DISCUSSION.

Mr. Dickinson said : There are few questions of greater public interest connected with our profession than those which deal with the various uses to which electricity is being adapted, and we must congratulate ourselves very much on having the opportunity to discuss such a valuable contribution as that which our Vice-President, Mr. Fischer, laid before us at our last meeting. It possesses more than ordinary interest at the present moment, seeing that so many proposals have been brought under the public notice to remedy the deficiencies of our present tram service. That it is far from perfect most of us will admit, and there can be no doubt that any substitute which can be worked more quietly, more cheaply, and with equal efficiency, will meet with the general approval, and, probably in the course of time, replace the present system altogether. The success of the cable lines recently laid by the Melbourne Tramway Trust, and which most of us have seen in operation, has no doubt given them a prominence in public opinion, which makes it necessary for the advocate of any other system of tram propulsion to show substantial grounds of superiority ; for nothing, from a passenger's point of view, could well exceed the convenience and comfort of that mode of street travelling. They are also able to show good financial results ; but this is no proof that there is no better system, nor that better results would not have been obtained by another system. Mr. Fischer has shown us fairly conclusively that electric traction is superior to cable traction on roads which present nothing extraordinary in the way of gradient or curvature. But he confines his comparison to the cable system, which is only one of many other systems of mechanical traction, and many of these superior, in efficiency at any rate, to that system. Mr. Fischer, however,

does not disguise his preference for the application of electricity by means of a conductor from a generating station. If electricity is to be adopted, he (the speaker) entirely agreed with him that the conductor is better than the accumulator or storage system. Secondary batteries are far from having attained that perfection which would warrant their extensive employment. They are too heavy and not sufficiently reliable in construction to withstand the variety of shocks and jars to which they would be subjected in a tram car in constant use. The conductor system seems to have given excellent results, and the applications of it, whether underground or overhead appear to work equally well, so that there does not appear to be much to choose between them on the score of efficiency. So that taking it for granted that we have only the question of Electrical Traction before us, the question turns upon how we are going to carry our conductors. If overhead, we must multiply the already existing nuisance of posts and wires by which our streets are disfigured, or incur the expense of a subway or conduit by which they are led underground. There is no question of practicability; each has been shown to give thoroughly good results. The Blackpool Tramway Service has been in constant work for the last four years. Mr. Fischer, in his comments on the overhead system, states that the only objection to this conductor is the unsightliness of the necessary posts and wires. He (the speaker) could not entirely agree with him that this is an objection which we can afford to disregard altogether. No one who had noticed the rapidly increasing number of telegraph posts and wires (more especially since the general adoption of telephonic communication) can have failed to ask themselves—How long will a long-suffering public endure this encroachment? One of the principal complaints against the narrowness of our main city streets is that the architectural features of the many noble edifices that beautify them, and the number of which is yearly increasing, is discounted by the distance which limits the perspective effects, or rather renders them too pronounced. While granting this to be the case, from having several times nearly broken his neck in attempting to observe the progress in the upper regions of the

Australia Hotel in Castlereagh-street, is this effect improved or the lower portions of these splendid edifices rendered more visible by double rows of telegraph poles with fifteen to twenty sixfold rows of wires, which appears to be what we are coming to very speedily. Would it not be a more sensible proceeding to allay the nuisance than increase it? An outcry is sure to be raised sooner or later against this ramification of overhead wires. It has come in the United States, and the question has been very summarily settled. If a tramway is to be run in our main streets, let the conductor be underground, and put it in a subway, in which also provision can be made for telegraph and telephone wires as well, at any rate within the city limits. The matter of the overhead conductors is not such a simple one as Mr. Fischer seems to indicate. Take, for instance, a curve such as that at the statue at the head of King-street into College-street. The conductor must be kept approximately parallel to the curvature of the track all round the curve, which means that this fine open space would have to be covered with a network of posts and wire-guys to preserve the necessary curvature of the conductor. Where the roads are fairly straight, wide, and open for traffic, the overhead wires and posts, if properly lighted, would not be such a great disadvantage, and it is quite probable that the economy in first cost would warrant their adoption; but he could not help coming to the conclusion that they would be a mistake in the city, and if placed there would shortly have to be replaced by the underground system of conductor.

Mr. Fitzmaurice remarked that the subject before us this evening is one of especial interest to the engineering community. Electricity is playing a most important part in nearly every mechanical branch, so that it behoves the engineer to turn his attention to this wonderful science, failing to grasp the present opportunity, he will, in the near future, find himself in the background. Mr. Fischer has in a very clear manner described the progress, systems and capabilities of the various electrical tramways, and also compared the cost, etc., of working same with that of the cable system, showing a decided advantage in favour

of the former. He (the speaker) did not know that his remarks would bring anything new to bear on the subject, for Mr. Fischer has quoted statistics and given undeniable evidence from the greatest authorities on electrical traction, that he has taken the wind out of the sails of those advocating this system. In discussing this subject he hoped to hear the opinions of those gentlemen in favour of other modes of traction such as compressed air, cable, etc., for at the present time our Government and Municipal authorities are considering which system will be the most advantageous one to adopt. Any person viewing our system of tramways cannot help admitting that it is a mistake from beginning to end, although at the same time they are a boon to the travelling public. With steam traction the working expenses are necessarily very high, for each train of cars is supplied with a steam motor weighing about nine or ten tons, and requiring two skilled men to work it. The wear and tear of these engines, owing to dust and mud, is considerable, so much so that it is necessary to keep two (one very large one at Randwick) repairing shops and a large staff of mechanics constantly employed day and night. The permanent way is also damaged considerably, owing to the extra heavy weight of cars and motors. On the other hand, a person visiting Melbourne cannot but admire the complete system of tramways, which every one here knows is the cable system. This system has been a complete success to the promotors from the start; but, for all that, this system is not adaptable for Sydney. In Melbourne the streets are very wide, and mostly straight, while in Sydney they are just the reverse, being very narrow and crooked. Mr. Fischer states that only twenty-eight per cent. of the power given out by cable engine is available on the road. This you will admit is indeed very small. However, allowing thirty-eight per cent. available power in the Melbourne system, not more than twenty-five per cent. would be possible on the Sydney roads, owing to the number of curves and grades. Seeing, then, that both these systems are unsuitable, the question arises—which is the most suitable? Mr. Fischer has aptly pointed out that in the cable system should any part of the mechanism break down, the whole system (through

being inseparably bound together) is affected. The cable is the weakest, yet the principal, link in the whole system. The cars can only travel at one speed, and cannot be reversed. Should a delay occur through taking on or letting off passengers so that the cars following are right on top of one another, there is no chance of increasing the speed to make up for lost time, all must travel at the same rate; should the cable break the whole system is at a standstill for some hours. Not so with the electrical system. There are at least three recognised systems of electrical systems, viz., the storage or battery, conduit, and overhead (double and single wire), it will be advisable to take them in the order named for discussing the merits of each. The Storage System—The storage cells are placed in long boxes and fitted under the body of each car in cupboards; they are then connected to the motor which is under the car by means of the switches or starting levers through (in some cases) a rheostat or resistance. The loss in this system is forty-five per cent., made up as follows:—Ten per cent. from dynamo to accumulators in charging, twenty per cent. at least from accumulator to motor, ten per cent. motor to gearing, and five per cent. gearing to rails. And as each car has to carry an additional weight of 3,500lb., it is patent that a large amount of additional power is required when compared with the other systems. This is one of the greatest objections to the storage system, and one that would hold good in some of our existing lines where the grades are very steep. Mr. Fischer draws attention to the fact, that in working steep and long grades, the chemical energy, instead of exhibiting itself in the form of electrical energy, exhibits itself in the form of heat, thereby destroying the cells. He (the speaker) would remind him such is also the case with motors and dynamos, that where there is a resistance offered to the passage of the current the effect is to produce heat, and providing the resisting force (whatever it may be) is excessive, the result will be damage to accumulators, rheostat or motor, but this, as Mr. Fischer must be aware, is only a mechanical error, and is overcome by the insertion of automatic safety devices, so that only a certain amount of current can possibly pass from accumulators or dynamo to motor. Anothe

objection to the use of accumulators is the depreciation, for the life of a cell is only reckoned at two years for continual use, especially when used for traction purposes, as they are called upon to work at such variable loads that the tendency is to buckle the plates. (Makers of accumulators now guarantee to supply cells which will not buckle, at the same time allowing for rapid discharging.) Another defect in accumulators is the depositing of the peroxide of lead in the bottoms of cells, causing in a great many cases a practical short circuit, destroying their efficiency. This is caused by either the plates buckling or through the jolting of the cars. Another defect is the gas thrown out in charging or discharging, which must be allowed to escape. These two plates (produced) will explain what he referred to respecting the buckling and depositing of oxides. For traction purposes, the Crompton-Howell accumulators appear to him to possess advantages over either the E. P. S. or Elwell-Parker, inasmuch that in the former the plates are formed of spongy lead, by which means the oxides are more intimately connected with the lead, while in the latter make of plates they are made in the form of a grating in which the oxide is placed. Should any buckling or shaking take place so as to displace the oxides the whole square is lost. He did not consider the accumulator system (as it existed at present) suitable for the streets of Sydney. They certainly could be used for branch lines of easy grades similar to the Crown-street or Moore Park lines. To sum up the storage system he would quote Mr. Sprague, at the Kansas City Electric Light Convention:—"Professor Eaton, of Liberty College: I would like to ask Mr. Sprague what his principal reasons are for his conclusion that the storage battery system will not successfully compete with the overhead or direct wire system. Mr. Sprague: It is this—firstly, the simple reason is that you cannot three times convert energy at the same economy that you can once; secondly, because you carry a dead load of two tons around, unnecessarily, without energy. It weighs as much as thirty-five to forty passengers. There are no storage battery equipments in existence, whose storage capacity will permit of more than twenty-five or thirty horse-power being taken out of

them. If you limit their size and weight you reduce their capacity. There is no storage battery in existence in the United States which any company dare recommend, that you can put on a six per cent. grade and operate it, nor are there any battery cars in the United States, that he was aware of, that are working eighteen, nineteen, or twenty hours a day, as is the case with the direct system of supply cars." Mr. Sprague, in making these remarks (which he had curtailed) stated that he hoped as cordially as any man that the storage system would be a success, as he was financially interested in one. Direct Conduit System.—Without a doubt this would be the ideal system were it not for the many obstacles in the way. This system, however, possesses numerous advantages over the cable, inasmuch that the conduits are smaller, the conductors are stationary, and the power can be increased without any additional strain or wear of conductor, and where there are a number of curves the wear and tear of a cable is enormous; not so with the electric conductor, for it is only bent to the curve and is subjected to no more wear than if it were straight. In this system the rails form one conductor, the other is placed in conduit in duplicate (one on each side) and connected to the car by means of a sliding contact on the long shank. The objections to this system are (as Mr. Fischer points out) the complications of switching and damage by storm waters; this last objection is the only practical one which would prevent the adoption of the conduit system in Sydney, and it is owing to the same cause that the system has been a failure in America. So that until we have a perfect system of sewerage throughout the city and suburbs it would be folly to adopt this system of traction. Overhead Double-wire System.—This system has not been very largely availed of in America. By the use of the two wires the earth as a conductor is dispensed with, thereby preventing any disturbance (in the way of induction, etc.) to telephonic circuits, the current is carried from conductors by means of a two-wheeled trolly to motor. With the double-wire system the objections are numerous, inasmuch as there is a great liability to short-circuiting, for if the wires are placed too close together there is a liability of them being short-circuited

by means of the wind, and if placed too far apart would require a second trolly arm, which increases the weight on car roof. The most objectionable feature in this system is the danger of short circuiting at turnouts or crossings, especially where double lines exist, for the number of frogs is necessarily increased ; at the same time it is almost impossible to thoroughly insulate the wires at the crossings, for in the case of a double line similar to the one at the junction of Elizabeth and Liverpool Streets the negative and positive conductors would cross at four different positions, and in a crossing eight positions, so that in passing over these crossings the current is broken, extinguishing the lights (of course it is only for a short duration) ; all of these obstacles entail a deal of extra labour and attention in keeping them workable. There is another point which must not be lost sight of, and it is this, that the resistance in conductors (providing these were of same area as used in a single wire system) of a double line would be twice that of a single line, for, by using the earth as a return, the resistance would only equal that offered in the single line, there being practically none in the earth. As this system has not found much favour elsewhere it is certainly not suitable for Sydney, so that we are obliged to accept the single wire overhead as the most economical, reliable, and safest system of electrical traction, and it is undoubtedly the simplest. The troubles connected with the double-wire system cannot possibly exist in the single wire, for the overhead conductors are of one polarity. Mr. Fischer had described the manner of operation so that it is useless for him (Mr. Fitzmaurice) to dilate on it. Mr. F. H. Whipple, in his work on "E. Railway," quotes the following total for constructing fifteen miles of track and 130 cars :—

Electric overhead, 791,000dol. (this should read 831,000, as he has omitted to calculate 40,000 for car-house and land).

do. conduit, 1,236,000dol.

do. storage, 1,253,200dol.

do. cable, 1,429,300dol.

By this it will be seen that the cost of a cable plant would be almost double that of the single-overhead, while the efficiency is as follows :—

System.	The loss in transmission being.				
	S.B.	Dynamo.	Conductor or Cable.	Motor.	Gearing
Electric overhead 65 per cent. =		10 per cent.	10 per cent.	10 per cent.	5 per cent.
Electric storage 55 per cent. =	20 per cent.	10 ,, ,,		10 ,, ,,	5 per cent.
Cable say 35 per cent.=			65 ,, ,,		

This system is simplicity in itself. Mr. Fischer mentions the use of the commutated field by the Sprague Co. He (the speaker) failed to see where any great liability would occur by the use of this method of regulation, for it seemed to him to be the most practical and economical method. By this commutated field the strength of the motor was regulated without the loss of power, whereas with the resistance or rheostat (the word implied loss of power) the power was reduced in motor at the expense of heating up the wire in rheostat; and as to comparing the two methods to a locomotive fitted with an automatic variable expansive gear, he could not see the comparison. With the commutated field the connections were a fixture, and operated by the drivers or car attendant, when required, by means of a switch. With an automatic variable expansion gear the governing power is always at work while the engine is working and the driver has no control over it. He did not wish, however, the members to think he was objecting to the use of the rheostat, for it is undoubtedly the simplest and most easily repaired of the two. Mr. George W. Mansfield, manager of the tramway department of the Thomson-Houston Co., makes the following ratio of costs in construction and working between the cable and electrical systems of traction :—

	Electricity.	Cable
Depreciation	1	2·04
Operating expenses	1	1·71
Construction of tramway ...	1	2·09
Motor, cars, etc.	1	1·21
Cars	1	0·81
Total	5	7·86
Average	1	1·57

That is to say, that to construct and work a cable tram for a given distance the cost would be half as much again as that of an electrical one of the same capacity. For this fact must not be lost sight of—in the cable system sixty-five per cent. of the total power given out by engine is lost in working cables, and whether the cars are working or not the cables must be worked. To do this, means a large yearly consumption of fuel. Not so with the electrical system, the loss being only thirty-five per cent. The load on engine is only in proportion to the power used by motor. Too much attention cannot be paid to the engines and boilers for generating station, as on these depend to a great extent the success of the line. The most approved type of modern engines and boilers should be erected in duplicate. In Sydney no difficulty would be experienced on that score, as we have abundance of coal and water for condensing, right at our doors; for, as Mr. Fischer points out, that with the electrical system the generating system can be erected anywhere to suit these conveniences. For a practical proof of the superiority of the electrical tramways over the cables, we have only to turn to America. The advancement of electric traction has been phenomenal. In one city alone (Boston) there were in 1889, 230 miles of track with 300 cars in operation. Mr. Ballou (Messrs. Thomson-Houston's representative), who is now in Sydney) and present this evening, superintending the erection of a short line of tramway in one of the suburbs of Sydney, informed him that there are now 1,100 cars running in the same city. Boston, from all accounts, is very similar to Sydney as far as narrow and crooked streets are concerned, so that no excuse can be made against the adoption of the overhead system. The *æsthetic* objection

(as Mr. Fischer terms it) should not hold much sway in Sydney when we are brought face to face every few yards in the city and suburbs with much more objectionable obstructions, viz., to the huge placards, etc., posted on every available wall and fence, yet we hear of no movement to abolish them. On October 19th, 1889, *The Electrical World* published a list of the electrical tram lines, showing there were 1,260·3 miles of track and 1884 cars operating on 179 roads, but during this last year a large increase has been shown in all branches of electrical traction. As a further proof of the superiority of the overhead system, he might mention that on the 179 roads just alluded to, only three are operated by storage batteries, one by double wire, and part of two by conduits; the remainder by the single wire system. There is one of our pleasure resorts at which this system could be carried out and worked by means of a turbine, viz., the Fitzroy Falls. At these falls there is an abundance of water, with a fall of between two and three hundred feet. The road from Moss Vale is very good, and with a few slight grades, the length is about twelve miles. The expense for working this road would be very slight, and the returns would no doubt be found to show a fair profit on the outlay, as it would induce thousands of people to visit one of the grandest sights in New South Wales. In conclusion, he trusted that this colony will follow the good example shown us by America by adopting the electrical system of tramways, this being the safest, most economical, and best system of traction.

Mr. Cruickshank said: Though he scarcely intended to speak, one remark made by Mr. Fitzmaurice gave him a little encouragement. He said unless engines and boilers were made of the very best quality, and up to the highest standard of mechanical efficiency, the electric tramway would be of no practical use. Perhaps a few practical remarks from one who has some little knowledge of the steam engine, though very little of electricity, may be of interest. He must congratulate Mr. Fischer upon his plain, practical and sensible paper. Respecting the merits of the two systems, it appeared to him that so far as the conductor system is concerned it has this advantage—that the

conversions of power are only two, that is the engine power has to be converted into electrical power, and this again into mechanical energy in driving the car; whereas in the accumulator system the conversions are three—first the engine power has to be converted into electrical power, then into chemical energy, and then reconverted into the mechanical energy which drives the car. Of course, all these conversions cannot be carried out without reducing, to some extent at all events, the efficiency of the system. Another thing to be considered was that in a crowded city like Sydney a conductor system is always charged and always unprotected, which he thought contained an element of danger; whereas in the battery system it was practically safe. From the references to Sir John Fowler and others contained in the paper, it appeared to him that the two systems required some development, which might result in the conductor system proving the best for the country and suburban lines, while the battery system would be found more satisfactory and safer in crowded cities. Of course he understood that the tension referred to in Mr. Fischer's paper was not to exceed 500 volts, which, according to Mr. Edison, was harmless, but there could be no question that the tendency was to increase the voltage very materially, because, like steam, the higher the tension the greater the efficiency, and certainly much greater the economy. Mr. Fitzmaurice remarked as to the importance of having the engines and boilers of first-class make and finish. Mr. Fischer says the uniformity of the motion should never exceed two per cent. He doubted whether this was done in ordinary practice, but he understood that several governors, Hartnell's and others, came near it. These requirements show that the design and workmanship of electric steam engines must be superior to ordinary standard practice, and mean more money for the steam power. The author of the paper states: "It is generally admitted that cable roads are vastly superior to horse and steam roads, and we shall therefore confine our comparisons to cable and electric roads." Under certain conditions he (the speaker) had no doubt Mr. Fischer was quite correct, and he joined issue with him in a sense, not from any special knowledge,