Circular Quay.—At the Circular Quay they had a Fowler's 20 h.p. nominal semi-portable compound engine (non-condensing) 3 No. 7 Brush dynamos (1 spare). Two of these were coupled up in series to feed 28 Brush lamps. The total voltage was between 1,300 and 1,400, and there had not been a single accident to any human being; but there had been a few accidents to the lamps through drays running into the poles. The cost per annum was as follows:—

		£	s.	d.
28 Arc Lights	Coal at 14s. 6d. per ton ...	£187	17	7
	Wages...	369	0	0
	Stores and repairs	182	12	0
	Water at 1s. 6d. per 1,000 gal.	11	11	3
	Cartage	2	14	4
	Total	£753	15	2

The lamps were worked for 3,804 hours per year, which, multiplied by 28, the number of lamps = 106,512 Lp. hours $\therefore \frac{£753\ 15s.\ 2d.}{106{,}512\ \text{Lp.h.}}$ = 1.7d., nearly, per lamp per hour, each lamp = 500 watts, nearly, therefore the price for Board of Trade unit was 3.4d., which was equivalent to gas at 1s. 11d. per 1,000ft. This estimate did not include depreciation or interest on plant; however, allowing 10 per cent. on £3,000 (value of plant) for interest and depreciation, it would only increase the cost to 4.8d. per B.T. unit, which was equivalent to gas at 2s. 9d. per 1,000 feet. This and Cowper's Wharf installation had overhead wires.

Cowper's Wharf.—Cowper's Wharf Installation consisted of one of Robey's 10 h.p. nominal semi-portable ordinary high pressure non-condensing engines, one No. 7 Brush dynamo, and 15 arc lamps. The cost per annum was as follows:—

	£	s.	d.
Coal at 14s. 6d. per ton	£155	6	5
Water 1s. 6d. per 1,000 gallons	15	9	0
Cartage	0	13	10
Stores and repairs	75	1	2
Wages	369	0	0
	£615	10	5

The lamps were worked for 3,804 hours per year ∴ 3,804 × 15 = 57,060 horse-power hours $\frac{£615 \text{ 10s 5d}}{57,060}$ = 2·5d per lamp per hour or 5d. per B.T. unit. equivalent to gas at 2s. 10d. per 1,000. This was merely working expenses, allowing 10 per cent. on £2,000 the cost would be equal to 6·7 per B.T. unit = gas at 3s. 10d. per 1,000.

So that it would be seen in each of these two installations they were producing the light at a much lower rate than the Gas Company. For the coming year he trusted it would be less, as there was a reduction of 1s. 1d. per ton in coal and 10s. per 1,000 in carbons.

Post Office.—Post Office Installation consisted of one 12 horse power Otto gas engine, 1 Edison and 1 Weston arc dynamo, 70 incandescent, 60 watt lamps, and 4 Weston arc lamps; making a total of 7,200 watts per hour. The lights were used on an average 5 hours per day = 1,560 per year. The cost of working was as follows :—

Gas at 5s. 3d. per 1,000 ...	£175	11	9
Wages	156	0	0
Stores and repairs	71	1	3
Cartage...	1	4	4
	£403	17	4 say £404

∴ £404 ÷ 11,252 unit hours (1,560 hours + $7\frac{1}{8}$ B.T. units) = 8·6d. per B.T. unit, which was equivalent to gas at 4s. 11d. per 1,000. To include 10 per cent. interest on this would equal gas at about 6s. 6d. per 1,000.

From these figures it would be clearly seen that an overhead system of high tension could more than compete with the Gas Companies and still pay respectable dividends, but as he stated before, this would not be allowed in a crowded city, hence the necessity of some scheme which would get over all these difficulties. If Mr. Van de Velde's figures were correct and would hold good in New South Wales, he should not experience any trouble in bringing his scheme to the fore. As regarded hydraulic power, he (the speaker) must plead ignorance, and, therefore, could not refute any of the statements contained in the paper, but would leave it for abler men to do.

Mr. Shellshear stated that the quantity of water which would be required in Sydney for such a system as that proposed would be enormous. Mr. Van de Velde said that 100 lamps would require 10,000 cubic meters per annum, or 2,200,000 gallons. For Sydney we should require about a million lamps, which would take something like 22 billion gallons of water per year. Also, that he was afraid that even in Sydney the question of hydro-dynamos was a serious one, owing to the cost of water supply, and up country, where sometimes you could not get water at any price, the matter was out of all consideration.

Mr. H. E. Dickinson remarked that it was a matter for regret that Mr. Van de Velde in preparing his paper did not devote as much pains to the calculations as he did to the declamatory portion. Several of the more salient points were touched upon in the discussion which followed, notably by Messrs. Fischer, Selfe, Fitzmaurice, and Shellshear, showing that accuracy had been in a great measure sacrificed to enthusiasm in the author's advocacy of his countryman, Mr. Van Rysselberghe's scheme; and although with more careful treatment it might, perhaps, be shown that under certain exceptionally favourable circumstances this system might be feasible he (the speaker) was afraid that we, as a scientific body, could only come to one conclusion, viz., that it was unsuitable for adoption in Sydney.

In the earlier portion of his paper Mr. Van de Velde endeavoured to reproduce the excited times following the Paris Exposition of 1881. An electrical "boom" was inaugurated, and the promoters of "bogus" companies were in great form, as anything which by an ingenious and craftily-drawn prospectus could be represented as tending to break up the monopolies of gas companies was eagerly taken up by the public, and many investors were thereby ruined.

But we had now settled down to a more reasonable frame of mind in this respect. The wonderful developments that the last decade had witnessed in the economical conversion of energy into electricity had familiarised its use in more operations than simply lighting. We had seen the antagonism between gas and electricity gradually converted into a firm alliance, and gas, in a word, had become the handmaid of electricity. Instead of being overturned, it seemed to him that gas companies could, if so minded, become the cheapest purveyors of electricity. It was no news that lighting by gas was a wasteful, unscientific and unhealthy process, but it was not so widely known that gas when used as a motive power gave better results as a lighting agency through the medium of electricity than by its imperfect combustion in the ordinary way.

* Sir David Salamon's comparison was given in the following comprehensive manner :—

" A gas-engine requires about 20 cubic feet of gas per indicated horse-power per hour, which in a properly designed installation should give current for at least 8 incandescent or glow lamps of 16 c.p. each. Consequently for every 20 cubic feet burnt in the engine there is produced a light equivalent to 130 candles or more, since a 16 c.p. lamp gives rather more than its nominal (lighting) power. A gas burner made to pass 6 feet of gas at normal pressure gives about the same light as a 16 c.p. lamp. Hence 20 cubic feet of gas burnt in the usual manner will produce a light of about 55 candles." The result is, therefore, about $2\frac{1}{3}$ times in favour of electricity.

No doubt, some of the members present had seen results as good as those quoted, obtained by the use of gas and air, in the proportions necessary for more perfect combustion and light obtained by the incandescence of a platinum burner. The economy of the gas engine had considerably increased of late years, and it had shown itself to be a very convenient motor, and when the manufacture became more general, on the expiry of patent rights, and competition reduced the cost, a great future was before it.

* "Electric Light Installation," Whittaker & Co., London, 5th Edition, 1890.

That the distribution of electricity by conductors was open to grave objections, no one would deny ; but some of Mr. Van de Velde's statements in condemnation of the system had been shown to be grossly exaggerated, more especially as regarded the section of cables required.

One misstatement he would notice, which, however, was comparatively a minor matter, viz. : that "Electricity was only one particular form of energy." This was a very general assumption, but the latest developments of electrical research had shown that such was not the case, but that electricity was material, and that Dr. Franklin's view was in the main a correct one.

Professor Oliver Lodge, in the preface to his "Modern Views of Electricity" stated : "Heat was once thought to be a form of matter ; it is now known to be a form of energy. The question remains, 'What is energy?' Electricity has been thought to be a form of energy ; it has been shown to be a form of ether. There remains the question, 'What is ether?'" He showed that certain electrical phenomena were inconsistent with any other than the material theory.

A systematic analysis of Mr. Van de Velde's assertions would probably take much more time than the paper itself ; for it was much easier to asert than to refute.

To put the matter in as brief a compass as possible : we were told that Mr. Van Rysselberghe had brought out a combination, called a "hydro-dynamo," which, in conjunction with a hydraulic power distribution, was to work wonders : giving the consumer light at a lower rate than gas, and a much superior article, and returning a profit to the fortunate shareholders of original stock of 100 per cent.

Unfortunately for this glowing picture, the figures advanced in support turn out delusive, and an analysis of them dispels the mirage.

M. Van Rysselberghe estimated the cost of 1 cubic meter of water under pressure, at Brussels, at 17½ centimes or 1¾d. to the Company. These were figures which could be checked against wel authenticated English practice. Professor Robinson, in his work on hydraulic power, gave the average cost for engine power + 15 per cent allowance, as interest on capital and depreciation of eight hydraulic pumping stations in Great Britain, at 1.26d. per unit of 100 foot-tons delivered in the main. This was, of course, past the accumulator, but had nothing to do with the cost of distribution.

1 cubic meter × 50 atmospheres × 80 per cent. = 1.33 units of 100 foot-tons, and at English rate became 1.67d, or quite close enough to the 1.75 for argument.

But the cost of power at the accumulator was a very different thing to that of power delivered at the consumers' motor, crane, or lift. The distributing mains had to be laid, and the charge to the consumer must include the interest on the outlay, consequent on the reticulation, the commercial expenses, and the profit to the company.

The London Hydraulic Power Company's charge ranged from 8s. per 1,000 gallons to small consumers, with a minimum charge of £5 per quarter, to 4s. per 1,000 to large consumers. The Melbourne Company's charge was about the same, he believed; therefore, he did not see how, in Sydney, the price could be any less.

One thousand gallons = 4.54 cubic metres, so that on a similar scale, the charge would range from 1s. 9d. or 10½d. per cubic metre. The great number of consumers would probably be on the smaller scale, as it would pay a large consumer of power in a compact area to generate his own by either a steam or gas engine. The mean rate of returns to the Company, as per schedule rates would, therefore, be about 6s. per 1,000, or per cubic metre $\frac{6}{4.54}$ = about 1s. 4d. per cubic metre.

The cost of the water must be added, or 1s. 6d. a 1,000 = 4d. per cubic metre, making 1s. 8d. as the cost to the average consumer,

This cost of distribution might, at first sight, appear to be very heavy; a little consideration would show that it must necessarily be so. The cost of materials in mains, branches, and valves, labour in laying them through streets and connecting to the premises of the consumers; repairs, renewals, and depreciation, office expenses, and the Company's profit. It was, therefore, not surprising that the actual cost of pumping should be merely a fractional part of the cost of the power delivered to the consumer.

When, therefore, Mr. Van Rysselberghe was represented as asserting that because the cost of pumping was $1\frac{3}{4}$d. that a charge of $3\frac{1}{2}$d. would return a profit of 100 per cent., he was either making a grave error, or was misrepresented by Mr. Van de Velde.

This error was, however, persisted in throughout the paper, and, of course, calculations on that basis must be equally misleading, and required to be multiplied by 6 to obtain an estimate of cost sanctioned by actual practice.

Again, the quantity of water under pressure to generate electricity in the typical installations was very much under-estimated. Taking the 40-lamp installation first, it was stated that 2,000 cubic metres per annum, or 13.7 cubic metres per hour was sufficient to generate the current.

$$\frac{2204 \times 1.37 \times 50 \times 14.7 \times 2.305}{33{,}000 \times 60} = 2.58 \text{ ind. horse-power,}$$

or, the highest possible amount given out by the pumps, but as the maximum efficiency in the main was at the very outside 80 per cent., a cubic metre would only carry 206 indicated horse-power to the consumer's motor. Under these considerations, it was important to the consumer that he should employ a motor which would return as much of the work stored in the water which passed through his meter as possible, and we had to consider the motor of M. Van Rysselberghe. Whatever it might be, it was only represented as giving out an efficiency of 50 per cent. This meant that every $2\frac{1}{2}$ indicated horse-power at the pumps gave back 1 indicated horse-power at the dynamos. Sir D. Salamons stated the results of practice as 10 lamps per indicated horse-power, which was a well-known allowance. The conclusion, therefore, that was forced upon us by this analysis, was that the quantity of water under pressure which Mr. Van de Velde wished us to consider as sufficient for a 40 lamp installation, was in reality, only qualified for one of 10 lamps. This conclusion was corroborated by the figures Mr. Van de Velde put on the blackboard for us, which were stated thus: 1 $M^3 = 1$ electric horse-power=746 watts, but as his subsequent factors were incorrect, namely, the number of lamps per electric horse-power, which should be 10 instead of 14, as he stated, and the cost of water which had been shown to be very much under-estimated, it was unnecessary to follow his equation any further. Another example he (the speaker) must refer to, as illustrative of the general want of accuracy in the author's figures was the relative quantities of water under pressure required for the two typical installations. The smaller one which he had dealt with, was stated to require 2,000 cubic metres for 40 lamps, the larger one for 120 lamps, or three times the number was said to require, 10,000 cubic metres, or five times the quantity. A brief consideration of these figures showed that even were the estimates reliable, the motor portion of the hydro-dynamo for which so much was claimed, was a most wasteful machine, eminently unsuitable for such a limited water supply as ours. To sum up the analysis, the water under pressure would cost the consumer from five to six times as much as Mr. Van de Velde estimated, and the quantity required with Mr. Van Rysselberghe's motor would probably be from $3\frac{1}{2}$ to 4 times as much as estimated in the paper.

Mr. Callender said: In considering the paper read by Mr. Van de Velde, there were two points upon which, it appeared to him, the whole question really turned.

First, the statement that the transmission of electricity at high tension was inadmissable on account of the danger to life. While admitting that at a tension of 2,500 volts, which was about the highest in use at present, electricity in inexperienced hands was dangerous, we had ample proof that in the hands of a competent electrical engineer it was perfectly safe. The many eminent authorities quoted by Mr. Fischer as to this would seem to be quite sufficient to convince any one; but we had, if possible, a more convincing proof, in the large number of central stations all over the world now using this system. Among others, he might instance the Grosvenor Gallery, and the Brompton stations in London, Eastbourne, Hastings, Rome, Turin, Milan, and Tours, and many other cities on the Continent, in most of which the mains were underground, and where there had been no fatalities up to the present in spite of the high tension in use (2,500 volts).

It was true that in America there had been a number of deaths, where the high-tension system was in use to an enormous extent; but every one of them was directly traceable to careless work in fitting up the plant; or, still more frequently, to the low class of insulation used on the wires and cables.

The second point was the question of cost, and this was really the key of the whole matter. Mr. Van de Velde stated that to transmit electricity to light 1,000 lamps at a distance of 1,000 meters at a loss of 5 per cent., would require 720,000 kilos of pure copper, costing, at 2s. per kilo, £72,000, or with insulation, £144,000.

Now, accepting these figures as correct, we could by the use of the three-wire system of Mr. Edison and Dr. Hopkinson, reduce this at once to 216,000 kilos, still keeping the E.M.F. at 100 volts, and the loss at 5 per cent. This amount of copper would cost, at 2s., £21,600, or, with insulation, £43,200.

But if we increased the E.M.F. to 500 volts, a pressure which was admittedly safe, and use the three-wire system, we could still further reduce the weight of copper to 9,500 kilos, costing, at 2s., £950, or, with insulation, £1,900.

Again, by the use of the alternating system at a pressure of 2,500 volts, which had, he maintained, been proved to be perfectly safe. We could still further reduce the cost.

With an E.M.F. of 2,500, to give a loss of 5 per cent., we should require only a weight of copper of 1,500 kilos. As this conductor would be somewhat smaller than experience had shown to be satisfactory, he would assume a loss of only 1 per cent., instead of 5 per cent. This would require a weight of copper of 6,500 kilos, costing, at 2s., £650, with insulation, £1,300.

In conclusion, he hoped he had shown how the cost of the mains could be reduced from the alarming figure of £144,000, given by Mr. Van de Velde, to the comparatively insignificant figure of £1,300, and this with a loss of only 1 per cent., instead of 5 per cent., and considered that we were justified in giving a direct negative to the statement of Mr. Van de Velde's that "Electricity cannot be transported economically."

Mr. Webb stated that Mr. Van de Velde had asked if any Companies could be named who were supplying the electric light at the same price as gas, and paying a reasonable dividend. There was the Central Station at Milan, which had been paying a dividend for some years. The last one paid was 4 per cent., and they put by a large reserve fund. There are two Companies in Berlin, one paying 5 per cent., and the other 7½ per cent.

Mr. Van de Velde also stated very emphatically that electricity could not be transported economically. Behring, in his book, gave the commercial efficiencies of electricity, hydraulics, pneumatics, and wire rope. At 100 metres the commercial efficiency of electricity was 69 per cent., and of hydraulics 50 per cent. At 1,000 metres, electricity 66 per cent. efficiency, and hydraulics 50 per cent., and on further increasing the distance to 20,000 metres, the commercial efficiency of electricity was 32 per cent., and of hydraulics 20 per cent. Then the author gives efficiencies and losses in the conductors. But he must remember that with electricity, when transmitted to 1,000 metres, it was in a position to give light at once, but with water power, the water must first of all pass through the hydraulic motor, where there was a loss according to his own showing of 50 per cent. Then there was another loss of 10 per cent. in the dynamo, at the very least, which gave 40 per cent. efficiency, whereas allowing him 17 per cent. loss in electricity, we had 83 per cent. efficiency by means of electric power.

Again quoting from Behring's book, the capital outlay required for the various methods of distribution, up to 500 metres, hydraulics had rather the advantage. The ratio of capital outlay per horse power for 500 metres, for 5 horse-power: electricity, 78; hydraulics, 66; but at 1,000 metres, the capital outlay for electricity was 81, and of hydraulics 87, and when increased to 20,000 metres, the capital outlay of electricity was found to be

210, and for hydraulics, 1,180. Further, the cost of the water-mains increased considerably with the increase of pressure, but with electricity this was not the case, as there was but little difference between an insulation for a low and a high tension current. Mr. Van de Velde stated that his hydro-dynamos were to be as simple as a gas meter; but even then there must be a certain amount of wear, and it would also require a certain amount of attention, as it must necessarily run at a high speed, and no comparison could be drawn between it and a gas meter.

The main point of Mr. Van de Velde's paper was that he had taken a case in which he proposed to transmit to 1,000 metres or more, a current at 100 volts pressure, but he, the speaker, thought this was entirely out of the question. In America they seemed to hold to their transformer plants, and the demand for this type of plant was rapidly increasing.

In the paper, Professor Forbes was quoted as condemning all cables, but it was plain it was simply one particular kind of cable he condemned.

Mr. Ashcroft said he considered, as a new member, it would be an act of presumption on his part to make any remarks till he had become better acquainted with our proceedings, especially as he had not read the paper previously. But there was one point in connection with the paper that he wished to mention and that was that it seemed to favour a most wasteful application of hydraulic power. We had many contrivances—hydraulic engines—that gave a much higher percentage of efficiency than the one proposed.

Mr. Cruickshank said he had listened with great pleasure to the reading of Mr. Van de Velde's paper and the criticisms which the various speakers had passed upon it. He did not pretend to be able to speak with any degree of authority upon electricity; but there were one or two things in connection with it which perhaps might bear on the subject, looking at it from a mechanical point of view. It appeared to him that Mr. Van de Velde's paper,