Geschiedenis van de auto van morgen

GESCHIEDENIS VAN DE AUTO VAN MORGEN

GIJS MOM

KLUWER BEDRIJFSINFORMATIE

Stellingen

1. De ontwikkeling van de auto met verbrandingsmotor is niet denkbaar zonder die van de elektro-auto. Onze huidige auto is, historisch beschouwd, een 'geëlektrificeerde' auto, zowel in technisch als in cultureel opzicht.

2. De accu heeft niet zozeer in technische, als wel in culturele zin bijgedragen tot de ondergang van de vroege elektro-auto in particulier bezit: als 'anti-machine'paste hij niet in het beeld en de praktijk van de auto als een in wezen mechanisch apparaat.

3. De luchtband als bepalende factor bij de vroege ontwikkeling van de autotechniek is tot nu toe ten onrechte in de autohistoriografie buiten beeld gebleven.

4. Het belang van de 'crisis van 1907' bij de domesticatie van de benzine-auto als 'avonturenmachine' wordt in de autohistoriografie onderschat.

5. Degenen die de transportrevolutie aan het eind van de negentiende eeuw primair als een paardenvervanging interpreteren, vergeten dat het verdwijnen van het paard zo'n anderhalve eeuw in beslag heeft genomen.

6. Het gangbare beeld van de elektro-auto als een 'gemankeerde benzine-auto' is historisch onhoudbaar. Beleidsadviezen die dit beeld niet ter discussie stellen en de elektro-auto rechtstreeks met de auto met verbrandingsmotor vergelijken gaan daarom mank aan een fundamentele denkfout, die alleen onopgemerkt blijft door een ongefundeerd geloof in een 'wonderaccu'.

7. Veel sociologisch geïnspireerde techniekgeschiedenis versterkt ongewild het geloof in de almacht van de techniek.

8. Techniekgeschiedenis vormt een ideale brug tussen de Twee Culturen.

9. De kleinzonen en -dochters van de pioniers van het auto-avontuur van rond de eeuwwisseling zijn tegenwoordig te vinden op de motorfiets en in de pleziervaart.

10. De onthaaste maatschappij dient zo spoedig mogelijk te worden ingevoerd.

11. Er is slechts één menselijke toestand ellendiger dan schrijven: niet schrijven.

GESCHIEDENIS VAN DE AUTO VAN MORGEN

CULTUUR EN TECHNIEK VAN DE ELEKTRISCHE AUTO

PROEFSCHRIFT

ter verkrijging van de graad van doctor aan de Technische Universiteit Eindhoven, op gezag van de Rector Magnificus, prof.dr. M. Rem, voor een commissie aangewezen door het College van Dekanen in het openbaar te verdedigen op dinsdag 4 november 1997 om 16.00 uur

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INHOUD

A HISTORY OF TOMORROW'S AUTOMOBILE

CULTURE AND TECHNOLOGY OF THE ELECTRIC VEHICLE

SUMMARY

Expectations and technological boundaries: a reconnaissance tour

The electrically powered vehicle has been grossly neglected in the historiography of road transport. This was not noticed until the recent development of electric propulsion as an alternative to the noisy and polluting internal combustion engine. For some time people would simply dispose of the electric car as the hobby horse of wealthy environmentalist extremists. However, when the established car industry started to look into the design seriously, and even Zero Emission Vehicles became mandated in California, public opinion began to change. Suddenly terms like 'Tomorrow's Automobile' appeared in print, referring to the electric car. It was hoped that automobile engineers might enter a new era of exciting innovations and developments, the consumer could look forward to a whole range of new fancy designs in flashy colours, the authorities would in due course aim their environmental policies at other problems than cars, and the car industry could repair the damaged reputation of 'the car'.
To the outsider it appears that this idea of an electric car came out of the blue: a phenomenon almost without a history. There was only a vague memory of an earlier period when the electric car must have been an important element in road transport. Indeed, as will be shown in the rest of this book, about one hundred years ago, some people also expected the electric car to be 'Tomorrow's Automobile'.

The renewed attention for electric cars also affected historiography, as it was discovered that its early history was covered in myths and popular memory. Recent trends in general automobile historiography, both in Europe and in the United States are of a more academic nature than before, and these new approaches also had their effects on the reinterpretation of events surrounding the electric car.
Important contributions to this new historiography were made by Michael Schiffer, Virginia Scharff, and David Kirsch, who all in one way or another tried to explain the failure of the early generations of electric vehicles by referring to social and cultural aspects next to technological developments.
In the present study, the central question is: how was it possible that the electric vehi-

cle did not manage to become the dominating technology? Was it the commercial failure of an otherwise superior technology, or should the question be analysed in altogether different terms?
The approach taken in this book is in part inspired by various recent studies, like the ones referred to above. In fact, being conscious of the dangers of myopia or single-mindedness, I have opted for a multidisciplinary approach which resulted in a whole complex of partial but interrelated explanations rooted in various disciplines: anthropology, macro-economics, cultural history, sociology, business administration, and: various fields of technology.
International comparison proved to be crucial to the research: I found that one needed to be aware of the subtle differences between various national environments where electric cars thrived or failed. This goal could only be reached by unearthing large quantities of British, American, German, French, and Dutch archives, periodicals, and secondary sources.

In my opinion, some of the recent automobile historiographers have gone too far in their attempts to show that cultural or sociological forces shaped the coming of the automobile age, as they deny technology played any role at all. To restore the balance somewhat, I set out my research from the rather provocative assumption: the failure of the electric vehicle had a technological basis. This should not, however, be understood as a return to the technological determinism for which the 'old' automobile history was notorious.
Because of my starting point I will pay special attention to straightforward technological problems that were experienced by the historical actors themselves, like battery capacity or the quality of tyres. Taking technology seriously is not the same as denying the possibility that non-technological arguments were at stake as well - or perhaps in due course turn out to be even more crucial than technology. As this study shows, understanding the history of electric vehicles is a matter of allowing for national differences and piecing together a great variety of elements taken from various disciplines.

Dealing with a complex technological artefact like a motorised road vehicle requires the use of some well-defined concepts to create order in the mass of facts, phenomena and relations.
Three central concepts in this study are 'fields', 'systems', and 'structure'. The term field is used in three particular contexts

- field of application: the various situations in which cars may be used, given the state of technology and a certain geographical situation, like cities, or rural areas. The field of application is decisive for the type of engine or motor that will be preferred. The issue of choosing between alternatives - petrol, electricity, steam, hybrid - has generally been described as a purely rational problem. In the following chapters, evidence will be given that there is much more to it.
- fields of expectation: the phantasies, dreams and expectations of future technology that guided the historical actors - individuals, groups, companies, governments - in their dealings with mechanised transport.
- technological fields: here ideas and expectations are translated into a technological artefact. Technological fields often act as a filter, where some expectations are stopped as being considered too unrealistic, while others are allowed to pass and inspire further technological developments. The range of the technological field is constrained by the state of the art in automotive technology, as is demonstrated in this study by the differences between the various generations (five in all) of electric vehicles.

To integrate the various aspects of the automobile in a wider context, the systems-approach was found a proper tool when combined with the idea of structures. The car itself is a structure consisting of substructures or components, arranged hierarchically, and this structure changes over time. As a technological artefact, on the other hand, the car functions as part of a large system, comparable to the systems analysed by Thomas Hughes in his study of electrification in the Western world.

2

Replacing horses and propulsion system choices in the 19th century

The advent of the automobile in the last decade of the 19th century did not take place in a vacuum. All individuals and institutions involved in 'automobilisation' were on the one hand part of a contemporary network full of technological, social and cultural interaction; on the other hand, they were part of various historical traditions. As early as the first decades of the 19th century, long before the hesitating arrival of the automobile, one may observe a clear increase in demand for transportation: even before the coming of the railways, personal travel was a growth industry, based on steam and horse traction.
The railways satisfied more than just a need for transport. They also created a new sensation of speed, and after initial scares about travelling at a speed three times that of a stage coach, the traditional horse transport companies responded by setting up their own high speed networks served by horsedrawn mailcoaches. The railways caused an 'industrialisation of space and time', in which the train passenger got an altogether new experience of the landscape, which the German historian Wolfgang Schivelbusch has called the 'panoramic view'. Whereas modern steam powered rail transport took place between cities, a revolution of urban transportation took place as well. As this revolution was at first mainly based on horse drawn vehicles, which only after many years would be succeeded by the more spectacular electric tramway, historians have paid little attention to these developments. However, the increase of public and semi-public transport by means of horse drawn cabs and buses is of extreme importance. The transport companies employed vast numbers of horses and vehicles (US figures for 1880 show that 100,000 horses pulled 19,000 trams along some 3,000 miles of tracks; figures for London, Paris, Berlin are equally impressive), but apart from solving part of the transportation problem, they also added to problems of rising costs, congestion, manure-polluted roads, and supply of feedstock and new horses.

These problems caused many of the urban transport companies to think of alternatives to horse drawn vehicles. Especially late 19th century Paris can be regarded as an enormous test ground for steam and electrically powered rail vehicles. The fascination for electricity as an alternative can to a certain extent also be regared as a typical Fin-de Siècle desire to have a clean, science based and very powerful source of energy.
During the 1880s, the first experiments with commercially viable electric trams in Berlin, Brighton, Vienna and the United States were not immediately successful. In the United States a crucial alliance between power companies and the new traction industry managed to create networks of electric urban transport, which in itself affected the layout and planning of the growing American cities.
In some areas, the overhead supply lines required to operate electric tramways could not be installed because of local regulations or a variety of other reasons. Engineers tried to overcome this problem by developing battery-powered trams and buses. This was the start of an international and very competitive development in battery design. French, German, and American engineers found themselves backed by huge financial interests to obtain new patents that could be made profitable worldwide.
Some of these inventors and producers, like the Electric Storage Battery Company (ESB) and the German Accumulatorenfabrik AG (AFA) would soon also show great interest in the development of electric vehicles for individual transport, like cabs and cars.

The experiments with battery powered trams were not as successful as had been expected, to the regret of the power companies that had just begun to build the expensive infrastructure needed for 'normal' electric trams and battery trams. Both types of electricity consumption acted as 'load levellers' and they would help the utilities to overcome problems with peak loads and idle generating capacity at other moments.

In all, there was a widespread interest in electricity as a potential solution to problems of modern mass transport.

3
The socio-technical dilemma: culture and technology of the early autmobile

Contrary to what one might expect from the preceding chapter, the first 'horseless carriage' was not powered by electricity. This chapter deals with the dilemma, or even trilemma, that confronted the first automobile makers: should their vehicles be powered by electricity, petrol or steam?
To understand the preference many manufacturers had for internal combustion engines, we must find out what these engineers were aiming at. As we have seen in the previous pages, the development of electrically powered vehicles was rooted in problems of urban public transport.

The internal combustion vehicle, however, was related to an altogether different set of questions. It was intended as an individual means of transport which allowed for a high degree of adventure. In this respect, the motorcar was an immediate successor of the bicycle.

Although the first electric cars drew heavily on the technology that was developed for electric trams, its structure had to be reconceived entirely: the car's smaller dimensions had important consequences for the size, weight and energy density of the batteries it carried. Whereas trams were driven by trained staff along smooth tracks, a car had to be a safe and reliable instrument in the hands of any adult, who might be willing to drive along roads where the uneven surface and steep climbs would badly affect the functioning of the battery and the mechanism as a whole.
In the last two decades of the 19th century these requirements were considered a challenge by a great number of engineers and coach-builders. The number of solutions and concepts almost equalled that of the makers. Car contests between electric vehicles were used to find out whether a solution was an improvement or should be rejected, and in a similar way, it was tried to settle the issue of superiority of electric and internal combustion vehicles.
In the United States, initial rivalry existed not so much between electric and gasoline cars but rather between electricity and steam as a motive power. There, too, contests were organised in which car builders, many of whom came from the bicycle or sewing machine industry, could show the quality of their products.

The organisation of contests for cars was not exclusively meant to obtain objective results concerning a car's technical performance. The idea of such competitions is also related to the bicycle races which by the end of the 19th century had become extremely popular and were surrounded by intensive coverage in the emerging mass media. There was demand for records of all kinds, as these achievements were the clearest proof of man's Progress. In due course, speed contests of automobiles would enjoy a similar popularity.
Not only did bicycles and cars demonstrate man's unlimited powers, these technical artefacts also played an important role in bringing man back into contact with nature in its purest form. Touring the countryside, leaving the crowded and stinking cities behind to enjoy total freedom on the road and experience the beauty of nature, all this was first done on bicycle, and then by car.
Travelling by car was considered a kind of active travelling in sharp contrast with the passive 'sit and wait till we get there' attitude of the train passenger. And judging from various sources, it was the unreliable internal combustion vehicle which required great skill to drive that proved to be an even greater adventure than travelling in an easy to handle and smoothly running electric car. As one contemporary put it: 'Apart altogether from its limitations of range and speed, it is certain that there is not much sport in driving an electric carriage. It is far too simple and too unexciting to be attractive. The fascination of the petrol engine to the man who is born with an engineering instinct is largely due to its imperfections and its eccentricities. In these respects, it possesses a soul that has much in common with the human, and one may safely prophesy that when the day arrives that every motor-car shall run with monotonous certainty, the main attraction of driving will have departed, and the amateur

will turn his attention to balloons or airships, seeking for further difficulties to overcome.'

Both the bicycle and the automobile fitted in well with the late 19th century desire among the higher classes to spend their leisure in an autonomous and individual way. The Self should be developed by healthy recreation. Riding a bicycle was an elitist leisure activity, and driving a car was an even stronger demonstration of a wealth lifestyle. Especially in Europe it was the aristocracy who set the pace and the trend for the new car industry. The engineers interacted with the car users to find technical solutions that satisfied all actors involved in the now fashionable automobile world. The technical problems drivers faced were not always considered a drawback - some impracticalities were simply regarded as an extra challenge that added to the sense of adventure. However, there were several parts of the structure of cars to which the engineers continued to devote much of their creativity. Especially the transmission mechanism, the ignition and the gearbox needed further improvement in order to create a larger market for cars in general. And the success of any innovation - including a car's outward appearance - would be repeated over and over again by the press when an improved automobile would perform well at one of the numerous contests and races.

In this continuing circus of contests, the electric vehicles managed to keep a position that was almost equal to that of the other types - gasoline or steam. Camille Jenatzy even was the first to break the 100 km/h record, in 1899, driving an electric racing car.

The electric vehicle conceived as a car for touring purposes required a huge infrastructure of battery loading stations, and in 1899 a French company was established to create such a network. Nineteen routes with charging facilities were planned, starting in Paris or Brussels and leading into Italy, Spain, Switzerland, the Netherlands and Germany. Parallel to these incentives, battery producers and car manufacturers in various countries tried hard to optimise the performance of batteries in order to allow longer distances to be covered on one charge.
On the other hand, some people involved in the development of electric vehicles decided that they should not try to compete with the internal combustion vehicle in a field where the latter had an unmistakable advantage. It was emphasised that the electric car should have a strong market position based on its specific characteristics, which were different from those of the other automobile types. In the United States, France, and Germany this led to a focus on the electric vehicle as a town car. It had an exceptional capacity of slow driving, stopping and starting, and it moved along without noise or smelly exhaust gases.
The electric vehicle as a town car needed an infrastructure for charging batteries, and a variety of solutions was elaborated. There could be charging facilities at the car owner's home, or drivers might stop at special 'electric hydrants' in the streets. In Paris a plan was conceived to set up numerous garages acting as battery charging or changing stations for electric vehicles.

During the 1890s, the number of manufacturers of electric vehicles rose rapidly, which may be interpreted as a sign that this kind of car was regarded as having a large commercial potential. It was by no means evident that the internal combustion vehicle was to be the superior technology for all purposes. However, this rather optimistic attitude towards the future development of electric cars is not reflected by the actual number of vehicles on the roads. Perhaps surprisingly, in Europe and in the United States, electric private cars remained a minority in the whole of motorised road transport.

4
Failed experiments: the electric taxi of the first generation (1896-1902)

In this chapter three major experiments with electric cabs will be analysed: in London, Paris and in the United States. Attention will be paid to the technological and socio-cultural factors involved in the failure of these early experiments.

The London Electrical Cab Company, established in 1896, was the result of a cooperation between coach builders, the London Electric Supply Company, the Great Horseless Carriage Company and the Daimler Motor Company. The design of its vehicles was a creation of Walter C. Bersey and was improved by a consulting engineers' firm which specialised in electric trams. The involvement of such a varied group of actors led to a cab design consisting of many technological styles that were hard to match. The so-called Bersey cab was designed in separate parts that were pieced together, instead of being conceived as a whole. It was too heavy for common rubber tyres, which made the operating costs much higher than expected, and the Bersey cab lacked sufficient power and speed to really compete with the London hansom cab. Within three years, the experiment was over.
In Paris the largest horse cab company CGV set up a separate Compagnie Française des Voitures Electromobiles (CFVE) in 1897, to produce and assemble a fleet of electric cabs. CFVE had strong personal ties with the London Electrical Cab Company management. It used modified Bersey cabs and a different type of batteries. Nevertheless, it seems that the choice for the Bersey 'mixed technology' design here, too, greatly contributed to the fleet's failure in 1901.
Somewhat different was the development of the Electric Vehicle Company, established in 1897 in New York. This enterprise, too, failed within a few years, but its founders had planned operations on a much larger scale, viz., thousands of cabs in all major cities of the US.
The dramatic history of EVC has been analysed and told by a number of historians, like Greenleaf, John B. Rae, Richard Schallenberg, and David Kirsch. By using other sources than these historians, and by comparing the events in America with the two European examples, one may shed new light on both the EVC story and the role of battery technology as a crucial element in the failure of the first generation of electric cabs.

As far as EVC is concerned, our research shows that its cabs were thought of as small battery trams running on roads instead of rails. This conception had serious consequences for the technological characteristcs of the vehicles, but also for the organisation controlling daily operations. Apart from these aspects of EVC as a whole, there were numerous local peculiarities that decided the company's fate in the various cities where it operated a network. The history of the New York branch of EVC differs from that in other cities as it shows a conversion of the technology of its original vehicles into a heavy, two ton structure running on solid rubber tyres.
A comparison of all three cab experiments leads to the conclusion that EVC was not a 'traditional' cab company that looked for a new technology to replace its horsedrawn cabs. Unlike the European companies, EVC was strongly rooted in circles of battery producers (ESB) and businessmen who held explicit ideas about building nationwide networks of holding companies and daughter companies. Whereas the London and Paris companies failed mainly because of the still immature battery technology, the American attempts were frustrated by technology as well as by organisational deficiencies.

Throughout this chapter, special attention is paid to three aspects of the electric vehicle of the first generation: its structure as a whole, consisting of interrelated components; the organisations set up for operating the vehicles; the role of batteries and tyres as factors for the success or failure of the early electrics.
All available evidence seems to support the view that, given the state of the art in storage battery technology in the 1890s, the electric vehicle could not compete with horses in public cab service. By 1900, the electric vehicle had not fulfilled the expectations of being the most likely alternative for individual urban transport. However, at the time there was hardly anyone who thought that the internal combustion engine would perform better on this specific market. Both technologies were still unable to replace the horse from its dominant position in urban transport.

5

Along separate roads: the town car, the touring car, and the 'crisis of 1907' (1900-1910)

This chapter analyses the rise of an urban automobile culture during the first decade of the 20th century. After a hesitating start, in the shadow of a powerful expansion of the internal combustion car, a second generation of electric vehicles can be observed in the latter part of the decade. This second generation differed from the first generation, which can be seen as electrified horseless carriages, in terms of technical sophistication and reliability. In spite of their impressive numbers in the United States, the electric vehicles remained a minority against the petrol cars.
In those years, the petrol driven car entered a kind of domestication process, in which

it gave up the functional part of its 'adventurous' character. It became a more reliable and useful vehicle for urban purposes. This development was inspired by the desire of the manufacturers to invade the city and enter into a direct competition with the electric vehicle in its own realm.

The electric vehicle as an urban car was especially popular among the very rich who used it to replace their horsedrawn private carriages. In some European and American cities, companies were established where electric vehicles plus drivers could be rented. A special group of owners could be identified in the United States, viz., medical general practitioners, who unanimously praised their electric cars for their simplicity, speed and reliability. Significantly, these men often owned a second, petrol driven car which they used for touring during weekends and holidays.

In 1907, a crisis struck the automobile sector as a whole. It was not just a matter of falling demand. The automobile suddenly was perceived as a danger on the roads, which affected its popularity as a participant in urban traffic. At the same time a technological crisis occurred in tyre manufacturing.
All these phenomena were experienced in the United States and in Europe within months of each other. The commercial crisis caused a very important differentiation in market segments: at first there had been just one market, where the rich purchased very expensive cars. Car manufacturers now had to lower prices in order to maintain some level of sales at all. New types of car were launched, and car production was rationalised where possible. Mass production seemed an interesting road to follow, although not for all manufacturers. Some remained active in their well-known upmarket segment, whereas others tried to find a mix of cheaper and more expensive models, and a third group concentrated on the cheap, mass produced vehicles, for which new technologies were developed.
The problem of the sudden rise of the automobiles' reputation as a killer has not been looked into by historians so far. It is a remarkable fact that around 1907 the technical press began seriously to discuss schools and licenses for drivers and formal legislation to control behaviour on the roads.
The third element in the 1907 crisis was the pneumatic tyre. It turned out very difficult to 'translate' the Dunlop pneumatic tyre, which had been developed for typical bicycling purposes, into an artefact that was able to withstand the forces generated by an automobile. Cars were much heavier and their speed was higher, so there was a need for stronger tyres that also would last longer than the common rubber ones.
The tyre was even called 'the car's Achilles' heel', and a great number of solutions was proposed to get by the problem - some of these involved the construction of shock absorbing wheels or 'spring wheels'.
In tyre technology, the Dunlop patents continued to frustrate other manufacturers until they expired in 1904. Then the road was free for companies like Michelin, Continental, and Goodyear to introduce new rubber compounds and experiment with other structures and materials like canvas to reinforce the rubber. However, it would take many years before car manufacturers could dispose of tyres that met their specific requirements.

In spite of this cumulation of setbacks, the automobile did not lose its identity as an adventure machine. Especially the Prinz-Heinrich reliability trials in Germany, which were held for the first time in 1908, inspired automobile engineers to take a different approach to relevant engine parameters and to design new car bodies. The result was a trend towards faster cars that did not look like motorised carriages, but had a new aesthetic unity by themselves: slender, aerodynamically proportioned vehicles expressing power. It should be noticed that this new style first developed with petrol cars, and that the electric vehicle builders for some time continued to design their products in accordance with the typical urban use of a horseless private cab.
Batteries were considered the major constraint that kept the electric from widespread use as a car for touring the countryside. This fact contributed in the first decade of the 20th century to a bitter struggle among patent holders, producers and electric car manufacturers for the 'best' battery concept. American, Swedish, German, and French companies tried to secure a leading position on the battery market by constantly improving their products and claiming ever better results.
But another line of approach was followed as well to make the electric vehicle into a competitor in the fields dominated by petrol cars. The hybrid vehicle combined elements of the electric vehicle technology with those of 'the other side'.
These attempts to find a compromise between two different technologies were much debated in specialist publications. As a source for understanding the ideas and criteria guiding further developments in automobile technology, these texts are invaluable.

6
Big fleets: the struggle for the taxi market (1905-1925)

Already before the 1907 crisis, it was evident that the cab market was crucial to the spread of automobilism as a whole. Contemporary writers mentioned the motor cab as a propaganda medium that allowed the less wealthy classes to experience the advantages and pleasures of the automobile.
By 1905, we see a second start of motorised cab operations in the cities. These were not just a reprise of the earlier initiatives that had failed in the late 1890s. Circumstances had changed drastically since then. Both petrol and electric vehicles had improved, each in their own ways.

In Paris, the earlier failure of electric cabs opened the road for a second attempt to conquer the horsedrawn cabs through petrol cars. After intensive trials and preliminary research, the Compagnie Fran‡aise des Automobiles de Place (CFAP) selected Renault as the supplier of hundreds of taxis. Between 1905 and 1910, nineteen other companies were established in Paris alone, at least three of whom used (hybrid) electric vehicles.
Within a few years, competition put heavy pressure on taxi rates, and many firms ceased their activities as they were unable to reduce operating costs. Once again it turned out that tyres were the most important technical cost factor, for petrol as well as for electric cabs.

The French car industry received a strong stimulus from the massive increase in demand for taxis and hired cars. When CFAP set up the General Motor Cab Company in London (1907), French car exports to Britain rose rapidly. A similar attempt to get a foothold in New York did not provoke an immediate reaction from American car manufacturers, who were rather indifferent to petrol cabs being imported from Europe. In 1911, some 3,000 out of 5,000 taxis in the United States were made in Europe, and especially in France.
The success of the European cabs in cities like New York did not affect the ideas concerning the commercial viability of new electric vehicles used as taxis. A number of companies successfully operated these electric cabs until circa 1917. Then the taxi sector as a whole became subject to an impressive upscaling process, initiated by the Yellow Cab Company. In this cheap mass market, the electric cabs found it hard to compete. The problem they faced specifically was that the vast American cities required higher battery capacities than usual, but these were hard to obtain.

Especially in Germany, new incentives for the taxi market emerged around 1900. Some of these were based on petrol cars, but others used second generation electric vehicles, with improved batteries. The liberalisation of the Berlin taxi licensing system led to an almost chaotic increase in the number of taxis.
A powerful force behind the relative success of the electric cabs was the German battery producer AFA. Its archives proved an extraordinary source for understanding the events that led to the failure of one of the major Berlin electric cab companies, Bedag, in 1911. This was due to a combination of technological and organisational elements. In other German cities, local bye-laws restricted the use of internal combustion vehicles as taxis, which put the electric cabs into a very comfortable position. Within a few years, the electric cab companies managed to build up an important body of expertise, both technological and managerial, which allowed them to operate large fleets of vehicles at relatively low cost. The interaction between these users and the battery producers was relevant to both parties.

One more electric taxi project could be analysed because of the discovery of extensive archives: the Atax company in Amsterdam. This was a relatively late development, compared to other countries, but it also continued longer than most of its foreign counterparts, viz. well into the 1920s.

When comparing these four different national and partly local stories of the rise and fall of electric cabs, one must conclude that there was a highly complex interaction between factors that differed from one place to the other. In Germany, legislation and bye-laws played a more important role than in the US; the involvement of battery producers and power companies did steer the process of developing networks to supply power to the taxis, but not in the same direction everywhere; the size of the cab fleet turned out to be a crucial element for success, but not in all countries to the same extent. Unlike the electric cabs of the first generation, it appears that the second generation vehicles did not fail in the long run because of insurmountable problems with

tyres and batteries. When taking a very close look at the competition between electric taxis and their petrol driven rivals, one must come to the conclusion that the latter managed to 'win' because of their extra capacity of taking passengers farther outside the urban electricity supply network of the electric vehicles. But within the 'natural' domain of the electric's range, and given a professionally supervised and well maintained fleet, electric propulsion even at this date was unmatched in reliability and profitability. Part of this success was due to 'mass charging' instead of energy charging: at the stations, the entire battery was replaced by a new one. The used batteries were recharged and stored for other taxis. This required the taxis to have two or more sets of batteries on board, but they had to spend only a very short time idling at a charging station, which increased their economic performance.

7

Great men, small fleets: the mechanisation of the German fire brigades (1899-1940)

As has happened more often in this study, several important archival finds have led to the elaboration of a special case study, viz. the mechanization of the German fire brigades. In fact, there were hardly any fire brigades using electric utility vehicles outside Germany.
In this study the fire engine is taken as an example of the wide range of special utility vehicles. In more than one respect, the fire engine is comparable to the taxi: it typically first appeared in the major cities, it was part of a fleet of vehicles surrounded by a more or less professional maintenance staff, and it was meant to replace horse traction.
As the fire brigade is very much a male domain, the presumed gender aspect of the 'female' electric car could have been of no relevance when a fire brigade decided to use electric vehicles. Criteria of reliability and safety (the absence of inflammable fuels) may have dominated the discussion leading to the adoption of this innovation.
The German preference for electric instead of petrol driven fire engines must be placed against the background of the semi-military organisation of the professional fire brigades. Early in the 20th century, an increasing number of civil and mechanical engineers made their way into the organisations, armed with a scientific education that helped them to decide in various technical matters. These engineers, especially when they had reached the top of the hierarchy within a municipal fire brigade, dominated the discussions held at meetings of the national association of professional fire brigades. Three of these leading characters were instrumental in the process of mechanization and the struggle between various technical alternatives: Maximilian Reichel, Johannes Schänker, and Wilhelm Scholz.

By 1900, experiments had shown that petrol driven vehicles lacked various qualities required by the fire brigades. Most of all, their engines were too unreliable.
As an engineer and senior fire officer of the Hanover and, later, Berlin fire brigades, Maximilian Reichel managed to negotiate with electric vehicle manufacturers to the extent that they developed a standard vehicle that exactly matched the local situation where he was in command. In due course, however, these fire engines turned out to be too customized to be of interest to manufacturers and customers in other parts of the country. A number of technical problems, with batteries and pneumatic tyres, that occurred with taxis, were felt less in the specific context of the very large and professional fire brigades.
The increasing reliability of the petrol engines during the first decade of the century made these vehicles a serious alternative to the very expensive electric fire engines, at least for the fire brigades in smaller towns. Gradually, the car manufacturers managed to get a say in the negotiating process, as Maximilian Reichel lost his dominant position after 1910. His place was taken by some other senior fire officers, who emphasised the problems surrounding the use of electricity to drive the high pressure centrifugal pump on the engine. Petrol engines performed much better in this dual purpose role.

8

The electric town horse: the utility vehicle as a machine (1897-1930)

This chapter is a first attempt to fulfill Richard Schallenberg's observation that 'the electric car and the taxi faded, while electric vans and trucks gained popularity. The reasons for this are not entirely clear, since the subject has not been subjected to any detailed analysis by historians of the automobile.'
Utility vehicles in general make up a story that is altogether different from the history of fire engines or private cars: their performance is judged by criteria like operating costs, practicability, and suitability for special or general purposes. The organisational context in which utility vehicles were to operate, also differed greatly from the paramilitary German fire brigades.
An interesting early development was the adoption of electric traction by various municipal services, like the postal service, the municipal sanitation department, the police and the ambulance service. These vehicles were customized to a high degree. As the professional operators set high standards for daily use, these vehicles were a great source of information to the manufacturers and the designers of parts. Discussions in technical journals and books on the results obtained by the various users are also a valuable source for the historian trying to grasp national differences and developments over time.

By 1900 electric buses could be seen out in the streets of New York, London, and Berlin. There were important differences between these cities, both in the general

situation of urban public transport and in the organisation surrounding the electric competitor of horsedrawn buses and horsedrawn or electric trams.

The development of electric trucks shows some similarities to the history of electric cabs. It was accompanied by endless series of trials and competitive tests. Especially the military had a keen interest in the potentials of this new type of traction that might replace thousands of horses behind the front lines.

In spite of intensive activity on the part of car manufacturers and (potential) users, the development of trucks, petrol or electricity propelled, did not affect the very strong position of horses in the goods transport sector until the 1920s. For the greater part, the new motorised vehicles were used to meet increasing demand for extra transport capacity and this just could not be satisfied by horses alone. In some cases, the vehicle's engine served a dual purpose, i.e., as a motive power and as a source of energy for equipment carried by the vehicle.

A fourth case study in this book deals with the electric utility vehicle in the United States. A crucial development in this story was the getting together of the American truck industry with two new partners - garages and power stations - which was named the Electric Vehicle Association of America (EVAA), in 1910.
This organisation was the outcome of several processes that ran parallel in time. In the field of technology, new transmission systems were developed by a General Electric daughter company, GeVeCo, and others. The improvement of battery characteristics was a worldwide process the effects of which were also felt in America. In 1908/1909, Edison introduced a new battery, the tube type plate accumulator. With its high energy density and improved construction, it was able to withstand 'boosting', a kind of rapid overcharging which increased the vehicle's range considerably. This Edison A-type battery set the stage for further competition and developments in the industry: especially between Edison and the Electric Storage Battery Company, producer of the Exide Ironclad lead acid battery, an all-out battery war broke out that lasted for several years. This was not just a matter of frustrating the other side's battery sales, it was also a competition between rivalling systems of charging and maintenance.
The managers of power stations, united in the Edison dominated National Electric Light Association (NELA) had their own rationale for stimulating the use of electric vehicles. Offering cheap off-peak current to charge and boost batteries seemed an effective weapon for the central stations to discourage the establishment of so-called isolated plant generating stations.
The New York Edison Company set up an Electric Vehicle Department for its own vehicles, and much attention was paid to other (potential) truck users, like express companies and breweries. Similar developments took place in other American cities. With the formation of EVAA, a well-organised and nationwide publicity campaign in support of electric trucks gained momentum. In this campaign, emphasis was laid on the 'education' of a non-informed potential user, and on 'service', thus drawing heavily on the public relations tradition of the utilities in their general quest for more electricity users. It is interesting to see that in its publications, EVAA paid only slight attention to technology. When looking closely at the state of the art in various fields

of electric vehicle technology (batteries, tyres, transmission and motors), one comes to the conclusion that by 1910 technology had ceased to be considered a serious obstacle to the profitable operation of trucks.
From the start EVAA developed an electric vehicle service concept in which garages were to play an important part. However, this brought EVAA into conflict with organisations of car dealers and independent garage owners. A next step in the marketing strategy was the propagation of education as a means to make customers familiar with a 'scientific method of transportation'. In a thoroughly organised campaign, EVAA began a massive assault on the dominance of horse traction in the cities.
To stimulate potential users to buy an electric truck, two options were discussed within EVAA: cheaper vehicles had to be built by the car industry, and the organisation of battery charging needed further improvement - it had to be cheaper, faster and less elaborate for the vehicle owner.
An interesting aspect of EVAA, which until now has received hardly any attention, was its self-imposed role of a near-religious movement. Close-reading of EVAA and NELA sources reveals a multitude of terms like preaching, believing, spreading the gospel and missionary work.

It was the American involvement in the First World War that led to the breakthrough of the petrol truck in urban goods transport. The armed forces ordered enormous quantities of petrol vehicles, and after the war the car industry continued its cheap mass production of improved petrol driven trucks.
The only niche markets for electric utility vehicles were those where highly customised designs were required. Port facilities and large industrial establishments used small electric trucks for transport within their compounds. Other urban users of special electric trucks were laundry services, the dairy industry, bakeries, and express companies. For them, the exceptional stop and go capacity of the electric truck was a valuable asset. Here, as with the fire engine and the taxi, big fleet owners preferred the electric, whereas smaller towns and the individual truck user preferred the petrol truck. But even among the big utility companies opinions about the virtues of the electric truck were divided. Even in this field of seemingly pure utilitarian thought, the 'adventure' character of the petrol engined truck played an important role. Various sources critically referring to joy-riding by utility personnel and to the speed maniacs among them are evidence of this.

Comparing the European and American development of the electric truck shows the role of the specific lay-out of cities and the degree of organisation supporting various aspects of the vehicle's operation.

9
The Pluto effect: the 'failure' of the electric vehicle

Together with chapters 3 and 5 this chapter makes a triptych dealing with the electric private car. This chapter also takes up part of the issue introduced in chapter 1, as it resumes the discussion of the potential failure factors brought forward by various scholars.
Here the third generation is subject of analysis, and this development is characterised by its appearance as an electric version of the petrol car.
Between 1910 and 1920 the private car with an internal combustion engine gradually turned into a reliable, universal vehicle. Its earlier specific quality as a racing and high-speed touring car was absorbed by a vehicle that on the one hand was fast and powerful, but on the other hand was domesticated for 'civilised use' as a family car and a town vehicle.
In those same years, the culture of electric vehicles in Europe shifted from France to Germany, where battery manufacturer AFA was a central figure in various networks of industrial and comercial enterprise. Nearly all these incentives, however, became victims of the First World War and its aftermath.
In the United States, the electric private car experienced a boom period shortly after 1910, when several manufacturers launched cheap, mass produced types. Even electric tourism seemed to become a serious option in 1914 and 1915, due to the activities of EVAA, Ford and Edison and others. But in America, too, the First World War frustrated the further development of the electric car industry into a real mass supplier of multi-purpose private cars. The market was simply buried by the overwhelming production of petrol cars.

Once again it is relevant to see to what extent technical deficiencies in the electric vehicle's structure contributed to its commercial failure. As we have elaborated in chapter 6, the later generations of AFA batteries caused no problems with the electric taxis. However, these batteries were not suited for use in private cars as their lifespan very much depended on cycles of intensive use and maintenance.
In the United States, the degree of electrification in the larger cities was higher than in Europe, and this allowed for a more widespread use of home charging devices. But the common owner of an electric car was a technical layman and had difficulty learning the secrets of battery maintenance. Even the intensive EVAA 'educational programme' was unable to change this.
Tyres continued to be another technical obstacle. Electric vehicles could not use the same type of tyres that were used on petrol cars, as the latter had more energy to spare to overcome the losses associated with the common, and not too expensive, pneumatic tyres. A crucial step forward was made by the Goodyear Tire and Rubber Company when it introduced the cord tyre for electric vehicles, a high resilience design that maximised mileage per charge. Resiliency, however, at first appeared hard to combine with a characteristic that was of prime importance to petrol vehicles, viz., low mileage cost. It took more than ten years before the expensive cord tyre was

improved to the extent that it became an acceptable alternative for petrol cars as well.
Next to the technical factors affecting the inability of the electric vehicle to whitstand competetion, one must look at an argument that has been put forward time and again in historiography: was the electric vehicle really the domain of female drivers and snobs?
It takes some very careful re-reading of the historical evidence available, and one has to rethink the logic of both users and manufacturers, to see that it was not so much the 'negative' connotation of electric cars and female drivers, but rather the qualities of the post-1910 petrol cars that appealed more to prospective drivers, male and female. This shift of preferences can be explained by looking at the increasing capacity of the petrol car to compete with electrics in their special urban domain. Gradually, the former became a really universal vehicle that was fit for touring, racing, shopping, and private urban transport. The electric self starter was introduced in 1912, which made the petrol car much easier to handle in an urban setting. In fact, there are various instances where the petrol car manufacturers implicitly or explicitly referred to special qualities of the electric, saying that their latest model had similar characteristics.

Would, finally, the infrastructural requirements of the electric car have been of major importance for its lack of long term success? Here we may use the system-concept as presented by historian of technology Thomas P. Hughes. In fact, the petrol and even steam powered vehicles needed a well organised infrastructure as well before they could be operated at full capacity. For automobilism in general, we have to widen Hughes' idea of a system, as it now should include more than a technical and organisational infrastructure consisting of energy supply points, maintenance facilities with skilled staff and suppliers of parts. We must also take into account the quality of roads, roadbuilding techniques, and the political and financial organisation behind roadbuilding.
It appears that the initial infrastructure needed to operate electric vehicles was indeed more elaborate and costly than that for petrol vehicles. However, one must realise that this was mainly perceived as a problem in rural areas, whereas from the start the electric car was intended to function as an urban vehicle par excellence.
There is no reason to conclude that the electric failed because of a lack of infrastructure. Paris, London, and America provide ample evidence that a modest kind of electric tourism was possible, and that charging stations could provide the energy that was required. The diffusion of the electric stopped before these options were fully explored.

10
Driven off the roads: super utilitarianism and the new electric adventure (1920-1997)

From the mid-1920s onward, the electric vehicle began to disappear little by little from the American streets. As in Europe, special utility vehicles continued to be an

interesting market. The German postal service and other delivery companies and municipal services operated impressive numbers of electric trucks in the 1930s. Occasional French incentives during the interwar years, especially in the Lyon area, show that the electric vehicle was considered a solution for crisis situations, when other types of propulsion were subject to restrictions of some kind.
In Britain, the interwar and postwar decades saw an enormous increase of electric trucks. Especially the dairy industry employed large fleets of electric vans for delivery purposes.

The 1965 Clean Air Act in the United States sparked off a rather ambivalent attitude among the Big Three American car manufacturers: they divided their R&D capacities among Zero-Emission projects and a fundamental reduction of exhaust gases with their 'conventional' petrol engines.
Similar developments can be seen in Europe, especially after the 1973 and 1983 oil crises.
It is a typical and important aspect of the attempts to popularise electric vehicles over the last decade or so, that new rational arguments based on very elaborate pollution calculations, are combined with lifestyle arguments that try to convince buyers that electric vehicles must not be seen as 'second rate petrol cars', but as a 'statement' in themselves.
As far as the various producers are concerned, it is evident that there are important national differences and different (technological) design styles among manufacturers that can be traced back to different approaches of the electric vehicle as a concept.

11
Pluto and Imelda's shoes: conclusions

A reconstruction and analysis of the origins, the development and 'failure' of the electrically propelled vehicle is not possible within the conceptual frameworks used in the history of its petrol driven counterpart. Expectations, technology, practice and culture that accompanied these artefacts were too different. Whereas the petrol car is rooted in the adventurous and individual pastime of bicycling, the electric vehicle is related to problems of urban mass transport dominated by horses.
Over a longer span of time, we see attempts of both kinds of vehicle to enter the domain of the other. The electric car should become a tourer and even a racing car, and the petrol car tries to find its way into the city.
To put both moves into perspective, the historian may use sources with a high technical content next to a detailed elaboration of cultural, political and social signs of the time.
In this way, the interaction between 'the engineers' and 'the drivers' becomes clear - and then one may be able to grasp differences between generations of electric vehicles, between national developments, successes and failures.

CURRICULUM VITAE

Gijsbertus Petrus Antonius Mom (Nijmegen, 21 maart 1949) deed in 1967 eindexamen gymnasium ß op het Canisius College in Nijmegen. In januari 1975 legde hij het doctoraalexamen Nederlandse taal- en letterkunde af aan de Katholieke Universiteit Nijmegen.
Na zijn afstuderen was hij enkele jaren werkzaam als docent Nederlands aan de HTS te Arnhem. In 1978 besloot hij tot een nieuwe studie aan de HTS-Autotechniek in Apeldoorn, die hij vier jaar later cum laude afsloot.
Na enige omzwervingen door de internationale auto-industrie (waaronder bijna een jaar bij de afdeling Motorenontwikkeling bij Renault in Parijs), besloot hij zich in Nederland te vestigen als publicist en vertaler op het gebied van de geavanceerde autotechniek. In deze functie schreef hij vele artikelen voor de Belgische en Nederlandse ingenieurs- en autotechnische vakpers, terwijl hij ook een tiental werkplaatshandboeken vertaalde uit het Frans, Duits en Engels. Sinds 1983 is hij bovendien hoofdredacteur van het tiendelige standaardwerk 'Steinbuch, De Automobiel', waarvan ook enkele delen in het Duits zijn vertaald.
In 1989 werd hij benoemd tot docent Verbrandingsmotoren aan de HTS-Autotechniek, inmiddels als afdeling van de Technische Faculteit van de Hogeschool van Arnhem en Nijmegen gevestigd in Arnhem. Daar is hij onder andere ook werkzaam als Coördinator van het Bureau Buitenland, terwijl hij sinds augustus 1997 een vierdejaars keuzevak 'Techniek en maatschappij voor ingenieurs' op het niveau van de Technische Faculteit verzorgt.
Van zijn hand verschenen, behalve de historische en de meeste theoretische hoofdstukken in de Steinbuch-serie, ook monografieën over auto-elektronica (als medeauteur), de elektrisch aangedreven auto, en de geschiedenis van het Nederlandse automobilisme. Het laatste gebied is het onderwerp van een aparte serie, de Conamreeks, waarvan hij de coördinatie voert en waarin inmiddels vier delen zijn verschenen. Wetenschappelijke artikelen op het gebied van de (auto)techniekgeschiedenis verschenen in het tijdschrift *Technikgeschichte* en in een door Mercedes uitgegeven bundel *100 Jahre LKW*.

De auto, meer [illegible] meer weg te denken factor in onze maatschappij. Toch is de academische belangstelling voor zijn geschiedenis bescheiden. Met zijn *Geschiedenis van de Auto van Morgen* schreef Gijs Mom, hoofdredacteur van een meerdelig autotechnisch handboek en docent Verbrandingsmotoren aan de HTS-Autotechniek, het eerste Nederlandse proefschrift op dit gebied.

Niet voor niets is dit boek gewijd aan de concurrentie tussen de elektrisch aangedreven auto en de auto met verbrandingsmotor: de 'strijd der systemen' is tegenwoordig weer actueel, maar blijkt een verrassend rijke voorgeschiedenis te hebben. Kort vóór de Eerste Wereldoorlog reden er in de Verenigde Staten zo'n 30 ... 40 000 elektrische personenauto's en nog eens 10 000 elektrotrucks. In Duitsland was aanvankelijk nagenoeg het gehele brandweerautopark elektrisch, terwijl bijna een kwart van de Berlijnse taxi's door accu's werd aangedreven. En in Amsterdam en Haarlem reden tussen 1909 en 1926 zo'n tachtig elektrische taxi's. Later, in de jaren vijftig, beliep de elektrische bestelautovloot in Engeland naar schatting 60 000 eenheden.
Geen reden dus, om zonder meer van een 'mislukking' van dit voertuigalternatief te spreken. Door deze vergeten geschiedenis op te halen en grondig te analyseren biedt Gijs Mom een nieuwe kijk op de geschiedenis van de auto. Waarom groeide de elektro-auto, betrouwbaarder en goedkoper in onderhoud dan de benzine-auto, niet uit tot onze nationale heilige koe? Waren het technische of sociale en culturele factoren die hier de hoofdrol speelden? Met dit boek schrijft Mom techniekgeschiedenis als een spannend verhaal, met geknakte illusies, chauvinistische reactionairen, als kinderen rondcrossende aristocraten, speculerende schurken, een half-extatische secte en ingenieurs, die een ideaal van een 'elektrische avonturenmachine' najoegen, waarvan de heftigheid ook al sommige tijdgenoten het hoofd deed schudden.

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