January 12, 1864.

JOHN ROBINSON M'CLEAN, President, in the Chair.

THE following Candidates were balloted and duly elected:—ROBERT CHAPMAN, TRAVERS HARTLEY FALKINER, and HENRY VOSS, as Members; CHARLES CHAMBERS, GEORGE HENRY COBB, HENRY BURDETT HEDERSTEDT, EBENEZER WILLIAM HUGHES, JAMES CARRINGTON SIMPSON, and THOMAS HITCHIN SMITH, as Associates.

Mr. M'CLEAN addressed the Meeting in the following terms, on taking the Chair for the first time, after his election as President:—

GENTLEMEN,

The greatest honour a Civil Engineer can attain is to become the President of this Institution, and I beg to thank you for having, by your suffrages, placed me in that distinguished position.

I feel deeply the responsibility of presiding over an Institution, comprising, as it does, upwards of one thousand Members and Associates, gentlemen who personally represent every branch of Civil and Mechanical Engineering and practical science, and amongst whom there are so many better qualified than I am to occupy this Chair. But as you have not considered it necessary to depart from the custom of electing your senior Vice-President to the important office of President, I will accept the trust, and endeavour, with your continued support, to discharge conscientiously the duties connected with that office.

My first duty is to address you on assuming the Chair, and I will now claim your attention to the few general remarks I have to make.

The progress of Engineering science has been so fully recorded by my distinguished predecessors in office, that I propose on the present occasion, instead of describing any Engineering works, to point out the extraordinary effects these works have exercised, during the last thirty years, in promoting the material and intellectual progress of Great Britain, and increasing the comforts and

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social enjoyments of all classes of its inhabitants. I will endeavour to show that the wonderful prosperity attained during that period is to be attributed mainly to our Railway system, which has enabled us to develop the mineral resources of the country, and at the same time to provide secure and reproductive investments for the profits realised by the successful working of the system.

It is a prevalent opinion, that the increased prosperity of the country, to which I refer, has been the result of improvements in the cultivation of the land, better drainage and farming, and in consequence of the railway system having provided better means of access to markets and places for disposing of the products of the soil, and obtaining suitable materials for renewing its fertility. In order to show the incorrectness of this opinion it will be necessary to refer to the Reports of the Commissioners of Inland Revenue, which give returns of the property and income of Great Britain, at two different periods especially suitable for the comparison I wish to make; one before the works of the Civil Engineer had attained much importance, and the other after the successful application of the Steam Engine to Locomotive purposes had led to the construction of our present magnificent system of Railways.

The years selected for the purpose are 1815, and 1856, the return of the property and income of the country being fully given for those years in the Reports of the Commissioners. Besides, the year 1815 was the last year of the income tax in which accurate statistics can be obtained of the property and income of Great Britain. It was also the last of a long series of years of war, during the whole of which the property and income tax had been in operation; and, as the financial necessities of the Government were great, we may safely accept these returns as accurate, and rely that no source of income, or property, which could be brought within the operation of the Chancellor of the Exchequer, has been omitted from the account, and allowed to escape taxation. It was, moreover, a period in which most of the great discoveries of the Engineer, except the Locomotive Engine, were in full operation. The steam-engine as improved by Watt, had been in operation forty years before, pumping water from mines, raising minerals, and providing motive power; and Arkwright and other great inventors had perfected the machines employed in textile manufactures, and had brought them into general use.

In the Returns referred to we find each source of income under a separate head; and, in order to make the comparison as simple as possible, I take in all cases the amount of the tax under that head as the measure of the value of the property or income assessed, as set forth in the following Table:—

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TABLES

OF THE NET AMOUNT OF THE PROPERTY AND INCOME OF GREAT BRITAIN, FROM ALL SOURCES, LIABLE TO ASSESSMENT FOR TAXATION IN THE YEARS 1815 AND 1856.

TABLE No. 1.

YEAR 1815.

	£.
LAND :—	
Land, Tithes, Manors, Fines	£41,521,492
HOUSES (exclusive of Farmers' houses)	16,259,400
PROFITS ON REALIZED PROPERTY :—	
Quarries, Mines, Ironworks, &c.	1,452,104
Farmers' profits . . .	21,762,280
Funds	30,048,620
Profits of Trade and Professions	30,211,880
Government Departments	11,132,450
Total . .	£152,388,226

Incomes and Profits exempt under £50 per annum during this year.

TABLE No. 2.

YEAR 1856.

	£.
LAND :—	
Land, Tithes, Manors, Fines, Fisheries	£38,153,935
HOUSES (exclusive of Farmers' houses)	48,435,585
PROFITS ON REALIZED PROPERTY :—	
Quarries, Mines, Ironworks, Canals, Railways, Gas Works, And other Property	18,087,963
Farmers' profits . . .	24,224,443
Funds	24,407,360
Profits of Trade and Professions	74,551,046
Government Departments	14,607,036
Total . .	£242,467,368

Incomes and Profits exempt under £100 per annum during this year.

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In Table No. 1 we find, that in the year 1815, or forty years after the steam-engine had been improved and used for saving labour and producing motive power in connection with mining and manufactures, the whole annual income derived from quarries, mines, ironworks, and other property was only £1,452,104.

In Tables No. 1 and 2 we find the net income available for taxation, derived from land, and the profits of the farmers, taken together, in 1815 to be £63,283,772; whilst in 1856 it was only £62,378,378.

The net income derived from houses during the same period, had increased from £16,259,400, to £48,435,585, an augmentation of £32,176,185, or nearly three hundred per cent.

The net profits derived from mines, quarries, ironworks, canals, railways, and other profits, had increased from £1,452,104 in 1815, to no less a sum than £18,087,963 in 1856, or upwards of twelve hundred per cent.

From these figures we learn that during the forty years, over which the comparison extends, the profits and income of land together had not increased, notwithstanding the construction of roads, railways, canals, and other public works, and the relief from poor-rates afforded to it by the extension of the rate on other property, and by the absorption of the increased population in new occupations (as shown by the Population Returns), the number of labourers employed on the land at the Census of 1861 being less than in the year 1815. No doubt the condition of all classes connected with the land, including the landlord, farmer, and agricultural labourer, had improved during the period in question, and much capital had been expended in farm-buildings, drainage, and machinery. Yet the net annual income available for taxation in 1856, derived from land and farmers' profits, was not greater in 1856 than in 1815, although the income derived from all other sources of property, during the same period, had largely increased, as we find in the Tables,—the net amount of income derived from the profits of trades and professions available in 1815 being £30,211,880, and in 1856, £74,551,046, showing an increase in the latter year of nearly 150 per cent., the exemptions from Income Tax being under £50 per annum in 1815, and under £100 in 1856.

In these Tables we also find the total net amount of income derived from all sources available for taxation in 1815, to be £152,388,226, and in 1856, £242,467,368, showing an increase of sixty per cent., or upwards of £90,000,000 (which, on the basis of the taxation of 1815, would have yielded £9,000,000 additional tax), from sources independent of the land.

I will now attempt to point out the causes of the enormous increase of the income of Great Britain, shown by the Tables, representing the profits of many hundreds of millions sterling in-

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vested in railways, canals, mines, ships, and other works, in this country, in India, and in our colonies.

Fortunately the railway system, since the introduction of the locomotive engine, improved by Stephenson, gave it vitality, has been a complete success, in the reproduction of capital, in the enormous saving in the cost of transport, and in the facilities it affords for the development of mines, and of nearly all branches of national industry.

After the opening of the Manchester and Liverpool Railway, the accumulated wealth of Great Britain, which, previous to that time had been but sparingly invested in public undertakings, and was for the most part hoarded, or placed on doubtful securities, was thrown lavishly into the railway system; and, although for a time this led to the belief, that the supply of capital for the construction of such undertakings was inexhaustible, and induced excess of speculation, temporary distress, and subsequent distrust in the system; yet the progress of railways ever since that period has been steady, and a reproductive profit has been assured on a capital of nearly £400,000,000. This vast capital has been created because railway securities, on the principle of limited liability, occupy the highest place in public estimation, for investing the realised profits of the country, in consequence of the facility with which they can be purchased, and transferred in amounts suited to the requirements of every class of society; and this leads to a constant accumulation of capital by inducing people to save a portion of their income,—not merely for their own support in an after-period of life, but for the benefit of their descendants. Thus railway securities afford the means of transmitting wealth, as printing does knowledge, from one generation to another.

The beneficial effects of the railway system has not been confined to Great Britain. Before the introduction of railways the land was nearly the only safe means in Europe for the investment of capital; and, in consequence of the competition for this security, the interest was reduced to a minimum rate, and was barely sufficient to induce people to save a portion of their income. The construction of railways, by inducing saving, has established a wealthy and educated middle class in most countries in Europe, who have not only developed the industrial resources and increased the capital of the country to which they belong, but have also, as in this country, promoted education, and humanized the conduct of all classes of the people.

I have only one more remark to make on railways as a cause of the increase of wealth. The land occupied by railways in Great Britain is under two hundred thousand acres, including stations and other conveniences, and to obtain possession of this land it has been

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necessary, during every session of Parliament, for the last thirty years, to engage the services of the ablest Counsel and the most eminent Engineers in the Committee Rooms of both Houses at an incalculable expense. The land used for agricultural purposes is about forty million acres, and yet the railway system, occupying only about one half per cent. of the total area of the land, now pays nearly as great an amount of Income and Property Tax as is paid by the whole of the farmers of Great Britain.

Another source of wealth is the great deposit of coal, and iron, stone, and other minerals—in nearly every part of the kingdom.

The most important of these is coal. The quantity of coal raised in Great Britain is now about one hundred millions of tons yearly, produced by the labour of about three hundred thousand men.

We are indebted to Professor Liebig, the celebrated German chemist, for data by which we can estimate the value of this enormous quantity of fuel, by comparing it with wood, or any other produce of the soil.

Liebig informs us, that every acre of fertile land will produce yearly about two tons and a half of wood, or other crop, which contains about the same quantity of carbon (80 per cent.) as one ton of coal. The one hundred million tons of coal now raised annually from our mines contain about eighty million tons of carbon: and to produce the equivalent of this in wood would require one year's growth of, in round numbers, one hundred millions of acres of land,—an area about four times larger than the arable and pasture land of England, (which does not exceed twenty-five million acres,) and as nearly as possible equal in extent to the area of the empire of France. Yet this supply of fuel, even if it existed in the form of wood, would be practically useless as a substitute for coal; the labouring population of the kingdom would be unable to cut and convert it, the whole of our railways and canals would not suffice to transport it, while the cost of these operations, if no other obstacle intervened, would prevent them from being carried on beneficially.

The development of coal, then, is mainly the cause of the increase of wealth, but if railways had not proved reproductive investments, this mineral would have added little more to the wealth of Great Britain than it did in 1815, as shown by Table No. 1.

The serious question as to the permanence of this fuel, on which the wealth of the nation so much depends, has been prominently raised. Since the great discovery of Murchison that coal underlies, and may be found with reasonable certainty under the lower new Red Sandstone and Permian formations, which extend over millions of acres of Great Britain; and, if beneath them, at greater depths, under all the measures which overlie the Permian, and which, together, comprise upwards of one half the area of Great

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Britain, we may consider our coal-mines to be practically inexhaustible, and that we have not to fear any deficiency in quantity, arising from the exhaustion of the mineral, but rather the practical difficulty of obtaining it from a great depth below the surface, in consequence of the Central Heat of our Globe, which, it is alleged, will ultimately, and within a defined and not distant period, reduce the production to a limited supply.

Much may be said in support of the Theory of Central Heat, but I think undue importance has been given to it, as a difficulty in mining operations. A comparatively thin coating of clay, or fire-bricks, surrounding a blast furnace filled with molten iron, affords such protection that the hand may be placed without inconvenience on the outer surface of the brick-work, and it is difficult to understand how any internal heat can penetrate through the crust of the earth,—estimated to be thirty-four miles in thickness,—so as to interfere with the temperature at the comparatively small depth from the surface at which mining operations are carried on. I am of opinion that the heat, which undoubtedly exists in some mines, arises, not from central heat, but from superincumbent pressure, and defective ventilation. The gases in the coal are highly compressed, and, when liberated by mining operations, are at a high temperature; but we know that with large shafts air may be conveyed to any depth that has yet been reached in mining operations, without in the slightest degree altering its temperature; and that by a proper enlargement of the air passages, air descending the shaft may be distributed through the workings, so as to lessen the liability of accident from explosion, or serious inconvenience from heat, at any depth to which shafts can be sunk. The system of sending compressed air down the shaft by means of water is found to abate inconvenience in deep mines owing to an excess of temperature.

I therefore think that the time when we shall experience a want of coal, arising from exhaustion, or from difficulties occasioned by the depth of the mines, or an excess of temperature, need not at present in any way influence our conduct in the development and use of that important mineral; especially as the power (which is the substitute for labour) derived from coal is so cheap, that we are enabled to consume daily for our domestic comforts, for machinery in the conversion of minerals, and for other manufacturing processes, and for export, a power equal to twelve millions of horses, at a cost, at the mine, of not more than one penny per horse-power, working ten hours a day, and no saving in consumption of this enormous quantity of coal can be made, except by employing more expensive labour as a substitute.

With this power at our command the cost of sinking to, and of

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raising minerals from the greatest depths, is inappreciable; while the intrinsic value of coal, when compared with any other fuel, is so great that it may be drawn profitably from almost any depth,—the only limit being the strength of the machinery and materials required to raise it.

The next mineral in importance is ironstone.

In the year 1862 the production of ironstone and iron ore in the United Kingdom amounted to 7,586,956 tons, which, by the operation of five hundred and sixty-two blast furnaces, was converted into 3,943,469 tons of pig iron.

The importance of the iron and coal trade as a source of wealth is proved by the fact, that the declared value of the iron and coal exported from this country during 1862, either in a raw, or a manufactured, or a partially manufactured state, was nearly £25,000,000, due altogether to the development of our natural resources; and this sum represents the cost price only, and is exclusive of carriage, or freight and profits of trade, which may fairly be taken to represent one half more.

In 1862 our other mines produced the following quantities of minerals, viz.:—

Tin ore	14,127	tons.
Copper ore	224,171	„
Lead ore	95,311	„
Zinc (blende)	7,497	„
Pyrites (sulphur)	98,433	„
Salt	981,598	„
Fire-clay, china-clay, and porcelain stone	853,803	„

These minerals, and the metals produced from them by means of coal, have enabled us, with the assistance of the shipping interest, to obviate, to a great extent, the effects of the failure in the supply of cotton; for notwithstanding the great decrease of the export of cotton goods (to the extent of £10,000,000 in the year 1862), the total amount of exports during the financial year just ended (1863) has been £124,137,812, exclusive of carriage and freight, and we have thus been enabled to pay for all imports, and partially to alleviate the distress among the cotton operatives in Lancashire.

I will not occupy your time in detailing all the various profitable employments which result from mining and manufacturing operations, but will only refer to, perhaps, the most remarkable of them—ship-building.

The Government returns for 1861 show, that in that year 975 ships, representing 200,839 tons, were built and registered in the United Kingdom;—of these 91,095 tons were constructed of iron,

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the average of the iron vessels being a burthen of 430 tons each.

And this, it should be remembered, is exclusive of iron ships built in private yards for the Royal Navy, and of the ships constructed for foreigners.

The iron screw steam-ships, in consequence of their great and regular speed, due to engineering skill, have practically become an extension of the railway system, over all parts of the world, and have enabled us more freely to exchange the products of our industry for those of other nations, thereby conducing to the employment, the intellectual and social enjoyment, and the convenience of the people, and providing for the further increase of population and universal wealth.

On these considerations I am justified in stating, that the increase of the income of England since the year 1815, has not arisen from the land; but that it is mainly due to the discoveries of our great engineers. There remains still to be considered the question of the distribution of this wealth, which has been the means of providing profitable employment for millions of a rapidly increasing population who, but for such industrial undertakings must have remained a burthen on the land, and a cause of poverty and discontent; unless reduced in number by famine, or by extensive emigration.

The Tables I have given show that the wealth has been fairly distributed among all classes of society, and that while the "rich have been growing richer, the poor have become less poor;" and that the "wide interval that formerly separated the extremes of wealth and poverty" is being gradually closed, not by the reduction of wealth, but by the diminution of poverty, arising mainly from the mining and industrial sources which I have described.

We may also congratulate ourselves that this wealth has not been employed in reproductive undertakings alone, but that the great cause of education has felt the stimulus of it, and that every year the importance of developing and directing the intelligence of the people is more distinctly recognized.

I will now make a few remarks on the extension of the railway system, and especially on the construction of the proposed new lines in the metropolitan districts. It is evident that parliamentary sanction will not be given to all the lines which have been suggested, but the convenience of the public, and the necessity for relieving the streets from the heavy traffic passing to and from the present railway stations, require that some of these lines should be constructed without delay. The success of Mr. Fowler's Metropolitan Line, due to the talent exhibited in its construction, as well as to the tenacity of its promoters in overcoming all difficulties,—those of finance not being the least,—has proved that

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Railways in the metropolis can be made a source of profitable investment.

Much has been said as to the destruction of property which, it is assumed, will result from the execution of the proposed metropolitan extensions, and the question has been discussed, as if the property taken were wasted, or destroyed, forgetting that it is only a change of occupation, and that the houses pulled down will, in many cases, be much better restored, in accordance with modern sanitary improvements, or the sites will be applied to more profitable uses, tending to the general improvement of the metropolis, the convenience of the public, the relief from local taxation, and the better occupation of the working-classes.

The construction of these railways, by means of private funds, is less objectionable than by funds derived from a tax on the coal and wine dues, or any other mode of local, or public taxation. If public funds were to be resorted to, the works now so much needed would never be executed, as the enormous capital required would prevent either local boards, or the Government itself from undertaking them. Besides, it is only right that those who use these railways should pay for them, and not people living remote from the metropolis who may never enjoy them.

Occasionally unproductive works of national importance, such as the Thames Embankment, may be executed at the public expense, but the principle of Government construction is inadmissible in this country, in the case of railways or any other public work which can be rendered reproductive by private enterprise.

In consequence of the great interest now evinced in the progress of the works of the Isthmus of Suez Canal, and as the subject has never been brought directly under the consideration of the Institution, I will take this opportunity to make a short statement respecting the labours of the English members of the International Commission, who in the years 1855 and 1856, examined the question of the practicability of forming a ship canal through the Isthmus of Suez.

In the year 1855 M. Ferdinand de Lesseps, acting for H.H. the late Said Pacha, Viceroy of Egypt, invited me with the late Mr. Rendel, and your Honorary Secretary, Mr. Manby, to form part of an international commission, for the purpose of considering and reporting on the practicability of forming a ship canal between the Mediterranean and the Red Sea, and the best mode of constructing it, and for that purpose I accompanied M. Conrad, of Holland, MM. Rénaud and Liéussou of France, and M. de Négrelli of Vienna, to Egypt in that year. The commission was an honorary one, and we were considered the guests of the Viceroy from the time of our leaving Marseilles to our return to Europe.

In Egypt we met M. de Lesseps, Mougel Bey, and Linant Bey,

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Engineers, and other gentlemen in the service of the Viceroy, and in the months of December 1855 and January 1856, we made a careful examination of the harbours in the two seas, which it was proposed to unite, and of the desert lying between them, and arrived at the conclusion, that a ship canal was practicable between the Gulf of Pelusium in the Mediterranean and the Red Sea, near Suez. Thus far we all agreed, but we differed as to the mode of construction. The English members were of opinion that a ship canal raised twenty-five feet above the sea-level and communicating with the Bay of Pelusium at one end, and the Red Sea at the other, by means of locks, similar to the sea-entrances of the Caledonian Canal, might be constructed, there being no difficulty in abundantly supplying the canal, at all times, with water from the Nile, by a cut made from a suitable level, without depending in any way on the closing of the 'Barrage' of the Nile. The foreign members of the Commission were, however, of opinion, that a canal twenty-seven feet below the sea-level from sea to sea, without any lock, was the best system, with harbours at each end, one to be constructed in the Mediterranean by piers and dredging, and the other in the Red Sea by dredging to the deep water, which in both seas is at a considerable distance from the shore.

On a comparison of the two systems it was found that the ship canal above the sea-level, with locks, would save many millions of cubic yards of excavation, principally dredging, a difficult and expensive operation, and would involve no more than the ordinary contingencies which might attach to any similar engineering work of equal extent, while the difficulty arising from rocks at Suez, and running sands and silt at Pelusium would be avoided, and a large sum of money saved in the cost of construction, by employing locomotive engines instead of human labour.

The English members also considered this system the best for the shareholders, and most calculated to give productive returns for the capital invested.

The whole of the members of the Commission [see Appendix, page 167], with the exception of Mr. Rendel, met at Paris in June 1856, when the Report of the English Engineers, signed by Mr. Manby on their behalf [see Appendix, page 164] was presented, and after full discussion, was rejected by the foreign members of the Commission, who preferred a canal without locks; and, as they formed the majority, the Report to H.H. the Viceroy recommended the system now actually in course of construction.

As the English Engineers were members of a purely honorary Commission, their labours terminated with the Report.

Five years after the discussion in Paris of the mode of construction by the International Commission, your Past-President, Mr. Hawkshaw, was requested by H.H. the late Viceroy to "exa-

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mine the site of the proposed ship canal, intended to connect the Red Sea and the Mediterranean, across the Isthmus of Suez, and to report his opinion of that work." In February, 1863, he made a very able and elaborate Report, which details the actual progress of the ship canal and its accessories, up to the end of the year 1862, constructed in accordance with the system adopted by the majority of the Commission, from which it appears that there had been executed of the Ship Canal (principally dry earthwork) six million cubic metres out of ninety-six millions, or one-fifteenth part of the whole—the expenditure up to that period, including the partial execution of the fresh-water canal, being £1,200,000—leaving to be excavated ninety millions of cubic metres; or twenty millions of cubic metres more than the entire quantity required to complete the Canal according to the system proposed by the English Members of the Commission.

I will now address a few remarks to the Junior Members as regards the future prospects of the profession.

I have shown that, during the last thirty years, the works of the Engineer, or those executed under his direction, have led to the present prosperous condition of Great Britain—and by the extent of the works that have been done during that time we may fairly measure those that are yet to follow. The extension of the railway system is necessary for the progress and well-being of the world, and must be carried out by our young Engineers in this country and in every part of Europe, in India, and in our Colonies. There is no country that will not become richer by the introduction of railways, and the richer a foreign country becomes, the more it adds (by the extension of commerce) to the wealth and prosperity of this kingdom. And, if our railway system is extended, new harbours, docks, canals, steam ships and other Engineering works will be necessary to meet the requirements of traffic and the demands of increasing commerce.

Nothing but unwise legislation, and the imposition of restrictions on commerce, for which happily the public mind is not prepared, can prevent the progress of those great works—unless the railway system became a 'protected interest,' which would be disastrous to all mining and manufacturing undertakings, which mainly depend for their prosperity on the further development of the system; and also to the public, who would be deprived of their safest and best security for the investment of their annual savings. If Railway Companies were relieved from the risk of competition, instead of making new lines to meet the requirements of trade, and the wants of an increasing population, they would probably, with the view of improving the value of their shares, consider their best interest lay in imposing higher charges, and giving only limited accommodation to the public.

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In conclusion, I hope the day will arrive when the basis of fixed taxation will be so extended as to enable the Government to abolish all our present Customs duties, nearly the last restrictions on commerce, which limit the free exchange of traffic between ourselves and other nations, and when free intercourse will be permitted to be carried on by railways and steam-ships, as part of one system, without interruption at the sea ports, and without the impediments and waste of labour and expense occasioned by the interference of bonding warehouses and Government officials, required under our present system of taxation.

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APPENDIX.

ISTHMUS OF SUEZ CANAL.

Comparative advantages of the Two Systems, proposed for constructing a direct Canal between the Mediterranean and Red Seas.

FIRST SYSTEM.

(*Adopted by the* majority *of the Commissioners.*)

The level of the top water of Canal to be the same as the level of the low water of the Mediterranean Sea at Said.

SECOND SYSTEM.

(*Proposed by the English Members of the Commission.*)

The level of the top water of the Canal to be 7 metres above the low water of the Mediterranean Sea.

In each case the Canal to be 8 metres deep, and to have the internal slopes in cuttings 2 to 1, and in embankments 3 to 1. The width of the bottom in all cases to be 68 metres.

LOW LEVEL.

The total quantity of excavation will be 130,000,000 cubic metres. One-half of that quantity below the natural drainage of the country, will require to be dredged.

The method proposed of forming a small Canal first, and afterwards enlarging it, is impossible, unless Lake Timsah and the Bitter Lakes are avoided. The stone found in the cutting cannot be made available for the harbour of Said, until the Canal is opened throughout.

The difficulties arising from stone and running sand, forming part of the material, may be great; the former at Suez, the latter in Lake Menzaleh.

HIGH LEVEL.

The total quantity of embankment will not exceed 70,000,000 cubic metres, and may be much reduced by a judicious selection of the line of Canal.

The whole of the excavation will be above the natural drainage of the country, and may be conveyed with great rapidity into embankments, by means of railways and locomotive engines.

The stone found in the cuttings and in the ground adjoining El Guisr, may be used for the harbour of Said.

The difficulties will not be greater than in an ordinary engineering work.

HARBOUR OF SUEZ.

There will be considerable difficulty in forming a channel 400 metres wide and 3,000 metres in length, by dredging-engines, and every probability of meeting with coral reefs and indurated sands, or conglomerate, similar to the rocks at Suez.

HARBOUR OF SUEZ.

The Canal may be carried round the Bay of Suez, in the manner shown upon the chart, and the locks formed in deep water, which will avoid the necessity of dredging, and all the risk attendant upon it.

There will not be any necessity for jetties, as the harbour is completely sheltered, except from the north wind, and the embankment of the canal will afford ample protection.

The Canal will be close to the quarries of Attaka, an object of great importance in the execution of the works of the Canal and harbours.

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PORT TIMSAH.

The cost of establishing a port in Lake Timsah will be considerable, and much dredging will be required.

PORT TIMSAH.

The high level will save the cost of the locks at this point. The Maritime Canal and the Branch Canal to the Nile will be on the same level, and great expense will be avoided in the construction of wharves and other works.

Between the Nile and the Maritime Canal only two, or three regulating locks will be required.

IRRIGATION.

A Canal is proposed between the Nile Branch Canal and Suez, for the purposes of irrigation and fresh water supply, and a conduit from the same branch to the Mediterranean, for similar purposes. Steam-engines of 500 horse-power, at a working cost of £27,000 per annum, are to be erected.

IRRIGATION.

The Canal and conduit may both be avoided by adopting a higher level, and supplying the Canal from the Nile below the barrage. Irrigation may be carried on much more advantageously for the whole distance between Suez and the Mediterranean Sea, by supplying the Maritime Canal with fresh water, and using it as a great reservoir, during the inundations of the Nile (which would be impossible in a conduit).

The whole of Lake Menzaleh may be reclaimed.

SUPPLY OF WATER.

The Canal will depend for a supply of water on tides of the Red Sea.

Unless there is a current out of the Bitter Lakes, as well as into them, the evaporation of 5,000,000 cubic metres of salt water daily, during three months in the year, will form deposits; as nearly 3 per cent. of salt will be deposited after a certain time, or 150,000 cubic metres daily.*

At the present time the water is salter at Suez than in the Pacific, and were it not for the constant outgoing current of brine at Babelmandel, the Red Sea would fill up with salt.

The tidal observations do not give the simultaneous condition of the tides at Suez and in the Mediterranean, nor the variation during each half-hour of low and ebb, so that it is impossible to estimate the velocity of the currents through the proposed Canal.

One great difficulty will be to fill the Bitter Lakes.

If the sea is freely admitted, the velocity into the lakes, even at low water, will be 6 feet per second, which would completely destroy the channel.

Even supposing them to be filled, the tides will barely be sufficient to supply the waste arising from evaporation and absorption, and a current will flow from both seas, until the channel gradually becomes filled up.

SUPPLY OF WATER.

The supply of water will be direct from the Nile at its lowest level, and be regulated by locks during inundations.

There will not be any possibility of failure, either from winds or from scarcity, during dry seasons; the minimum discharge of the Nile being 50,000,000 cubic metres per hour.

The abstraction of 1-24th part of the water of the Nile during low-water time, and 1-30th part during inundation, will provide for loss of water, by evaporation and leakage, and for an average lockage of 100 vessels daily.

The deposit of the limon of the Nile will take place in the Branch Canal, and may be removed annually, without interfering with the navigation; or it may be sent down the Maritime Canal to sea, by scouring, in a particular method devised for that purpose.

* *Vide* Maury, "Physical Geography;" and Lyell, "Elementary Geology," p. 347.

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HARBOUR OF SAID.

Two jetties, one 3,000 metres, and the other 2,500 metres, in length, will have to be constructed, and the space, 400 metres between, dredged and conveyed away in barges.

The stone must be brought from the islands in the Mediterranean Sea.

No dredging can take place until a temporary harbour has been constructed, as it is a lee-shore during nine months of the year.

There will be no back-water to keep the channel open; on the contrary, there will be a gradual flow into the Canal, which will tend to form a new beach in the Harbour and Canal.

There will be no certainty that the work will ever be finished. It will altogether depend on contingencies, over which the Engineer has no control, and which cannot be estimated.

HARBOUR OF SAID.

The locks and harbour may be constructed without more than ordinary difficulties, and no dredging will be required except at the tail of the lowest lock.

The stone from El Guisr may be used in the harbour, as a railway will be required for constructing the banks.

The scouring power of the water will always keep the channel open.

The contingencies will not be greater than usually belong to works of this magnitude.

Therefore, under the First System, the construction may be regarded as impracticable, whilst under the Second System it may be considered feasible.

Approved by

J. M. RENDEL and J. R. McCLEAN,

And signed by

CHARLES MANBY,

For the Members of the English Commission.

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The International Commission was composed of the following Members, viz. :—

M. F. W. CONRAD	Chief Engineer of the Water-Staat, the Hague.
CAPTAIN HARRIS	Of the Honorable East India Company's Navy, London.
CAPTAIN JAURÈS	Of the Imperial Marine, and Member of the Council of the Admiralty, France.
M. LENTZE	Chief Engineer of the Works on the Vistula, Berlin.
M. LIÉUSSOU	Hydrographical Engineer to the Imperial Marine of France, Paris.
MR. J. R. McCLEAN	Civil Engineer, London.
MR. CHARLES MANBY	Civil Engineer, London.
M. MONTESINO	Director of Public Works, Madrid.
M. DE NÉGRELLI	Inspector-General of Railways in the Austrian Empire, Vienna.
M. PALÉOCAPA	Minister of Public Works in the Kingdom of Sardinia, Turin.
M. RÉNAUD	Inspector-General and Member of the Council for *Ponts et Chaussées*, Paris.
MR. J. M. RENDEL	Civil Engineer, London.
M. RIGAULT DE GENOUILLY	Rear-Admiral of the Imperial Marine of France, Paris.

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