DISCUSSION.

MR. G. FISCHER stated that he had been requested by the President to open the discussion, it afforded him pleasure in moving that a vote of thanks be accorded to the author of the paper, for, although he did not at all agree with Mr. Van de Velde's conclusions, he deserved the thanks of our Association on account of his paper forming a basis on which a discussion can be started on this most important question of electric lighting. The contents of the paper might, for the purposes of discussion, be shortly summarised under two headings, viz: 1. That the distribution of an electric current at a higher tension than 100 volts is not only dangerous to living beings, but is absolutely impracticable, for does he not come to the remarkable conclusion in the following words:—"In conclusion, the electric current, which in the general opinion is so easily transported, is not transportable at all." In the second part of the paper, Mr. Van de Velde attempts to demonstrate that the only feasible way to admit of every inhabitant of a city partaking of the benefits of the electric light is by means of a high pressure water service, generating the electric current on the consumer's premises. To refute in detail all the statements made would take as much, if not more time, than the reading of the original communication. He should, therefore, content himself with quoting, in answer to the first part of the paper, the opinions of some of the most eminent authorities of the present day. On reference to the *Electrical Engineer* of April 2, 1890, p. 176, you will find certain answers in reply to questions issued by the New York Senate Committee, relating to the practicability and safety of underground high tension circuit; they are as follows:

Q. 1.—Can high tension, direct and alternating, currents for lighting and power purposes be safely and successfully distributed by means of underground cables? If so, up to what voltage can this be done?

Sir William Thompson: Yes, I believe so, up to 2,500 volts.

Professor George Forbes: We have ample proof that high-pressure electric currents, either direct, or alternating, can be distributed safely and successfully for lighting purposes, by means of underground cables. Our experience in the past has been limited to 2,500 volts, as a maximum.

Dr. John Hopkinson: It has been conclusively proved that alternating high-tension currents can be supplied without inconvenience, by means of underground conductors, if the work is properly done; it has also been proved that this can be done with a potential of 2,400 volts.

Mr. W. H. Preece: I see no difficulty, whatever, in maintaining such a system of distributing currents by underground cables, and I form that opinion from actual experience, and not from mere theory. Underground cables are safe, durable and efficient. I have had full experience of a high pressure alternating current system in Eastbourne, where such a system, working with a voltage of 1,800 volts, has been at work since 1886, without a single accident or failure, and is now feeding 2,600 lamps. A similar system, of which I have had similar experience, has been applied in London at the West Brompton Central station; 1,800 volts have been distributed for over twelve months, through sixteen miles of underground wire for lighting purposes throughout the rich and flourishing neighbourhood of Kensington, without a single failure.

Mr. E. Fresquet: Direct and alternating currents of high-tension, for lighting and power, can safely and successfully be distributed by means of underground cables, provided ordinary precautions, known to all electricians, are taken. In my own experience I have used 3,000 volts.

Q. 4.—What is your opinion as to the safety of the consumer and the public at large, of the converter or transformer system of electric lighting, involving the use of high-tension alternating currents in the street main?

Sir William Thompson: With properly laid mains the high-tension alternating currents in the street mains underground, involve, I believe, no danger whatever to the public at large. The converter, or transformer system, can, I believe, be made absolutely safe to the consumers by proper arrangements. It has already been largely practised in London, Glasgow and elsewhere, and, as far as I know, no instance has occurred of any consumer having met with an accident.

Professor John Forbes: After the alternating current transformer system had been proved to be efficient, it was accepted as the required solution of the difficulty, because the house-wiring is, on this system, completely separated from the street mains. Everyone in this country who then came to this conclusion, and has had experience of the system, has been confirmed in his belief that the transformer secured the required safety.

Dr. John Hopkinson: There is, in my opinion, no reason whatever, why high tension alternating currents should not be used in the street mains.

Mr. W. H. Preece: I have advised the Metropolitan Electric Supply Company of London to adopt the same system, and they are doing so, and I have also advised several local authorities in England to do the same thing, and they are going to do it. I do not express my opinion lightly on this subject. There are about 30,000 miles of underground insulated wire of the United Kingdom under my control, and I have had thirty-seven years' experience of such wires. I venture to think that this experience is unique in its continuity and extent.

Mr. E. Fresquet: The converter or transformer system, involving the use of high tension alternating currents, can be used with absolute safety to the consumer and the public at large. No accident can happen if well-known precautions are taken, and the neglect of them implies great ignorance.

He had only given a few short abstracts of this valuable evidence, but he was satisfied that the opinions advanced by such authorities as Sir William Thomson, Professor George Forbes, Dr. John Hopkinson, Mr. W. H. Preece, and Mr. E. Fresquet would convince any unprejudiced and disinterested person, that the statements made by Mr. Van de Velde regarding the distribution of electricity at higher tension than 100 volts were, to put it mildly, erroneous. Let us now go on to the second part of the paper, and for convenience and brevity's sake assume that M. Van Rysselberghe's Hydro-Dynamo is an established mechanical success; consequently the matter is narrowed then to the question of £ s. d., or to put it in plain language, is it cheaper to light a city with the electric light by means of the Van Rysselberghe system than by a perfectly safe system of high tension alternating currents, converted to low tension before entering the consumer's premises? He feared M. Van de Velde's figures at the end of the paper were of very little practical value, as for example in the case of Sydney, instead of the Hydraulic Power Company being able to sell the water at about 1s. 3d. per 1,000 gallons (equal to thirty-five centimes per cubic meter) as in Brussels, they would have to pay 1s. 6d. per 1000 to the Water and Sewerage Board in the first instance, which would more than double the price quoted, quite regardless of all the other items tending to increase the cost of production over that said to exist in Brussels.

However, the comparative cost could be ascertained in a different manner. The distribution of electricity could be utilized for either lighting or power purposes, and in Mr. Gisbert Kapp's book on "Electric Transmission of Energy," p. 234, you will find a table giving the "price in pence of one horse-power hour obtained at the receiving station." This table was based on averages obtaining on the continent of Europe and Great Britain, and compared the cost of electric, hydraulic, pneumatic and wire-rope transmission of energy; the two first only interest us here. We will assume that we want to light 1,000 16 c.p. lamps at an average distance of 1,000 meters from the generating station. To do this it would take in round numbers 100 horse power for the electric system, which would cost 1·91 pence per horse-power hour, or about 16s. per hour for 1,000 lights; for the hydraulic system we should require just about double or 206 horse-power, as we could hardly rely on obtaining more than 50 per cent. of the original power supplied out of a number of small hydro-dynamos, which at 1·78 pence per hour would give for the 1,000 lamps about 30s. as against 16s. by alternating current distribution, which was about 47 per cent. in favour of the latter. Of course these figures would not apply to Sydney, but they were reasonably correct for purposes of comparison. He (Mr. Fischer) thought it might be fairly claimed to have been demonstrated that, to enable us all to enjoy the undoubted blessings which the electric light confers on modern society, it would be necessary for us to cast about and select a different system to the one described by Mr. Van de Velde.

Mr. Norman Selfe said: Mr. C. Van de Velde's paper was entitled "Van Rysselberghe's Hydro-Dynamo System of Electric Lighting," but after careful reading he was bound to confess he was as far off as ever from knowing in what Mr. Van Rysselberghe's system consisted, and what were the improvements which that gentleman had introduced. The paper was of considerable length, was very discursive, and at the same time while it abounded in platitudes it contained a number of statements with which he (Mr. Selfe) felt sure many members of the institution would join issue. There were, however, in it three main propositions, and to these he would shortly refer.

Firstly, he was quite disposed to agree with the assumption that Electric Lighting could not at present be economically and safely carried out by the distribution of the current from a central station *over a very wide and scattered district;* because the fearful accidents that had occurred with high tension currents in New York and elsewhere, had prejudiced the public mind against such heavy pressures of electricity as were there used being allowed in the streets either underground or overhead; and the amount of copper required for voltages, as low as 100, effectively precluded their use over long distances. At the same time it must be borne in mind that the greatest Electric Light Station in the world—at Deptford, England—was preparing to send out currents of 10,000 volt power, and if the annular conductor that had been invented for that great distribution possessed half the qualities claimed for it, such extreme electrical pressures might yet become common.

On the second proposition of the paper that it was better to generate the power at a central station and transmit it by hydraulic pressure or compressed air to secondary stations where such power was transformed into electric currents for distribution, could not by any means be considered Mr. Van Rysselberghe's system. He (Mr. Selfe) had read papers before this association in March, 1886, and September, 1889, in which he had referred to the Hydraulic and other Power Companies, and had advocated the distribution of power by compressed air; he had also made special reference to the driving of dynamos for the electric light by such powers, citing the "Popp" System now so successfully working in Paris. The question of driving dynamos by water engines from the mains of Hydraulic Power Companies had not only been discussed for years back, but had been in actual operation. Mr. Van Rysselberghe's system must, therefore, consist in some details of the Hydro-Dynamo, which Mr. Van de Velde had, he presumed, inadvertently omitted to give the particulars of in his paper; in fact it was a "performance of Hamlet with Hamlet himself left out."

The third and most important portion of Mr. Van de Velde's paper was contained in the statements that Mr. Van Rysselberghe had made a special study of the question of hydraulic motors, and had designed a hydro-dynamo which would give a uniform speed "in spite of the fluctuation of the hydraulic pressure, and the variable quantity of the light consumed;" in fact, the invention was, Mr. Van de Velde said, a case of Columbus and the egg over again. Mr. Van Rysselberghe "has found the simple and elementary solution of the problem," but the solution was not given, a statement which sounded very well. Further, Mr. Van Rysselberghe, it was said, could supply hydraulic power in Brussels under a pressure equal to 50 atmospheres, for 35 centimes per cubic metre, and get 100 per cent. profit, as the power cost him only 17½ centimes a cube metre; and, lastly, that Mr. Van de Velde was prepared to supply the light here in Sydney on the same basis for 3½ centimes per light per hour, and make a profit of 100 per cent.

It would be interesting to the members of the Association to know in what way Mr. Van Rysselberghe had succeeded in obtaining a hydro-motor to keep uniform speed under variable pressure and work, because it was obviously much more difficult to do so with a non-expansible medium like water than it was with steam or compressed air, and it might be done with engines of variable stroke as made in England, but the author had said *nothing* about this.

With regard to the supply of water in Brussels at 50 atmospheres pressure for 17½ centimes per cubic metre, and in Sydney on the same basis, this, it must be noted, was 1·75 pence for, say, 220 gallons, or within a minute fraction of 8d. per thousand gallons. Now, as was well known, in Sydney the water alone costs 1s. 6d. per thousand gallons, so that if Mr. Van de Velde sold it at 35 centimes, or 3½d. per cubic metre, or 1s. 4d. a thousand gallons, instead of making 100 per cent. profit, as he stated he would, it appeared really that he would be making 2d. a thousand gallons loss, even if he got somebody to lay the mains and do all his pumping for nothing. The real fact was, the Hydraulic Power Company of Sydney was empowered by Act of Parliament to charge 12s. 6d. per thousand gallons, and if it reduced the price to the Melbourne rates to encourage custom, as explained by Mr. Swinbourne, the Melbourne company's engineer, in this room recently, the cost of water would then be 8s. a thousand gallons instead of 8d. Under these circumstances, and until these great discrepancies were explained away, it appeared useless to carry the investigation further, and compare the rates of 3½ centimes per hour, which Mr. Van de Velde proposed to charge for the electric lamps, to see if such rates would yield him 100 per cent. profit, as he stated.

In the statement made in the paper that the capacity of a hydraulic tube increases as the *fifth* power of the radius, there was probably some clerical error—it was certainly not correct.

Mr. Selfe, in conclusion, expressed a hope that the author in his reply would give particulars of it, and would state with regard to the calculations presented in the paper.

1. The efficiency of the main steam engines in lbs. of coal per horse-power per hour.

2. The cost of pumping per 1,000 gallons (to 50 atmospheres) pressure.

3. The cost of the hydraulic mains per mile and size per hundred horse-power to be transmitted.

4. Loss by friction per mile in pressure, etc. When such data was before it, this meeting would have something to discuss.

Mr. Fitzmaurice remarked that not having a great deal of leisure time at his disposal, he had not been able to give the subject the attention which was necessary, but it was one which should interest, not only the electrical and engineering community, but the general public.

Electric Lighting had made enormous strides during the last few years, and the demand for electricity in all its phases, and particularly as a lighting medium, was increasing at a wonderful rate. Even in New South Wales alone the progress was very marked, for in the year 1883 the number of incandescent lamps in use could be counted in hundreds, while at the present time the number exceeded 15,000, and large orders for more, notably the Centennial Hall (1,500 incandescent and 16 arc) the Australia Hotel and others were in hand. It could not be denied that a great deal of danger existed if high tension currents were used and proper supervision was not given in the erection of the wires, for in New York overhead electric lighting had been carried out to such an extent, and without regard to safety, that the authorities had been compelled to use the pruning knife to all overhead wires, and compelled the companies to carry them underground.

In cities such as Sydney, the cost of making conduits and laying cables would necessarily be very expensive owing to the network of gas and water pipes.

In underground conduits the greatest source of danger the electrical engineer had to contend against was gas and water, for owing to leaky mains gas had escaped into the subways, had frequently caused explosions, although at the same time the cause of ignition had not always been definitely proved, yet it had invariably been charged to leaks in the electric cables. Some short time back a violent explosion took place in the Devonshire Street sewer considerably damaging the road; the cause (if his memory served him correctly) was assigned to the refuse from the railway gas plant finding its way into the sewer, but in this case there was no electric spark to cause ignition, so it was put down to spontaneous combustion. If such was the case, was it not likely that the explosions in the electrical subways were caused by the same agent? As long as faulty gas mains existed, so would also the dangers to subways exist, unless ventilation by forced air was resorted to, which meant additional expense. Water, on the other hand, was a dangerous enemy owing to its conductivity, and by coming in contact with cables destroyed the insulation and eventually grounded the circuit, making it extremely dangerous to handle if the current be of high tension, at the same time increasing the load on dynamo. Notwithstanding all these obstacles electric lighting was making tremendous strides all over the civilised world, and if we weighed up the number of accidents caused by its use it would show a very low percentage comparing with gas or kerosene. Gas and kerosene being very old friends of the public, very little notice was taken of explosions by either.

Mr. Van de Velde in his opening remarks made reference to the Gas Companies being able to reduce the price of gas considerably without compromising their own interest. But he (the speaker) considered that it was due to the rapid strides made in electric lighting that had reduced the price of gas to its present rate, for it was only a few years back when the price was just double. If electric lighting did not affect the profits on gas shares, it certainly excited the minds of the shareholders. (The late meeting to protest against the introduction of electric lighting in Newcastle to wit).

Mr. Van de Velde in making comparisons between the rival system of distributing mains, had taken an extremely low potential for central station electric lighting, and one which would never be attempted in Sydney; it was quite unnecessary for him to quote figures at that potential. Increase the voltage by 10 times, the loss of energy in transmission would be decreased by that ratio—that was to say, supposing in a 100 volt circuit the loss of energy be 85 per cent. per 1,000 feet of conductor, only 85 per cent. would be lost by increasing the potential to 1,000 volts, for it could be seen at a glance that a plant of 10,000 50 watt lamps of 100 volts would require a cable sufficiently large to carry a current of 5,000 amps, whereas with a 1,000 volts, to obtain the same number of watts, would only require a cable of 500 amps capacity. So that allowing a cable of 1,000 amps capacity would only = 1 square inch in area, weighing 1·7 tons per 1,000 feet or about 5½ tons per 1,000 meters, or, with double leads, 11 tons per 1,000 meters; and taking Mr. Van de Velde's price of copper, viz., 2s, would equal say £10,000, this showed a decrease of £60,000 according to estimate given in the paper in cost of cables for the same number of watts. He considered that a pressure of 1,000 volts was perfectly safe for underground circuits if carried out under proper conditions, but any considerable increase over that was undoubtedly troublesome and dangerous owing to the causes previously pointed out. If, as the author of the paper asserted, the future did not belong to central stations, the greater was the reason why this paper should be studied. By a system of hydraulic motors in working dynamos, the danger by high tension currents would be considerably reduced, if not totally so, but it was a very questionable matter as to the consumers' interest in producing the electric light himself. One great objection was the care required in keeping the dynamo in thorough working order and free from sparking. He was afraid this would be the chief stumbling block in the introduction of this system. For business houses, offices, etc., this system should work admirably, for there would be a considerable economy in space where private lifts or lighting were concerned. The one motive power would supply three very great commodities, viz., light, lifts, and safety from fire, for with a pressure of 50 atmospheres fire engines could be dispensed with. Moreover it would do away with the noise of engines and dispense with skilled labour, which seemed to be the aim of all inventions.

The cost of laying the water-mains would naturally be much less than cables, as the same care was not necessary in the one as the other, and there would be no danger of explosion, shocks, or leaks.

In making out the cost of erection and maintenance, Mr. Van de Velde had not been very precise, for the cost of erection, measuring instruments, etc.; also, the price of water appeared very low. Did the cost of plant include the lamps, sockets, and wire, etc.? and did the sinking fund allow for renewal of lamps every year? If not, there would be a very considerable increase on the 230 francs.

Would it be possible in Sydney, where fresh water was sometimes a scarce commodity, and in view of the distance that an Hydraulic Company would have to go to pump water from a fresh water river, would it be possible to sell it to customers at the price quoted, viz., 35 centimes per meter, which was equivalent to 1s. 4d. per 1,000 gallons, when the Sydney public had to pay 1s. 6d. per 1,000 gallons, and yet did not return any profits? The price of water in this system would be the principal item to consider in adopting it.

If the prices given were correct, there would, indeed, be a great future in this system of lighting, for, in the case of the 1000 watt plant (20 lamps), the cost was only 6½d. for Board of Trade unit, or equivalent to gas at 3s. 7d. per 1,000. In the 5,000 watt plant (100 lamps) the cost was only 5.2d per B.T. unit or = gas at 3s. per 1,000. To compete with this only, an overhead system of cables could do it, but in a crowded city this would not be tolerated.

It would not be verging from the subject to mention that at the Jenolan Caves, the natural fall from the outlet of the underground river was being made use of for working an 8¾ Leffel turbine for driving a 6,000 watt dynamo for lighting the interior of the caves. This turbine at the trial worked admirably, not a variation in the voltage being noticeable during many hours' run; the fall or head of water was 45ft.

Before concluding, he would like to draw attention to the cost, etc., of working the Circular Quay, Cowper's Wharf and Post Office.