewer polluted source of the Thames for pure sources.

Finally, your attention is earnestly besought to the great precedents of what has been achieved in the matter by the several municipal governments for the benefit of their several populations, which may serve for the achievement of the like relief for the population of the metropolis. You have for your aid the counsel of sanitary officers, and for your guidance the results of the careful inquiries in the recommendations of commision after commission of inquiry; and you have, moreover, a measure founded upon them, brought in by Colonel Beresford, and supported by Sir Charles Russell, Captain Ritchie, Mr. Forsyth, and Mr. Gordon, which may probably be improved by your serious practical attention to it. But your beneficient intervention is especially besought with the right hon. and hon. members, the shareholders of the New River Company, and others, to consider fairly the municipal precedents as to compensation, and whether such terms as those which the shareholders of the Birmingham Trading Water Company deemed acceptable for the sale of their property to the municipality, or the terms sanctioned by Parliament in other the like instances, are not such as the shareholders may be fairly invited and called upon to accept as equitable and even liberal—whether the conclusions of expensive inquiries by competent and impartial Commissioners and officers ought to be further set aside, and relief delayed, for the sake of a further increase of the dividends of the trading companies at the expense of the health and the security of life and property of 4,000,000 of the population.

I have the honour to be, Sir,
Your humble servant,
FAY LANKESTER.
Secretary to the National Health Society.

CORRESPONDENCE.

MR. BARFF'S PAPER.

As some of the remarks I made at the conclusion of my paper on the prevention of corrosion in iron were not fully reported in the *Journal*, I should be glad to be allowed to repeat now what I then said.

Some time ago a notice of my invention appeared in several papers, when it was stated that I was of the London University; in consequence of this several letters were sent to me to that institution, and gave its officers some trouble in forwarding them to me. I do not belong to the London University; I am a member of the University of Cambridge, and all the early experiments which gavo rise to this invention were performed in the laboratory of this college. All the specimens exhibited on Wednesday evening were treated at another place, where I had suitable furnaces built by my friend Mr. Hugh Smith, to whose able assistance I am much indebted. I think it right to state that Mr. Stephen Williams, who is now scientific adviser to Mr. Griffiths, worked with me in my investigations into the zinc paint, and also in my experiments on iron.

FREDERICK BARFF.
Catholic University College, Kensington, W.,
February 20th, 1877.

NOTICES.

PROCEEDINGS OF THE SOCIETY.

ORDINARY MEETINGS.

Wednesday evenings, at 8 o'clock. The following arrangements have been made:—

FEBRUARY 28.—"Middle Class Education in Holland,' by JOHN YEATS, Esq., LL.D., F.R.G.S. The Rev. MARK PATTISON, D.D., Rector of Lincoln College, will preside.

MARCH 7.—Lecture on "The Growth and Present Position of the Science of Mechanics," by Professor A. B. W. KENNEDY, C.E.

MARCH 14.—"The Treatment of Town Refuse and Sewage," by Prof. ANSTED, F.R.S.

MARCH 21.—Lecture on "Vital Air," by Dr. W. B. RICHARDSON, F.R.S.

AFRICAN SECTION.

Tuesday evenings, at 8 o'clock. The following arrangements have been made:—

MARCH 13.——"Our Commercial Relations with West Africa, and their Effects upon Civilisation," by JAMES IRVINE, Esq., of Liverpool.

APRIL 10.—"The Social State and Prospects of the South African Communities," by ROBERT RICHARDS, Esq., of Grahamstown.

APRIL 24.—"The Trade and Resources of Morocco," by Dr. ARTHUR LEARED.

INDIAN SECTION.

Friday evenings, at 8 o'clock. The following arrangements have been made:—

MARCH 2.—"The Progress of Trade in Central Asia," by Sir T. DOUGLAS FORSYTH, C.B., K.C.S.I. Sir RUTHERFORD ALCOCK, K.C.B., will preside.

MARCH 16.—"The Native Indian Press," by Dr. GEORGE BIRDWOOD, C.S.I. ANDREW CASSELS, Esq., will preside.

APRIL 20.—"The Existing and Possible Commercial Communications between Persia and India," by Major-General Sir FREDERICK JOHN GOLDSMID, C.B., K.C.S.I.

MAY 4.—"Thaumato-dendra, or the Wonders of Trees," with illustrations from life, by WM. TAYLER, Esq.

CHEMICAL SECTION.

Thursday evenings, at 8 o'clock. The following arrangements have been made:—

MARCH 8.—"The Sizing of Cotton Goods," by W. THOMPSON, Esq., F.C.S., of Manchester.

APRIL 12.—"The Cinchona Alkaloids; their Sources, Production, and Use," by Dr. B. H. PAUL.

APRIL 26.—"Phosphor-Bronze and its Applications," by ALEXANDER DICK, Esq.

MAY 10.—"A New Process for the Production of Carbonate and Caustic Soap, without the Formation of any Noxious Waste and the Recovery of the Sulphur," by GEORGE E. DAVIS, Esq.

SCIENCE LECTURES.

These will be given on the following Wednesday evenings, in place of the usual paper and discussion. The rules for admission will be the same as for the Cantor Lectures. Each member can admit ONE friend by giving the usual order from the book supplied at the commencement of the Session:—

MARCH 7.—Professor A. B. W. KENNEDY, C.E., "The Growth and Present Position of the Science of Mechanics."

MARCH 21.—Dr. B. W. RICHARDSON, F.R.S., "Vital Air."

APRIL 18.—E. J. REED, C.B., M.P., F.R.S., "The Modifications which Ships of War have Undergone during the last 20 Years."

MAY 2.—J. BAILLIE HAMILTON, "New Musical Instruments."

MAY 16.—Professor W. K. CLIFFORD, F.R.S.

CANTOR LECTURES.

Monday evenings, at eight o'clock. Second Course, "On the Chemistry of the Manufacture of Coal Gas," by A. VERNON HARCOURT, Esq., F.R.S.

LECTURE I.—MARCH 5.

Formation and chemical nature of coal. Changes produced by the application of heat. Solid, liquid, and gaseous products. Coke—its advantages as a fuel. Separation by condensation of liquids from permanent gas. Composite nature of tar. Process of tar distillation.

LECTURE II.—MARCH 12.

Ammoniacal liquor; its composition, treatment, and valuation. Purification of gas from ammonia. Scrubbers and washers. Probable effect upon gas of prolonged contact with tar and ammoniacal liquor. Purification from carbonic acid and sulphuretted hydrogen. Use of lime and of oxide of iron.

LECTURE III.—MARCH 19.

Composition of coal gas. Common impurities—carbonic acid, carbon bisulphide. Products of the combustion of gas containing sulphur. Question as to the injurious effect. Modes of purification. Action of calcium sulphide. Effect of contact with heated surfaces. Tests for sulphur.

LECTURE IV.—MARCH 26.

Principal constituents. Hydrogen, carbonic oxide, marsh gas, olefiant gas. Value for heating and for illumination. Luminous flames. Development of the illuminating power of coal gas. Burners. Gas compared with other illuminants. Different qualities of gas. Photometry. Standard burner. Unit of light.

Each member can admit one friend to these lectures. No special tickets are now required for the purpose; the tickets issued to members at the commencement of the session are available for the Cantor Lectures, as well as for the Ordinary and Sectional Meetings.

MEETINGS FOR THE ENSUING WEEK.

MON. ...Royal United Service Institution, Whitehall-yard, 8½ p.m. Mr. R. Griffiths, "The Application of the Ordinary Screw (or Screws), to the Discharge of Water from Leaks, &c.; also a New Form of Vessel for War Purposes."
Institute of Surveyors, 12, Great George-street, S.W., 8 p.m. Mr. J. Lucas, "Hydrogeology; one of the Developments of Modern Practical Geology."
Royal Geographical, University of London, Burlington-gardens, W., 8½ p.m. 1. Mr. E. D. Young, "Recent Journey to Lake Nyassa." 2. Rev. Roger Price, "Examination of a Route for Wheeled Vehicles between the East Coast of Africa and Ugogo."
Institute of Actuaries, The Quadrangle, King's College, W.C., 7 p.m.
Medical, 11, Chandos-street, W., 8.30 p.m.
London Institution, Finsbury-circus, E.C., 5 p.m. Mr. F. W. Brearey, "The Problem of Flight."
TUES....Royal Institution, Albemarle-street, W., 3 p.m. Prof. Garrod, "The Human Form; its Structure in Relation to its Contour." (Lecture VII.)
Medical and Chirurgical, 53, Berners-street, Oxford-street, W., 8½ p.m.
Civil Engineers, 25, Great George-street, Westminster, S.W., 8 p.m. Renewed Discussion on "The Sewage Question."
Anthropological Institute, 4, St. Martin's-place, W.C., 8 p.m. 1. Mr. J. Walhouse, "Non-Sepulchral Rude Stone Monuments." 2. Messrs. Wimot Power and Edward Laws, "A Kitchen Midden Found in a Cave near Tenby, Pembrokeshire." 3. Mr. Hodder M. Westropp, "Some Kitchen Middens near Ventnor, Isle of Wight."
WED....**SOCIETY OF ARTS**, John-street, Adelphi, W.C., 8 p.m. Dr. John Yeats, "Middle-class Education in Holland."
East India Association, Pall-mall Restaurant, 14, Regent-street, Waterloo-place, 5 p.m. Mr. Robert H. Elliot, "The Indian Problem, and Indian Famines."
Royal College of Physicians, Pall-mall, E., 5 p.m. (Gulstonian Lectures.) Dr. Lauder Brunton, "Pharmacology and its Relations to Therapeutics." (Lecture II.)
THUR....Trades' Guild of Learning and National Health Society (at the HOUSE OF THE SOCIETY OF ARTS), 8.30 p.m. Prof. W. H. Corfield, "The Laws of Health." Part II. (Lecture VI.)
Royal, Burlington House, W., 8½ p.m.
Antiquaries, Burlington House, W., 8½ p.m.
Linnean, Burlington House, W., 8 p.m. 1. Mr. J. G. Baker, "Report on the Liliaceæ, Iridaceæ, Hypoxidaceæ, and Hæmodoraceæ of Dr. Welwitsch's Angolan Herbarium." 2. Mr. Edgar A. Smith, "A remarkable form of New Zealand Ophiuridæ."
Chemical, Burlington House, W., 8 p.m. Prof. Thorpe, "The Theory of the Bunsen Flame."
London Institution, Finsbury-circus, E.C., 7 p.m. Mr. W. R. S. Ralston, "English Nursery Tales." (Lecture II.)
Medical and Chirurgical, 53, Berners-street, W., 8 p.m., Annual Meeting.
South London Photographic (at the HOUSE OF THE SOCIETY OF ARTS), 8 p.m.
Royal Institution, Albemarle-street, W., 3 p.m. Mr. William Pole, "Theory of Music." (Lecture III.)
Royal Society Club, Willis's Rooms, St. James's, S.W., 6 p.m.
Psychological, 11, Chandos-street, W., 8½ p.m.
Civil and Mechanical Engineers, 7, Westminster-chambers, S.W., 7 p.m. Mr. W. J. Adams, "Joints in Woodwork."
FRI.....**SOCIETY OF ARTS**, John-street, Adelphi, W.C., 8 p.m. (Indian Section.) Sir Douglas Forsyth, "The Progress of Trade in Central Asia."
Royal United Service Institution, Whitehall-yard, 3 p.m. Mr. Donald Currie, "Maritime Warfare; the importance to the British Empire of a complete system of Telegraphs, Coaling Stations, and Graving Docks."
Royal Institution, Albemarle-street, W., 8 p.m., Weekly Meeting; 9 p.m. Prof. Huxley, "The History of Birds."
Geologists' Association, University College, W.C., 8 p.m.
Philological, University College, W.C., 8 p.m.
Royal College of Physicians, Pall-mall, E., 5 p.m. (Gulstonian Lectures.) Dr. Lauder Brunton, "Pharmacology and its Relations to Theraputics." (Lecture III.)
SAT.....Foremen Engineers (at the HOUSE OF THE SOCIETY OF ARTS), 8 p.m.
Physical Science Schools, South Kensington, S.W., 3 p.m.
Royal Institution, Albemarle-street, W., 3 p.m. Prof. Henry Morley, "Effects of the French Revolution upon English Literature." (Lecture II.)

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