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THE ELECTRIC LIGHTING OF SYDNEY AND SUBURBS.

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The object of the author in writing this paper is to bring before the Members of the Engineering Association of New South Wales the importance of carefully considering the best means to adopt in lighting electrically the streets and houses of Sydney, and to invite discussion upon a subject which is of considerable interest to the community at the present time.

As the author has had no actual experience of lighting such large areas as the city of Sydney and suburbs by means of electricity from central stations, and, as he only possesses a knowledge of some of the principal means that can be employed for the purpose, his excuse for reading a paper on the subject must be that he is anxious that the discussion which he hopes will ensue will tend to thoroughly investigate the merits and demerits of the methods and systems that can be employed, before the inhabitants of Sydney are committed to any one particular scheme.

With this object in view the author proposes to give a general *résumé* of what has been done, and is at present being done, in connection with the electric lighting of Sydney; and afterwards to describe, for the purpose of discussion, those methods or systems of lighting that are available for successful and economical lighting of large areas from central stations.

Whenever a change is made from an existing custom or method of carrying out any particular work there should be valid reasons for the change, and, therefore, before changing the present method of illuminating our streets and highways from gas to electricity, let us pause to consider the advantages and benefits likely to accrue from lighting by means of electricity.

Any person who has passed down King Street, from Elizabeth Street to Pitt Street of an evening, cannot fail to have noticed the striking difference in contrasting the illumination of this part of King Street with the streets in the immediate neighbourhood. Although King Street at this particular spot is, if anything, excessively illuminated, there being no less than ten large arc lamps in a length of about a hundred yards, it gives some idea of the superiority of arc lamps for city street lighting in comparison with gas lamps.

It may be urged that lighting by arc lamps costs more than the present gas lamps, but it must not be forgotten that the proportion of light given is far in excess to the proportion of cost, and that candle power for candle power it is much cheaper. Another advantage is that the lamps can all be simultaneously lighted or extinguished from the central station at the proper time.

In the minor suburban streets, where the lighting would probably be carried out by means of incandescent lamps, the advantages are not so striking, as, light for light with the gas lamps, the cost is about the same as that now paid for gas, and, further, the amount of air vitiated by a gas lamp is of no importance in a street, it is therefore difficult to see what gain is effected by incandescent street lighting, except that it be the ease of control by which the lamps can be turned on or off, and that in windy or stormy weather such lamps are not partially or wholly extinguished as gas lamps sometimes are

It is, however, for interior illumination that the incandescent lamp excels; in houses, offices, shops, theatres, churches

there is no other means of lighting so suitable, so elegant, or so convenient, or which possesses such pronounced hygienic qualities.

In a climate such as that of Sydney, where the heat of summer evenings is at times almost unbearable, anything that will add to the comfort of the inhabitants must at once, when known, be greatly appreciated. There is a marked and very appreciable difference between a sitting room lighted with gas and one lighted by means of incandescent electric lamps.

Mr. W. H. Preece, of the General Post Office, in London, has stated that after an experience of several years, he has found that the introduction of the electric light into the offices has had a beneficial result on the health of the clerks employed, and has considerably reduced the amount of sick leave.

Figures go to prove, and experience in the past has shown, that street lighting without house to house lighting is not, commercially speaking, a profitable undertaking. Street lamps are too scattered in relation to the amount of mains necessary for supplying them. We should, therefore, dismiss from our minds any idea of lighting the streets *only*, and, further, as has been shown, it is for house lighting that electricity has such unapproachable advantages.

The price fixed by the Board of Trade as the maximum price for the sale of electrical energy in London is 8d. per 1,000 watt-hours usually called a Board of Trade unit, or B.T.U., and its illuminating power is about equal to 100 cubic feet of gas; so that, to obtain the relative value of gas and electricity, it is merely necessary to multiply the price per unit by ten, which will then represent the price of an equivalent amount of electricity equal to 1,000 feet of gas, and thus eightpence per B.T.U. is equal to gas costing six and eightpence. The present price of gas in Sydney is 5s. 3d., and electricity at an equal price would cost 6s. 3d. per B.T.U.

In addition to the cost of the electricity there is the cost of lamp maintainance. In Sydney the price of lamps suitable for

house lighting is 5s. each, and they should have an average life of 1,000 hours; at this price an ordinary 16 candle-power lamp taking 60 watts, costs 1d. per B.T.U., and an 8 c.p. lamp, taking half the energy, or 30 watts, costs 2d. per B.T.U.; this, when reduced to gas equivalents, is, for the 16 c.p. lamp, 10d. per 1,000 feet, and for the 8 c.p. lamp, 1s. 8d. per 1,000 feet, which you will see is a serious increase. However, by the time that Sydney is in the enjoyment of the electric light, the patent rights, which at present so enormously increase the manufactured price of these lamps, will have lapsed, and they will probably be sold here at a price varying from 1s. to 2s, and then their cost, when added to the price per unit, will be comparatively insignificant.

Although labour in Sydney is much more costly than in England, the price per B.T.U. should not be higher here than there, as the price of coal in Sydney is about half the cost of it in London, and these two items generally make the largest figures on the cost of production sheet.

In large compact private installations of the electric light, such as those at the "Australia Hotel," Messrs. Anthony Hordern and Sons, the Daily Telegraph Office, or the "Metropole," the cost of production would probably be as low, if not lower than the supply price of current from a central station, in the same way as hydraulic power can be produced, when on an equally large scale, at a lower price than that asked by the Hydraulic Power Company for water taken from their mains.

Plate XVII., Fig. 1, represents the load curve of the electric lighting at the Australia Hotel on November 11-12, 1891, or what is practically a summer evening. You will notice the lighting commences at four o'clock in the afternoon, and gradually increases to about 80 amperes at five o'clock, and in the course of the next hour, viz., by six o'clock, it has risen to 300 amperes; from this time the rise is more uniform and less abrupt up to 8 o'clock, when the maximum output for the evening was reached, viz., 360 amperes; a gradual fall then occurs to 10

o'clock, after which the load decreases more quickly, and with a uniform fall, till at four o'clock in the morning it is down to 50 amperes. At five o'clock, the next day practically commences, and the load increases again up till 8 o'clock, when it falls rapidly, till at 9 o'clock the lighting has ceased altogether The output of this particular card is 304·7 B.T.U's., which represents 500 indicated h.p. given by the steam in the engine cylinder during 17 hours, or an average of 29·41 one h.p. per hour, and the cost comes out as follows :—

	£	s.	d.
500 one h.p. @ 6 lbs. coal per one h.p.= 1 ton 7 cwt @ 13/-	0	17	6½
500 one h.p. @ 20 lbs. steam per one h.p.= 1,000 galls. water @ 1/- per 1,000 galls.	0	1	0
Engineer, 17 hours @ 1/6 (mean wage of the three engineers employed)... ...	1	5	6
Fireman, 17 hours @ 1/-	0	17	0
Petty Stores, Oil, &c.	0	5	0
Depreciation & Interest on Plant, Wiring & Fittings @ 12 % on £7,000, per 24 hours	2	6	8
Lamp Life @ 1d. per B.T.U.—304·7 B.T.U.	1	5	6
	£6	18	2½

This comes out at 5·44d. per B.T.U., or equal to gas lighting at 4s. 6½d. per 1,000 cubic feet. If we omit to take into consideration the cost of lamp life, as is always done when speaking of the price per unit, it is then 4·43d. per B.T.U., or equal to gas lighting at 3s. 8½d. per 1,000 cubic feet. Even then, however, it is not a fair comparison with gas in this particular instance, as interest should be charged on the piping and fittings for gas additional to the cost of gas consumed, as capital would have had to have been sunk on these pipes if illumination by gas had been adopted instead of electric lighting. A supply company could not very well supply current at this price, although they would probably have more efficient plant,

because, for the greater part of the day, the majority of the plant in the central station lies idle, and does not contribute to the earning part of the concern, whereas at buildings such as the "Australia," only the engine and dynamo are at rest, the steam from the boiler being utilized during the day for other purposes, and there is not the loss occasioned by raising steam for only a few hours' work, as has to be done at central stations, for the steam is always on. Again the wages bill is also considerably affected, as only the time during which the light is actually running has been put down in the list of charges just given, and in a central station it would be necessary to put down the 24 hours time, although the maximum output only occupies a few hours.

Plate XVII., Fig. 2, is a load diagram taken on November 21st, 1891, at the author's residence, from his own private electric plant and may be considered as fairly representative of the requirements of the average ten-roomed house in the suburbs. The light commenced at about twenty minutes to six, and at seven o'clock was 7·2 ampères, and practically continued steady to a little after eleven o'clock.

The total value of this card is ·927 of a B.T.U., and on reference to the book containing the cost of running, the price per B.T.U. at the time was about 6·5d. or equal to gas at 5s. 5d. per thousand, or again, taking the lamp life into consideration, 8s. 3d. per B.T.U., or 6s. 11d. per 1,000 feet of gas. This price, however, only represents the nett cost of production, and does not take into consideration depreciation of plant or interest on money, which would, in such a small installation as this, probably very nearly double the price. From this it would appear that a company supplying electrical energy would be unable to compete with very large private installations, but that to compete with gas in shops, hotels, theatres, churches and residences, it should be able to supply current at from 6d. to 7d. per B.T.U., and at this price, although equal in cost of illluminating power to gas, it is in reality

cheaper, as it does not blacken ceilings, or injure pictures and curtains, or contaminate the air of the room as gas does, the use of matches is also considerably reduced; these, although they appear small items in themselves, amount to an appreciable figure in the course of a year.

Having thus generally commented on the advantages to be gained from electrical illumination, and its relation to the cost of gas, we have now to consider what has been already done in Sydney to bring the electric current to our doors.

The Australian Gas Light and Coke Company have an application for the supply of electric current at present under consideration by the Assembly. The Sydney Electric Light Company have also a bill in hand. The capital of the Company is a quarter of a million, and they intend to put down a plant on the Continuous Current Battery Transformer system for 100,000 lamps, and complete their system in four years. The City Council have also a bill embodying a scheme for lighting the streets of the City of Sydney from three generating stations' one sitnated near the gas works in Kent Street, one at Woolloomooloo, and one in Prince Alfred Park. It is proposed to light the principal streets by means of arc lamps on poles between 35 feet and 40 feet high, placed at a distance of four chains apart, and arranged alternately on two circuits, so as to prevent total extinction of the light in the event of a possible break-down occurring. The less important streets are to have twenty-five C.P. incandescent lamps. Besides this the plant is to be capable of supplying current sufficient to allow of 16,000, sixty Watt lamps being connected, or about two-thirds of the number provided for by the Sydney Electric Light Company. The current, or at least the principal portion of it, will be alternating, at high pressure, and reduced by means of transformers to suitable potential for incandescent parallel lighting, the price proposed being 8d. per B.T.U., or equal to gas at 6s. 8d. per thousand feet.

The Municipality of Redfern are just completing a central station and plant for lighting the streets of the Municipality, and for supplying current to private consumers. The generating plant consists of two steel Multitubular Boilers, 6 ft. diameter, and 14 ft. long, each boiler having an independent feed water-heater, pump and injector. The engines—two in number—are compound, with cylinders 13 in. and 23 in., with 24 in. stroke, running at 110 revolutions per minute, and drive by means of 7½ in. ropes, a counter shaft arranged with a centre coupling, so that either engine can drive either shaft. The electrical plant consists of two of Messrs. Mather and Platts' alternators of a capacity of 100 units each, with an exciter to each machine. The switchboard is arranged for twelve circuits, with double pole switches and fuses, also lightning arresters, meters &c. The switches are arranged so that any circuit can be connected to either alternator, and further, that either exciter can be put on to either of the alternators as may be desired. There are 400 lamps of 25 C.P. each, covering twenty miles of streets, each has a clear glass globe and reflector, and is suspended from a wrought iron bracket attached to the poles carrying the lighting wires for the streets and private supply. The current is generated at a potential of 1,000 volts, and the pressure is reduced by means of transformers at the consumers' premises. The work is being carried out by the Williamson Electrical Engineering Company, to whom the author is indebted for the particulars given.

Up to the present time all the proposals that have been made for the Electric Lighting of Sydney or Suburbs have limited the area of supply to either the City of Sydney or to the area comprised within one of the suburban municipalities, and no suggestion, so far as the author is aware, has been made for a comprehensive system of supply large enough to serve the whole of Sydney and its principal suburbs. It undoubtedly appears at first sight a large order, and if controlled by a single company, would mean a large expenditure of capital, and at the

same time would be, like the present Gas Company, a huge monopoly.

From the *Statistical Register* for 1890, compiled from official returns by Mr. T. A. Coglan, A.M.I.C.E., it would appear that the number of dwellings and tenements in the City of Sydney and adjoining suburbs is about 69,000. If we allow that in 10 per cent. of these the inhabitants would still retain their primitive methods of lighting, viz., by means of candles, gas or kerosene, the total is reduced to about 62,000, and presuming that on an average each dwelling would not have more than eight 30 Watt lamps alight at one time, the total power necessary to maintain these, allowing for losses in transmission, generating, &c., would be between 30,000 and 40,000 indicated h.p., and would allow of about 1,100,000 lamps being connected, or about 10 times as many as provided for by the Sydney Electric Light Company.

From the same authority there are 115 miles of made streets in Sydney, and 573 miles in the adjacent suburbs. Allowing that in Sydney 50 miles out of the 115 miles would require lighting by means of arc lamps, and in the suburbs 200 miles of the 573 miles, the length of streets lighted by arc lamps would be 250 miles, and with 20 lamps to the mile the total number of arc lamps would be 5,000, and would require between 5,000 and 5,500 indicated h.p. for their lighting.

The remaining 438 miles, if lighted with 25 c.p. incandescent lamps, placed at varying distances apart according to the locality, so as to give an average length apart of three chains, or about 27 to the mile, would require about 12,000 indicated h.p. at the supply station.

The indicated horse power would then total as follows:—

House to house, say	40,000
Streets lighted by arc lamps	5,500
Streets lighted by 25 c.p incandescent lamps	12,000
	57,500

The area over which this amount of current would be supplied extends as far north as the northern boundary of the municipality of North Sydney; east to the Pacific coast, including Randwick, Waverley, and Woollahra, but not Manly; south, as far as the southern boundaries of Kensington and the municipalities of St. Peter's and Marrickville; and lastly, west, by the western boundary of the municipality of Ashfield, and includes the eastern portion of Five Dock, and the Municipality of Balmain.

In order to cope with this output, the author would suggest the establishment of centres of supply. One at Ball's Head Bay, one at Rushcutter's Bay, and one at Rozelle Bay, and would approximately proportion the power among them as follows.—Ball's Head Bay, 10,000 indicated h.p.; Rushcutter's Bay, 25,000; Rozelle Bay, 25,000; total, 60,000 indicated h.p., or 2,500 indicated h.p. above the estimate obtained from the number of dwellings and length of streets.

The same style and class of machinery should be adopted at each of the stations, in sets of combined condensing engines and dynamos of about 1,000 indicated h.p. each, and at each station say two smaller sets of 300 indicated h.p. each.

By arranging the plant in units as described, sufficient machinery could at first be put down to just cope with the demand for current at starting, and units added afterwards as more current was required, and further the necessity of a complete duplication of plant and its attendant increase of capital laid out is avoided, as never more than one or two of the sets at most would be disabled or laid up for an overhaul at one time.

Moreover, this splitting up of plant enables those in charge of the stations to add machines to cope with the supply as the demand arises during the day, and so keep those machines that are running fully loaded, or, in other words, working at their most economical rates of output; for nothing tends more to