(1) பக்கங்களின் எண்ணிக்கை 236

(2) புதுக்கித் திருப்பிய நாள் 8-88

(3) ஆதாரங்குறிப்பவர் சுருக்கொப்பம்

தமிழ்நாடு ஆவணக் காப்பகம்.

தமிழ்நாடு அரசு

பாசும் பணி துறை

அரசாணை எண்.
மு. கோப்புத் தாள் எண். 2044-45-W அச்சகம் பலவகை

நாள் : 20.8.1884 19

படித்தவரோ கண்டபடி கையாளவோ கூடாது

ஆணை. கா-1—18,006—15-6-87.

2044/2045

GOVERNMENT OF MADRAS.

PUBLIC WORKS DEPARTMENT.

Buildings and Roads.
Military Works.

READ—the following papers:—

From A. T. ARUNDEL, Esq., President, Municipal Commission, Madras, to the Chief Secretary to Government, dated Madras, 29th April 1884, P.W.C. No. 476.

With reference to G.O., No. 3425 W., dated 30th November 1883 (Public Works Department), I have the honor to forward the report on the electric lighting of Fort St. George drawn up by Mr. J. A. Jones, Vice-President of the Municipality, while on furlough.

2. This interesting report is complete in itself, but the report which Mr. Jones has drawn up for the Commissioners on the different systems of electric lighting will shortly be printed, and will then be available for reference by Government.

3. I enclose a copy of Mr. Jones's letter, No. 412, dated 18th April, together with a copy of a letter addressed to him by the Under Secretary of State withholding the Government grant of Rs. 500 until Mr. Jones went to America. Mr. Jones, on receipt of the Government Order above quoted, wrote to inform me that he would not be able to prosecute his inquiries into electric lighting in America without an extension of furlough and a larger grant for travelling expenses, but as I understood from him that his inquiries could be efficiently completed in England, it seemed unnecessary to make an application to Government and to the Commissioners on the subject. I request, therefore, that Government will be pleased to order the payment to Mr. Jones of the grant of Rs. 500 towards his expenses in preparing the report on the electric lighting of Fort St. George.

ENCLOSURES.

From J. A. JONES, Esq., Vice-President, Municipal Commission, Madras, to the President, Municipal Commission, Madras, dated Madras, 18th April 1884, P.W.C. No. 412.

I have the honor to forward, in compliance with G.O., No. 3425 W., dated 30th November 1883, Public Works Department, a report on the electric lighting of Fort St. George, with tracing accompanying.

I may state that since last July I have been almost daily occupied in acquiring information on the matter, and in visiting the many installations in London, Woolwich, London Docks, Glasgow, &c., and in the preparation and copying of the reports, plans, &c. I more than expended (but have kept no detailed account of) the Rs. 500 allowed me by the Municipality. The preparation of the report on lighting Fort St. George has entailed on me considerable additional trouble and expense.

The Secretary of State for India declined payment to me of the Rs. 500 sanctioned in Government Order above quoted (see copy of letter attached) until I proceeded to America, or received further orders on the matter. As I did not proceed to America, I allowed the matter to stand over until my return to Madras, and trust you will be good enough to move Government for payment to me of the amount sanctioned.

From J. A. GODLEY, Esq., to J. A. JONES, Esq., Albany Place, Dumfries, Scotland, dated India Office, S.W., 19th January 1884, P.W. No. 2530.

I am directed by the Secretary of State for India to inform you that the Government of Madras has, in a letter recently received, requested that a sum of Rs. 500 might be placed at your disposal towards meeting your travelling expenses, in view to the inquiry you are making on behalf of the Madras Municipality being extended so as to include the question of lighting Fort St. George by means of electricity.

Having learnt by your letter of the 2nd instant that you have written to the President of the Madras Municipality for information and instructions in regard to your visit to America, the Secretary of State will withhold the payment to you of the equivalent of Rs 500 until he is informed by you of the result of your reference to Madras, when, should you have to proceed to America, a draft for the amount will be forwarded.

REPORT ON ELECTRIC LIGHTING OF FORT ST. GEORGE.

No better place than Fort St. George, Madras, could be selected in order to test the suitability and economy of electric lighting.

The lighting, both public and private, is in the hands of one body, the Government, while the area is perfectly defined and of a circular form; the streets are regular, and the buildings pretty equally distributed over the area.

The extent, again, is not above what might be reasonably expected, could be perfectly lighted, and the lighting controlled from one central station.

Conditions so favorable are seldom, if ever, met with, and it is because of these circumstances I am able to present to Government so complete an estimate such as I have the honor to include in this report.

Before the receipt of G.O., No. 3425 W., of 30th November 1883, Public Works Department, I had, in making inquiries and studying the question of electric lighting on behalf of the Municipality of Madras, decided in favor of the Siemens' system as being the most complete and the one most suitable for India. The reasons which led me to this decision I need not repeat; they will be found in my report to the Municipal Commissioners, which is of course available to Government.

Neither do I consider it necessary in this report to again detail the theory of the production of the light, nor the various ways in which electricity is produced; such also will be found in the report before referred to. I may, I think, therefore confine myself more particularly to the subject on hand.

I observe in G.O. of 29th October 1883, No. 5797, that Government have ordered the removal of the present gas-works and the disposal of all plant, stores, &c., connected therewith. I am unaware of the state of the gas-works, and whether it is possible to continue making gas by them, were such a course desirable, and I therefore refrained from addressing Government on the matter, which has reference to the motive power necessary for the production of the light. Before passing on to consider the general question of motive power, I may, however, observe in passing that gas can be more economically used in producing motive power, which itself is used to produce electric light, than by burning the same amount of gas at a gas-burner, that is to say, the illuminating power per thousand feet of gas is much greater in the former than the latter, in fact, as 7 to 1 if arc lamps are used.

In electric lighting the first question to consider is the motive power. The cheapest of all powers is water-power derived from a stream or waterfall. No such source of power is obtainable in or near Madras. We have available, however, wind-power and steam-power (produced by burning coal or oil) and power from a gas-engine. The first-named power is extremely uncertain, though with accumulators it might be used for the production of light in small buildings. There therefore remains steam-power and gas-power; and as the gas-works in Fort St. George may not have been removed by the time this report reaches Government, I have deemed it my duty to consider this question fully.

The cost of coal in Madras may be taken as 35*s.* per ton. A steam-engine working economically consumes 2½ lb. per Indicated H.P. per hour. This 2½ lb. would maintain an arc light of 1,000 candle-power for one hour, and the cost would be about ¼*d.*

For a gas-engine 20 cubic feet of gas are required per H.P., and taking gas manufactured in Fort St. George as costing Rs. 4-8-0 or 7/6 per 1,000 cubic feet, the cost for one hour for the same amount of light would be nearly 2*d.* or four times as much.

Thirty-five shillings per ton for coal is exceedingly high, and will be no doubt gradually reduced when greater facilities for transport allow of the use of Indian coal.

A gas is now being manufactured in England from anthracite coal found in South Wales and sold at 3/3 per ton. The gas is unsuitable for illuminating purposes, though well suited for heating and motive power. Such coal could probably be delivered in Madras at 24*s.* per ton.

The gas made from this coal is produced by Dowson's system, and the only portions of the present gas-works suitable would be the purifiers and gasometers, while Dowson's patent generators would be required.

This gas can be produced in England for about 3*d.* per 1,000 cubic feet, and taking the cost of the coal in England and India as 1 to 6, the cost of 1,000 cubic feet in India would be 1/6 per 1,000 cubic feet.

One hundred cubic feet of this gas is required against 20 of ordinary coal gas to one horse power per hour, and the cost therefore for one hour would be $\frac{1/6}{10} = 1{\cdot}8d.$ per H.P. per hour. This is not very much under the cost of the power produced by coal gas and very much more than the cost of steam-power.

It is evident, therefore, that steam-power is the cheapest under present circumstances.

I have not had time to consider the question whether petroleum might not be cheaper to use than coal for the production of steam, but that question can be decided by experiment in Madras.

I regret that it was not possible to determine the actual requirements of the Fort as to the amount of light, because, while having a knowledge of the streets, &c., and thus being able to decide on amount of outside lighting desirable, I was not so intimately acquainted with the buildings in the Fort as to be able to allot very judiciously the amount of light required for each.

The number was, however, left for my decision, and the estimates are based on the following number of lights:—

	Incandescent of 20 candle-power.	Arc of 1,000 candle-power.
3. Fort Dispensary ...	5	...
5. St. Mary's Church ...	30	2
7. Officers' quarters ...	10	...
9. Officers' Mess ...	20	2
12. Sergeants' Mess ...	10	...
13. Barracks ...	100	6
14. Canteen ...	5	...
17. Brigade Major's office and house ...	15	...
19. Engineer's office and house ...	10	...
21. Adjutant-General's office and house ...	15	...
22. Engineer's quarters ...	10	...
23. Main Guard ...	20	...
25. Married quarters ...	50	4
26. Out-houses ...	20	...
Outside lighting ...	...	32
Total ...	320	46

This gives a total illuminating power of 320 × 20 C.P. = 6,400 + (42 × 400 C.P.) + 4 × 1,000, a total of 27,200 candles. The engine-power, however, provided for in the estimates will allow of 64 incandescent lamps being added where desirable, and as one arc lamp can be substituted by eight incandescent lamps, I am somewhat sanguine that the total illuminatory power provided will meet the requirements.

I regret that G.O. of 21st December 1883, No. 3671 W., reached me after a considerable portion of this report had been written and after the estimates had been completed, so that I have been unable to exactly comply with the wishes of His Excellency the Commander-in-Chief. It will be observed, however, that the lights on the walls will illuminate the approaches beyond the walls, and the 64 additional lamps above referred to and the 10 allowed for the officers' quarters will allow of 74 lamps being provided for the barracks, Nos. 4 and 24, which are the only ones I have omitted from the estimate, and these 74 will no doubt be found sufficient.

I have not included the Grand Arsenal in the scheme. I believe there is a large amount of steam-power already available, and if it is desirable to provide light for working at nights in cases of emergency, a separate system worked by an additional dynamo machine can easily be arranged.

It seemed to me very desirable, when introducing electric lighting into the Fort, that some provision should be made for what is called a search light, which would be useful for military purposes for use at night in case of wrecks, or for watching vessels approaching the harbour at night. I have therefore arranged for a holophote, which could be placed in the truck of the flagstaff, and which would give a light equal to 40,000 candles.

The accompanying tracing shows the position of the lights proposed.

The greater bulk of the outside lighting will be quite independent from the inside lighting, only four of the outside arc lamps being in connection with the inside system.

The lamps numbered 1 to 28 will be worked from one $\frac{W}{D\,7}$ alternate machine, worked by a compound steam portable engine.

The position of each lamp is indicated by a ×, and the lamps 1 to 7 will be on the first circuit, 8 to 14 on the second, 15 to 21 on the third, and 22 to 28 on the fourth circuit.

The remainder of the lighting is proposed to be done by two continuous current machines called in Messrs. Siemens' list S. D∞ (self-regulating), each capable of giving a current of 150 ampères with difference of potential of 120 volts at the terminals of the machine.

From these machines the arc lights 29 to 32 (outside) would be supplied, arranged two in series for a current of about 12 ampères, so that these four lights would have about twice the power of the other arc lamps.

The dotted line on the plan indicates the course of the main circuit of continuous currents, and the marks thus △ indicate service boxes where connections are made to the various buildings, &c. The search light would also be worked from these continuous current machines.

28. *Alternate Current Lights.*

The current passing through these lights would be between 11 and 12 ampères. The conductors are proposed to be placed underground, though overhead wires are cheaper.

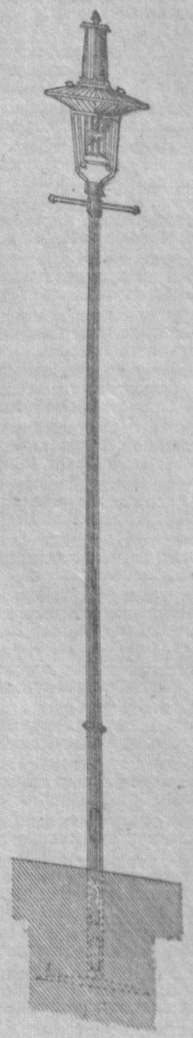
I considered that the wires in such latter position would be much more liable to injury, and might interfere with the fire or working of the guns.

The wires estimated for, therefore, consist of a copper strand insulated with gutta-percha and protected by jute and a sheathing of iron wires.

As has been already stated, the lamps would be divided into four groups of seven lamps each. The two groups, 1 to 7 and 8 to 14, comprise the lamps on the walls, and these lamps would throw light outside the inner walls as well as inside, unless it were desirable to arrange for all the light being inside. By this arrangement all the lights on the walls could be extinguished at a moment's notice were it at any time found desirable to have no lights showing beyond the walls. Only one lamp would remain burning on the walls, viz., No. 15, and this would have a special switch in the engine-house, so that it could also be extinguished without interfering with the other two circuits.

The four circuits unite, as shown on plan, near the buildings 25 and 26, whence a bare copper strand is laid as a common return wire back to the engine-house.

The lamp-posts proposed to be used are what are shown in the sketch given below, but their height can be reduced if necessary. The lamps on such posts are arranged to burn 12 hours without attention; the carbons used have a diameter of 10mm. and burn at the rate of 3″ per hour per lamp.



The current would be supplied by one alternate current machine, excited by a dynamo machine. I give a full detail of the Siemens' system in the appendix, with sketches of the various machines, &c., to which reference may be made.

This plant would only be in use for about 90 to 100 hours per month.

II. Continuous Lighting.

The outside arc lamps, Nos. 29 and 30 and 31 and 32, would be on circuits from the engine-house, where they could be turned off and on as desirable. Light No. 29 it is proposed to fix to a bracket on the Government buildings.

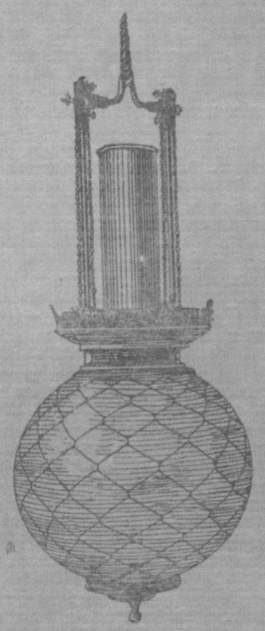
These lamps, as before stated, are more powerful than the other arc lamps. They would be placed on lamp-posts similar to those already described.

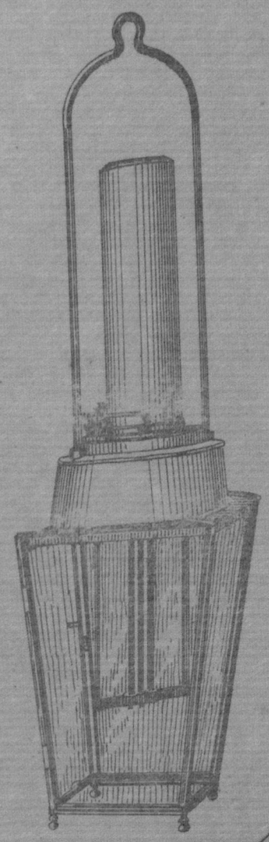
The engine-room, it will be noticed, has been placed on the plan near the flagstaff, but I am unaware whether such location is possible. Its position it was necessary to fix for the purpose of the estimate, and though a change in position would necessitate an alteration in the circuits, the amount of the estimate would not vary to any great extent.

Taking the engine-room, however, for our present purpose as being near the flagstaff, it seemed most convenient to have St. Mary's Church and the Fort Dispensary on a separate circuit as indicated on plan. The two arc lights proposed for the church are also under the control of a switch in the engine-room, having also a separate circuit.

The main circuits will consist of two leads No. 1325*g* insulated and protected as before stated. This circuit is shown in dotted lines, and the two leads can be placed in one trench about 2 feet 6 inches to 3 feet underground. In two places the circuit is taken through buildings Nos. 25 and 13, but this seems unobjectionable. The service boxes indicated by △ are made of cast iron and are closed on the top by a lid which is locked. In these boxes are connecting boxes, so that branch wires can be joined to the main cables. The joining is effected by screws, so that when the electricity is to be cut off from any building, the disconnection is easily effected, when switch inside the building is not accessible.

For the inside arc lights it is proposed to supply lamps of either of two following patterns, in both of which the mechanism controlling the due supply of the carbons is placed above the globe.





The following sketch shows the incandescent lamp fittings it is proposed to use, and these can be placed either close to the ceiling or on the walls, or suspended by wires from the ceiling to any height above the floor.



Fittings much more ornamental can, of course, be supplied where it seems desirable, but the above have been estimated for throughout.

In some cases each fitting will have a switch, and where they are in large numbers each ten or twenty will be controlled by a switch. The lights will therefore be entirely under the control of those using them.

As already stated, the continuous currents will be generated by two of Siemens' S. D$_{00}$ machines, each driven by a C. compound garret engine, and it may be observed that each B. engine works up to a maximum of 35 I.H.P. and each C. engine to a maximum of 50 I.H.P. Messrs. Siemens do not deem it wise to employ smaller engines, as they last much longer when not worked up to their full power.

In the engine-house a suitable switch board would be provided to turn on and off the various machines and to connect them to the various measuring instruments, of which a complete set have been quoted for, so that faults in any portion of the system it can be made available at any moment.

By connecting the search light to the system it can be made available at any moment.

The connections from the service boxes to the interior of the buildings will be made by twin wires fitted at one end with a screw connection for the box and being connected at the other end to the main switch of the building.

In each building the switch would consist of a case attached to the wall in a convenient position covered with a glass cover and containing the actual switch for turning on and off the lamp, and also a safety fuse which melts when the current is too strong for the wires, and thus shuts off the electricity from the building. It will be advisable to place the twin wires from the service boxes to the various buildings in iron pipes to guard them against injury.

The following is Messrs. Siemens' estimate, and if it is decided to lay down the necessary apparatus, full particulars and drawings will be provided. A convenient size for the engine-room would be 40′ × 60′, and perhaps some room or vault in the Fort is available; no amount is, however, included in the estimate for this work:—

A. Outside Lighting (Alternate Currents).

	£	s.	d.	£	s.	d.
I. Machinery—						
1 B. compound steam-engine	330	0	0			
1 W. Dy. alternate current machine	300	0	0			
2 Sets of foundation rails	7	0	0			
40 Feet of No. 2 link belting, 8 inches wide, at 7*s.*	14	0	0			
40 Feet of No. 2 link belting, 3 inches wide, at 2*s.* 8*d.*	5	6	8			
				686	6	8
II. Leads—						
4,000 Yards No. 100*f* at 8*s.* 10*d.*	340	0	0			
400 „ No. 100*l* at 4*s.* 5*d.*	19	0	0			
500 „ No. 200*a* at 4*s* 5*d.*	23	15	0			
				382	15	0
III. Lamps and fittings—						
1 Terminal board with switches	13	0	0			
28 Lamp-posts No. 3 at £28	784	0	0			
				797	0	0
			Total ..	1,866	1	8

In addition to this there would be the cost of erection, say Rs. 1,000.

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B. Inside Lighting (Continuous Currents).

	£	s.	d.	£	s.	d.
I. Machinery—						
2 C. compound steam-engines at £565 ...	1,130	0	0			
2 S. D$_{00}$ machines (120 volts) at £400 ...	800	0	0			
2 Sets large foundation rails at £7	14	0	0			
80 Feet No. 2 link belting, 9 inches wide, at 7*s.* 10*d.*	31	6	8			
				1,975	6	8
II. Engine-house fittings—						
1 Switch board	50	0	0			
3 Dynamometers, Nos. 2, 3 and 4	23	10	0			
1 Voltmeter No. 6	25	10	0			
1 Universal galvanometer No. 1	18	0	0			
1 Detector, with battery complete	4	0	0			
				121	0	0
III. Main circuits (outside)—						
400 Yards No. 100*f* (circuits to dispensary and church) at £8-10-0 per 100 yards	34	0	0			
1,000 Yards No. 44*j* (for lights 29, 30, 31 and 32 and two lights in church) at £6 per yard ...	60	0	0			
3,000 Yards No. 1325*g* at £55 per 100 yards ...	1,650	0	0			
17 Service boxes at £7	119	0	0			
				1,863	0	0
IV. Outside lights—						
3 Lamp-posts No. 3 (fig. 22) at £28	84	0	0			
1 Bracket (fig. 23)	30	0	0			
				114	0	0
V. Internal fittings—						
No. 3 on plan. Fort Dispensary—						
5 Lamps with fittings at 15*s.* ...	3	15	0			
5 Small switches at 2*s.* 6*d.* ...	0	12	6			
1 Main switch	0	10	0			
20 Yards No. 100*bd* with connection	3	0	0			
20 Yards No. 27*b*	0	8	10			
				8	6	4
No 7. Officers' Quarters—						
7 Incandescent lamps at 15*s.* ...	5	5	0			
7 Switches at 2*s.* 6*d.*	0	17	6			
1 Main switch	0	10	0			
40 Yards No. 100*bd* with connection	5	10	0			
100 Yards No. 40*b*	2	16	0			
				14	18	6
No. 5. St. Mary's Church—						
30 Incandescent lamps at 15*s.* ...	22	10	0			
1 Main switch	0	10	0			
20 Yards No. 100*bd* with connection	3	0	0			
200 Yards No. 44*b*	5	12	0			
2 Arc lamps in No. 14 lanterns at £18-15-0	37	10	0			
				69	2	0
No. 9. Officers' Mess—						
20 Incandescent lamps at 15*s.* ...	15	0	0			
2 Main switches	1	0	0			
2 No. 14 arc lamps, &c.	37	10	0			
1 Switch and rheostat	5	0	0			
20 Yards No. 100*bd*	3	0	0			
50 „ No. 44*b*	1	8	0			
				62	18	0
No. 12. Sergeants' Mess—						
10 Lights at 15*s.*	7	10	0			
1 Main switch	0	10	0			
40 Yards No. 100*bd* with connection.	5	10	0			
100 „ No. 27*b*	2	4	0			
				15	14	0

		£ s. d.	£ s. d.	£. s. d.
No. 13. Barracks—				
100 Incandescent lights at 15*s.*				
5 Switches at 10*s.*	...	75 0 0		
40 Yards No. 100*bd*	... ...	2 10 0		
6 Arc lamps with No. 17 lanterns at £14-5-0	... ...	5 10 0		
3 Switches and rheostat at £5	...	85 10 0		
800 Yards No. 100*b* at £4-15-0	...	15 0 0		
		38 0 0		
			221 10 0	
No. 14. Canteen—				
5 Incandescent lights at 15*s.*				
1 Main switch	... ...	3 15 0		
40 Yards No. 100*bd* with connection.	...	0 10 0		
100 „ No. 27*b*	... ...	5 10 0		
		2 4 0		
			11 19 0	
No. 17. Brigade Major's Office—				
15 Incandescent lights at 15*s.*				
1 Main switch	... ...	11 5 0		
15 Small switches at 2*s.* 6*d.*	...	0 10 0		
20 Yards No. 100*bd* with connection.	...	1 17 6		
100 „ No. 44*b*	... ...	3 0 0		
		2 16 0		
			19 8 6	
No. 19. Engineer's Office—				
10 Incandescent lights at 15*s.*				
1 Main switch	...	7 10 0		
10 Small switches	... ...	0 10 0		
40 Yards No. 100*bd* with connection	...	1 5 0		
100 „ No. 44*b*	... ...	5 10 0		
	...	2 16 0		
			17 11 0	
No. 21. Adjutant-General's Office—				
Same as No. 17	... ...		19 8 6	
No. 22. Engineer's Quarters—	...			
10 Incandescent lights at 15*s.*				
1 Main switch	... ...	7 10 0		
20 Yards No. 100*bd* with connection	...	0 10 0		
50 „ No. 27*b*	... ...	3 0 0		
		1 2 0		
			12 2 0	
No. 23. Main Guard—				
20 Incandescent lights at 15*s.*				
*2 Switches at 10*s.*	...	15 0 0		
2 × 20 Yards No. 100*bd* with connection at £3	... ...	1 0 0		
100 Yards No. 27*b*	... ...	6 0 0		
		2 4 0		
			24 4 0	
No. 25. Married Quarters—				
50 Incandescent lamps at 15*s.*				
3 Main switches	...	37 10 0		
10 Small switches	... ...	1 10 0		
2 × 20 Yards No. 100*bd* with connection at £3	...	1 5 0		
4 Arc lights in No. 17 lanterns at £14-5-0	... ...	6 0 0		
2 Switches and rheostat at £5	...	58 0 0		
400 Yards No. 100*b* at 4*s.* 15*d.*	...	10 0 0		
		19 0 0		
			133 5 0	
No. 26. Out-houses and Cook-room—				
20 Incandescent lights at 15*s.*				
3 Switches at 10*s.*	...	15 0 0		
40 Yards No. 100*bd* with connection	... ...	1 10 0		
100 „ No. 27*b*	... ...	5 10 0		
		2 4 0		
			24 4 0	
				654 10 10

*It is very important to have the lights all right, and therefore two independent circuits of 10 lights each are provided, each circuit being connected to a separate service box.

		£. s. d.	£. s. d.	£. s. d.
VI. Search Light—				
200 Yards No. 275*f* at £14-15-0	...	29 10 0		
1 Holophote with Fresnel lens	...	132 0 0		
1 Hand-lamp for same	... ...	28 0 0		
			189 10 0	
				4,917 7 6

In addition to this there would be about Rs. 3,600 required for erection, &c.

Some reserve parts of the machines and fittings it would no doubt be necessary to have on hand, but these may be considered as included in the maintenance estimate.

I am unaware in what manner the Government would propose to disburse the money for this work, whether by loan in England or remittance from India from available funds, but I have taken the latter as a basis for the completion of the estimate of prime cost and for the estimate of cost of maintenance.

	£ s. d.
The totals so far then have been—	
Outside lighting	1,866 1 8
Inside lighting	4,917 7 6
Total ...	6,783 9 2

To this has to be added an amount for freight, say £316-10-10, which gives us a total of £7,000.

The cost of this at present rate of exchange (1/8) will be Rs. 84,000, and if to this is added Rs. 4,600 for erection, we arrive at a total first cost of Rs. 88,600.

This amount does not include digging trenches for foundations for engines or engine-houses. Blocks of wood or concrete would serve for the foundations.

The above amount of Rs. 88,600 may be divided as follows:—	Rs.
Machinery, including freight and exchange	34,380
Leads, fittings, &c.	49,620
Labor, &c. ... ... Total ...	4,600
	88,600

Annual Maintenance.

The estimate of annual cost is based upon the assumption that the 32 outside lights are used 180 days for 12 hours, or 2,160 hours per annum (*N.B.*—The street-lamps in Madras burn for only 1,300 per annum). That the church lights are used 600 hours and the 12 inside arc lights for 2,000 hours per annum. The incandescent lamps will last about 1,000 to 1,500 hours each. The above taken together is probably a good deal more than what will be the actual consumption:—

Carbons—	£ s. d.
28 Outside arcs (alternate currents) 180 days = 10mm. S. } ...	171 2 0
4 „ „ (continuous currents) 12 hours = 12mm. S. } ...	8 15 0
2 Church lights, 600 hours = 12mm. B.C.	100 0 0
12 Inside arcs, 2,000 hours = 12mm. S.	125 0 0
500 Incandescent lamps at 5*s.*	630 0 0
360 Tons of coal at 35*s.*	52 0 0
Oil and waste, say £1 per week ... Total ...	1,086 17 0
To this may be added for freight for carbons ...	22 15 0
	1,109 12 0
	Rs. 13,320

Or with exchange amounts to ...

Wages would be about—			
Management	3,000		
1 Electrician	3,600		
Two Engine-drivers	3,600		
Laborers	2,400		
	3,438		
Depreciation and Interest—			
10 per cent. on machinery 34,380 = ...	2,481		
5 „ on leads, fittings, &c., 49,620 = ...		5,919	
Total ...		31,839	

If to this is added interest on the first cost at 4½ per cent., we have a total of Rs. 35,826. I may now make a comparison between this amount and the late gas lighting in the Fort.

The number of lights provided for are 32 arc lights outside, 14 inside, and 320 incandescent. The arc lights take up about 45 H.P. and the incandescent lamps about the same power. The cost of carbons, however, has to be placed against the arc and the renewal of incandescent lamps against the incandescent system. A comparison may therefore be made thus:—

Cost per annum for arc lamps—

	RS.
Total cost	35,826
Less cost of replacing incandescent lamps	1,500
	34,326 ÷ 2
	17,163

which divided by 46, the number of arc lamps, = say Rs. 373 per lamp per annum, or taking 2,000 hours of average burning, about 2·9 annas per hour per lamp.

For the incandescent lamps—

	RS.
Total cost	35,826
Less carbons	3,600
	32,226 ÷ 2
	16,113

which again divided by the number of lamps, 320, = Rs. 50 per annum, or taking 2,000 hours = 0·40 annas per light per hour, or about 5 pies.

These incandescent lamps give only 20 C.P. each, the arcs give about 400 candle-power, the four on the inside circuit about 1,000, so that the proportionate cost of light would be for the incandescent against the arc as—

20 × 0·40 annas to 2·9 annas,

or

8 annas to 2·9 annas,

that is to say, that it is about three times as expensive to produce the same amount of light by the incandescent as by the arc, but of course the former is infinitely more suitable for inside lighting owing to its greater suitability for sub-division.

These prices include payment of interest on cost of plant.

The cost of gas in the Fort per 1,000 cubic feet was in 1877 about Rs. 10-13-0, but it is stated this might have been reduced to Rs. 5-8-0 per 1,000 cubic feet, though it has never been consumed at such a price. This amount of gas burned in gas-burner consuming 5 cubic feet per hour would allow of 200 gas-burners each 20 candle-power, each equal to one incandescent lamp, or one-twentieth part of an arc lamp; the proportionate cost for gas against electricity would therefore be—

	Per hour. ANNAS.
Gas, Rs. $\frac{5/8}{200}$ = ...	
Arc light $\frac{2\cdot9 \text{ as.}}{20}$ = ...	0·44
Incandescent lamps	0·14
	0·40

so that when arc lights are used, the cost is enormously reduced, and with incandescent lamps it is 10 per cent. less.

To compare the amount of light afforded by the gas and the scheme of electric light we have—

For the gas—

	Hours of 20 candle-power.	C. P. hours.
263,345 feet at 5 cubic feet per hour	52,669	= 1,053,380

While of arc lighting there would be—

NO.	= C. P.		
2,000 hours of 42 ×	400	... ...	36,800,000
2,000 " of 4 ×	1,000		

Plus incandescent—

2,000 hours of 320 × 20 = ...	...	12,800,000
Total ...		49,600,000

or fifty times the amount of light given formerly by the gas, while the cost of gas per annum was—

	RS.
Gas { Manufacture	2,869
{ Interest at 4½ at * 1,10,000 = ...	4,950
	7,819
and of electricity	35,826

or only five to one.

* This is taken from information given in the precis on the gas works (G.O., 29th October 1883, No. 5797).

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Rs. 35,826 does not seem to me (seeing that such sum also includes interest on first cost of plant) a very large sum to expend annually on lighting the streets as well as the major portion of the buildings within the Fort. Again, if coal is placed in Madras at a much reduced rate, as it is hoped it soon will be, the cost of maintenance will be materially if not proportionately also reduced. The work itself is apparently very necessary, and even were it not so, no better place than Fort St. George could be selected for the experimental introduction of the light into the Presidency. The system proposed is one which has been applied to areas much greater than Fort St. George, and there is no doubt whatever of its being a success.

The experience which would be gained from the execution of these works would be most valuable to all Municipalities and Local Fund Boards who might wish to introduce the light within their bounds, and there are many places eminently suitable for its introduction on economical grounds.

The recent advance of electrical science has opened out a large field for electricity, supplanting in many ways other sources of power, and I have ventured to add an appendix to this report embodying some ideas which have occurred to me during my various investigations in England, and which I trust will be of interest if not of service to Government. I have added to this report in order to make it as complete as possible, a description of the Siemens' system of lighting, which will, perhaps, tend to elucidate some points which may not be understood from the report itself.

In conclusion, I would claim the consideration of Government in respect to the arrangement and amount of light estimated for the inside of the various buildings which, from my superficial knowledge of their capacity and arrangement, may be somewhat unequal to their requirements, and I wish at the same time to express the pleasure it has given me to prepare the report and my thanks for having had afforded me the opportunity of acquiring some knowledge of a subject which is every day becoming of greater public importance.

(Signed) J. A. JONES,
Mem. Inst. C.E.

DUMFRIES,
February 1884.

SIEMEN'S SYSTEM.

The dynamo-electric generator of Messrs. Siemens Brothers, which occupied a prominent position from the time of its introduction, still maintains that position, and is probably the most powerful generator in existence, whether estimated by a comparison of its high-producing power with its bulk and weight, or by the absorption of motive power or cost of working. Its most remarkable characteristic is its small size and weight in proportion to its power.

There are two classes of Siemens' machines, the continuous and the alternate current machines.

The following sketches show two forms of machines of the former class:—

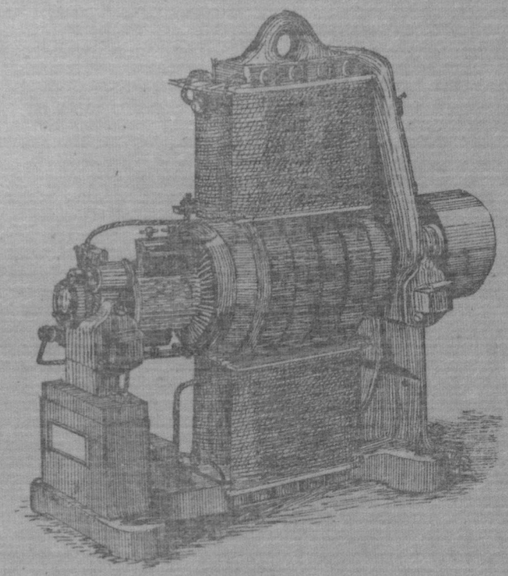


FIG. 1.

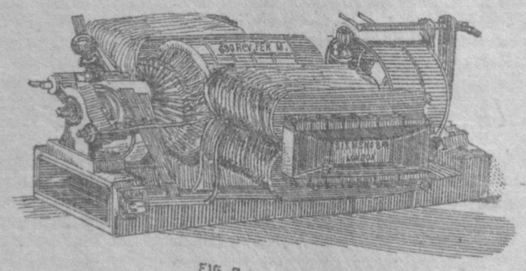


FIG. 2.

The armature of these machines is that of the class known as drum armatures. The iron axis of the machine is surrounded by a wooden shell wrapped with iron wire, on which coils of insulated copper wire (wound in several sections) are wound.

These longitudinal coils of wire completely envelop the iron cylinder, all sections being wound at equal angular distances from each other parallel to planes passing through the axis.

The ends of the coils are brought two by two to the copper sectors on the axis, which sectors are insulated from one another and together build up a cylindrical commutator.

The method of attachment of the coils is shown in the following figure, in which an armature of eight coils only is shown. The numbers are marked plus + and — and show the opposite ends of the same coil.

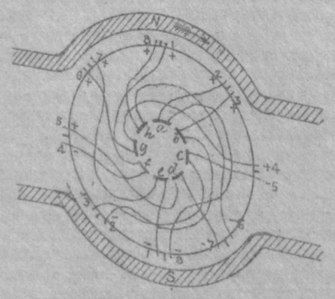


FIG. 3.

If the connections be traced, it will be seen that all the coils form one continuous circuit.

This armature is surrounded by the permanent or field magnets, the coils of which are included in the circuit of the rotating armature through the brushes.

The curved bars passing over the armature are prolongations of the cores of the electro-magnets.

The cores are wound so as to give a north pole on the upper side of the armature and a south pole on the under side. The curved portion of each cord surrounds the armature to an extent of two-sixths of the entire circumference, and an intense magnetic field is thus produced. These cores, it will be observed, are slit up into several portions; this is for the prevention of cross currents, for the circulation of air to prevent heating, and for convenience of manufacture.

In the shunt generator the wire from the brushes, instead of being continued round the magnets, is divided after leaving the brushes, a smaller wire passing round the magnets and the larger going directly to the external circuit in which the lamps are placed.

Alternate Current Machines.

These machines are illustrated in the following diagram, and, as will be seen, consist of a base plate on which are erected, vertically, two circular frames which are bolted together:—

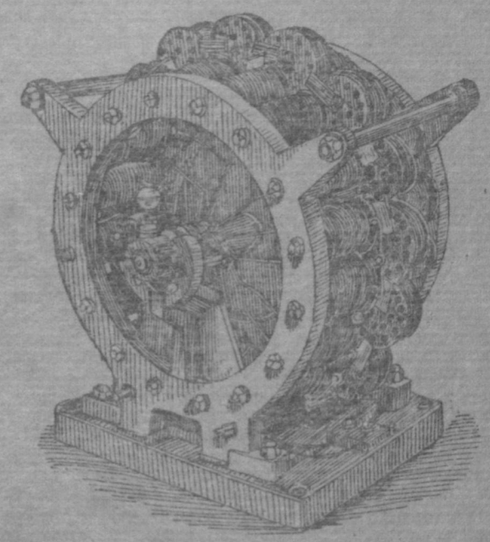


FIG. 4.

On these frames are arranged the electro-magnets, consisting of iron cores encircled with wire. These cores are turned down at their ends and passed through the frames and fixed with a nut as shown. There are an equal number of magnets on each frame, and they are so wound that the free end has a reverse pole opposite to it and on either side of it.

The armature is formed of a number of coils with wooden cores of elongated form (radially) mounted on a disc or wheel which rotates between the magnets already described. The field magnets in these machines are excited by a separate machine and not by being placed in the main circuit.

The following is a diagram of the exciting machine:—

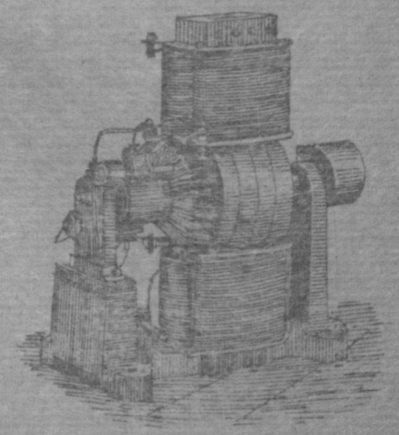


FIG. 5.

The armature coils are coupled up in series or in multiple are according as currents of high or low potential are required.

These machines can be divided into any number of circuits, and if there be sixteen armature coils on a machine, then four of the coils are connected together and their loose ends carried to the

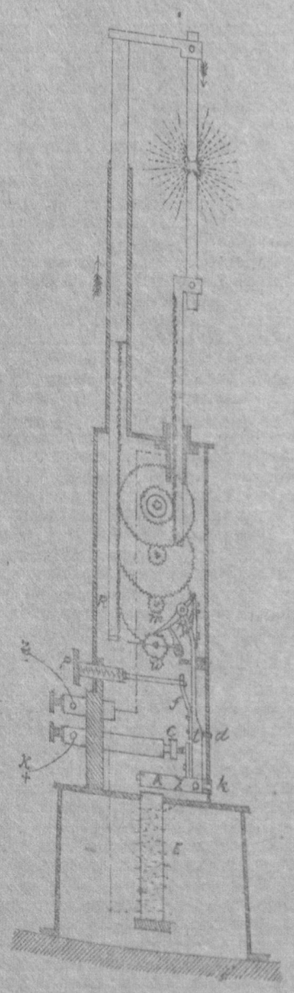
ring on which the brushes press and convey away the current. No commutator is necessary in this machine, as the currents are alternating.

The armature coils when connected in multiple arc are suitable for incandescense lighting, or a portion may be connected in series to supply arc lamps, while the remainder may be connected in multiple arc to supply such as Swan lamps.

The Siemens' direct current machines run at speeds varying from 500 to 1,500 revolutions per minute, and give lights varying from 500 to 12,000 candles at an expenditure from 1½ to 7 H.P. The alternating machines run from 500 to 800 revolutions per minute, and require from 5 to 20 H.P. Either Siemens' machines will work an arc or incandescent system of lighting. For arc lighting continuous current machines are generally used, while for incandescent both systems are in use; the use of the alternating current machine is said, however, to allow of longer life to the incandescent lamp.

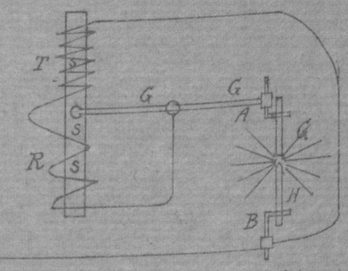
When continuous current machines are used for arc lighting, the positive carbon burns away twice as fast as the negative carbon, and where only the upper carbon is moveable, it is evident that the point of light is gradually descending. There are two kinds of arc lamps made by Messrs. Siemens, one in which this descent goes on, and the other in which the point of light is kept at the same height by the movement of both carbons, the latter being called the focus keeping lamp, and where reflectors are used for throwing rays of light horizontally, it will be seen that this latter form of lamp is of considerable advantage.

The ordinary Siemens lamp, as designed by Von Hefner Alleneck, Messrs. Siemens' Manager, is illustrated below (Fig. 6) and the action is as follows:—



The lamp is regulated in its action by an electro-magnet operating a ratchet wheel and gear. The positive current enters at K, passes to the upper carbon-holder by two routes, one direct and the other through the coil E; after crossing the arc it returns to the generators at Z. The two carbon-holders are geared to two wheels, one of which is half the diameter of the other to allow for the difference in the consumption of the carbons. When no current is passing, the action of gravity brings the two carbons together. When the current commences to circulate, the armature A is attracted to the electro-magnet, and the lever (t), which is pivotted at (k), is drawn forward and moves the train of wheels which separates the carbons. By the movement of (t) it comes in contact with the screw C, and the current then ceases to pass through the electro-magnet and passes through (t) direct to the carbon. When this action takes place, it is released, and the spring (f) pressing back the lever (t) to its original position before the current passed is again resumed. This action continues, and the action is so instantaneous that the carbons are kept the proper distance apart. When the current round the magnet becomes too feeble to overcome the action of the spring (f), which is in electrical communication with the upper carbon-holder, the lever (t) remains at rest, and, as the carbons consume, it gradually falls back against the set screw (d) until the pawl in is lifted out of gear by the stop (n) allowing the pawl again to act on the wheel train, and thus brings the carbons closer together.

Such lamps as are above described are generally worked singly, and where several lamps are in circuit the following arrangement is used. The lamp itself is not illustrated, the figure below only indicating the principle:—



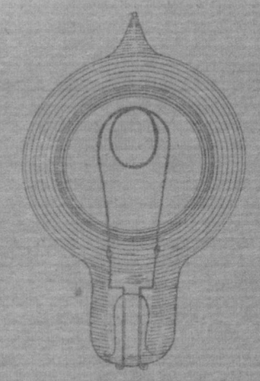
R represents a coil covered with thick wire, and T a high resistance coil of thin wire. Both these solenoids are fitted with a cone SS connected with the lever GG with the upper carbon-holder A, while the lower carbon-holder is stationary

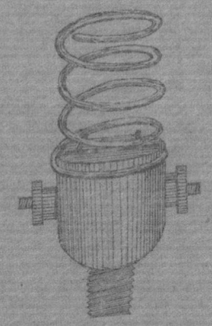
The current enters at L, is divided at the lower carbon, one portion passing through it and the arc thence to the coil R and on to the return wire, while the other portion goes straight to the higher resistance coil T. The rise and fall of the cone SS is therefore due to the difference of the magnetic attraction of the two coils.

If the current enters at L when the two carbon points are far apart, then the resistance of the arc is so great that the current all passes to the upper coil T. The cone SS then rises by the higher magnetic influence of the coil T which depresses the upper carbon G, and thus brings the carbon close together; in this position the upper carbon is automatically detached from the upper carbon-holder and the current all passes to the lower coil R, and the reverse action takes place, and a steady arc is thus maintained.

These lamps are made self-focussing, the lower carbon being forced by a spring upwards against a copper ring of slightly less diameter than the carbon itself, and only that part of the carbon which is consumed passess through the ring. These rings do not waste rapidly and are easily replaced.

The incandescent lamp used with the Siemens' machines is that known as the Swan lamp, named after its inventor. The following is a sketch of the lamp with its attachment:—





It is extremely simple in construction, and is a small glass globe from which all the air has been exhausted, and in which is fixed a small filament of carbon connected with two platinum wires which are passed through and fused into the glass. When the current passes the carbon by its great resistance becomes intensely hot and emits a soft, clear light; there is no combustion, as there is no air in the lamp, and there is very little heat.

The diagrams shown above are of the most recent form of lamp. As will be seen the lamp is entirely of glass, and from the short stem at the top project two platinum loops, the terminals of the carbon inside. The socket shown with the lamp in the right side figure is of obonite screwed at one end for attachment to a holder, the other having a spiral spring; two small catches, continuations in reality of the main circuit wires, pass through the side of this socket, and when these catch the similar hooks on the lamp by the force of the spring, a good electrical contact is completed.

This arrangement is far superior to that of Mr. Edison.

The lamps can be made of from 2½ to 100 candle-power. The electro-motive force required is from 6 volts to 100 volts, and currents of from 1·3 ampères to 3 ampères are required.

The resistance of Swan's lamp is about 35 ohms, while that of an Edison is about 135 ohms. The Swan Company now, however, that a demand has arisen for lamps of high resistance, manufacture them so that ½ an ampère of current will give a light of 20 candles; and there is no other lamp which will give such a light with so small a current. The prices of such lamps vary from 5/ to 7/6, say, Rs. 3 to Rs. 5. The best machines to use with these lamps are the Siemens' machines.

J. A. J.

APPENDIX.

In my report on lighting Fort St. George by electricity, it will be noticed that a large amount of engine power is provided, which is out of use for some 18 hours per day. No doubt a large portion of this time is a necessity for the due inspection and repair of the engines and machines, and it would be unwise to utilise the same engines throughout the day as well as the night.

It appears to me, however, that a portion of the power, which is considerable, might be so utilised.

It may be unnecessary to explain to Government that while a dynamo machine converts mechanical into electrical energy, it is also reversible, and that, when supplied with electricity, it will give out mechanical energy. That is to say, we may generate electricity at one end of the Fort, convey it through a wire attached to a dynamo at the other end, and from this dynamo we can drive machinery, and about 50 to 60 per cent. of the original mechanical energy can be obtained after its electrical transmission.

In this way the machinery in the arsenal could be driven, and it does not, I believe, require very large power.

With a system of wires in Fort St. George, each fire-engine might be furnished with a small dynamo, which, on occasion of a fire, could be attached at the service boxes to such system, and the engines in the engine-house could thus drive the fire-engines at any point in the Fort within reasonable distance of the system of wires. I merely give this as an illustration of what can be done in this way.

I have stated on page 2 of the report that water-power is the cheapest of all powers for the production of light; so also is it the cheapest of all powers in supplying mechanical energy.

Following out the same idea as before, it will be seen that it is possible to take power from a stream to places far above its level as easily, or perhaps more easily than we at present divert a portion to some water-wheel below its level, *i.e.*, by having a dynamo driven by a turbine in the stream, and a dynamo or dynamos connected to the first dynamo by a wire at the place or places where the power is required.

Towns situated near streams, of which there are many in India, and of which Coonoor is a good instance, can be most economically lighted by means of water-power. I saw in Scotland a large private house lighted by means of a small stream dammed up, so as to give sufficient water to drive a turbine which again drove the dynamo; the dynamo and turbine being some quarter of a mile away from the house.

The best example of the transmission of power by electricity has been executed by Messrs. Siemens and Company and is the Portrush Electric Railway in the North of Ireland. I visited this line, being anxious to see the system as one which might be extremely applicable to India, and which to me seemed so admirably adapted for a light railway, though called a tramway. I regret that at the time of my visit it was not being worked by electricity, but I travelled over the line in the cars pulled by horses. I cannot, I think, do better than give here an account of the line copied from *Engineering*.

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The Portrush Electric Railway.

"While the subject of the electric transmission of power is being investigated experimentally by M. Marcel Desprez in France, it is being gradually worked out on a practical scale in Germany by Messrs. Siemens and Halske, and in this country by Messrs. Siemens Brothers and Company. The latter firm, as is well known, have been for some time engaged upon an electric railway at Portrush, in the North of Ireland, and recently their experiments have been brought to a successful conclusion by the introduction of the first car into the general traffic of the line. Taking advantage of the occasion Mr. Alexander Siemens and Dr. Edward Hopkinson have recently communicated to the Society of Arts a paper upon the transmission of power by electricity, in which, in addition to an account of the new railway, they have dealt with the subject on a wide basis, demonstrating the conditions for the successful construction and installation of electric motors both experimentally, graphically, and analytically. After a short account of the electric railways already in existence, Mr. A. Siemens illustrated by experiment the arrangements that will be possible when electricity is laid on like gas and water. There were placed in the lecture room, in parallel circuit, two motors, a large and a small one, and a number of incandescence lamps, and it was demonstrated that each could be worked independently of the others, always taking the proper amount of current for its requirements. A small hoist, designed by Dr. John Hopkinson, and constructed by Messrs. Siemens Brothers, was then shown in operation. It was coupled up to the leads proceeding from the motor, and a weight of 1 cwt. was hung to the chain. It was then started, the speed of the lift and the current being as follows:—

Weight.	Speed.	Current.
1 cwt.	4 feet per sec.	9 ampères.

"The weight was then doubled without any alteration in the other conditions, and then the measurements gave:—

Weight.	Speed.	Current.
2 cwt.	2·5 feet per sec.	13 ampères.

"Secondly, the former weight was replaced, but a resistance was inserted in series with the motor, when the current and the speed were:—

Weight.	Speed.	Current.
1 cwt.	2 feet per sec.	9 ampères.

"When the weight was doubled the results were:—

Weight.	Speed.	Current.
2 cwt.	1 foot per sec.	13 ampères.

"Thus it was demonstrated that the current in a given motor remains constant at all speeds, and that the speed depends upon the resistance in circuit. In the annexed table are shown the

Resistance inserted in Circuit in Ohms.	Work done. Load 56 pounds. Speed in feet per Minute.	Work done. 7·3 Ampères. Foot-lb. per Minute.	Work done. Load 1 cwt. Speed in Feet per Minute.	Work done. 9·2 Ampères. Foot-lb. per Minute.	Work done. Load 2 cwt. Speed in Feet per Minute.	Work done. 12·9 Ampères. Foot-lb. per Minute.
·3	212	11,870	180	20,160	130	29,120
1·2	190	10,640	164	18,370	112·5	25,200
2·2	169	9,480	150	16,800	90	20,160
3·2	157	8,790	130	14,560	71	15,900
3·7	150	8,400	125	14,000	59·5	13,330
4·8	141	7,850	111	12,430	36·5	8,180
5·7	130	7,280	90	10,080	19	4,260
6·3	129	7,200	84	9,410		
8·3	98	5,480	56	6,270		
9·7	83	4,230	27·3	3,060		
11·6	47	2,628				
12·7	35	1,960				
14	18	1,008				

results of a series of experiments with the same hoist, made at the works of Messrs. Siemens Brothers under conditions of greater accuracy than could be attained in the lecture-room. Three conclusions are to be drawn from the results which comprise the fundamental principles of the theory of the electrical transmission of power:—

1. That the motor, as a machine, is entirely independent of the generator, and must be designed for the particular work it has to do without reference to the generator.
2. The current depends wholly on the load on the motor.

3. The speed depends upon the electromotive force of the generator, and the total resistance in the circuit of the machine. If the mains which supply the current to the motor be maintained at a constant potential, and the motor be separately excited, or have permanent magnets, the speed is proportional to the potential of the main, less the loss of potential due to the resistance of the armature.

"As a practical corollary the generator must be designed to give the current required of it by the motor, and electromotive force sufficient, after allowing for fall of potential through the resistance of the mains, to give the requisite speed.

"Turning now to the Portrush Electric Railway, Dr. Edward Hopkinson explained that it extends from Portrush, the terminus of the Belfast and Northern Counties Railway, to Bushmills, in the Bush Valley, a distance of six miles. For half a mile the line passes down the principal street of Portrush and has an extension along the Northern Counties Railway to the harbour. For the rest of the journey the rails are laid on the seaward side of the county road. The line is single and has a gauge of 3 feet, the gradients being exceedingly heavy in parts, rising to as much as 1 to 35. It is intended to connect the line with an electrical railway from Dervock, for which Parliamentary powers have already been obtained, thus completing the connexion with the narrow gauge system from Ballymena to Larne and Cushendall. Turbines are being erected near a waterfall on the River Bush, where there is abundant water-power, but pending their completion, the power is derived from a small steam-engine at the Portrush end.

"The system employed may be described as that of the separate conductor—a rail of T-iron, weighing 19 lb. to the yard, is carried on wooden posts, boiled in pitch and placed 10 feet apart, at a distance of 22 inches from the inside rail and 17 inches above the ground. A cap of insulite is placed between each post and the conductor, the insulation varying from 500 to 1000 ohms per mile according to the weather. Hence the total leakage cannot exceed 2·5 ampères, representing a loss of three-fourths of a horse-power; or under 5 per cent., when four cars are running. The current, generated by a shunt-wound dynamo machine, driven by an engine of 25 indicated horse-power, is conveyed from the conductor to the carriage by two steel springs, one at each end. These double brushes enable the car to bridge over the numerous gaps which necessarily interrupt the conductor to allow cart-ways into the fields and commons adjoining the shore. There are two or three gaps too broad to be bridged in this way. In these cases the driver will break the current before reaching the gap, the momentum of the car carrying it the 10 or 12 yards it must travel without power.

"From the brushes the current is taken to a commutator worked by a lever, which switches resistance frames in or out, as may be desired. The same lever alters the position of the brushes on the commutator of the dynamo machine, reversing the direction of rotation. From the dynamo current is conveyed through the axle-boxes to the axles and wheels, and thence to the rails, which are uninsulated. The conductor is laid in lengths of about 21 feet, connected together by fishplates and also by double copper loops soldered to the iron, the joints in the rails being similarly made. The resistance of a mile of conductor, including the return by earth and the ground, is actually 0·23 ohms. If calculated from the section of iron it would be 0·15 ohm, the difference being accounted for by the copper loops and occasional imperfect contacts. The electromotive force at which the conductor is maintained is about 225 volts. The dynamo is placed in the centre of the car, beneath the floor, and through intermediate spur gear drives, by a steel chain, on to one axle only. There is, at present, only one car fitted with a dynamo, but four more machines are being constructed; and since two of these will be capable of drawing a second car, there will be an available rolling stock of seven cars.

"The dimensions of the dynamo machine are determined by the following considerations: Let W be the couple, measured in foot-pounds, which the dynamo must exert in order to drive the car, and w the necessary angular velocity. Taking the tare of the car, including machinery, at 50 cwt. and the load as 30 cwt., we have a gross weight of four tons. If it be assumed that the maximum work required is that the car shall carry this load at a speed of seven miles an hour up an incline of 1 in 40, then the resistance due to gravity may be taken at 56 lb. per ton, and that due to other causes at 14 lb. a ton, or 70 lb. per ton in all. Thus, in order to propel the car, by rotating its axle, it will be necessary to exert a force of 280 lb. at a radius of 14 inches (equal to the radius of the driving wheel), or of 327 lb. at a radius of a foot. The angular velocity of the axle corresponding to a speed of seven miles an hour is 84 revolutions per minute. Hence

$$L = 327 \text{ foot-pounds, and } w = \frac{2\pi \times 84}{60}$$

"If the dynamo be wound directly on the axle, it must be designed to exert the couple L, corresponding to the maximum load, when revolving at an angular velocity w, the difference of potential between the terminals being the available electromotive force of the conductor, and the current being the maximum, the armature will safely stand. But when the dynamo is connected by intermediate gear to the driving wheels, the two factors L and w may be varied, provided only that their product remain constant. In the present case L is diminished in the ratio of 7 to 1, and w is consequently increased in the same ratio. Hence the dynamo, with its maximum load, must revolve at $84 \times 7 = 588$ revolutions per minute, and exert a couple of $\frac{327}{7} = 47$ foot-pounds.

"Let E be the potential of the conductor from which the current is drawn, measured in volts, C the current in ampères and E_1 the electromotive force of the dynamo. Then E_1 is proportional to the product of the angular velocity and a certain function of the current. For a velocity Ω, let this function be denoted by $f(C)$. If the characteristic of the dynamo can be drawn, then $f(C)$ is known.

"We have then

$$E_1 = \frac{w}{\Omega} f(C) \quad . \quad . \quad . \quad (1)$$

If R be the resistance in circuit, by Ohm's law

$$C = \frac{E - E^1}{R}$$

$$= \frac{E - \frac{w}{\Omega} f(C)}{R}$$

and, therefore,

$$w = \frac{\Omega(E - CR)}{f(C)} \quad . \quad . \quad . \quad (2)$$

Let a be the efficiency with which the motor transposes electrical into mechanical energy, then

$$\text{Power required} = L\,w = a E_1 C = a C \frac{w}{\Omega} f(C)$$

$$\text{Dividing by } w \quad . \quad . \quad . \quad L = \frac{a C}{\Omega} f(C) \quad . \quad . \quad (3)$$

"It must be noted that L is here measured in electrical measure, or adopting the unit given by Dr. Siemens in his British Association address, in Joules. One Joule equals approximately ·74 of a foot-pound. Equation (3) gives at once an analytical proof of the second principle stated above, that for a given motor the current depends on the couple, and upon it alone. Equation (2) shows that with a given load the speed depends upon E, the electromotive force of the main, and R, the resistance in circuit. It also shows what will be the effect of putting into circuit the resistance frames placed beneath the car. If R be increased until C R equals E, then w vanishes and the car remains at rest. If R be still further increased, Ohm's law applies and the current diminishes. Hence, suitable resistances are first a high resistance for diminishing the current, and consequently the sparking at making and breaking the circuit; and, secondly, one or more low resistances for varying the speed of the car. If the form of $f(C)$ be known, as is the case with a Siemens' machine, equations (2) and (3) can be completely solved for w and C, giving the current and speed in terms of L, E, and R. The expression so obtained agrees with the results of experiment.

"The work of traction on the Portrush Railway has hitherto been performed by steam tramway engines, constructed by Messrs. Wilkinson and Company of Wigan. Hence material is afforded for a comparison of the relative costs of the two systems of haulage. Owing to the high prices of coke and the difficult nature of the line, the actual experience of the week's expense for the locomotive gives 8*l.* 4*s.* 9½*d.* for a distance of 312 miles, while a calculation, based upon experiment, shows that the cost by electric car, for the same load and distance, would be 5*l.* 19*s.* 1*d.* This includes twenty shillings as wages for the driver of the stationary engine, but nothing for the driver of the car, from which it would seem that it is intended to add this duty to the office of the conductor.

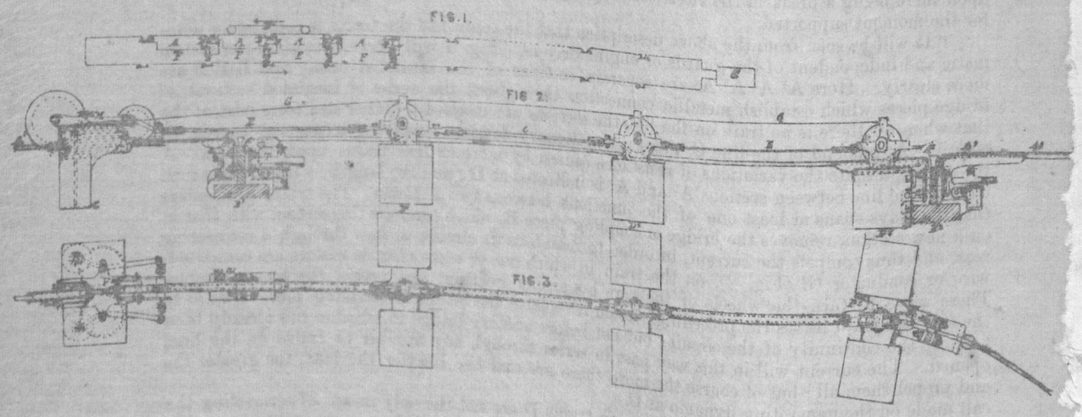
"It will be seen that the paper is one of extreme interest, not only as an account of the first commercial venture in electric railways in this kingdom, but also from the lucid manner in which the fundamental laws governing the distribution of power by electricity were experimentally demonstrated and presented to the audience."

It has become impressed on my mind that the Coonoor Ghât Railway is one which might have been easily and cheaply made and worked as an electrical railway. The power is to be had in shape of the stream at Coonoor and the line of course could be made much lighter were engines not to be used.

I do not expect that Government will seriously consider such a scheme, but as I have before said, there must be many other places where the light railways proposed to be constructed could be so with electricity as the motive power at very small cost, and I venture to submit this point to Government for consideration.

There is another system which has lately been introduced by Professor Fleeming Jenkin called Telpherage, which seems to me very suitable where only goods have to be carried and not people, though both of course can be so. Of this system I also append a description extracted from *Engineering*.

Jenkin's Electric Telpherage.



Professor Fleeming Jenkin's Electric Telpherage.

"'Telpherage' is the name given by Mr. Fleeming Jenkin, the well-known electrician and professor of civil engineering in the University of Edinburgh, to a system which he has devised for transporting vehicles, containing goods and passengers, to a distance by the electric current independently of any control exercised from the vehicles themselves.

"The system has been patented, and it is to be hoped that a practical trial of it will soon be made. Professor Jenkin's idea is to employ strained metal cables which will serve both to sustain the load and convey the electric current. The frames or trucks supporting the load run along the cable on wheels, and the cars or loads are suspended below them from the axles of the wheels.

"In the simplest arrangement of the line there is a break of continuity at each post supporting it; and the sections of cable are themselves insulated from each other, and the earth. They are, however, capable of being connected by movable coupling pieces, actuated by the train, so that all the sections receive the exciting current and form part of the general circuit.

"The current is supplied to the line by a stationary dynamo-electric machine driven by a steam engine or other motor; and since the line is elevated from the ground on insulating standards, the same dynamo will supply a considerable length of line, as the leakage need not be excessive if proper precautions are taken. With ground lines of electric railway, like that of Siemens or Edison, the leakage is very marked, and Mr. Edison has adopted the plan of dividing the whole line into short sections of a few miles, with stations and feeding dynamos at each. Dr. Werner Siemens favors the use of an insulated conductor supported beside the line, and giving current to the motor on the train by means of a running connexion pulled by the train. Professor Ayrton and Perry have, as is well-known, sought to overcome the leakage difficulty by making the line in very short sections, each of which is put in circuit with the dynamo in turn as the train progresses, by an automatic action of the train itself. In this way there is only one section electrified at a time, namely, that over which the train is running, and the leakage on the whole line is consequently very small.

"The loads or cars on the telpherage line are connected together in trains, and the length of a train is nearly the length of a section of the cable or conductor. On passing either of the movable coupling pieces between two sections, the train throws it out of action, disconnecting the two sections at that point; but the circuit between these sections is maintained through the wheels of the train itself and a conductor on the train. In circuit with this conductor is a dynamo-electric motor, which is actuated by the current, and propels the train by driving the wheels. The power provided is more than sufficient to keep up a maximum speed, and the train is provided with a governor which, when the speed is sufficient, closes a shunt and allows the current to pass without traversing the coils of the electro-motor. The governor acts directly to check the train if the speed becomes excessive, by short-circuiting the electro-motor, or otherwise bringing electric brakes into operation.

"To further insure that one train shall not overtake another, Professor Jenkin provides an automatic telegraphic communication along the line, and the trains in passing close and open the telegraphic circuits. This automatic telegraph actuates circuit closers between the different sections of the main cable or conductor, so as to maintain connexion between the sections for a certain distance behind the train quite independently, it may be, of the movable coupling pieces.

It is obvious that a following train entering upon a part of the line in which the sections are thus connected will have its speed checked, as the application of the power upon the train depends upon there being a break in the electrical coupling between the two sections on which the train is for the moment supported.

"It will be seen from the above description that the control of the trains is completely automatic and independent of the guards or engine drivers. Fig. 1 will serve to explain the system more clearly. Here A^1 A^2 A^3 A^4 are separate sections of the insulated cable, and B B B are bridge pieces which establish metallic connection throughout the series of insulated sections, so that wherever there is no train on the line the sections are coupled together and form part of the circuit. At one end of the line C, there is a stationary dynamo supplying a constant current to the circuit, despite the variations of resistance caused by more or less trains upon the line. A train on the line between sections A^2 and A^1 is indicated at D; and the length of this train is such that it always spans at least one of the junctions between two sections. The train, as it enters on a new section, removes the bridge or coupling piece B, which connects this section with that in rear, and thus compels the current, in order to maintain its circuit, to flow through a connecting wire or conductor G^1 (Fig. 2), on the train in which one or more electric motors are connected. These serve to turn the wheels of the cars by proper gearing, and propel the train. Before the tail of a train leaves the preceding section it replaces the bridge or coupling piece B so as to keep up the continuity of th[illegible]cuit; but not before another bridge in advance has already been opened. The current wi[illegible] way pass in series through any number of trains on the line, and propel them all; but [illegible] the more there are and the heavier the load, the greater the call made on the generatin[illegible]o at C.

"The bridge pieces B [illegible]e passing trains D are not the only means of connecting the sections electrically. There a[illegible] circuit closers E E, Fig. 1, and these are brought into action by means of electro-magnets. [illegible]each magnet an insulated wire F passes forwards along the line past one or more of the sect[illegible], as may be desired. The wire F is then brought to one of the bridge pieces B, and the sa[illegible]ovement which removes the bridge piece connects the wire F with the main circuit. The wire [illegible]en diverts a small portion of the current to its electro-magnet E, which attracts an arma[illegible] thereby keeping connection for a time between the sections in rear of a train, notwithstan[illegible] the advance of a following train.

"The telpherage line is shown in fu[illegible]detail on the plan and elevation, Figs. 2 and 3, where A_1, A_2, A_3, A_4, are sections of a single wi[illegible]rope or rail, supported above the ground by insulating supports B_1, B_2. In general two lines of cable would be used, but the single line will serve in some cases. A train of three cars, D_1, D_2, D_3, is shown passing over the line between sections A_1 and A_2. Every support, such as B_1, is provided with a switch lever a, which, in its normal position, establishes electrical communication between the sections A_2, A_2, and A_1, A_1, the lever then bearing against a piece of metal, which is in electrical connection with one section, whilst the lever itself is, through its axis, in connection with the other. The first vehicle of each train is fitted with a cam F, so arranged as to catch each lever as it passes, and throw it over into a position, such that electric communication between A_1, A_2, is severed, and at the same time a portion of the main current is diverted through the lever and the new contact, which it now makes into an auxiliary telegraph wire.

"The train consists of an electric locomotive C and three cars D_1, D_2, D_3, connected together by light coupling rods E E E, which may be made of tough wood and are attached to the carriages by metal pins and end pieces. On the leading vehicle, which in this case is a locomotive, there is a cam F, which pushes aside from the normal position every switch lever a of every insulator. The cam F_2 on the last vehicle restores every switch lever over which it passes to the normal position.

"The end of an insulated conductor G is metallically connected to the frame of the last carriage and the other end is led along the train to the main binding screw H (Fig. 2) on the electro-motor on the locomotive, and completes the circuit of the motor by connecting its other terminal to the metal wheels running on the rope. Since the locomotive has passed over B, the switch lever has been moved from the normal position and there is no electrical communication through it from A_2 to A_1, as the last carriage has just passed over B_2 the switch lever then is in the normal position and the current is free to pass from A_3 to A_2. The whole of the current now passes from the section A_2 A_2 to the section A_1 A_1 through the train, so propelling it along until a new section is reached and the process of opening by the front vehicle and closing by the last is repeated.

"In order to prevent a following train from coming too near the one in front, Professor Jenkin arranges an electro-magnet m (Fig. 2) having its core in metallic contact with c_2. The wire which works it comes from the contact made by the lever a of the preceding insulator; it passes round the core, and is connected to c_2. A soft iron armature n is centred at o on a metal wire p insulated from c_2 but electrically connected with c_1, so that when the armature n is in contact with the core of the electro-magnet, the section A_1 is in electrical communication with A_2, no matter in what position the lever a of that particular insulator may be. A spiral spring q holds n clear of m when no current is passing in the wire of the electro-magnet.

"Instead of employing strained ropes, Professor Jenkin also designs to use trough-like conductors, the two sides of the trough serving as rails for the wheels to run on. He also

proposes another arrangement of the telpherage line, whereby the sections are much larger than the trains, and the break in one is at or near the middle of the other. In this case, when no train is passing, the current crosses backwards and forwards between these conductors by movable coupling pieces, the train or vehicle (as in the arrangement we have described) breaking one of these connexions as it passes, and establishing connexion between them through its electro-motor. The coupling pieces in this plan are replaced by an automatic telegraph appliance, and maintained until the vehicle or train is at any desired distance from each successive break.

"Professor Jenkin's invention certainly promises to be useful, and we anticipate that it will soon have a fair trial, either in the carriage of coal hutches or other goods. For passenger conveyance it appears especially suitable in large towns and suburbs, where it could be erected along streets, and might, by its continuous action, convey a constant stream of passengers."

A wide field for the employment of electricity seems to me therefore to have been opened out, and in that field India, I think, may be included, as over large areas of it not only on the hills but on the plains where there are numerous tanks constantly discharging with some considerable head and pressure, and when there is running to waste, as it were, immense sources of power which if properly fostered might be employed to a great extent in place of the present manual or animal labor.

I trust that in drawing attention to these facts, I may be pardoned for uttering truths which perhaps are well known to many who are better qualified to discuss and bring them to the notice of the Government.

J. A. J.

No. 1022, Financial.

Transferred to the Public Works Department, with reference to paragraph 2 of the order in that department, dated 21st November 1883, No. 3320 W.

(By Order.)

OOTACAMUND,
9th May 1884.

(Signed) J. D. REES,
Acting Under Secretary.

From Brigadier-General R. C. STEWART, Quartermaster-General, to the Secretary to Government, Military Department, dated Ootacamund, 25th June 1884, No. 391 C.

I am desired by the Commander-in-Chief to return the documents as per margin received with your reference order, No. 2521, dated 27th May 1884, relative to the lighting of Fort St. George with electric light.

Letter, No. 179 E., dated 26th May 1884, from the Secretary to Government, Public Works Department, with four enclosures, one plan, and Mr. Jones' report.

2. It would appear from Mr. Jones' report, which is most exhaustive and complete, that the initial cost of the scheme would be about Rs. 88,600, and that the cost of annual maintenance would be, inclusive of depreciation of machinery and interest on original outlay, Rs. 35,826.

3. This expenditure, in the opinion of the Commander-in-Chief, makes the introduction of the electric light into Fort St. George on the system proposed by Mr. Jones absolutely prohibitive.

4. The Commander-in-Chief would venture to urge on Government the desirability of still further prosecuting their inquiries on the subject of the expenditure connected with the introduction of the electric light into India, and would suggest that communication be opened with the Municipalities of Calcutta and Bombay, where the electric light is made use of, as to the cost of introduction and of maintenance.

No. 3074, Military.

Transferred, and the previous papers returned, to the Public Works Department, with intimation that the Government in the Military Department concurs in the opinion of His Excellency the Commander-in-Chief, as expressed in paragraph 3 of this letter.

OOTACAMUND,
27th June 1884.

(By Order.)

(Signed) A. R. KENNEY-HERBERT, Lieut.-Col.,
Offg. Secretary to Government.

From J. A. JONES, Esq., Vice-President, Municipal Commission, to the Deputy Chief Engineer, Public Works Department, dated Madras, 15th July 1884, No. 816.

With reference to your No. 1247 D., of the 12th instant, I have the honor to inform you that I understood the amount of Rs. 78,824 had reference only to the estimate of Rs. 84,000, and that this estimate did not include the original estimates of Rs. 24,000.

The estimates sanctioned were as follows:—

	Rs.		
1.	12,410	...	For oil gas.
2.	12,000	...	For adaptation to coal gas.
3.	80,000	...	January 1866, sanctioned.
4.	72,800	...	March 1868.
	1,77,210		

It is not clear whether the works estimated for in (3) were carried out or whether the new estimate (No. 4) of Rs. 72,800 was a revision of No. 3.

There is no mention of any estimate amounting to Rs. 84,000. It was I thought unlikely that the works sanctioned, amounting to Rs. 24,000, *plus* Rs. 80,000 would in the end be completed for Rs. 78,224, and as it is said that these amounts of Rs. 78,224 was against the original estimate of Rs. 84,000, it appears to me that it had no reference to the original expenditure of Rs. 24,000.

I came to the conclusion, therefore, that an amount of Rs. 78,224 had been spent in addition to the Rs. 24,000 spent about 1861. The total of these amounts is Rs. 1,02,000, and to this, in order to make a fair comparison, I added Rs. 8,000 for contingencies and engineering, bringing up the amount to Rs. 1,10,000.

The estimate was made to the best of my ability from the figures before me, but from the statements in the precis more than one conclusion could no doubt be arrived at.

From Colonel B. H. W. MAGRATH, Commissary-General, to the Chief Engineer, Public Works Department, dated Madras, 19th July 1884, No. 2380.

In reply to your letter, No. 1248 D., dated 12th July 1884, I have the honor to enclose a statement i. n the Executive Commissariat Officer, Madras, giving all the information you require regarding the lighting of the fort by kerosine oil lamps.

ENCLOSURE.

STATEMENT showing the present cost of lighting the Barracks and the Fort with kerosine oil per mensem.

Particulars.	Amount. Rs. A. P.	Total. Rs. A. P.
Cost per mensem—		
265 Imperial gallons of kerosine oil for lighting barracks of 2nd Battalion, S. W. Borderers, Royal Artillery, and street and guard lamps at Fort St. George, at Re. 1-8-0 per Imperial gallon ...	397 8 0	
127 Yards wicks 9 inches long, at R. 0-1-0 per yard	7 15 0	
41 Chimneys, being renewals for breakage, at 15 per cent. per mensem at R. 0-8-0 each	20 8 0	
15½ Yards cloth at R. 0-5-0 per yard	4 12 3	
172 Chittack chalk at R. 0-0-¼ each	0 2 6	430 13 9
Establishment—		
1 lamp lighter residency	7 0 0	
5 lamp lighters, at Rs. 5-12-0 each	28 12 0	35 12 0
Total ...		466 9 9

N.B. 1. Number of lamps used are as follows—

171 lamps, kerosine, in use with 2nd Battalion, S. W. Borderers.
13 do. do. do. Royal Artillery.
98 lamps, kerosine, street, Barrack department.
23 do. do. in use with guards.

305

2. Cost per lamp per mensem—

146 lamps, kerosine, at R. 0-12-0 each for Till. Tattoo scale.
38 do. at Rs. 1-15-6 each for entire night scale.
98 do. (street) at Rs. 1-11-3 each.
23 do. (guard) at Rs. 1-15-6 each.

3. Cost of superintendence per mensem Rs. 35-12-0

4. First cost of plant—

	Rs.
Cost of 98 street lamps, kerosine, inclusive of the cost of removing the posts of old gas works and fixing at the places shown, &c., and posts and brackets painted	972
Cost of 207 lamps, kerosine, hanging, &c., at Rs. 12-0-0	2,484
Total ...	3,456

FORT ST. GEORGE,
17th July 1884.

(Signed) J. W. BRUCE, Major,
Assistant Commissary-General.

ORDER—dated 20th August 1884, No. 2044 W., Public Works.

Mr. Jones, the Vice-President and Municipal Engineer of the Madras Municipality, having been engaged while in England last year on inquiries respecting electric lighting, the Government embraced the opportunity thus afforded to obtain information as to the cost and best means of lighting Fort St. George by electricity. Mr. Jones was accordingly requested to extend his inquiries with this object.

2. A full and interesting report has now been submitted by Mr. Jones, for which the thanks of Government will be conveyed to that gentleman, through the President of the Madras Municipal Commission.

3. The scheme drawn up for Fort St. George is calculated to cost Rs. 88,600; of which the machinery is estimated at Rs. 34,380, the leads and fittings, &c., at Rs. 49,620; and labor at Rs. 4,600. The project provides for 320 incandescent lights of 20 candle power each; 46 are lights of 1,000 candle power each; and 1 holophote of 40,000 candle power. The cost of annual maintenance, including interest on outlay and depreciation, is set down at Rs. 35,826; the corresponding charge for gas being Rs. 26,570, while that for kerosine oil is Rs. 15,095.

4. The large outlay for electric lights, both on first cost and subsequent annual maintenance, renders the project, in the opinion of His Excellency the Commander-in-Chief, prohibitive, so far as Fort St. George is concerned.

5. As suggested in paragraph 4 of the Quartermaster-General's letter, No. 391-C., dated 25th June 1884, further inquiry will, however, be made as to the expenditure incurred in Calcutta and Bombay, where the electric light is in use.

6. The Examiner, Public Works Accounts, will arrange for the disbursement to Mr. Jones of the sum of Rs. 500, being expenses incurred on behalf of Government.

(Here enter Nos. 2045 W. and $\frac{2045 \text{ W.}}{\text{A}}$, dated 20th August 1884.)

(True Extract.)

(Signed) J. SHAW-STEWART, Colonel, R.E.,
Secretary to Govt., P.W.D.

To the Superintending Engineer, V Circle.
" Examiner, Public Works Accounts.
" Military Department.
" Financial do.
Ex.I. E. Fernandez.
Spare Copies

(13) 2044/2045

BUILDINGS AND ROADS.
MILITARY WORKS.

Govt. of {1884} Madras.

PUBLIC WORKS.

Dated August, 20th.

Read. *Entd.*

G.O., 20th Aug. 1884, No. 2044 W.

AUGUST.

Port St. George

Orders on Mr. J. A. Jones' scheme for the electric lighting of —.

(19) 2044/2045

20TH AUGUST 1884, No. 2045 W., PUBLIC WORKS.

PUBLIC WORKS DEPARTMENT.

Buildings and Roads.
Military Works.

LETTER—from

COLONEL J. SHAW-STEWART, R.E.,
Secretary to the Government of Madras,
Public Works Department,

To

THE SECRETARY TO THE GOVERNMENT OF BENGAL,
PUBLIC WORKS DEPARTMENT.

SIR,

In forwarding, for the information of His Honor the Lieutenant-Governor of Bengal, the accompanying copy of proceedings on the subject of electric lights for Fort St. George, I am directed to request that the Madras Government may be favored with such information as may be available as to the cost of the introduction and maintenance of electric lights in Calcutta.

I have the honor to be,
Sir,
Your most obedient servant,

Major, R.E.,
Under Secy. to Govt., P.W.D.

OOTACAMUND,
20th August 1884.

Rcd. E. Fernandez.
Spare Copies

BUILDINGS AND ROADS.
MILITARY WORKS.

Govt. of [1884] Madras.

PUBLIC WORKS.

Dated August, 20th.

Read. Read.

20th Aug. 1884, No. 2045 W.

AUGUST.

Electric Lights

Government of Bengal requested to furnish information as to the cost of the introduction and maintenance of — in Calcutta.

(B) Roll 2044/2045

20TH AUGUST 1884, No. $\frac{2045\ W.}{A}$, PUBLIC WORKS.

PUBLIC WORKS DEPARTMENT.

Buildings and Roads.
Military Works.

LETTER—from

COLONEL J. SHAW-STEWART, R.E.,
Secretary to the Government of Madras,
Public Works Department,

To

THE SECRETARY TO THE GOVERNMENT OF BOMBAY,
PUBLIC WORKS DEPARTMENT.

SIR,

In forwarding, for the information of His Excellency the Governor in Council of Bombay, the accompanying copy of proceedings on the subject of electric lights for Fort St. George, I am directed to request that the Madras Government may be favored with such information as may be available as to the cost of the introduction and maintenance of electric lights in Bombay.

I have the honor to be,

Sir,

Your most obedient servant,

Major, R.E.,
Under Secy. to Govt., P.W.D.

OOTACAMUND,
20th August 1884.

Rad. E. Fernandez.
Spare Copies

BUILDINGS AND ROADS.
MILITARY WORKS.

Govt. of {1884} Madras.

PUBLIC WORKS.

Dated August, 20th.

Recd.

Encl.

20th Aug. 1884, No. 2045 W. / A

AUGUST.

Electric lights

Government of Bombay requested to furnish information as to the cost of the introduction and maintenance of — in Bombay.

W.

(18)

2044/2045

We have now received replies from Govt of Bengal & Bombay to the references made regarding cost of electric lighting, in accordance with para 5 of G.O. 2044 W., of 20th august, 1884.

Eden Gardens.

The lighting of the Eden Gardens is the only example available in Calcutta, and for purposes of comparison, of little use.

There are in all 196 lights, on the Jablockoff system, which are worked for only an hour and a half every morning.

The cost of working is Rs. 408 per mensem or Rs. 4900 per annum.

The total cost of the installation was Rs. 32,630, and if we take depreciation and interest on this amount at 10%, we have an annual outlay of Rs. 8163.

Unfortunately we do not know the candle power of the lights used, but if we assume each Jablockoff light to have a power of 20 candles, we have 3920 candles, lighted for an hour and a half every evening, or 5880 candles × 365 = 2,146,200 candles an hour at a cost of Rs. 8163.

Under Mr. Jones' system (Siemens) we would have 49,600,000 candles an hour at a cost of Rs. 31,939.

The comparison here is entirely in favour of Mr. Jones' scheme, but the assumption that each Jablockoff light has only 20 candle power is probably quite incorrect. If each light has 400 candle power, that of the outside lights in Mr. Jones' system, we would have for the Eden Gardens 42,934,000 candles for Rs. 8163, which is eleven times better than the Fort

Bombay / Calcutta

Street Scheme — but in the absence of definite information as to the illuminating power the comparison is valueless.

Bombay —

Here we have, on the Wheeler principle, the following lights costing Rs. 18000 per annum: —

14 × 2000 = 28000 candle power
3 × 2000 = 6000 —"—
16 × 2000 = 32000 —"—
66000 candle power

In this case unfortunately it is the period during which the lights burn that is not stated, but assuming that they burn as the street lamps in Madras, for 1300 hours per annum, we have a total of 57,800,000 candle hours for Rs. 18000, as against the Port Trust Estimate of 49,600,000 candle hours for Rs. 31839.

The system being worked by a Company to which the Municipality pay fixed rates, the cost of machinery, allowance for interest & depreciation, working expenses, &c. could not be given, but as the sum charged must cover the profits of the Company, besides recouping them for all outlay, it is clear that Rs. 18000 per annum must be more than cost & maintenance.

The comparison is against the Port scheme, but how again the hypothesis of time of working may be quite wrong.

Will it be worth while writing again to Calcutta & Bombay — to ascertain, as regards the Eden Gardens, the candle power of the lights used, and as regards Bombay streets & markets, the hours during which