

ELECTRIC TRANSPORT VEHICLES.

By C. TUNSTILL OPPERMAN.

OBJECT.

THE object of this short paper is to assist in popularising the use of electricity in the transport of goods, whether on ordinary roads, on wharves, in factories, in markets or on railways, and thereby saving labour and needless waste of human energy.

Electricity at 1*d.* per unit, in view of what it can be made to accomplish, bears a remarkably small proportionate cost when compared with the present-day labourer at twenty pence per hour. As an example of the low rates at which electricity can be obtained, the author finds that a project is on foot to utilise the water power in Tasmania to furnish current, for which it is proposed to make a charge of 45*s.* per year per horse-power.

The author will endeavour to put forward the advantages of the various systems and means of utilising the energy available at the electric power stations, so that we may be able to turn to the best possible account the energy contained in the coal, and he thinks it will be agreed that in view of the state of the coal industry in the country at the moment, it behoves everyone, from the Station engineers down to the man or woman who drives an electric vehicle, to do the utmost in their power to exercise the strictest economy, and by so doing help to improve the position of the nation generally, by assisting in the great effort to save both labour and coal.

As an instance of needless waste of energy, the author has had occasion to notice the method adopted at a certain munition works to move the finished shells from the factory to a waggon standing in the road ready to take them away. In the earlier stages of the War, he noted that this work was done by three men, two of whom were occupied in raising the shell by means of chain blocks and falls. It was then rolled along a plank into the waggon,

where the three men put it into position. He presumes that this method of transport proved too arduous for the men, for the number gradually increased until, on the last occasion when he took note of what was being done, there were no less than eight men employed. Perhaps the reason of the increase might be due to the method sometimes adopted by the Ministry of paying contractors by a percentage on cost. It would have been quite a simple matter to have designed and installed a small electric apparatus, including electric lift and traveller, which could have been easily worked by one person (a girl could have manipulated it), the one man remaining in the cart to put the shell in position.

In order to more readily appreciate the great extensions which have taken place during the past few years in the more general use of electric vehicles for the transport of goods, and it is certain that, had it not been for the War, a much greater increase would undoubtedly have taken place, it may be of interest to trace briefly the nature of some of the earlier attempts to deal with the problems in which electric accumulators were used in order to provide the energy. The author will, however, confine himself to the cases which have come under his personal notice, although much valuable work has been done in many different quarters for which great credit is due.

Probably one of the earliest attempts to use accumulators for tramways was made by Anthony Reckenzaum, at East Ham. These vehicles were run for some considerable time, but the cost of the accumulators was prohibitive. Early in 1894, Walter C. Bersey designed a goods delivery van, which had a very useful career, and in the same year the author designed a parcel post van, which was used by the Government for some considerable time, but the cost of the battery again, in both these attempts, proved the stumbling block.

Messrs. Ransome, Simms and Jeffries, of Ipswich, and many others, are now manufacturing vehicles suitable for almost any purpose, so that there is no difficulty in obtaining reliable vehicles for any purpose desired.

Upon examining the vehicles in general use, there is, the author thinks, very little to choose between them from the point of view of mechanical and electrical efficiency, the general practice being to transmit the power from the motor to a dead back axle by means of chains, and although he made tests some years ago with both front and rear driven vehicles, he was unable to find

any marked difference in the amount of current required, neither does he find in any of the vehicles on the market much room for improvement, and, taken as a whole, there is little or no fault to find with them. The transmission in others is by means of a small pinion on the motor shaft, gearing with an internal rack which forms a part of the road wheel. This is a very efficient system, but the experience the author has had with this type shows that the pinions and racks wear out somewhat rapidly, as it is impossible to run them in a dust-tight gearcase.

There is one point to which attention should be given, and that is the design of a simple change speed gear, so as to enable the vehicles to negotiate hills more readily, for notwithstanding the mechanical loss which this would entail, by the adoption of such an arrangement the motor would always run at or about its normal speed instead of dropping to about half as is commonly the case now. The saving here alone would go a long way towards compensating for the loss in the gear, and what is of far greater importance, excessive discharges from the batteries would be prevented.

The Americans seem to have given far more attention to the electric transport problem than we have here, and although the author is not aware that they had at any time at their disposal better batteries than we had, yet the proposition evidently caught on to an extent almost inconceivable, for he finds that in even 1915 the value of the electric vehicle rolling stock in general use throughout the country, consisting of heavy vehicles alone, amounted to nearly 21 million dollars, irrespective of many thousands of goods trolleys used in and about factories, railway stations and goods yards. Of course it may be owing to local conditions that the cost of competitive means of transport is greater than here, and that therefore they could afford to stand higher battery maintenance cost, but it is more likely due to the encouragement given by Central Stations that the use extended in this marvellous way; the author feels sure that if the Central Stations at home were to use electrical vehicles more than they do; it would encourage their customers to do the same, and they would become still more popular, not only benefiting the manufacturers, but providing a very substantial source of revenue. Although the author's experience has been mainly with the lighter pleasure vehicles, he is afraid that the time has not arrived when he can confidently recommend their use for pleasure purposes.

The limited distance over which they can be used so often leads to disappointment, and inexperienced persons would run the battery to a standstill, and he is very much afraid that it is because people were, in the early days, led to expect too much from this means of conveyance that they have got into somewhat bad odour; although there were several well organised concerns in London at one time whose business it was to hire out these carriages, yet on many occasions a great deal of annoyance was caused to their customers owing to the batteries being pressed to do more than could be reasonably expected. Pasted batteries have been used for many years on comparatively light pleasure carriages, but in no cases have the undertakings proved commercially successful, and the author attributes this in a large measure to the want of a satisfactory and more robust form of accumulator.

In the early days there was a considerable amount of difficulty in getting batteries charged at Central Stations, although, of course, there were many notable exceptions where every assistance was given in order to further the use of these vehicles, but very little headway was made until a few years before the War, when several of the railway companies and private firms adopted them generally, running them on commercial lines.

The crux of the whole question is the type of battery to be used. The author's experience of the ordinary pasted type of battery proves that it is not altogether satisfactory, for reasons which are explained later, and although fairly successful in many pleasure vehicles (owing to their lightness), they are really not a commercial proposition.

Of the pasted type of cells there is to the author's mind only one which is being used with any degree of success, and this is the Exide. The positive plates of this battery are somewhat like the prongs of a fork. These prongs are covered entirely with peroxide of lead, over which a tube of ebonite is slipped, and in order that there shall be a good flow of electrolyte around the active material the tubes are slit across. It will readily be seen that the tubes prevent the active material or paste from working away from the lead prongs or frame of the battery, and it is stated that these batteries have run as much as 25,000 miles before requiring renewal. Further, the manufacturers are prepared to guarantee the life of the battery under certain conditions, which are understood to be somewhat as follows:—If during the

two years after the supply of the battery any plates get into such a condition as to be incapable of giving 80 per cent of their normal capacity, new plates will be provided at a price which bears the same proportion to their selling price as the time elapsing when the new plates become necessary does to the full period of two years, the old material taken from the battery becoming the property of the company. Put in another way, supposing a new set of plates becomes necessary after one year's use, then the charge made for the new set of plates is half that of the old plates. This arrangement is, of course, subject to the variations in the market value of the raw material. The author has not come across any other types of batteries which would give similarly good results, although he has used batteries far lighter in weight, but he must admit that their life was a short and merry one.

There remains only one other class of battery which could be considered at all useful for the purpose, and that is the Edison nickel and iron battery, in which the electrolyte consists of an alkaline solution. These seem to have a very long life, and it is interesting to examine the respective merits of these two classes of batteries, that is, the lead and the nickel-iron, from the technical standpoint.

From the point of view of lightness there is nothing to be gained, whilst the space occupied by the iron battery is very considerably more than that required for the lead one. Users who are qualified to express an opinion from experience with both types, state that the lead battery requires less attention. One very objectionable feature of the alkaline battery is that the salts creep, and thereby cause surface leakage and short-circuiting. This deposit has to be removed by steam, and takes much time. The men engaged in handling the batteries find the contact with the diluted acid used in the lead type of cell far less objectionable and harmful than the contact with the caustic potash.

Another serious objection to the iron battery is the low electromotive force given, which is never more than a mean of a little over one volt per cell, and falls very appreciably if only double the normal discharge is taken from it, so that the speed of the vehicle when climbing hills drops very considerably more than is due to the gradient alone. This objection has, the author believes, been removed on the later types.

This disability does not apply in the case of the lead accumulator, which also appears to have considerable advantages in charging.

Weighing all these considerations, and before coming to a definite conclusion as to the respective merits, it is instructive to compare the respective chemical actions which take place in the batteries.

In the lead cell, the action in the reduction of the lead peroxide is never complete, and as the result of the variations in specific gravity of the two salts of lead, a considerable amount of expansion takes place with consequent contraction at the end of the discharge. This action, coupled with the wash of the electrolyte, the vibration due to the motion of the vehicle and the constant heavy discharge causes the material to be gradually detached from its supporting frame. The consequence is that it falls to the bottom of the container and causes a certain amount of short-circuiting, whilst the amount of active material available for useful purposes in the cells becomes daily less, so that in general the number of cycles, that is the number of charges and discharges which the cell is able to stand, is limited to about 150, whilst in the case of the Exide cell already mentioned, this might amount to as many as 300. In the Edison battery the reversibility of the chemical re-actions is practically complete, and there is in consequence theoretically no deterioration of the battery; it is thus obvious why the life of this cell is so much longer than that of the lead cell. The material used being oxide of nickel and iron in a caustic potash electrolyte, it would appear that the chemical processes are completely reversible, and to this fact can be attributed the attendant advantage that there is no loss of ampere hour capacity however much the battery is overdischarged, and owing to the explanation already given, it seems that the chemical changes and reversals can be continued almost indefinitely, and as far as the author has been able to investigate the matter, the only loss arising is that due to the electrolysis of the water.

RECUPERATION.

Whilst on the subject of the battery it will be advisable to consider whether recuperation, if applied to the vehicle, would be of advantage. By recuperation the author means the system by which the braking when descending a hill is done by turning the motor into a generator, and the current resulting from this

action is utilised to charge the batteries. Mr. Leitner first suggested this to the author many years ago, and he made a trial on one of his vehicles, fitted with a simple means of carrying this out, but he has been unable to discover whether it is being used to any large degree here or in America, and whether it is worth the trouble and expense entailed in its installation on the vehicle.

In order to increase the distance over which an electric vehicle can be used without unduly discharging the battery, a heavy charge of electricity can be put into the cells in a comparatively short time—"Boosting"—and there is no doubt that it is an advantage to do so. The only trouble is whether the Central Stations would care to be called upon to provide a large number of vehicles with a "boosting" charge, amounting in each case to, say, 100 amperes, if called upon to do so at one time.

The principal reason why electric vehicles have not been more generally used is, the author thinks, entirely owing to the limitations of the radius within which they can with safety be operated. It is a very serious matter if a battery, when used beyond its limits, is discharged below a certain point—more serious in the case of the lead cell than in that of the Edison cell. A very great deal of damage is done to the plates, and the user is put to the expense of towing the vehicle home. In the case of the London Electric Cab Company, of which Mr. W. C. Bersey was the originator (and who had a fleet of 200 cabs), it was certainly the heavy expenses consequent upon the disregard of the drivers of these limitations which helped towards the failure of the company.

Cost.

The author has found it very difficult to obtain detailed figures of the actual running costs, owing to the general derangement of trade consequent upon the War, but there is no doubt whatsoever from the figures placed at his disposal that where the journeys made are regular and over known routes from day to day, there is no means so economical as that provided by electricity, and it is quite possible for the user to know within very close limits what his cost per ton mile will be, and this can be absolutely maintained under guarantee from the makers both of the vehicle and of the battery.

The comparative costs of electric and horse traction used on

dust collection, as given in the report presented by Mr. F. Morgan, the Borough Surveyor to the Croydon Council, are as follows:—

	s.	d.	
Depreciation on chassis and body ...	5	2·5	per day.
„ „ battery	6	6·4	„
„ „ tyres	1	2·3	„
Electricity	2	1·5	„
Attendance		9·4	„
Insurance		8·4	„
Driver	8	9	„

The depreciation on the chassis and body is taken at 10 per cent per annum, and on the battery at 50 per cent per annum.

The cost of collecting by the $3\frac{1}{2}$ ton electric waggon, including loading and bonus paid to the men, worked out at 9s. 4d. per ton, while the cost of collection and loading and bonus by horse-drawn vehicles (including cost of depreciation on and repairs to our own vans) was 11s. 10d. per ton, or 2s. 6d. per ton above the cost of collection by the electric waggon.

The average quantity of refuse collected daily was:—

	tons	cwt.	qrs.
Electric waggon	7	10	$1\frac{1}{2}$
Horse-drawn van	2	9	$1\frac{1}{3}$

From these figures it will be seen that the work done by the electric waggon was equal to that of three horses.

In this case an Exide Ironclad Battery was used, but the author has no hesitation in saying that if an Edison battery were to be installed the cost would be reduced, owing to the decrease in the charge for depreciation, which at $12\frac{1}{2}$ per cent per annum would be brought down to less than 4s. per day, which would show a further saving over the cost of the work if done by horses, so that the total saving per ton would be approximately 2s. 11d.

A well-known firm of Universal Providers who are using the Edison battery, and have a fleet of nearly a hundred electric vehicles of 15-cwt., 1-ton and 2-ton capacity, states that the costs are as follows:—

Battery maintenance...	} 2·9 pence per mile run.		
Tyres			
Repairs			
Electricity	0·775	„	„

One of the largest Railway Companies, having a large fleet of electric vehicles, gives the following figures:—

30-cwt. parcel van, per annum (Edison battery)—

	£	s.	d.
Current	32	0	0
Tyres	14	15	0
Repairs	21	10	0
Maintenance	11	10	0
Oil and Stores	2	5	0
Standing charges	96	5	0
	178	5	0

Cost per mile 4·28*d.*

1-ton parcel van (Edison battery)—

	£	s.	d.
Current	24	0	0
Tyres	13	0	0
Repairs	27	10	0
Maintenance	11	5	0
Oil and Stores	2	5	0
Standing charges	81	15	0
	159	15	0

Cost per mile 3·84*d.*

1-ton parcel van (lead battery)—

	£	s.	d.
Current	26	10	0
Tyres	13	10	0
Repairs	29	0	0
Maintenance	11	15	0
Oil and Stores	2	5	0
Standing charges	116	5	0
	199	5	0

Cost per mile 4·78*d.*

Note:—

Based on 10,000 miles per annum.

Current taken at 1*d.* per unit.

Tyres at 18,000 miles.

Repairs, maintenance and oil at cost.

Standing charges with Edison battery at 10 years and lead battery at 2½ years.

The report of Mr. W. Greig, the Cleansing Superintendent of the Glasgow Corporation, is as follows:—

EXTRACT FROM THE MUNICIPAL JOURNAL, AUGUST 23RD, 1918.

“In his annual report for the year ended 31st May, Mr. W. Greig, the cleansing superintendent of the Glasgow Corporation, states that two petrol-driven waggons, each of three tons carrying capacity, have been utilised since the beginning of 1913 for the removal of domestic refuse. As noted in previous reports, these waggons are advantageous in some respects, notably in the rapid transit of the material to the destructor works, but in costs, due mainly to the numerous stoppages during the process of collection, do not compare favourably with horse haulage. The respective figures are:—

	<i>s.</i>	<i>d.</i>
For motor traction	4	6½ per ton.
For horse traction	4	1½ „ „

“Extensive repairs have again been required by these machines, and on several occasions they have been out of commission owing to the difficulty of obtaining materials for carrying out the necessary repairs. This explains to some extent the high cost above stated. Further, experienced drivers and mechanics are difficult to obtain, and it is obvious that, as conditions exist at present, these machines are labouring under a severe handicap. In the circumstances, any statement of costs is not of real value, and does not admit of a fair comparison. Pending a return to normal times, better results can scarcely be expected.

“The two ‘Edison’ 2-ton electric vehicles which were put into commission in December, 1916, and May, 1917, respectively, have proved very satisfactory, being efficient, dependable, economical and easily driven. An order for two additional machines of a similar type was placed some time ago, and it is hoped that delivery may be obtained in the near future. Compared with horse haulage, the figures for the past year are as under:—

	<i>s.</i>	<i>d.</i>
For electric vehicles	3	5½ per ton.
For horse traction	4	1¼ „ „

To the user who confines his operations to a large city and its immediate surroundings, there is no method of transport which offers him the advantages of the electric system. From an

economical point of view it is cheaper than either horses or petrol vehicles, for the following reasons:—

- (1) It requires less skill and experience in supervision.
- (2) It requires less attention to details.
- (3) The tyres last longer.
- (4) The insurance is less.
- (5) The oil bill is less.
- (6) Far less skill is required in driving.
- (7) It is more cleanly, although this is a point appreciated more in the provision and kindred trades than in, for instance, the coal trade.

As an example of the reliability of electric vehicles, the Midland Railway Company's Engineer states that out of a fleet of nine 30-cwt. parcel vans, four ran throughout the year 1917 without losing a single day's service, and by the end of the year the machines were two years old and had run 30,000 miles each.

In regard to No. 3, it is no uncommon occurrence to find that a set of tyres will last upwards of 30,000 miles. That this excellent result is possible will be understood when the very gradual manner in which the current is applied is compared with the method used in starting a petrol vehicle, where the engine is running at normal speed and is developing its full power, when the clutch is let in, more often than not, with a bang.

To the user who has long journeys to make, the author can only say that petrol is the only satisfactory form of power to adopt.

BATTERY SERVICE SYSTEM.

In the course of inquiries which the author made in the United States regarding electric vehicles, he was particularly struck with a system of providing batteries in general vogue there, called the Battery Service System. By this system the user of the vehicle contracts with the Electric Supply Company for the use of the battery and the supply of current, payment being made on mileage rate and for the battery service.

The author may, perhaps, be allowed to point out that the business of the Central Station is to supply its customers with electricity, and also to deliver it. Under usual conditions, the delivery may be made through sub-stations, over a distributive system of transformers, through the street mains and private house connections, but if the Battery Service System could be carried out, the

Central Station would deliver current in the battery, and thereby save a very considerable expense in the distribution. A well-organised Battery Service System would undoubtedly be the best means of providing a big day and early morning load for the Power Station. It would have an enormous influence in the sale of electric vehicles, because it would simplify matters for the user and reduce running costs to a definite known basis.

Although this is a comparatively new method of delivering current to the consumer, it is just as much a part of the regular business of the Central Station as the old method, with the addition, however, that in the new method the investment in batteries becomes productive as soon as it is made, and this investment is paid back to the Central Station on the instalment plan by the user.

From a paper read by Mr. P. D. Wagoner before the National Electric Light Association in Chicago, the author has borrowed the following figures, giving some details of three 5-ton electric vehicles operated on the system:—

Cost to customer per vehicle,	£	s.	d.
Battery Service per month	7	4	0
Mileage 826·8	11	5	0
Garaging	5	5	0
<hr/>			
Total garaging, Battery Service and mileage, including current	23	14	0
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Cost of garaging, Battery Service and mileage, per ton	7½		
Cost of garaging, Battery Service, per ton mileage	2·5		
Average current consumption per mile	2 units.		

Mr. Wagoner sums up the advantages very ably as follows:—

“The idea behind the Battery Service System is commercially sound. It makes possible, through co-operation, the distribution of what might be called the development difficulties of all three parties interested—the electric vehicle manufacturer, the Central Station and the electric vehicle user. It makes it possible for the manufacturer to give more adequate service to the industry; it does away with the stumbling-blocks which have heretofore confused and discouraged the electric vehicle user.

"There is a difference, however, between battery exchange and Battery Service. Duplicate battery plans as developed by large firms or others independent of the fundamental idea of service as developed in the above plan, fall short of the idea which I have tried to present.

"Under the Battery Service System the operation of electric vehicles is reduced to the simplest possible form, and means to vehicle users:—

"A substantial reduction in vehicle investment; no charging apparatus or garage investment; unlimited mileage and continuous service from vehicles; busy season difficulties and bad roads overcome; relief from care of batteries, and a reduction of all items of battery cost, including current, to a definite monthly basis of miles travelled."

As to the relative costs of carrying goods by means of petrol or electric vehicles, the author does not think that there can be the slightest doubt that if, as previously mentioned, the routes are regular and well-known, particularly in cities, the cost of carriage by electricity is far and away cheaper than that by petrol. It is sufficient evidence of this to remind members that several of the largest and most successful business concerns, amongst whom may be mentioned Messrs. Harrods, Ltd., Messrs. J. Lyons & Co., Ltd., the London and North-Western Railway Company, and the Midland Railway Company, are using electric vehicles, and it will be found that the tables of cost which have been given will be quite unapproachable if the work were to be done by a petrol vehicle.

In conclusion, as many here are aware, the author spent many years as an electric vehicle and lead battery man—though his interests at the moment are with petrol vehicles—and he is acquainted with the uses and limitations of both, but it would be a source of great satisfaction to him to see the more general extension of electric vehicles, if only to prove that he was not altogether wrong in making his choice originally when he first leaned towards the electric vehicle about twenty-five years ago, and he is sure that if the Central Station Engineers will give all the encouragement and assistance in their power to popularise the electric vehicle by bringing to the notice of their customers the advantages obtained by their use, they would become far more general, and should more nearly approach the numbers used in America.

THE DISCUSSION.

Mr. F. AYTON, in opening the discussion, said : The author, as a pioneer in the electric vehicle business, had to face great difficulties, and I am sure it must be a source of satisfaction to him to see how the difficulties which he experienced in the early days have been got over in the modern electric vehicle. At the outset, I would like to emphasise this, that the electric vehicle is not a competitor with the petrol vehicle in the realm of motor transport to-day. There is plenty of room for both these vehicles, and if this paper succeeds in stimulating the interest of the automobile manufacturers in this country in the electric vehicle and succeeds in inducing some of them to see the advantage that will accrue to them by taking up the manufacture of the electric vehicle and making it an additional line to the petrol vehicle, it will not have been in vain. I am sure that those manufacturers will come shortly to realise, if they do not realise it already, that the electric vehicle is merely complementary to the petrol vehicle, and that the motor transport problems of this country will be solved by a reasonable application of both these types, coupled with the steam vehicle. Each has, I think, its own well defined sphere of utility, and if any attempt is made to apply the electric vehicle outside its own limited sphere of suitability, trouble will be bound to follow. The electric vehicle is essentially one for short distances and moderate speeds, and in our towns and cities and their suburbs there is an immense amount of work which can be done by these vehicles with great economy compared with the methods at present in use. The author gives as his reason for the small use of these vehicles in this country, their limited mileage, but I venture to differ from him there ; the reason, in my opinion, is that the automobile engineer has developed the petrol vehicle up to so remarkable a state of efficiency. It is a monument, I think, to the automobile engineer to-day. The mechanical engineer, as he then was, got the start ; he interested the financial people who were able to assist the movement, and the electric vehicle was left behind as there was no one to come forward in this country and help it through its difficulties. That is not so in the United States, where electric vehicles had a better

chance, and where, generally speaking, the chief development has taken place.

I think it will interest members to hear more as to what the development has been in that country. It was computed some three years ago that there were over 70,000 electric vehicles in use there, and some of the fleets are really remarkable in size. For instance, the Ward Baking Co. operates no less than 610 electric delivery vans; the Adams Express Co., which is equivalent to such firms as Carter, Patersons and Pickfords here, operates 375, and I believe that my figures, which are some two or three years old, are probably below the actual figures of to-day. The brewing firm of Jacob Rupart operates 145 vehicles, the George Ehret Brewery 136, and the Commonwealth Edison Co. 114—that is an electric lighting company, and it shews what the electric supply companies over there do; the New York Edison Co., another electric lighting company, operates 130; Gimbel Bros., 119—that is a departmental store—Carson, Pirie and Scott, 67, and Marshall Field, a big Chicago departmental store, 230 vehicles. To give an idea as to the rate at which vehicles were being manufactured in America, I have got a return, in round figures, compiled on the basis of inquiries sent out by the Electric Vehicle Association in 1916. The passenger vehicles sold in that year totalled 4,000, commercial vehicles 2,500, and electric trucks 1,500, making a total of 8,000. I think we are pretty certain to see these annual sales in America greatly exceeded in the future, and surely that is an indication of what could be done in this country.

There is another good reason that I can put forward why automobile manufacturers should really be thinking about this matter. The petrol situation, I think it will be agreed, is getting serious, while the consumption is going up by leaps and bounds; it is extending in connection with the use of agricultural tractors, not only in this country but in all parts of the world, whilst America, which was in years gone by a very big exporting country of petrol, is so greatly increasing her consumption that she will soon not have any petrol to export at all. It might be said that there is benzol, but do we know that there is going to be enough benzol to go round in the future? Therefore, I think it would be a good move to recognise that something should be done to conserve petrol by putting electric vehicles to work in that sphere for which they are really useful, namely, short dis-

OPPERMAN.

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(Mr. F. Ayton.)

tance work in towns, and let the petrol vehicle do the work which is really its own work, that is, long distance haulage. I have stated that the electric vehicle is a moderate speed vehicle, but in town and city work it has been found, as the result of actual tests, that it can get from point to point just as quickly as a petrol vehicle, because the latter very seldom gets a chance of reaching its maximum speed. The electric vehicle has a very much higher rate of acceleration than the petrol vehicle, and the result is that the moderate speed electric vehicle can get to its destination in cross town and city work just as quickly as a petrol vehicle.

I have emphasised the point that the electric vehicle is essentially a town vehicle. If such a vehicle is sent out into the country and on country roads, the result is that the varying road resistance which it meets with upsets all calculations as to the mileage which the batteries will give. This was very clearly brought out in some tests made a few years ago by the Massachusetts Institute of Technology on a one-ton electric van in order to determine the variation in road resistance, which shew clearly why the electric vehicle should be kept on good roads. At 15 miles per hour, on poor condition asphalt, the road resistance was 29.7 lb. per ton; on fair asphalt it was 26 lb. per ton, and on good asphalt it was 22.5 lb. per ton. On wood paving at 14 miles per hour, the figure was 26.8 lb. per ton, while on granite sett paving the speed went down and the road resistance went up to 37 lb. per ton where the road was in fair condition, and to 32 lb. per ton where it was in good condition. On fair condition macadam roads, dry and hard, the figure was 28 lb. per ton at 14 miles per hour, but where the road was dusty the resistance went up to 31.4 lb. per ton at 13 $\frac{3}{4}$ miles per hour. On poor macadam roads, damp and with holes, the resistance went up to 44 lb. per ton at 13 miles per hour, and on tar macadam at 15 miles per hour it was 31.5 lb. per ton. These figures are for the ton of 2,240 lb. On bad tar macadam with holes, it actually went up to 60 lb. per ton—a variation from 22 lb. to 60 lb. per ton. Of course, that means that a road of that sort will very considerably reduce the mileage of the vehicle and lead to disappointment even if the vehicle has not to be towed home, and clearly indicates that the electric vehicle is not better than the steam or petrol vehicle outside towns and suburbs.

In America, the manufacturers provide a special quality of

solid rubber tyre for electric vehicles, which gives a higher efficiency. In the case of pneumatic tyres for the lighter vehicles, it is very important to have the right degree of inflation, otherwise mileage will be reduced, but in spite of all this, the electric vehicle when applied to its proper purpose gives the cheapest possible means of haulage. The author states that he does not think that the time has arrived when electric pleasure vehicles can be recommended; it depends upon what he means by pleasure vehicles. If he means a vehicle that is to take trips out into the country, I quite agree with him. The petrol vehicle is the one for that purpose, but I do think there is a very great future indeed for the use of the electric passenger carrying vehicle in urban and suburban areas, especially in taxi-cab work. In Detroit, which is the home of the petrol car in America, it is a significant thing that the Detroit Taxi-Cab Co. some few years back, owing to the high cost of operating petrol taxi-cabs, decided to try electric cabs. They started with about a dozen electric cabs and they now have over 100. They found that they could operate electric taxi-cabs for 40 per cent less than petrol cabs. The result of that experience was that electric taxi-cabs were also adopted in Chicago, whilst at the time the War broke out there was a project on foot to introduce a fleet of electric taxi-cabs into New York. About 600 electric taxi-cabs had also been in use in Berlin for some years when the War broke out, and the municipal authorities arranged their licensing for taxi-cabs in such a way as to encourage the electric cab. They have also been successfully used in Amsterdam. Therefore, I think that for that work, and also for private cars running about town, the electric vehicle of the modern type will give every satisfaction. The author refers to the internal rack and pinion system of transmission; I have seen the vehicles he refers to, but I can assure him that the modern vehicles of that type made in this country and in America do not give any trouble whatever through dust getting into the gears.

I do not altogether agree with the author in his comparison between the Ironclad Exide battery and the Edison battery. My experience is that at the end of a certain number of years, when everything is taken into account, there is practically no difference whatever between the two which are really the most successful batteries to-day for electric vehicles; I should be perfectly satisfied to use either. At the present time we have in our garage twelve heavy vehicles all fitted with the Ironclad Exide battery,

(Mr. F. Ayton.)

which is a most satisfactory battery, and the vehicle which we have had longest in use, a 3-ton tip wagon, had run for two years and ten months, on very hard work indeed of all sorts in connection with the Borough, before we had to renew the plates. The maker's guarantee was for two years, and we regard that as a very satisfactory performance. We allowed depreciation at the rate of 50 per cent on the battery plates and we found we had allowed too much, although the vehicle had regularly to run over a soft field to get to a sand pit, and it did not get fair use, and we only renewed the batteries because the mileage had dropped off to 80 per cent of their original capacity, a figure which was inconvenient. I think some of the cases which the author mentions when the batteries ran out and the vehicles had to be towed home, were due to the absence of a proper meter. Modern vehicles are provided with a meter which shews what amount of energy has been used from the battery, and really there is no excuse nowadays for a vehicle being stalled if the driver keeps his eye on the meter.

Mr. E. W. CURTIS: During the past fifteen or sixteen years the petrol engineer, the trader and the manufacturer have been too busy to investigate the possibilities of the electric vehicle, but I hope now they will take advantage of the return to normal times. The electric vehicle makes friends and retains them. The electric vehicle has one advantage which will probably be appreciated by the mechanical man, and that is that it does not necessarily have more than forty moving parts, and any of the units can be replaced overnight while the vehicle is being charged, thus giving an opportunity of keeping the vehicle on the road 365 days in the year, which is a very big consideration to the commercial man. The author makes his calculations with current at 1*d.* per unit. It may interest members to know that that is equivalent to petrol at 6*d.* per gallon, roughly. He makes reference to a system of gear shifting, but this has been tried, and the advantages did not compensate for the additional mechanical complication. I think all designers of electric vehicles endeavour to keep away from complications. One of our chief claims is that we eliminate the human element. The driver has no influence over the mechanism. We have no gear box, no clutch, etc., and the complication of a gear box would not help the proposition materially. The motor takes its overload automatically, and no serious damage occurs to the battery. The vehicle does slow up on hills, but not materially.

I think the Central Stations in this country have helped the proposition as much as they have in America. Of course, we have the advantage over there of having more privately owned stations, and they can do a good many things that the Municipal undertakings here cannot do, but throughout the country, with the assistance of the Electric Vehicle Committee, the Central Stations here have done heroic work for the electric vehicle.

MR. W. WORBY BEAUMONT: The author has been for many years a quiet leader in the popularisation of electricity for vehicle propulsion, and some fifteen or sixteen years ago, he had a great deal to do with electric vehicles of light weight, and he, with others, suffered because too much was claimed for that type of vehicle. It is remarkable that the electric vehicle, which years ago was regarded as useful for carrying light loads, should now be shewing us the way to carry heavy loads most economically, but that is the case, and it is because the electric vehicle has now shed a great many of its ambitions and taken the position which should rightly belong to it, that it is going to do a very great deal more than the English public, at all events at present, realise; not that the electric vehicle can occupy the field of the long distance petrol vehicle or of the steam vehicle, but it will be the friend of the horse and make a great deal of the worst horse work unnecessary. Of the hundreds of these vehicles that are in use in Great Britain we find that those that give us the best examples are those that are doing the slow heavy work of coal haulage, dust and refuse collection and the cartage of materials over short distances, which require so very much stopping and starting. The electric vehicle can do its stopping perfectly contentedly, and it costs nothing while it stops, it is very easily driven, and there is no other vehicle in which the cost can be seen so precisely from minute to minute or from day to day. But good as the vehicle is for so many purposes, it is not a good vehicle to replace or to do the work of one horse, but wherever there is work for two or three horses for urban and suburban work, there the electric vehicle begins to offer profits. I notice that the firm of Ransome, Sims and Jefferies is mentioned, but it should be mentioned that a number of other firms in this country are already making electric vehicles, such as Garrett's, of Leiston, the Electric Vehicle Co., the General Vehicle Co. and others.

The author has told us what he thinks of the chain driven and the gear driven vehicle. The latter includes the type, of

(Mr. W. Worby Beaumont.)

which there are many in America, with the gearing entirely in the driving wheels, not an epicycloidal gear, but a sun and planet gear which, as in the Walker vehicle, is fairly well enclosed and does work for a long time with considerable mechanical efficiency ; like everything else, however, where there is one part moving and one part fixed, there must be wear that gradually allows dust and dirt to get in. I must agree with Mr. Curtis on the question of changing gear, at all events to this extent, that if the electrical-mechanical engineer can manage to do without changing gear, it will be a very great deal better for the electrical vehicle, because a change speed gear introduces something that is at the option of the driver, something that may or may not be intelligently used, and something that means more working parts. I am not saying at present that it is possible to mount a hill without a change speed gear, but, generally speaking, that which has been wanted with the electric motor has usually been met with more or less completeness. On page 399 the author refers to the Edison battery as distinguished from the Exide lead battery, and the number of cells in the Edison battery does introduce a feature which is not present with the Exide battery. For instance, in one vehicle which uses the Exide battery there are twenty-four cells, whereas the same vehicle, if it used the Edison battery, would have to have forty-two cells. I do not think the author is quite explicit in his remarks as to the pasted type of battery at the top of page 400. The Exide battery is, in a way, a pasted battery, and I would ask whether the author is here referring to the pasted batteries such as the Plante, or the more usual forms of grid pasted batteries with grid pasted plates. With regard to the question of boosting, I believe that there are numbers of stations all over the country where a booster charge can be obtained.

With regard to the earlier types of vehicles, I would like to say that the electrobus was unsuccessful for a very definite practical reason. It was built by what was then known as the Electric Vehicle Co., and I think that the design of the chassis of that bus has in hardly any salient point been improved upon from that day to this, and although it is true that the unsatisfactory use by the drivers of these buses had a great deal to do with their bad operation, they were not unsatisfactory vehicles in themselves. They were very heavy and not efficient in some ways, but the cost of current alone at that time was enough to kill

them, even if everything else had been greatly improved. They had to pay 2*d.* per unit for the current they received before it was transformed down to the current that they wanted. On page 402 in the figures given by Mr. Morgan, the depreciation on the chassis, and all the other costs per day, total 25*s.* ; a little lower down we are told that the cost of collecting by the 3½-ton wagons, including loading and bonus paid to the men, works out at 9*s.* 4*d.* per ton, and with two horses at 11*s.* 10*d.* per ton. I would like to ask the author if that bonus is something like 7*s.* or 8*s.* per ton, or how it is that the cost comes out so high.

Mr. OPFERMANN : I am afraid the explanation is the large bonus the men had.

Mr. BEAUMONT : At all events, I gather that the author has a reason for thinking that the figures of 9*s.* 4*d.* and 11*s.* 10*d.* are in some way or other a contradiction of the figures on page 404. I am acquainted with the costs generally of the work done in various ways by different vehicles, and I am able to confirm the figures on page 404 although that fact does not enable me to understand those on page 402. The lessened wear on tyres on electric vehicles compared with others is put down almost entirely to the difference in the mode of application of the power to the tyres ; in other words, the gentle though quick action of the electric vehicle in starting instead of the jerk and sudden action of the petrol vehicle clutch. That, no doubt, is partly the explanation, but the real reason that the tyres of an electric vehicle wear so much less rapidly is that the vehicle never reaches anything like the speed of the other vehicles. Rubber may pass over a razor without being cut if it goes slowly enough, but at a speed of a few miles an hour it will cut on a blunt edge, such as tramlines. Thus, the abrasion of tyres on electric vehicles is much less than with others chiefly on account of the lower speed. In conclusion, I will repeat what I said in my Cantor lectures twenty-three and sixteen years ago, that the motor question is a road question, and the author remarks that the better the roads the better will be the transport of material and passengers, whether it be in town or country.

Mr. R. A. CHATTOCK : I want to say a few words on behalf of the Electric Supply undertakings. The author has rather led us to believe that the Central Stations have ignored the electric vehicle as a source of revenue. I am afraid that was rather so in the early days whilst the petrol vehicle was being developed, but then, I think, the business of the Central Station engineers was

(Mr. R. A. Chattock.)

rather to follow the trade in that respect than to lead it. They had to wait until satisfactory vehicles were on the market before they could really go into the matter and provide for them. As soon as these vehicles were demonstrated in America, some five or six years ago, they began to stir themselves. For instance, at the Municipal Electrical Association meeting in Kingston some two or three years before the war, the first demonstration of electric vehicles was made to all the electrical engineers in the country. Then, again, in Birmingham in 1914, there was another demonstration given entirely with the idea of interesting Central Station engineers in the proposition and getting them to assist, and I think that if the war had not intervened we should, by this time, have had a very big development in this country. As it is, I think there are between 200 and 300 stations where current can be obtained at a reasonable figure and under satisfactory conditions. The author refers to boosting charges, and he rather hints that Central Stations might not care to be called upon to provide a large number of boosting charges at a heavy rate. I do not think he need be anxious on that point at all. We are quite ready to supply any quantity of current that is demanded. Of course, it may be necessary to make special arrangements to do so if the business gets very large. Undoubtedly it will be, but I think that Electric Supply undertakings, which are out to sell current, are quite prepared to do anything in that line.

That brings me to the question of the Battery Service system which is referred to in the paper. It is suggested that Central Stations should undertake to provide interchangeable batteries, which could be supplied, charged and maintained at a certain overall figure. I am afraid a system of that kind could not be brought into use until there are a much greater number of electric vehicles at work in the country. It would be quite impossible for Supply undertakings to launch out and spend many thousands of pounds in purchasing batteries for that purpose unless they could be assured that the business to be got warranted it. They must see a return on their money before they could launch out, because in nearly all cases the Supply undertakings are Municipal concerns, and they cannot apply the ratepayers' money in the same way that a private firm can risk its capital. However, I quite agree that it is a good system, and I think that when the sizes of the batteries and battery boxes are standardised and made interchangeable for all

vehicles, it will be quite possible to arrange something of that kind. I am glad to be able to say that the Electric Vehicle Committee is considering that question of standardisation now, and we hope to reduce the number of different sizes and to standardise certain sizes of batteries, both as regards the dimensions of the lead plates and also the overall dimensions of the battery boxes, so that they will all be interchangeable in the different vehicles. Coming now to the batteries themselves, the author, as I read the paper, rather tends to depreciate the Edison cell, although he says at one point there is not much to choose between it and the lead cell. He refers, however, to the damage that might be done by short circuiting these cells. I quite agree that that is true as regards the lead cell, but with the Edison cell I understand it is an advantage to short circuit it occasionally and run it right out. It freshens the cell up and improves its working capacity, and if that is so—as I believe it is—it is a very valuable feature in connection with that battery, because batteries are put into the hands of unskilled drivers, and if anything goes wrong they often do damage by short circuiting in trying to put it right—inadvertently, of course. If, therefore, it is possible to make these cells fool-proof in the way I have mentioned, it would be a great advantage. I have had experience of both types of cells in vehicles under my control, and I quite agree with Mr. Ayton, that if they are properly looked after there is practically nothing to choose between them.

Mr. P. A. MOSSAY: I believe that the attitude of the petrol vehicle friends has slightly altered during the last four or five years, as they have been brought more into contact with the electric vehicle. A few years ago, when visiting one of our large motor car manufacturing works, the manager expressed very unfavourable opinions as to the electric vehicle. A few weeks ago I was in the same works, and I saw a number of small electric trucks, and in reply to my question the same manager said: "They have saved us an enormous amount of money, and have opened our eyes to the possibilities of the electric vehicle." It is for this reason that I believe this discussion has come at the right moment, and I hope it will have the result of inducing more manufacturers to look into the question.

With regard to the paper itself, I can say that the question of enclosing the gear pinions engaging with the road wheel has been entirely solved, and I can shew a pinion which has run 14,000

(Mr. P. A. Mossay.)

miles without any appreciable sign of wear. With regard to the suggestion to use a clutch, I think it is quite unnecessary. It is possible to design an electric motor with such characteristics as to render a clutch superfluous. I can give some figures of a motor which was designed lately which will shew the wonderful elasticity there is in an electric motor. The machine gives 7 h.p. at 1,800 revs. per minute with an efficiency of 89 per cent. It will give 6 h.p. at 600 revs. per minute, i.e., one-third the full speed, with an efficiency of 82 per cent. That motor will drive a $2\frac{1}{2}$ -ton vehicle fully loaded at 11-12 miles per hour on the level, and will take the same vehicle loaded up a gradient of 1 in 7 at a speed of 3-4 miles per hour. I have had some experience of regeneration, as we have manufactured some vehicles with regenerative control; for town work I would say that it has not much advantage, but when running out into the country on certain routes I have gained about 10 per cent in mileage with it, the test being made first without and then with the regenerative control.

Mr. G. E. HALES: I have been associated with the electric vehicle business for over twenty years, and most of it has been a time of very great sorrow and trouble. I am now with the Edison Accumulators, Ltd. Many of the speakers seem to wonder why America progressed with the electric vehicle while we did not. As a matter of fact, in England we established large companies, we poured out money and the best brains, and yet success did not come. But there is a strange coincidence which might put us on the right track to trace out the reason. The Edison battery was introduced seven years in America before it was introduced into this country. The electric vehicle business began to be a success in this country approximately seven years ago. The Edison battery was introduced at the Electrical Exhibition of 1911, and the electric vehicle has been a progressive success since that date. The guarantee by which the lead battery is covered has been mentioned by the author, but I would like to mention that the Edison battery has not a time guarantee but an actual mileage guarantee of 60,000 miles or eight years, whichever happens to transpire first, so that the battery cost is exactly known. The Edison battery has several advantages, in my opinion, over the lead battery. Take the question of weight. I believe Mr. Curtis will bear me out that on an equivalent chassis the Edison has a distinct advantage over the lead battery. The

weights are given side by side in all the catalogues. Then the question of "creeping" has been mentioned in the paper, but I cannot understand how the Edison battery gives trouble with creeping. The reason why there cannot be any leakage with the Edison cell is that the outside container is a metallic one, and whether the electrolyte is outside or inside makes no difference. Any cell could be completely immersed in the electrolyte and there would be no surface leakage. The carbonised sodium which forms on the outside of the container is certainly no detriment, and is, in fact, a preservative. We have assured ourselves that it is so, but for the protection of our customers we tell them to remove it once in two months, and these instructions are very simple compared with some that I have seen for the lead battery. The Adams Express Co. has been quoted to-night as possessing a very large fleet of vehicles. They use exclusively Edison batteries, having tried both, year in and year out. I hope some day we shall have an opportunity of testing the relative merits of the Edison and the lead battery, because there is a great difference between them. Mr. Ayton, who is undoubtedly a great authority on this matter, quotes the case of his own garage. I do not think that is fair. Why, even an old lead plate battery in Mr. Ayton's hands would give good service. He knows how to look after them, but I would suggest that the commercial public does not want a battery which requires an expert to look after it. We want a battery which some of our customers can put in the hands of their old horse managers and still get success.

MR. AYTON: In regard to Mr. Hales' last remark as to the need for expert attention to lead batteries, I would like to say that our lead batteries are looked after by two men who never had anything to do with batteries before. One of them is not a mechanic even, and the other is a wounded soldier. I never have to bother about these men. I very seldom see them from one week-end to another, and yet they have no difficulty in doing everything that is necessary to the lead batteries. I say this because I really want to see fair play between the two batteries.

MR. C. G. CONRAD: I think we owe our thanks to the Institution for bringing forward this subject at such an opportune moment. As we all know, everything is going to be electric in the near future, and a great part of transport work will certainly be carried out electrically. With regard to the Central Station aspect, the peak of the load due to the charging of vehicles clashes

(Mr. C. G. Conradi.)

with the peak load of the ordinary lighting ; I mean as between winter and summer. I have plotted out the consumptions for a rather large fleet of vehicles, and I find that there are really two peaks, one in January and another in November. There is a dip in the curve about Christmas time, no doubt due to the harder condition of the roads in frosty weather, and a low level portion throughout the dry summer weather. I have found that the use of a change speed mechanism would be an advantage from the current consumption point of view in a hilly town such as Sheffield, but on the whole I agree with Mr. Curtis and Mr. Mossay that it is a needless complication, especially in vehicles provided with two motors, where a complete solution of the problem may be obtained, at least as far as is necessary, by putting them in series. The regeneration question I do not think is a serious one. In fact, it is hardly worth consideration, as, in the ordinary way on town work, probably hardly a unit per day would be saved. The author states on page 402 that by using the Edison battery he would get an increased saving, but I think to be fair to both types it ought to be pointed out that with the Edison the inefficiency is greater and the current consumption would probably be more by 15 per cent. Taking it all over, for instance, in the fleet I am connected with, where we have 76 vehicles of the heavy type, there is really nothing to choose between the two batteries ; such a statement, however, should be qualified, because batteries ought to be chosen for the particular work the vehicle is to be used on, and in that connection advocates of both types of battery might look further into the question with a view to improvement. For instance, the efficiency of the Edison battery vehicle suffers because of the high internal resistance of the cell, whilst, on the other hand, the lead battery requires far more skilled attention than should be necessary in a commercial article. I might say that we are running Edison batteries in one town and lead batteries in another for these reasons. With regard to reliability, perhaps I might be allowed to give a few further figures. Last year we had eight vehicles which did not lose one day ; four in London and four in the Provinces, with an average of 3·7 per cent days out of service for the whole fleet. The depreciation of the petrol vehicle increases much faster than does the depreciation of the electric vehicle. I think that this is to be expected, and such figures as the foregoing after three years' hard work go to prove it. With regard to the running down of batteries and vehicles having to be towed home,

our experience does not point to this as being a vital matter. For instance, in 1918, we might have had one case of a vehicle having its battery run down in 2,500 vehicle days.

All motor vehicles with their high capital charges suffer from time lost in loading and unloading, and I would advise everyone to do all they can to reduce the terminal delays by means of demountable bodies and mechanical loading devices. Insufficient time and thought has been put into this question, which is most vital in all transport systems. In a general way, I think it may be taken that an electric vehicle saves three horses, and if terminal delays can be reduced to a minimum 30 per cent more will be got out of the vehicle, thus making it equivalent to four horses. Another question I should like to refer to is the vexed one of how to compare the performance of horses and motors. We have miles, tons, ton-miles, but none of them takes into account the effect of the density of the traffic through which the vehicles have to travel, nor the number of calls made per journey, and I think the attention of some of the members might be directed towards this problem.

Mr. L. A. C. DE LA GARDE: I believe the possibilities of electricity are absolutely unbounded. Experiments were made in Spain before the war with the object of collecting electricity from the atmosphere, and achieved a certain amount of success, inasmuch as a certain number of lamps were lit by this means. There is no reason to believe that within the next twenty years electricity will not be collected from the atmosphere by some convenient apparatus carried on an electric vehicle, which would obviate the carrying of electric batteries and make the electric vehicle absolutely pre-eminent for all time as a means of land transportation. The great point even at the present time is the simplicity of the electric vehicle, and anything that has few moving parts and is simple in design is surely nearing perfection.

Mr. C. N. GOOD: The author put the number of discharges of the Ironclad Exide battery at 300. I think he will find that this should more correctly be put at 600 under the guarantee which has been referred to. That is satisfactorily proved by the author's reference to an actual mileage of 25,000 to 30,000. In actual practice the number of discharges may very easily approach 1,000. Further, although the guarantee is for two years, the actual period over which the battery maintains its efficiency is frequently well

(Mr. C. N. Good.)

over $3\frac{1}{2}$ years and approaching 4 years. Mr. Hales shewed a considerable partiality for the Edison battery, but as a representative of the lead battery interests, I may say that the lead battery manufacturers are quite capable of accepting the challenge at any time and will welcome the opportunity.

Mr. R. J. MITCHELL: I think the suggestion that there should be a competitive trial between the two types of battery is an excellent one. We should then be able to find out the unique points of both, and useless or destructive quibbling in the future would be avoided. It seems to me that the function of the Institution of Automobile Engineers ought now to be quite frankly to broaden its outlook as has been done in America, i.e., there should be an Institution of automotive engineers and not merely of petrol car engineers, not steam vehicle engineers nor simply electric vehicle engineers, but an Institution of engineers interested in *all* methods of road transport both for passengers and goods, including allowance for new methods which might conceivably be developed during the next 50 years. In my opinion, it is in town transport that the electric vehicle will find its best field. Town transport should be conducted almost entirely by electric vehicles in the future, and even the engineers who are associated with electrical vehicles do not appreciate the colossal potentialities that lie before these machines. It is important that automotive engineers should look at this question *de novo*, and bring to bear upon it some of those magnificent mechanical refinements which have been applied to the development of the petrol propelled lorry and passenger car. If such designing ability is applied to the electric vehicle, it will have the effect of greatly improving the vehicle on the score of general performance. That would be a tremendous gain in popularising the electric vehicle and removing some of the prejudice which, in the past, has hindered its progress. The author did not mention another field of the electric vehicle, and that is in saving manual labour in factories. Its development in that direction has been colossal during the war.

A special type of miniature electric chassis called an industrial truck (see Plate XXIX), has been devised for this sort of service. Its function is the transportation of materials in works and factories generally, by which an immense saving of time and human muscle-power has been gained. Some idea of what this can amount to is given in the accompanying tables.

LOAD MOVED.	DISTANCE.	TIME TAKEN.	
		Electric Truck.	Hand Truck.
35 vises	200 feet.	1 min.	30 min.
160 hides	800 feet.	3 min.	40 min.
18 bags	100 feet.	$\frac{1}{2}$ min.	10 min.
1,500 lb. castings	115 feet.	$\frac{1}{2}$ min.	25 min.

These were all moved by a simple truck, where the loading and unloading are done by hand.

By using an improved type of truck which loads itself, the goods having been previously put on to straddle platforms under which the truck moves and then lifts clear of the ground by means of an electrically operated raising platform, the following even better results were obtained.

LOAD MOVED.	DISTANCE.	TIME TAKEN.	
		Electric Elevating Truck.	Hand Truck.
9 bales of hemp	1,000 feet.	3 min.	54 min.
6 carts of fish	1,500 feet.	4 min.	90 min.
2,000 lb. of castings	180 feet.	$\frac{1}{2}$ min.	30 min.
4 $\frac{1}{2}$ rolls of roof felt	600 feet.	2 min.	60 min.

Mr. OPPERMAN, in replying on the discussion, said: Mr. Ayton hits the right nail on the head when he draws attention to the fact that the efficiency and utility of electric vehicles depends in a large measure upon the roads. That is a matter to which the new Transport Minister ought to give his attention. Mr. Ayton seems, however, to have overlooked the one difficulty in endeavouring to use a watt-meter as a means of registering the output of a lead accumulator, namely, the fact that the capacity of the cells varies to an extraordinary degree according to the rate at which they are discharged; for instance, if the capacity of a certain battery is 100 ampere-hours at a five hour rate, it may be re-

(Mr. Opperman.)

duced to about 70 ampere-hours if it is discharged at, say, twice the normal rate, so that any readings taken might be misleading. The experience which Mr. Ayton has had with the Exide battery is most satisfactory, and if the life of the cells could be increased, they would be preferable for traction work owing to the higher electro-motive force available.

Mr. Curtis made the suggestion that with electricity at 1*d.* per unit, the relative price of petrol was 6*d.* per gallon. I am always very conservative in my estimates of the cost of electric power. About twenty years ago there was a discussion on motor cars generally, and I suggested that electricity might be put down at 2*d.* per unit. I was severely called to book by a very influential gentleman who was interested in the mechanical transport world, and he said that anybody who expected to get electricity at 2*d.* per unit was absolutely robbing the ratepayers. There is no doubt that one of the great features of the electric system—when put to its specific purposes—is that almost anybody can drive an electric vehicle, and I really think that the majority of electric vehicles are fool-proof. Mr. Beaumont seemed to think that I was not doing justice to the many other makers of electric vehicles by omitting the names of them. I fully appreciate that there are a great number of people in this country who are prepared to make electric vehicles and who are making a great number, but all their names cannot be mentioned in a paper like this. Mr. Beaumont also pointed out that certain cars required a battery equipment of twenty lead cells as against forty Edison cells. The average or mean effective voltage of the lead battery can be reckoned at about 1.9 volts per cell, and that of the Edison battery—or, rather, of those that I have had experience with—is not more than 0.85 volt per cell, which would account for the larger number of cells required as compared with the lead battery. In reply to Mr. Beaumont's question about the Planté cells, I think the objections I mentioned against the pasted cell also apply to the Planté cell. The chemical change which takes place is never complete and final because the fabric of the plate is continually breaking down until there comes a time when there is no fabric remaining; it has all been turned into peroxide and there is nothing to support the plate, so it collapses. Although Mr. Beaumont suggests that all the advantages of a two-speed gear can be obtained by electrical means, I am sorry to say I have not yet come across any such arrangement.

Regarding the somewhat heavy labour costs in the Croydon Refuse Collecting accounts, the men who make the house-to-house calls seem to be very well paid, and this, I think, accounts for the seeming discrepancy.

I was glad to hear from Mr. Chattock that there is now no difficulty in obtaining a boosting charge, and I am also pleased to hear that steps are being taken to standardise the various parts of the electric vehicle equipment. As to old-time difficulties in obtaining a charge, I remember some years ago that when I was stranded for want of a charge in a country town, a cable was laid out of a window, and I was charged half a sovereign for this. I could not do anything but pay, but that gives an idea of the encouragement given in the early days. From Mr. Chattock's remarks, I feel I may not have appreciated fully all that the Central Station engineers have done towards developing the electric vehicle, and I am very pleased to hear that they are giving the matter so much support, and are prepared to provide all the current needed for battery charging.

I was interested in the motor that Mr. Mossay spoke about, and I hope it will come up to his anticipations, as it would be most useful. That an electric motor having the characteristics as set out by him is an accomplished fact will go far to simplify the control of electric vehicles, and I am looking forward with much interest to a public demonstration of one. There seems to be some doubt about the creeping of salts in the Edison battery. Mr. Hales is a very good salesman, and he says it is an advantage, but in spite of that I notice that in their book of instructions the Edison Co. recommend users to remove it every two months. His remarks anent the Edison battery are very instructive, whilst the guarantee of 60,000 miles or eight years should still further popularise the electric vehicle for commercial purposes. Mr. Conradi thinks that the change speed difficulty would be got over by putting two motors in series, but I am afraid it would not. The only result would be to diminish the speed at once. My object in suggesting a change speed gear was in order to be able to keep the motor running very nearly at the normal speed, which would give not only a better speed on hills but would prevent the batteries discharging themselves unduly, although in the case of the Edison battery that seems to be an advantage. Whether it is or not, I have not sufficient experience to say. Regarding depreciation, Mr. Conradi has mentioned electric vehicles running

(Mr. Opperman.)

for four years quite satisfactorily. I do not want to be egotistic, but I might say that I saw one of my little electric broughams, which I built sixteen years ago for the Duke of Bedford, outside the House of Lords the other day, so it is evidently still being used. Mr. De la Garde raised an interesting question about electricity being collected from the atmosphere. I hope we shall be able to do so. Mr. Good points out that I was rather unfair to the lead battery when I suggested that 300 cycles was the limit. I have always been inclined to be conservative in my statements, and I am very pleased to hear that in some cases they have stood as many as 1,000. It would be an excellent idea if some comparative trial could be made between the lead and the nickel battery. I do not, however, think that the Edison is the only battery of the nickel-iron type. I have seen one which was made in Sweden before the war, and it seemed to be a most satisfactory production, and if we can get a little more competition in that way, it will be to everybody's advantage.

COMMUNICATIONS.

Mr. F. L. MARTINEAU wrote: In the early days, I considered the question of steam, electric and internal combustion operation of vehicles of various types, and my analysis pointed to the latter having the greater efficiency, considered from the fuel heat value, and I therefore decided that the greatest scope for working would be found with them. This is of special importance to-day, when our attention has been called publicly to the necessity of limiting transport of fuel, which makes it well worth while to study the efficiency of the electric vehicle in relation to the fuel used to propel it as compared with other forms of transport, and not by the mere question of cost per ton mile.

Presuming that a steam plant is used to generate the electrical energy necessary, it will be found that the following efficiencies are roughly correct, namely:—

Boiler efficiency	82 per cent.
Engine steam efficiency	24 „
Mechanical efficiency	90 „
Generator, Transformer, etc.	75 „
Battery efficiency	80 „
Motor efficiency	80 „
Car mechanical efficiency	90 „

The result is an efficiency at the road of only 7·7 per cent as a maximum. In other words, over 90 per cent of the heat energy of the original fuel are thrown away. In a petrol vehicle, the engine gives about 22 per cent efficiency, and the transmission about 85 per cent. The total is therefore about 18·6 per cent.

Now the coal used will have a thermal value of about 14,000 B.Th.U.'s per lb. and the petrol 18,000 B.Th.U.'s per lb. The relative weight of fuel to be handled in each case is in the ratio of $2\frac{1}{2}$ to 1 for the same work. If the electric vehicle is being run in London, for example, it will require the transport of $2\frac{1}{2}$ tons of coal to operate, when for the same work performed a petrol vehicle would only require 1 ton of spirit to be handled.

It would probably be far more economical if the generating stations were to distil coal, selling the gas for cooking and heating, motor fuel for transport, and electric energy for other purposes.

(Mr. F. L. Martineau.)

Mr. Curtis stated that 1*d.* per electric unit is equivalent to petrol at 6*d.* How the calculation was made is a mystery.

One gallon of petrol contains about 145,000 B.Th.U.'s.* One Board of Trade unit is equivalent to only 3,412·7 B.Th.U.'s (Hering's Conversion Factors, p. 77).

Now of the heat value of the petrol about 18½ per cent is used, and on the same basis about 57½ per cent of the heat value of the electrical units. The ratio of the one to the other is therefore 14 to 1.

Electric energy at 1*d.* per unit is therefore equivalent to petrol at 14 pence.

Mr. G. W. CURTIS wrote: Mr. Hales referred to the comparative weights of Edison and lead batteries, and I should like to clear up this point by quoting the weights of the various sizes of "G.V." Standard chassis equipped with batteries designed to give relative mileage:—

½-ton	60	A-6	Edison	.....	1,300 lb.
	44	11	Ironclad	.....	1,670 lb.
	44	15	GVX	.....	1,425 lb.
1-ton	60	A-6	Edison	.....	1,300 lb.
	44	11	Ironclad	.....	1,670 lb.
	44	13	GVX	.....	1,485 lb.
2-ton	60	A-8	Edison	.....	1,770 lb.
	44	15	Ironclad	.....	2,345 lb.
	44	17	GVX	.....	1,970 lb.
3½-ton	60	A-10	Edison	.....	2,172 lb.
	44	17	Ironclad	.....	2,650 lb.
	44	21	GVX	.....	2,410 lb.
5-ton	60	A-12	Edison	.....	2,688 lb.
	44	19	Ironclad	.....	2,955 lb.
	44	25	GVX	.....	2,790 lb.

The Ironclad and the G.V. batteries are in each case of the lead type. Some makers of electric vehicles using lead batteries have, I believe, designed their battery equipment on the basis of 40 cells, and these batteries work out in the case of the Ironclad practically equivalent to the Edison weight, and in the case of the pasted plate battery a trifle less, presumably to offset this argument.

* See Proc. I. A. E., Vol. III., p. 302.

On the other hand, the Edison battery requires considerably more space than the lead battery, and is usually assembled in road vehicles on the equipment of 60 volts as against 80 to 85 volts for the lead battery equipment, depending upon the number of cells used.

Concerning Mr. Hales' suggestion that the advent of the Edison battery is responsible for the development of the electric vehicle both in America and England, I would like to state that this is merely a happy coincidence. The difference between the situation in England and the situation in America following the electric vehicle boom of eighteen to twenty years ago was very pointed. England had no manufacturing investment in the electric vehicle whereas America had an enormous investment in electric vehicle manufacture, not only of vehicles, but of batteries, electrical equipment, and garages, and it was unquestionably this large investment that saved the electric vehicle from utter disrepute in America at this time. A number of companies largely interested in manufacture at that time were obliged to go through friendly receiverships, or in some cases bankruptcy, and those interested most heavily were successful, I think, in every case in purchasing the going business at a reasonable figure, and immediately set to work to get back, as it were, whatever they had lost in the transaction for their shareholders.

In some cases where the creditors were the largest and principal sufferers, they combined to purchase the assets of the manufacturing company, and in this way saved their own investment.

Long before the Edison battery had become of much use to the electric vehicle, the passenger vehicle at least had positively and definitely made a place for itself in the American automobile field, and the electric commercial vehicle was forging ahead at a very encouraging pace, the annual business increasing nominally from 100 to 150 per cent yearly.

Unquestionably, in the early days much difficulty arose from the poor service obtained with lead batteries of the pasted type. This was not entirely due to the quality of the battery, but in many cases to the lack of experience or knowledge on the part of the vehicle designer in selecting the electrical equipment in proper relation to the largest battery the vehicle could consistently accommodate. This is proved in some of the old electric broughams still running on the streets of London, which are demanding as

(Mr. G. W. Curtis.)

much current from the battery they carry as our present-day commercial vehicles of 5 tons capacity require.

I do not mean to detract in any way from the influence Mr. Edison and his battery had on the electric vehicle business. As everyone knows, the Edison battery had been heralded for many years before it eventually came into common use as the final solution of the electric vehicle, and we certainly are very thankful to Mr. Edison for pulling the doubtful ones out of the depths of distrust, and particularly in England for reviving the interest which had so shamefully been abused in the early days.

It might be very interesting, as Mr. Hales suggests, to have a paper read on vehicle accumulators and discussed by both the Edison and the lead battery adherents, but from my own experience no particular public good results from these discussions, as each side invariably endeavours to make the most possible personal campaign literature out of the argument. Some good does result, however, from an engineering standpoint to those who are competent to discuss the merits and demerits of either one side or the other.

Mr. G. J. DUCKETT wrote: Up to a short time ago we had to depend upon America for the supply of electric road vehicles, and, needless to say, these vehicles do not quite meet our requirements, as the running conditions in this country are not parallel with those in the United States.

Some of our large English manufacturing firms are now realising the commercial importance of the electrical vehicle, and are laying down plant to turn out these machines in considerable quantities.

Early in the paper there is a suggestion that a simple change gear box should be incorporated in the chassis. I must say this does not appeal to me, as the slight advantage accruing from the adoption of a change speed gear in a hilly district would hardly be worth while, besides one of the finest features of the "Electric" is its simple mechanical construction. I think that instead of using the complicated gear, an arrangement of motor field control would give the results desired, as the electric motor is the most efficient form of power over a large range of speed.

The author goes on to say that there is little between the iron battery and the lead battery from the point of view of weight; with this I agree, but he further adds that the lead battery requires less attention. I certainly do not agree, as from my experience I consider that one great advantage of the Edison cell lies

in the fact that it requires little attention. The removal of deposit by steam is not, from my point of view, at all satisfactory, and I find that the less moisture there is about the battery the better the results, also it is impossible to prevent rusting if steam is used for cleaning purposes. The proper system of periodical inspection and cleaning of the cells should prevent any unreasonable deposit of salts. I find that a good way of protecting the terminals and tops of the cells is to smear them with a thick oil or vaseline.

Caustic potash and dilute sulphuric acid are not pleasant liquids to handle at any time, but as the Edison cell is of a bottle type construction, whereas with the lead cell it is necessary to withdraw the ebonite lids and plates for washing, etc., etc., I think there is no doubt that the caustic potash, taking all things into consideration, is not likely to be as objectionable as sulphuric acid.

The remarks regarding the improvement of electro-motive force of the iron cell during discharge is very welcome information, and it will go a long way to improve the general usefulness of the electric vehicle.

The author puts down the available number of charges and discharges of an Exide cell as limited to 300. This I consider a very low figure, as from experience I have obtained considerably over double that number.

On page 405 he states that it is no uncommon occurrence to find that a set of tyres will last upwards of 30,000 miles. This may be so in London, where the roads have been designed to suit mechanically propelled vehicular traffic, but where roads are designed principally for horse traffic, as seen in practically all the towns outside London, or at least in the north of England, the useful life of the tyres is more like an average of 12,000.

There is no doubt that the heavy electric vehicle is most suitable for Municipal Cleansing Department work judged from results obtained at :—

Town.	Horse per mile.		Electric per mile.		Saving.
	s.	d.	s.	d.	s. d.
Pontypridd	4	9	3	2·69	1 6·31
Glasgow	3	3·15	2	10·65	4½
Sheffield	5	6·2	2	10·2	2 8

I do not think the 5-ton electric vehicle is quite good enough for average purposes as regards speed when fully loaded, and I think

(Mr. G. J. Duckett.)

we should concentrate our energies on vehicles of no greater capacity than $3\frac{1}{2}$ tons, that is, until we are in possession of more suitable batteries.

The actual cost of electricity for running electric vehicles is a very small item in the total cost, but still the current in units consumed can be reduced enormously by scientific design of chassis, employing as far as possible antifrictional bearings and lightness of general construction.

The question of tare weight compared with the carrying capacity is of interest; Table I shews the current consumption of a 15-cwt. vehicle running light, and with varying loads up to 20 cwt. In order to make the tests as accurately as possible, the weather conditions, road conditions, duration of stops, etc., were practically the same during each test. The vehicle without load consumed 60 amperes to cover the distance of 15.2 miles, the average battery voltage on discharge was 84, therefore the energy consumed was:—

$$60 \times 84 / 1000 = 5.04 \text{ units.}$$

or

$$\begin{aligned} 5.04 / 15.2 &= 0.34 \text{ units per mile at } 1d. \text{ per unit.} \\ &= 0.34d. \text{ per mile.} \end{aligned}$$

When the vehicle was loaded to 1 ton, the amperes consumed were 78, therefore $78 \text{ amps.} \times 84 \text{ volts} / 1000 = 6.55 \text{ units,}$ or $6.55 \text{ units} / 15.2 \text{ miles} = 0.43$ or $0.43d. \text{ per mile.}$

Therefore, to run the vehicle on no load costs $0.34d. \text{ per mile}$ as against $0.43d. \text{ per mile}$ with a load of one ton, or the actual cost of carrying the one ton was:— $0.43 - 0.34 = 0.09d. \text{ per mile.}$

The temperature of the motor and the battery was well within reasonable limits during the overload test, and possibly they could have withstood a considerably greater overload, but as the conditions under which the test was carried out were rather severe and the chassis was of an old pattern, and in many ways weak in design, it was decided not to carry the test further.

From these figures the importance of keeping down the tare weight of an electric vehicle to a minimum compatible with safety will be realised.

Of course these tests were based on the battery output, and therefore if provision had to be made for the inefficiency of the battery and charging apparatus the current per mile would be increased somewhat.

The author has not touched upon what I consider a most im-

TABLE I.

STATEMENT OF COST OF CURRENT FOR RUNNING 15-CWT. PARCEL VAN UNDER VARYING LOADS RANGING FROM "NO LOAD" TO 1 TON.
 ROUTES AND WEATHER CONDITIONS THE SAME IN ALL CASES.

Test No.	Time.	No. of Stops.	Running miles.	Load in tons.	Ton miles.	Ampere hours used.	Ampere hours per ton mile.	Cost per charge.	Cost per ampere hour.	Cost of Current per ton mile.	Each Run.	Average miles per hour.	Temp. of Motor.		Temp. rise of Motor.	Gravity of Cells.		Temp. rise of Battery.
													Start.	Finish		Start.	Finish	
1.	1.20.5	12	15.2	..	..	60	..	13.7	0.085	..	5.25	11.4	50°F.	72°F.	22°F.	1.275	1.225	6°F.
2.	1.21.5	12	15.2	0.25	3.8	64	16.8	13.7	0.085	1.428	5.43	11.3	50°F.	80°F.	30°F.	1.275	1.225	6°F.
3.	1.24.0	12	15.2	0.5	7.6	70	9.2	13.7	0.085	0.728	5.5	10.8	50°F.	80°F.	30°F.	1.275	1.215	7°F.
4.	1.25.0	12	15.2	0.75	11.4	77	6.7	13.7	0.085	0.569	6.5	10.75	50°F.	96°F.	46°F.	1.275	1.200	8°F.
5.	1.29.0	12	15.2	1.0	15.2	78	5.1	13.7	0.085	0.433	6.6	10.25	50°F.	98°F.	48°F.	1.275	1.200	8°F.

These figures are based on a charge of 1d. per unit for Current,

(Mr. G. J. Duckett.)

portant vehicle, namely, the warehouse type of truck. The prospects are good for the road vehicle, but the possibilities of the warehouse truck are abounding. It is certainly costly to buy, and the maintenance is fairly high, but the cost for charging is a very minor item indeed, and the difference in current consumption in running light and fully loaded will be seen from Table II.

TABLE II.

COST OF RUNNING INDUSTRIAL TRUCKS.

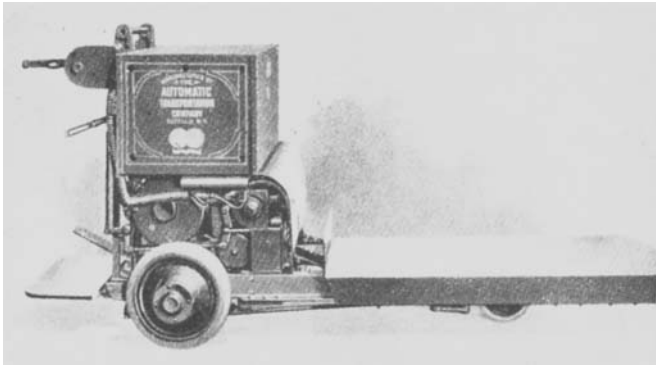
Concrete—Level Track.

Truck Capacity, 30 cwt.

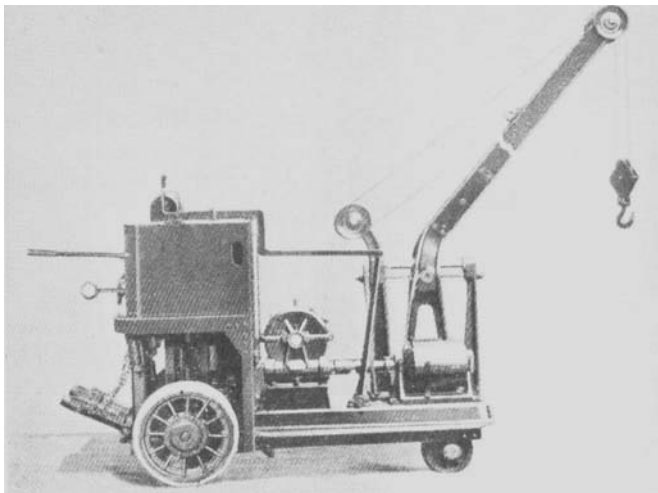
Tare Weight, 17 cwt. 1 qr.

Time, 10 hours.

Load.	Distance.	No. of Stops.	Units consumed.	Units consumed.		Cost of Current at 2d. per unit.	Driver's Wages, 33/- per week.	Total Cost per day.
				Per mile.	Ton mile.			
cwt.	miles.					d.		s. d.
0	18	600	8 0	0.44	..	..	7/-	8 4
10	17.2	600	8.6	0.5	1	2	7/-	8 5½
20	16.3	600	9.0	0.55	0.55	1.1	7/-	8 6
30	15.4	600	9.9	0.64	0.43	0.86	7/-	8 7¼
40	14.8	600	10.5	0.7	0.39	0.78	7/-	8 9



Electric Elevating Factory Truck.



Factory Mobile Electric Crane for 15 cwt. loads.