(No 29.)

1901.

PARLIAMENT OF TASMANIA.

LAKE ST. CLAIR, LAKE ECHO, AND THE GREAT LAKE WATER POWER:

REPORT BY K. L. RAHBEK, MEM. DAN. ASSOC. C.E.

Presented to both Houses of Parliament by His Excellency's Command.

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(No. 29.)

REPORT UPON THE WATER POWER WHICH MAY BE OBTAINED FROM LAKE ST. CLAIR, LAKE ECHO, AND THE GREAT LAKE.

Hobart, 30*th April*, 1901.

SIR,

AT the time I was gauging the Upper Derwent River, the Dee River, and the Shannon River, I also superficially inspected parts of the lakes from which these three rivers start, with the intention of examining into the practicability or otherwise of using these large bodies of water, first for power, and afterwards for irrigation and other purposes. By the kind assistance of the Surveyor-General I have been able to trace approximately the different watersheds, and have, consequently, found the sizes of the different catchment-areas, but I beg to emphasise the fact that all figures appearing in this Report are only approximate, as they are not based on permanent surveys.

Lake St. Clair is bordered with ranges of considerable magnitude on the western, northern, and eastern sides, the most conspicuous points being Mount Olympus on the western side, and Mount Ida on the eastern side.

Starting from the S.W. corner of the lake the watershed of the lake's catchment-area will be found to travel in a line over Mount Rufus, Mount Hugel, over Coal Hill to Mount Cuvier and Mount Manfred, thence over the Du Cane Range in a N.E. direction to the rugged mountains, afterwards travelling in a more or less broken line towards the south, thus forming the watershed between Lake St. Clair towards the west and the small lakes Lemona, Ida, &c., and the Travellers' Rest River to the east, and terminating at the S.E. corner of the lake. From the southern side the lake has no catchment. Three rivers, besides a number of smaller watercourses, empty themselves into the lake, viz., the Cuvier River at the S.W. corner, and the Hamilton or Narcissus River and Mount Ida River at the northern shore.

The part of the country which surrounds the southern side of the lake consists chiefly of low marshy land, most of which is scarcely more than a foot above the lake's winter water level. On a part of this southern border the lake itself has created low ridges of sand to a height of a few feet. The water in the lake is clear and of considerable depth. On the agricultural map the greatest depth is shown to be 92 fathoms. The difference between the water-level in the lake as I found it about the middle of March and the visible marks from highest winter water-level was 5⅓ feet in the sheltered S.W. corner where the boat-house is built, to six feet in height on the middle of the southern shore. The lake terminates at the S.E. corner in a kind of bay about one mile long and, say ¼ mile wide; this is called the lake basin, and is composed of low-lying marshy land. From the southern end of the lake basin the magnificent river, the Derwent, starts, and forms the only outlet from Lake St. Clair. A proper site for an eventual weir can be found only after instrumental surveys have been carried out, as most of the land is so low-lying that a series of levels must be taken before this important question can be settled.

It is to be regretted that no rainfall records have been taken, either at this lake or at Lake Echo, or even in the neighbourhood of the lakes. Perhaps not many years will elapse before the waters from these large natural reservoirs will be utilised, and then the want of knowledge about the rainfall may be the cause of increased expenditure in constructing the works. I therefore most respectfully but earnestly beg to urge that two stations for the record of rainfall should be established, one for Lake St. Clair and the other for Lake Echo. As there is no one living at the former place, perhaps it may be possible to have the records taken at the so-called "Iron-store" (not far from Mount Arrowsmith), where, I understand, there is already a telephone service established, and where, perhaps, the person who attends to the telephone would also be willing to take the daily rainfall records. As the "Iron-store" is only at a distance of six miles from Lake St. Clair, I believe the rainfall at the two places would be approximately identical.

As to the records for Lake Echo, Mr. Ellis, sen., residing at the Dee River (close to Forster's Bridge), is quite willing to have records taken daily if a rain-gauge is forwarded to him. The distance from Mr. Ellis's house to Lake Echo is five miles.

As no rainfall records for Lake St. Clair are available at present, I have reckoned with a mean of the 11 years' records at the Great Lake, which amount to 33·61 inches for the year. In doing so I think I am well within bounds, as there can be no doubt that the rainfall at Lake St. Clair exceeds that at the Great Lake.

In preparing the table herewith, showing the monthly and yearly discharges of Lake St. Clair, I have reckoned the catchment-area at 202 square miles (including the lake), and the area of the lake itself at 15 square miles, or 9600 acres. The available part of the rainfall I have reckoned at 0·667 divided for the different months as shown in the table, and the yearly evaporation at 20 inches.

As to the vexed question about compensation water for riparian owners, this is very difficult to settle, and, in many cases, where clashing interests oppose each other, they are settled only through the proper forum—the law courts.

In the present case, let it be assumed that the water is taken from Lake St. Clair, and, without tapping other streams, is carried in high-level canals, and discharged, say, at the junction of the Dee and Derwent rivers. It is then clear that downstream from this junction there will be no question of compensation water, as all the waters which used to travel there will be forthcoming. It is only for the distance of the Derwent River from the lake to the junction of the Dee River, a distance along the Derwent of about 44 miles, where compensation will be required. But, as it is not now proposed to tap the water from the Traveller's Rest River, the Navarre, the Guelph, and the Nive rivers, the waters from these rivers will, as usual, flow down the Derwent. At present, no land, or very little, in this part of the Derwent valley, is under culture, but it is to be hoped it will be in time to come; and, therefore, we must fix the amount of compensation water as if all the land were taken up. From inquiries I have made, it appears that, as far as the country is known in the Derwent valley above the junction with the Dee River, there is not much irrigable land. However, to be on the safe side, I will reckon as compensation water the quantity which will irrigate 10,000 acres, and which will be 1·5 × 10,000 × 43,560 ÷ 27 = 24,200,000 cubic yards per year, and required during, say, six months, from November to April.

LAKE ST. CLAIR.

Monthly and Yearly Discharges (in Million cubic yards).

Month.	Monthly available proportion of Rainfall as storage.			Monthly Evaporation.		Riparian Rights.	Surplus.	Deficiency.
	Gain.			*Loss.*				
	Rainfall. (Inches.)	Coefficient.	Storage.	Inches.	Quantity.	Compensation Water.		
January	2·05	0·5	17·814	2½	3·228	4·0	10·586	..
February	1·56	0·4	10·845	2½	3·228	4·2	3·417	..
March	2·06	0·5	17·902	2½	3·228	4·0	10·674	..
April	2·39	0·6	24·928	2	2·582	4·0	18·346	..
May	3·06	0·7	37·230	1½	1·937	..	35·293	..
June	4·02	0·8	55·899	½	0·646	..	55·253	.
July	3·56	0·8	49·502	½	0·646	..	48·856	..
August	3·51	0·8	48·806	1	1·291	..	47·515	..
September..........	2·52	0·8	35·040	1½	1·937	..	33·103	..
October	3·75	0·8	52·130	1½	1·937	..	50·193	..
November	2·41	0·7	29·320	2	2·582	4·0	22·738	..
December..........	2·72	0·6	28·367	2	2·582	4·0	21·785	..
							357·759	

Surplus per annum, 357,759,000 cubic yards.
Surplus per diem, 980,162 „

From all these dates, mostly assumed, the table has been computed; and, in accordance therewith, it appears that a yearly surplus of water of 357,759,000 cubic yards, or 980,162 cubic yards per diem, can be reckoned upon. From barometrical observations, I find that Lake St. Clair is at an altitude of, say, 2500 feet, and, before reaching the sea-level, the waters have to fall through this height. A quantity of water 980,162 cubic yards per diem, falling through a height of 2500 feet, would develop a power of 980,162 × 6·24 × 2500 × 27 × 10 ÷ 24 × 550 × 60 × 60 = 86,878 H.P., theoretically; but, in reality, it would not be so much. In the first place, the whole fall cannot be employed, as the water may also be wanted for irrigation, domestic, and other purposes; and secondly, in taking the power from the water, certain machinery is employed while developing the mechanical energy of the falling waters, and this machinery consumes power, and if, further, the power has to be transmitted by electricity for certain distances, in doing so, additional percentages of the original power will have to be paid. In the present case, let it be assumed that the water for power will be utilised as far as the junction of the Dee and the Derwent rivers, and which I find to be about 300 feet above sea-level. The fall available will then be 2500 — 300 = 2200 feet; but this fall will have to be reduced further, because (1.) the canals need fall (let this be reckoned at 150 feet), and (2.) it will probably be found most practicable to have three or more generating stations instead of one, and by this means another 50 feet may be lost, bringing the available fall down to 2000 feet, and which (in power) will be $980{,}162 \times 6{\cdot}24 \times 2000 \times 27 \times 10 \div 24 \times 550 \times 60 \times 60 = 69{,}502$ horse-power, theoretically, or, say, 46,000 actual horse-power, from the turbines-shafts.

In a few words, the scheme for tapping the waters from Lake St. Clair for power would be as follows:—

1. A weir, with proper sluices, by-washes, &c., will have to be constructed across the Derwent River, as close to the lake-basin as circumstances will permit.

2. From here the high-level canal will start, with a fall of, probably, only a couple of feet per mile, and after, more or less, a third part of the way to the terminal power-station has been traversed, and where the natural configuration of the country admits of so doing, the canal is directed to a point where the country has a fall of from 600 to 700 feet; the drop need not be perpendicular, but should, on the other hand, not be too long, say, within a quarter or half a mile in length—the shorter the better. The canal stops above, and the waters are now conveyed in iron pipes to the bottom of the drop, and where the first power-station will be situated.

3. The water-motors will consist of a series of high-pressure and high-speed turbines, and as it is not likely the power will be required at the station, dynamos of the continuous-current system will be fixed direct on the turbine shafts, so that the power can be transmitted by electric current to where it is required, within a reasonable distance of, say, 30, 40, to within 50 miles.

From the tail-water of the turbines the second part of the high-level canal starts, and continues until another drop of sufficient depth is met with, and where the second power-station will be situated, and so on until the terminal power-station at the junction of the Dee and the Derwent rivers is reached, and from where the waters will be liberated.

The site for the terminal power-station must be fixed at such a height that all irrigable land in the Derwent valley below the station can be commanded by the liberated water.

In case, then, that—(1) the catchment area of the lake; (2) the water surface of the lake; (3) the rainfall available; (4) the evaporation; (5) the water for compensation; and (6) further assuming that it is practicable, within reasonable expenditure, to construct the high-level canals as assumed: in case, then, all these suppositions prove correct, 46,000 actual horse-power will be available from Lake St. Clair, from the turbine shafts in three or more power-stations, of which the last one is situated at the junction of the Dee and Derwent rivers.

Lake Echo.—The catchment area for this lake, consisting chiefly of flat country, I estimate at 62½ square miles (including the lake), and the water surface of the lake at 12⅓ square miles, or 7900 acres.

As no rainfall has been recorded for this lake, I shall use the records from the Great Lake, in in the hope that there may not be much difference in the actual rainfall at these two places.

In preparing the accompanying table, showing the probable yearly and monthly discharges of Lake Echo, I have reckoned the catchment area and the lake's surface area as stated above.

LAKE ECHO.

Monthly and Yearly Discharges in Million Cubic Yards.

Month.	Monthly available Proportion of Rainfall as Storage.			Monthly Evaporation.		Riparian Rights.	Surplus.	Deficiency.
	Gain.			*Loss.*		*Compensation Water.*		
	Rainfall, in Inches.	Co-efficient.	Storage.	Inches.	Quantity.			
January	1·60	0·4	3·441	3	3·186	2·0	...	1·745
February	1·10	0·4	2·367	3	3·186	2·1	...	2·919
March	1·44	0·4	3·098	3	3·186	2·0	...	2·088
April	2·07	0·5	5·566	2½	2·655	2·0	0·911	...
May	2·67	0·6	8·612	2	2·124	...	6·488	...
June	3·02	0·8	12·994	½	0·531	...	12·463	...
July	3·22	0·8	13·852	½	0·531	...	13·321	...
August	2·30	0·8	9·897	1	1·062	...	8·835	...
September	1·87	0·8	8·044	1½	1·593	...	6·451	...
October	2·54	0·7	9·562	2	2·124	...	7·438	...
November	3·05	0·6	9·841	2½	2·655	2·0	5·186	...
December	2·78	0·4	5·980	2½	2·655	2·0	1·325	...
							62·418	6·752

Surplus per annum, 55,666,000 cubic yards.

Surplus per diem, 152,510 cubic yards.

From the 11 years' rainfall records from the Great Lake, I have taken a mean of the three consecutive driest years, 1898, 1899, and 1900; the mean yearly rainfall for these three years being 27·66 inches. Of the rainfall available for storage, I have reckoned 0·6, divided on the different months as shown in the table, and the yearly evaporation I have reckoned at 24 inches. From inquiries I made, there does not seem to be much irrigable land in the Dee River valley. At a distance from the lake of about four miles there is a fine flat, perhaps 600 to 800 acres in extent, which could be irrigated at a proportionate small cost; but further down the valley I was assured there were only a few hundred acres which might be irrigated, I assume that if I reckon 5000 acres for the whole of the Dee valley, I do not under-estimate its capabilities, and the compensation water upon this scale will amount to 12,100,000 cubic yards a year, but required during, say, six months. It then appears, from the table, that 55,666,000 cubic yards per annum, or 152,510 cubic yards per diem, will be available.

I find that Lake Echo is at a barometrical altitude of 2975 feet, and the junction of the Dee and the Derwent rises at an altitude of 300 feet. The Dee River has an approximate length from the lake to the junction of about 27 miles, and its total fall on this distance is 2975—300=2675 feet.

Deducting 175 feet as loss in fall for the high-level canals, and for at least three power stations, the available fall will then be 2500 feet, and $\frac{152{,}510 \times 6{\cdot}24 \times 2500 \times 27 \times 10}{60 \times 550 \times 24 \times 60}$ 13,518 horse-power theoretically, or, say, 9000 actual horse-power, from the turbine-shafts.

It was in the latter half of March this year that I visited this lake, and at that time the water-level in the lake was three feet lower than the visible marks from highest winter water-level.

There are two sites for weirs – one close to the lake will have a considerable length, and another about 1200 feet down the river from the lake will not be so long, but will, on the other hand, be so much higher, as the river has a fall on these 1200 feet. It must be decided by instrumental surveys which of the two sites will be the better.

As the terminal power station from Lake Echo and the last power station from Lake St. Clair would be situated at the same place, namely, the junction of the Dee and the Derwent Rivers, it would probably be most feasible to join them.

The Great Lake.—I have read the interesting report dated October 22, 1897, and signed by Mr. A. Mault (Secretary to the Board of Health), which treats on the water-power which may be obtained from the Great Lake, and when gauging the Shannon and the Ouse rivers close to this lake, on the 15th and 16th February last, I seized the opportunity of examining a part of the southern shore of the lake, more particularly the place where the Shannon River leaves the lake, thus providing the only outlet from same.

From visible marks on the shore indicating highest winter water-level I found the difference between this and summer water-level amounts to about 4½ feet. I was informed that, although in a very prolonged dry season the flow of the Shannon would be very small, yet it has not, during the last 16 years, been known to cease running altogether.

There is no doubt about the best site for an eventual weir at this lake; it will be found at the point where the Shannon leaves the lake, and where a rocky bar crosses the river bed and extends a little into the lake; this bar has, so far, prevented the summer water level in the lake becoming too low. In case this rocky bar should prove itself impermeable for water, and of sufficient hardness, then there are great facilities for constructing a weir here.

From the agricultural map, I find the lake's surface area to be 41 square miles, or 26,240 acres, and the catchment-area for the lake to be about 199 square miles (including the lake).

By the courtesy of the Meteorological Observer, I have received a table showing the monthly rainfall records at the Great Lake for the last eleven years, and reckoning a mean of the three consecutive driest years (1898, 1899, and 1900), I get a yearly rainfall of 27·66 inches.

By the computation of the accompanying table, showing the probable monthly and yearly discharges from the Great Lake, I have reckoned the catchment-area, the lake's water area, and the rainfall, as stated above. I have further reckoned that 0·6 of the yearly rainfall, divided for the different months as shown in the table, may be available for water-storage in the lake, and the yearly evaporation I have reckoned at 24 inches. As compensation water, I estimate that quantity, which will irrigate 10,000 acres, to be sufficient, and which is 24,200,000 cubic yards per year.

From the table, it then appears that there may be available 188,055,000 cubic yards per annum, or, say, 515,220 cubic yards per diem.

By barometrical observations, I found that the Great Lake is at an altitude of about 3350 feet above sea-level, and the junction of the Shannon and the Ouse rivers at an altitude of about 950 feet.

The River Shannon, from the Great Lake to its junction with the Ouse, has an approximate length of 36 miles, and its fall for this length is 3350 — 950 = 2400 feet. Assuming that 200 feet will be lost for the necessary fall for high-level canals, and for the power stations, of which there probably will be at least three, and of which the terminal one will be at the junction of the Shannon and the Ouse rivers, there will be a fall of 2200 feet to be divided between the power stations, and the power obtained will be $\frac{515{,}220 \times 6{\cdot}24 \times 27 \times 10 \times 2200}{60 \times 60 \times 550 \times 24} = 40{,}187$ horse-power theoretically, or, say, 27,000 actual horse-power, from the turbine shafts.

All the waters liberated at the terminal power station are available for irrigation, if, indeed, there is any considerable portion of the land irrigable in the Ouse valley from the junction of the Shannon to the junction with the Derwent.

THE GREAT LAKE.

Monthly and Yearly Discharges in Million Cubic Yards.

Month.	Monthly available Proportion of Rainfall as Storage.			Monthly Evaporation.		Riparian Rights.	Surplus.	Deficiency.
	Gain.			*Loss.*		*Compensation Water.*		
	Rainfall, in Inches.	Co-efficient.	Storage.	Inches.	Quantity.			
January	1·60	0·4	10·958	3	10·584	4·0	...	3·626
February	1·10	0·4	7·535	3	10·584	4·2	...	7·294
March	1·44	0·4	9·863	3	10·584	4·0	...	4·721
April	2·07	0·5	17·722	2½	8·820	4·0	4·902	...
May	2·67	0·6	27·432	2	7·056	...	20·376	...
June	3·02	0·8	41·369	½	1·764	...	39·605	...
July	3·22	0·8	44·107	½	1·764	...	42·343	...
August	2·30	0·8	31·507	1	3·528	...	27·979	...
September	1·87	0·8	25·614	1½	5·292	...	20·322	...
October	2·54	0·7	30·446	2	7·056	...	23·390	...
November	3·05	0·6	31·334	2½	8·820	4·0	18·514	...
December	2·78	0·4	19·040	2½	8·820	4·0	6·220	...
		12	317 28				203·651	15·596

Surplus per annum, 188,055,000 cubic yards.

Surplus per diem, 515,220 cubic yards.

RESUME.

From the very beginning of civilisation wind and water has been used as forces for driving motors.

As wind-power is very unreliable and fickle, it is used only in a small way for pumping water, for milling purposes, &c.

Water-power has always been used wherever it happened to be available for industrial purposes, but the drawback with this otherwise excellent motive-power is (or rather has been), that it is seldom to be had where power is required, and where water-power is present, it is often found in such out-of-the-way places that it cannot be profitably utilised.

During the last century the steam-engine has forced its way and has become the universal prime motor, and at the present it has been perfected to such an extent that further radical improvements cannot be hoped for.

Besides the steam-engine other motors have come into use, such as gas and other explosive engines, the caloric engine, and others, which are more commonly used in the small industries. But it is only in cases where a motor of a few horse-power, or a fraction of a horse-power, is required, that these small prime motors have been able to compete successfully with the steam-engine.

During the last quarter of a century electricity has advanced considerably, so that it is now quite commonly used for lighting, power, and other purposes; and whether it is required to run an engine of several thousand horse-power or a sewing machine, it does its work equally well.

But to generate electricity in a profitable way a prime motor is required. This is most commonly the steam-engine, but where water-power is available it is eagerly seized, because falling water is not only the least expensive force we can employ (the sun doing the work of lifting up the waters again to where they came from), but a water-motor can be made to work so smoothly and steadily, which cannot be equalled either by the best constructed or best regulated steam-engine or any other motor.

Where it so happens that a proportionately high fall of water is available, the turbine—which in such a case is always the kind of water-motor chosen—can be so constructed that its revolutions per unit of time is equal to that of the dynamo (by which machine the mechanical energy from the turbine is transferred into electric power), and the turbine and dynamo are fixed on the same axle. Especially in such a case can the turbine be said to be an ideal motor.

It is, therefore, not surprising that during the last 15 to 20 years water-power, especially in connection with developing electric force, has been extensively used in those countries which are fortunate enough to have this power; this has been the case with several countries in Europe, and in a specially marked degree in the United States of America.

The Australian States, with one notable exception, have a scarce and insufficient supply of water; it is as the Chief Engineer of the Victorian Water Supply Department says in his Report (1895) when speaking about irrigation. "The problem that generally presents itself is, not how to get the water on the land, but how to get water to put on the land."

The exception mentioned above is Tasmania, which over the greater part of its area is well provided with an ample rainfall somewhat evenly allotted during the different seasons. Most of the rivers of the Island gather their waters from the central plateau, which is from 2000 to over 3000 feet above sea-level, and some of these rivers form outlets of large lakes, which act as natural reservoirs, and in which the abundance of rain falling in the wet season may, by comparatively small expenditure, be stored for use during the dry season. This is the case with the three lakes mentioned in this Report.

If the assumptions on which I have based my computations are right, then the power from the turbine-shafts in the combined power-stations will be as follows:—

From Lake St. Clair	46,000	actual horse-power.
Lake Echo	9000	"
Great Lake	27,000	"
TOTAL	82,000	actual horse-power.

It must be borne in mind that by obtaining the power as specified above I have not in any way prejudiced the irrigation question; in fact, it has helped to solve it, inasmuch as I have made provision for giving ample compensation-water for all irrigable land for the parts of the rivers where water will be drawn for power, and below the terminal power-stations all the water is available for any purpose, and will be forwarded in a steady stream all the year round.

I need hardly point out that if more power is required it may be had from several other rivers, for instance, the Ouse and Nive rivers; but it is equally evident, that to obtain power from these rivers will involve proportionately heavier expenditure, as large artificial reservoirs will have to be constructed.

As it is probable that the power cannot be profitably utilised at the different power-stations, the power will have to be transferred to places where it is required.

In case it should be possible to make Hobart the manufacturing centre of Australia, amongst other reasons, on account of her facilities in producing inexpensive and reliable power, the 82,000 horse-power at the different power-stations would be reduced by about 30 per cent. (namely, by converting the mechanical energy into electric force, by friction and loss on line from power-stations to Hobart, and by re-converting the electric current into mechanical energy), and the power which could be distributed at Hobart would be say, 57,000 actual horse-power.

At present there is not one thousand horse-power consumed in Hobart for tram service and for lighting, but it is a true maxim that "supply creates demand," and if an inexpensive and plentiful supply of electric force was offered here the demand would increase; perhaps, under such conditions, Hobart itself might absorb from 5000 to 7000 horse-power, and 50,000 horse-power would be available for large manufacturing industries.

During the last few years great improvements have taken place with respect to transferring power over even moderately long distances (see Appendices A, B, C, and D), and this is the reason why water-power lately has come so much into use, because it is now possible, by electrical transformation, to utilise water-power, even if this happens to be developed at places difficult of access.

Judging by the rapid strides which have been made during the last few years by electrical engineers and manufacturers, it is more than probable that within a few years it will be practicable and profitable to run all the Tasmanian Railways, to supply light all over the Island (see Appendix E), and to run all motors as well in the mines as anywhere else within this Island by electric power derived from water, but all this cannot be accomplished to-day.

There is yet another feature I wish to bring forward. Although our world's supply of coal is not inexhaustible, yet there is, no doubt, coal enough for many centuries to come; but in some of those countries where good steam-coals are produced and consumed (for instance in England), and where the consumption is steadily increasing, people are already alarmed at the prospect that their home supply shall be exhausted. Long before this takes place the price of steam-coal will increase, and those countries which have no good steam-coal themselves, but are fortunate in having ample water-power, can with equanimity contemplate the increasing price of steam-coal.

The purport of this Report is to show what power may be had from Lake St. Clair, Lake Echo, and the Great Lake, and to point out that by the last few years' inventions it seems practicable and profitable to transfer power over considerable distances, whereby it may be directly remunerative to employ part of the large water-power available in this country, and thereby also improving the industrial and commmercial interests in this State.

I have the honour to be,
Sir,
Your obedient Servant,

K. L. RAHBEK, *M. Dan. Assoc. C.E.*

Appendix A.

The Engineer, 2nd February, 1900.

The Parliamentary estimates for the construction of the proposed Manchester and Liverpool Electric Express Railway places the total cost of the scheme at £1,750,000 sterling. The estimates give the length of the railway from Deamgate, Manchester, to its termination at the Blue Boat Hospital, Liverpool, as 34 miles 4 furlongs 2 chains. The railway will throughout its whole length be constructed as a double line on the monorail system. The principal items in the estimates are :—Stations, £76,600; land and buildings required to be taken, 310 acres, £451,600; the permanent way, estimated at £18,000 per mile, £621,450; viaducts, £175,300; and contingencies, £117,940.

Appendix B.

Scientific American, 9th March, 1901.

Mr. W. Langdon, the Superintendent of the Electrical Department of the Midland Railroad of Great Britain, recently read a paper before the Institute of Electrical Engineers, upon the practicability of converting the trunk railroads from steam to electric traction, and the numerous benefits that would accrue from such a change. He contended that the utilisation of electric traction for this purpose was perfectly feasible, and he was of opinion that the railroads could be worked much more economically by this means. He had obtained returns of the trains running over the main road of the Midland road between London and Bedford, a distance of 50 miles, in order to ascertain the amount of current required to deal with it, and the cost of installing and maintaining the necessary generating plant. From his deductions he discovered that the capital outlay for the installation of the plant would amount to 2,350,000 dollars, and the annual expenditure would aggregate about 194,800 dollars. In comparison with the cost of working the same by steam traction an economy of nearly two cents per train mile would be effected by the employment of electricity.

At the present time, owing to the high price of coal, the saving would be much greater. If all the railroads of the United Kingdom were to adopt electricity for the propulsion of their trains in place of steam, no less than 3,000,000 tons would be saved per annum.

Appendix C.

The Engineer, 23rd November, 1900.

ELECTRICAL ENGINEERING AT THE PARIS EXHIBITION (Thury System of Electrical Transmission).

Since the singularly successful Lauffen-Frankfort polyphase transmission in 1892, there has been a general tendency to look upon some form of polyphase transmission as the method of solving the problem of transmitting electrical energy over long distances which is the most likely to prove economical and technically successful in future. There are a good many reasons for questioning the validity of this conclusion. Amongst others may be enumerated the singular success attending the various undertakings which have been carried out on the Thury continuous series system by the Compagnie de l'Industrie Electrique of Geneva. One of the most successful of these undertakings has been the Chaux de Fonds and Soele transmission, in which 3600 h.p. is transmitted a distance of upwards of 31 miles at a pressure of 14,400 volts, with a loss in transmission varying from 6 per cent. at the maximum to 1 per cent. at the minimum.

The employment of continuous currents at high tension over long distances has a great many advantages compared with any of the alternating-current systems. The continuous current generators can be coupled up one after the other, so as to supply almost any pressure required. This cannot be done with alternators, not even with single face alternators, unless they are rigidly mounted in the same driving shaft. Again, with continuous currents we do not require any transformation down on the series system, except in special cases; that is to say, we can run motors of almost anypower directly on the line. This has never been done on any other system, though theoretically possible. The saving of expense thereby secured does not require to be dwelt upon at length.

Then again, we have considerable economy of copper. Without considering the question of transformers, the economy on the line is from 15 to 30 per cent. greater than with any of the alternating current systems, and with the series system we do not require any feeders. When we consider the question of insulation, there is another advantage attaching to the continuous current system. For the same effective pressure the actual pressure on an alternating current system rises at the top of each wave to 1·4 times what it ever is at the same pressure on the continuous current system.

When dealing with higher pressures this means a good deal. It means really, that a line carrying a nominal 20,000 volts has to be insulated for at least 28,000 volts. This extra 8000 volts makes a considerable extra demand upon the insulators.

The series type of Thury dynamo have in nearly all cases been coupled direct to high-pressure turbines, and various methods of governing the speed of the turbines have been adopted. The system being a series distribution, is essentially constant current, and various methods of regulation; the generators for the purpose of keeping the current constant have been employed.

Appendix D.

The Engineer, March 2, 1900.

In America there are some 20,000 miles of electric tramways open, and rapid extension is still going on.

An approximate computation shows that there must be about 1,000,000 H.P. of electro-chemical and power-transmission at work abroad.

Appendix E.

The Engineer, Nov. 23. 1900.

In a recent report Mr. Hughes, U.S. Consul at Coburg, states that in his district considerable attention is being paid to electrical appliances that can be used on the farm. Near Ochsenfurt, in Bavaria, a company, composed of landowners and small farmers, has been organised for the establishment of an electrical system for use on their farms and in villages. The power is to be generated by steam and water, and the current to be distributed from a central station to the places at which it is wanted. Sub-stations are to be established at given points, with the necessary apparatus for connecting with the farm or other machinery, and also for lighting purposes in the houses, offices, and streets.

JOHN VAIL,
GOVERNMENT PRINTER, TASMANIA.